Essentials of ORTHOGNATHIC Surgery

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To my wife, Ingrid, and children, Johan and Mignon

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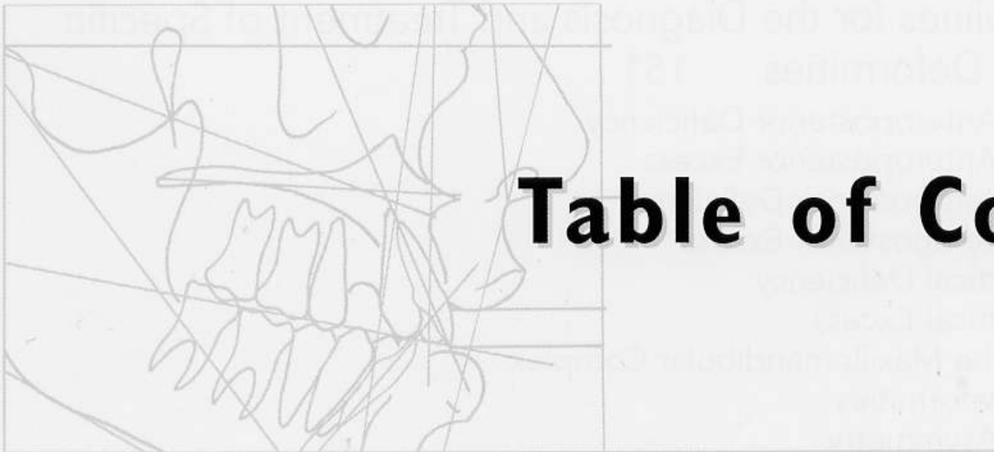

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Preface

Although many books have been written on the subject of orthognathic surgery, none of them specifically addresses the essentials of treating patients with dentofacial deformities. This book, which presents both the science and art of orthognathic surgery, was written to fill that void. The research component has been omitted, since those aspects have been adequately presented in other textbooks. Instead, it focuses on the surgical and orthodontic principles of orthognathic surgery, allowing the clinician to learn the subtleties of treating patients with dentofacial deformities without first wading through scientific data and treatment philosophies.

The text opens with a concise description of the principles of the clinical evaluation of a patient, analysis of diagnostic records, treatment planning, and surgical procedures with possible complications. Clinical cases are then presented to demonstrate treatment outcomes, which are evaluated in all three dimensions and may be used by clinicians as an atlas for patient education. The text is enhanced and clarified by detailed illustrations that are used liberally throughout the book in the belief that "one illustration is worth a thousand words."

This book specifically addresses several issues that are essential to orthognathic surgery. For example, cephalometric analysis is routinely used by orthodontists and oral and maxillofacial surgeons as a diagnostic guide and method of communication between members of a treatment team. However, because of their sheer numbers, relevant cephalometric analyses may become confusing and are often contradictory. To help assuage this difficulty, the relevance of the various analyses, including the new innovation of anteroposterior cephalometric analysis of the chin, is clarified with respect to skeletal, soft tissue, and dental relations in both lateral and anteroposterior cephalometry. An interpretation of each analysis is given to allow the clinician to choose the relevant analysis for the diagnosis of a specific facial deformity.

Another key issue in orthognathic surgery is the visual treatment objective. This tool is possibly the most meaningful, illustrative communication medium between team members as well as for patient information. Substantial space is therefore devoted to discussion of the development of a visual treatment objective for each deformity or combination of deformities in a step-by-step manner.

The modern orthognathic surgeon is exposed to a number of surgical procedures to correct dentofacial deformities. There is little doubt that the three most commonly used techniques are the Le Fort I maxillary osteotomy (including segmental surgery), the bilateral sagittal split ramus osteotomy of the mandible, and the sliding genioplasty. These three techniques are comprehensively described and clearly illustrated in a step-by-step manner. The basic principles necessary for a successful result, including the management of possible postoperative complications, are emphasized.

Although this book is designed to fit the specific needs of residents and young surgeons, experienced clinicians busily engaged in everyday practice also may find many refreshing reminders and hints for improving diagnostic and technical management of patients with dentofacial deformities.

I am deeply indebted to the pioneers of orthognathic surgery, on whose shoulders we, as modern practitioners, stand today, and feel extremely privileged to have been part of the exciting evolution of this fascinating field since the 1970s. Although it seems as if most of the basic scientific and technical parameters of orthognathic surgery have been established, new innovations and developments will improve the treatment we offer patients, and the development of the artistic flair that accompanies the science is unbounded.

This project was conceived about 10 years ago as a manual for a series of courses in orthognathic surgery written with the help of two orthodontic colleagues and friends, Tony McCollum and Bill Evans. I am eternally grateful for their enthusiasm, help and support, and also for making me think like an orthodontist—sometimes!

This book could not have been written without the support and encouragement of Dr Wynand van der Linden, a dear friend and colleague. A great debt is owed to Professor John Lownie for his enthusiasm and allowance of the time necessary to complete this project. The typing—and retyping—of the manuscript was done by Antoinettè Markram, who was simultaneously managing my busy private practice. Her expertise and competence are greatly appreciated.

Finally, I would like to express my love and gratitude to my extraordinary wife, Ingrid, and children, Johan and Mignon, for their patience, encouragement, and trust.

chapter 1

Principles of Orthognathic Surgery

People today usually recognize irregular teeth or obvious jaw deformities and seek treatment from an orthodontist, who can improve tooth alignment, function, and facial esthetics. More severe deformities that require a combination of orthodontics and surgery for correction are called *dentofacial deformities*. These deformities can affect physical orofacial function in several ways. Mastication can be impaired, and, especially in severe cases, this impairment can affect digestion and general nutritional health. Lip incompetence due to excessive vertical growth of the maxilla results in mouth breathing, which eliminates the physiologic effect of the nose on breathing. Speech is often affected by dentofacial deformities despite adaptive capabilities of the body. Irregular teeth may have a profound effect on maintaining proper oral hygiene and thus make teeth more susceptible to dental caries and periodontal disease. Normal temporomandibular function is also often affected by several types of dentofacial deformities.

The physical effects of a dentofacial deformity are important, but the psychosocial impact of a dentofacial deformity on an individual is often paramount. Such a deformity can profoundly affect the quality of life and entail lifelong adjustment.

The combination of surgery and orthodontic treatment makes it possible to treat dentofacial deformities that previously could not have been corrected orthodontically (eg, vertical maxillary excess and severe anterior open bite occlusion). Orthognathic surgery has created new and exciting opportunities in the treatment of patients with dentofacial deformities and has relieved the orthodontist of having only compromised treatment to offer patients with skeletal disharmony. Experience in orthognathic surgery, an increased understanding of its biologic basis, and a refinement of its art form now enable us to routinely deliver a stable, esthetic, and functional result to patients.

Three kinds of treatment are available when malocclusion is caused by severe skeletal discrepancies:

1. *Growth modification*. In growing children, dentofacial orthopedics can alter the expression of growth to some extent. (How much it can be altered varies and remains controversial.)
2. *Orthodontic camouflage*. Dental compensation for a skeletal deformity, or orthodontic

camouflage, not only can compromise or even impair the esthetics but also can jeopardize the stability of the results. This option may also increase the treatment time.

3. *Orthognathic surgery.* Combined orthodontic and surgical correction is considered the best treatment modality for dentoskeletal imbalances once growth has ceased.

Treatment Objectives in Orthognathic Surgery

Three treatment objectives are fundamental in orthognathic surgery: function, esthetics, and stability. These three objectives form the basis of goals in treating patients with dentofacial deformities and often go hand in hand.

Function

Functional and esthetic deformities often exist concurrently; when they do, treatment should be designed to correct both. When correcting a functional problem, the clinician has the opportunity to improve facial esthetics at the same time and should make full use of it. The treatment of patients with poor function but good esthetics is particularly challenging. In these cases careful planning must avoid worsening the esthetics while providing optimal functional relationships.

Esthetics

Facial appearance is often the patient's main concern. It is the patient's perception of what is esthetically wrong that is paramount, and one of the clinician's first tasks is to establish the patient's esthetic concerns. As Leo Tolstoy said in *Childhood,* "I am convinced that nothing has so marked influence on the direction of a man's mind as his appearance, and not his appearance itself so much as his conviction that it is attractive or unattractive."

Esthetic imbalance is often the result of a significant dentoskeletal deformity. In some cases the esthetics can be improved by surgery alone, although the functional problem will not necessarily be treated. An example is accepting a Class II malocclusion after surgical advancement of the chin for a patient with mandibular anteroposterior deficiency. In contrast, for a patient with vertical maxillary excess it may be possible to achieve a Class I malocclusion by orthodontic treatment alone; however, an ideal esthetic result is not possible.

Because the orthodontic placement of the teeth dictates the surgical movement and, ultimately, the facial changes, the practitioner must carefully assess patients with musculoskeletal deformities before the commencement of orthodontic treatment. Accurate preoperative orthodontic and surgical planning that considers the indicated surgical movement is necessary to ensure not only good functional results but an optimal esthetic outcome as well.

Figure 1-1 illustrates a case in which the dentition has been compromised for skeletal vertical maxillary excess and mandibular anteroposterior deficiency. Function and questionable stability have been achieved; however, the esthetic result is poor. Figure 1-2 illustrates an acceptable result after surgical compromise.

The patient in Fig 1-3 decided against surgical correction of her Class II malocclusion and vertical maxillary excess dentofacial problem. The orthodontic compromise treatment plan consisted of extraction of first maxillary premolars, retraction of maxillary incisors, and establishment of an occlusion. Four months after beginning orthodontic treatment, the patient felt her appearance was worsening and realized that this treatment option would not be acceptable to her. It was then decided to decompensate the maxillary incisors to open the extraction spaces in the maxilla. The surgical treatment plan consisted of a two-piece Le Fort I maxillary osteotomy, superior repositioning of the maxilla, and surgical closure of the extraction spaces by advancement of the posterior maxillary segment (Fig 1-4). The mandible would autorotate, and the chin would be surgically advanced by means of a sliding genioplasty. In this case an acceptable surgical solution could be

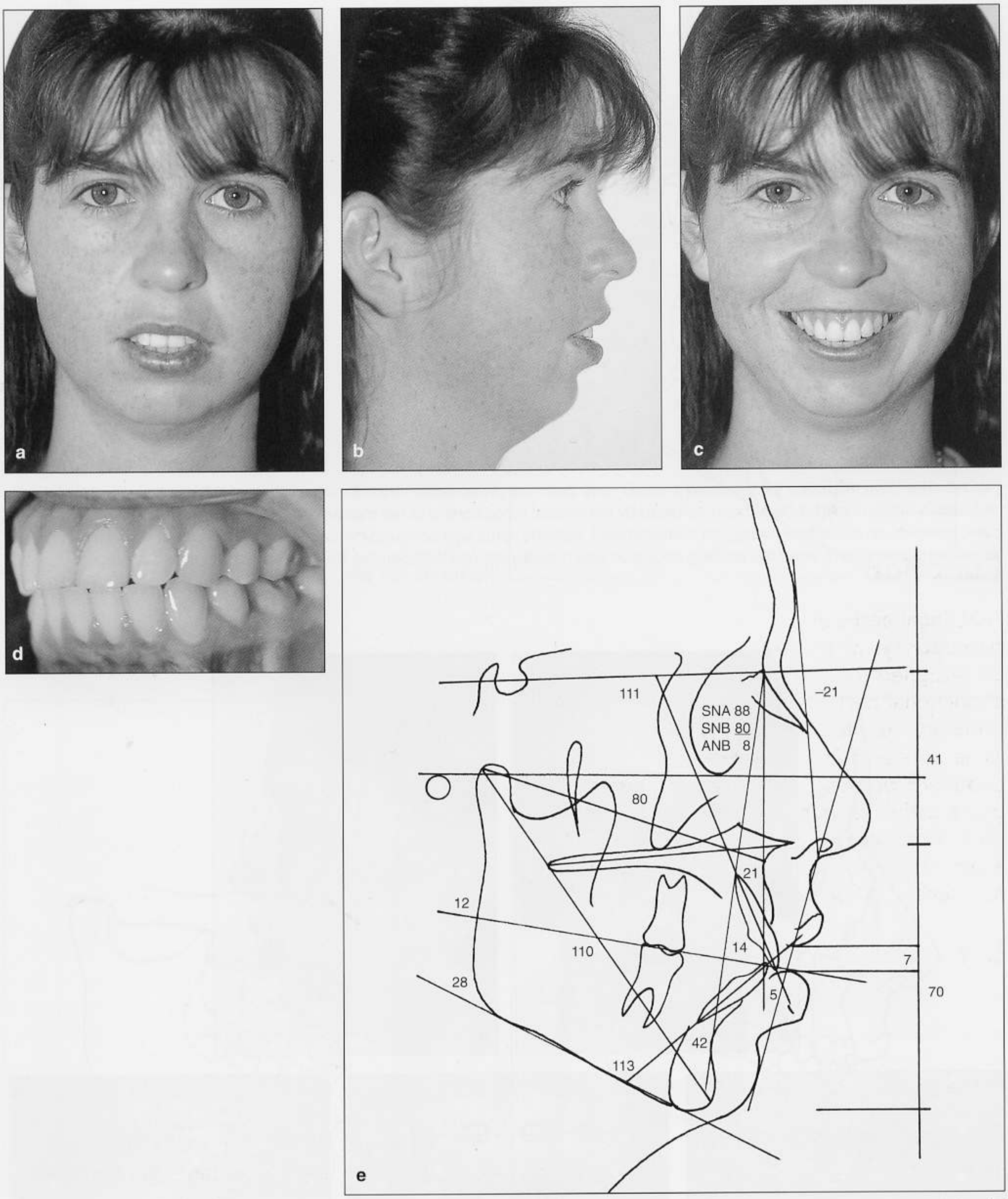

Fig 1-1 This 20-year-old patient was referred to the surgeon with the main complaint that her chin appeared too small and she did not like her "gummy smile." Previous orthodontic treatment lasted 3 years and consisted of extraction of four first premolars, retraction of maxillary incisors, and proclination of mandibular incisors. She was not offered the option of surgical correction of her skeletal problem. *(a)* Frontal view. *(b)* Profile view. *(c)* Smile. The dental compromise for the skeletal disharmony is evident in the occlusion *(d)* and the cephalometric analysis *(e)*.

Fig 1-2 The ideal treatment for this patient would have been the preoperative orthodontic creation of a Class II malocclusion (possibly with a different extraction pattern), followed by the vertical repositioning of her maxilla and advancement of her mandible. In this case, however, an acceptable, although compromised, esthetic result was achieved by superior repositioning of her maxilla and advancement genioplasty, while the existing occlusion was maintained. *(a)* Postoperative frontal view. *(b)* Postoperative profile view. *(c)* Smile.

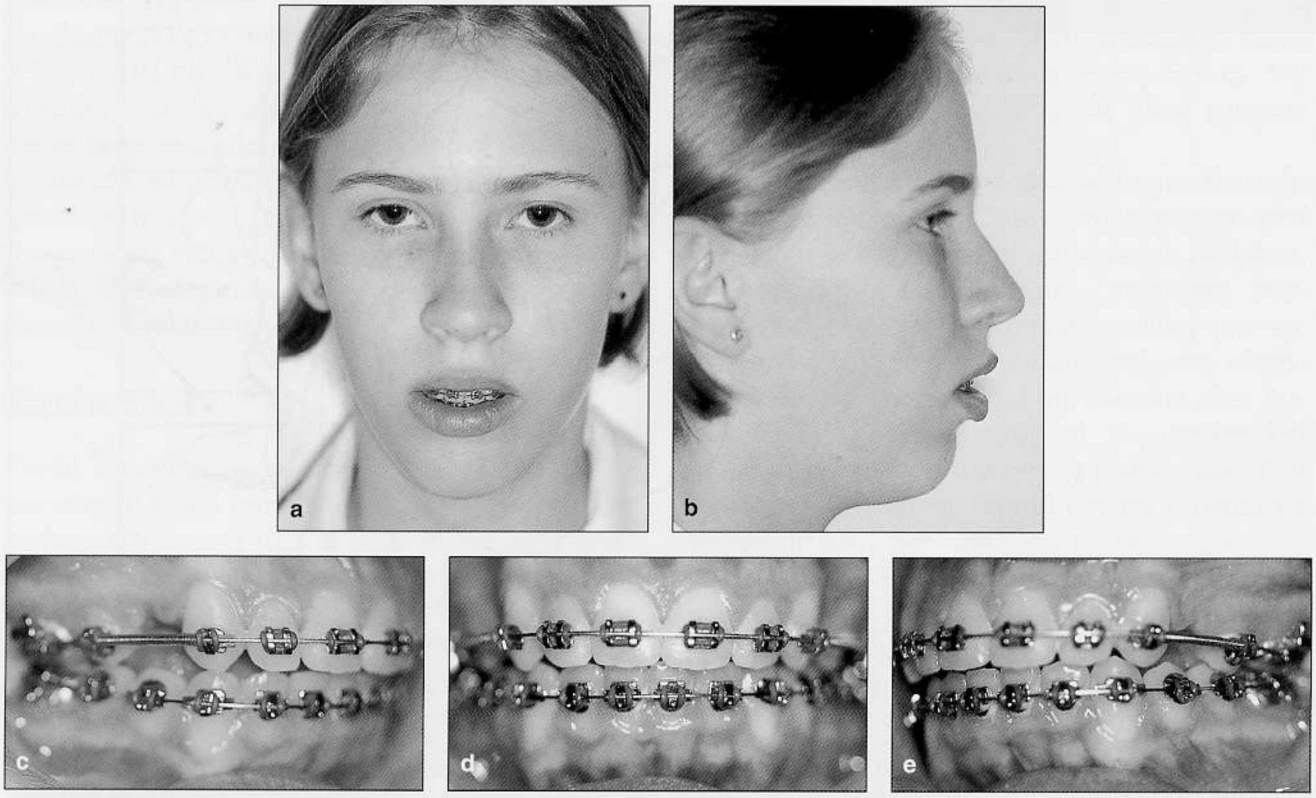

Fig 1-3 Because the patient decided not to have surgery, the compromise orthodontic treatment consisted of extraction of two maxillary first premolars and retraction of the maxillary incisor teeth. The deteriorating esthetic results are evident in the frontal *(a)* and profile *(b)* views. The occlusion *(c–e)* and cephalometric tracing *(f)* confirm the diagnosis of vertical maxillary excess and microgenia with a Class II malocclusion.

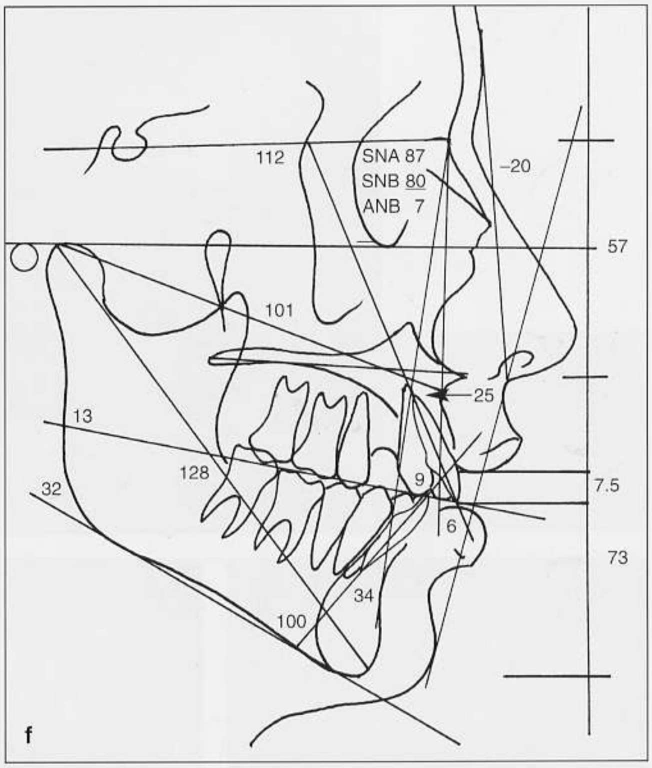

Fig 1-3 *Continued*

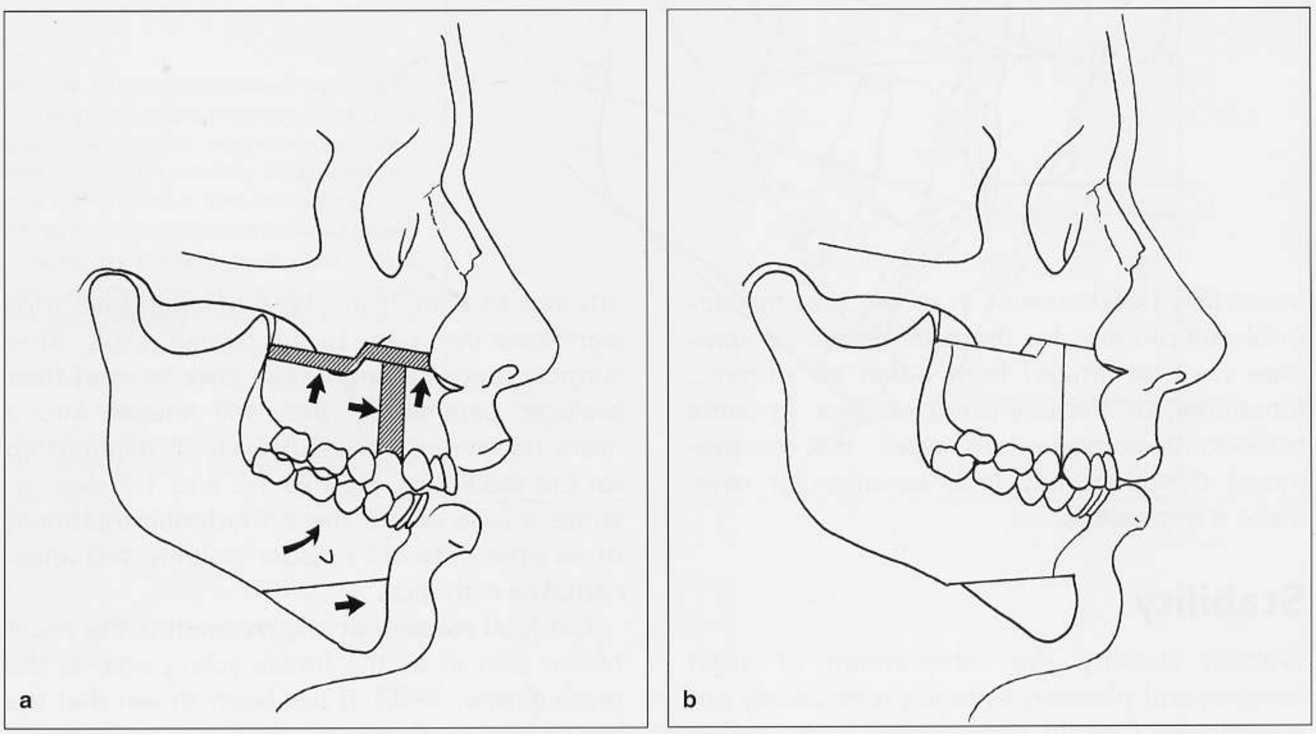

Fig 1-4 The maxillary incisors were decompensated, opening the spaces where the first premolars had been extracted. The surgery consisted of a two-piece Le Fort I maxillary osteotomy, superior repositioning of the maxilla, and advancement of the posterior segment to close the spaces. The chin was advanced by means of a sliding genioplasty. *(a)* Surgical treatment plan. *(b)* Postoperative dental, skeletal, and soft tissue positions.

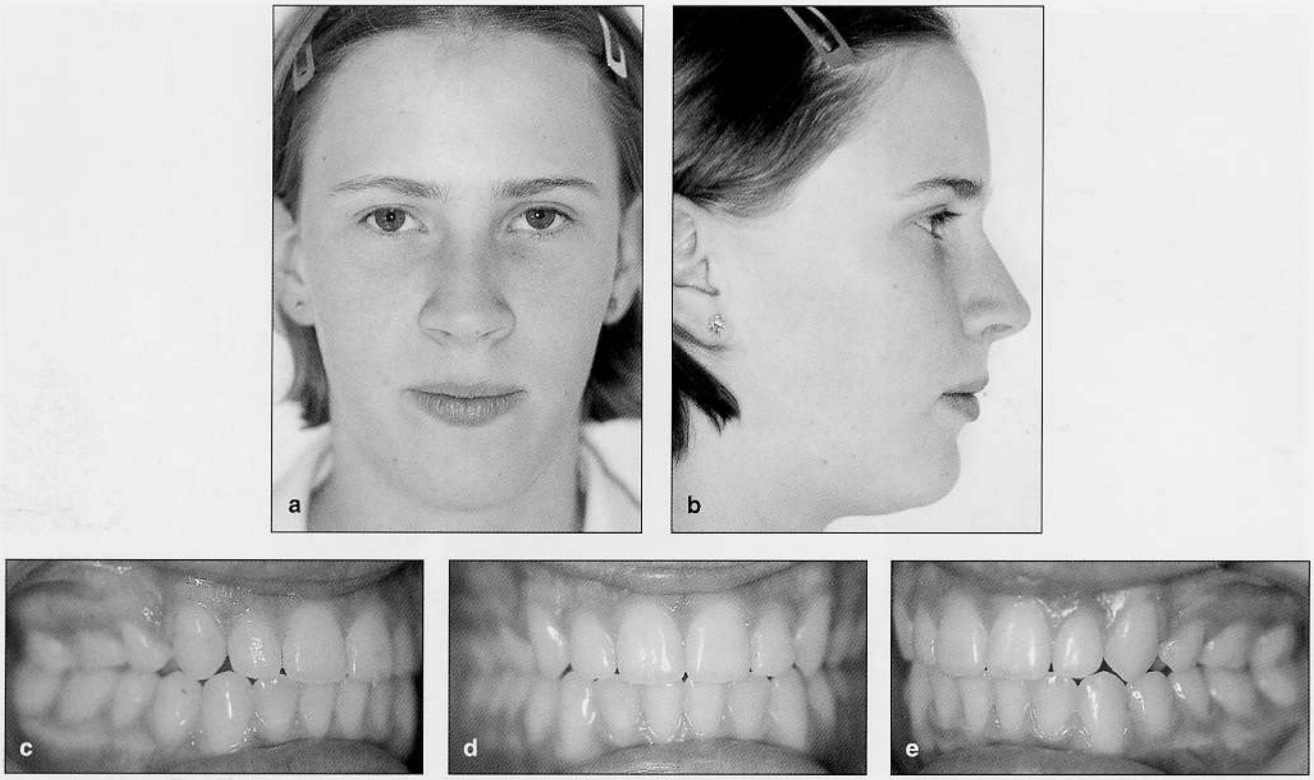

Fig 1-5 *(a)* Postoperative frontal view. *(b)* Postoperative profile view. *(c–e)* Postoperative occlusion results.

found (Fig 1-5); however, in some cases the surgical compromise for the orthodontic compromise may be limited from either an esthetic, functional, or stability point of view. In some orthodontic-compromised cases, the compromised dentition may limit salvation or even make it impossible.

Stability

Without stability, the achievement of good function and pleasing esthetics is obviously not acceptable. Certain orthodontic tooth movements have questionable stability. An example is the extrusion of teeth to correct a skeletal anterior open bite; any preoperative orthodontic attempt to correct this type of open bite adds significant instability to the overall result. After surgical repositioning of the jaws beyond their biologic parameters, they will relapse into a more harmonious musculoskeletal relationship for the individual. Figures 1-6 and 1-7 demonstrate a case where the orthodontic treatment of an open bite led to poor stability and unacceptable esthetics.

Occlusal stability at any moment is the result of the sum of all the forces acting against the teeth (Enlow, 1990). It has been shown that the use of sound orthodontic mechanics and surgical techniques will produce optimal stability, function, and esthetics.

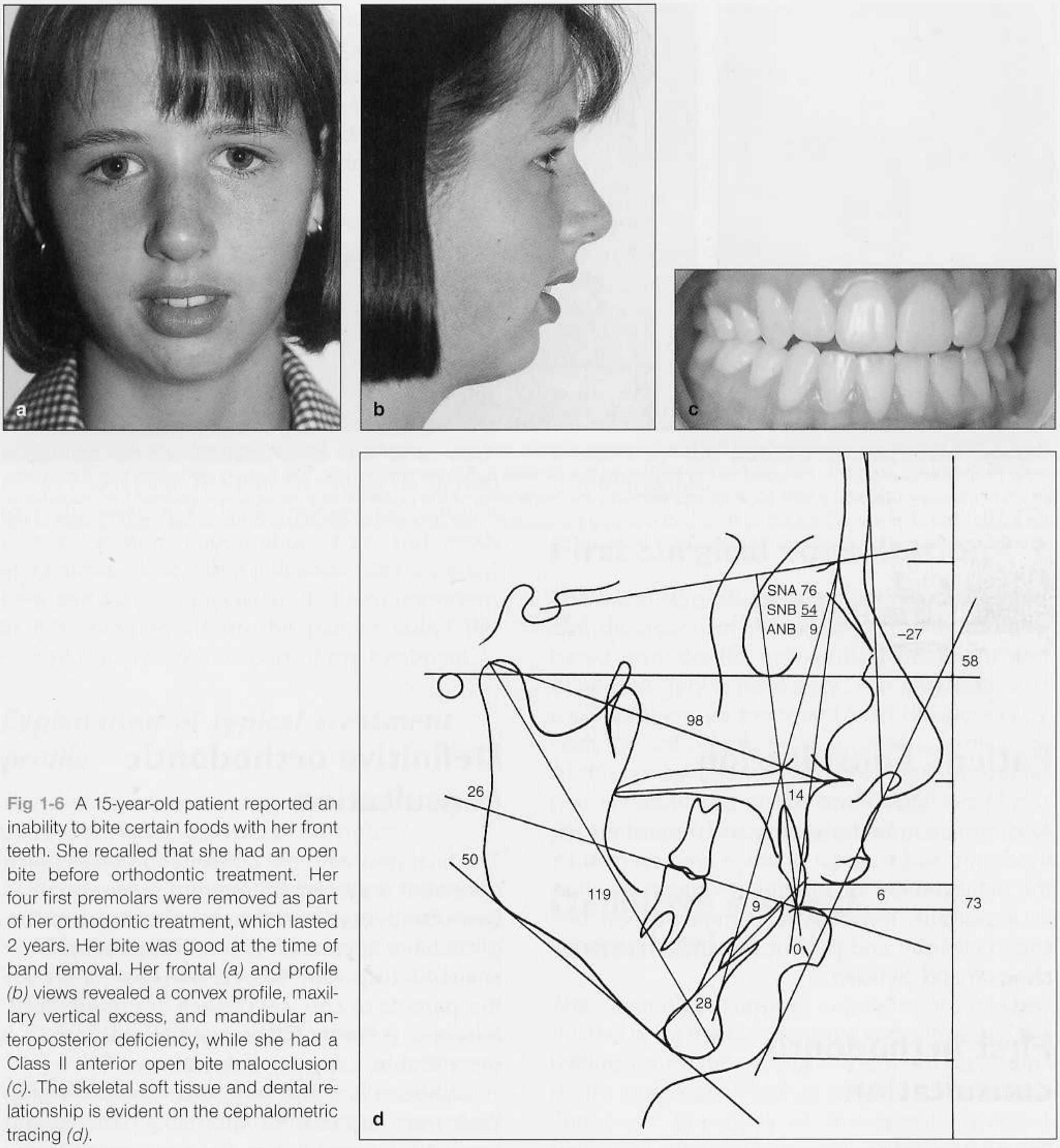

Fig 1-6 A 15-year-old patient reported an inability to bite certain foods with her front teeth. She recalled that she had an open bite before orthodontic treatment. Her four first premolars were removed as part of her orthodontic treatment, which lasted 2 years. Her bite was good at the time of band removal. Her frontal *(a)* and profile *(b)* views revealed a convex profile, maxillary vertical excess, and mandibular anteroposterior deficiency, while she had a Class II anterior open bite malocclusion *(c)*. The skeletal soft tissue and dental relationship is evident on the cephalometric tracing *(d)*.

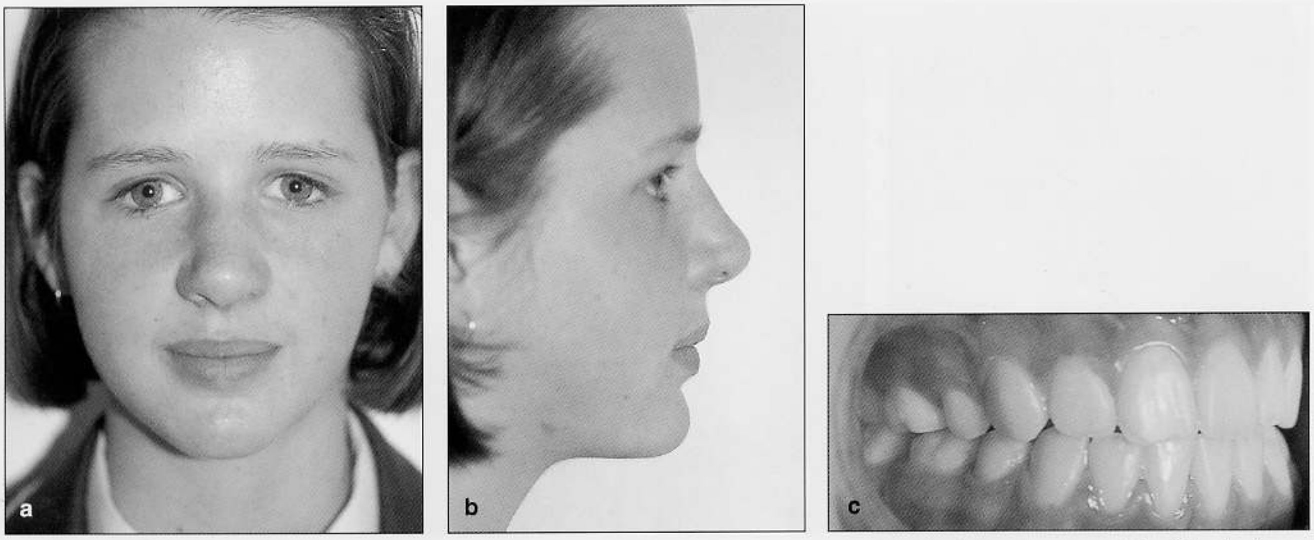

Fig 1-7 The patient was rebanded and the maxillary arch aligned in three segments; the anterior segment contained the incisors, while the posterior segments included all the teeth from the canines to the second molars. The surgery consisted of a three-piece Le Fort I maxillary osteotomy with superior repositioning and expanding of the posterior segments, which allowed the mandible to autorotate. The chin was advanced by means of a sliding genioplasty. The acceptable esthetic and functional result is seen in the postoperative frontal *(a)*, profile *(b)*, and occlusion *(c)* views.

Patient Consultation

Accurate treatment planning and meticulous orthodontic and surgical practice are essential to the achievement of treatment objectives. Just as important, however, is communication between clinician and patient, as well as between clinician and clinician.

First orthodontic consultation

Because people with irregular teeth and a jaw deformity usually seek treatment from an orthodontist, it is usually the orthodontist's task, at the initial consultation, to discuss the possible need for a surgical procedure as part of the treatment to achieve optimal results. During the first orthodontic consultation, a clinical examination is done and the appropriate records obtained. The records may be duplicated for the benefit of the surgeon.

Definitive orthodontic consultation

The final pretreatment consultation takes place only after a systematic patient evaluation has been conducted and the orthodontist and surgeon have agreed on a final treatment plan. It is mandatory that the patient (and perhaps the parents or spouse) be well informed. Well-informed patients follow instructions and, as a general rule, are easy to treat.

Orthodontists and surgeons should develop their own methods of informing patients and gaining their confidence. It is important to keep explanations simple and to use the patient's radiographs and dental casts to demonstrate the problems. Solutions for the problems should be discussed in general terms and the need for surgery explained. The importance of preoperative alignment of the teeth and the possibility of the bite not improving or even getting worse during this phase should be explained to the patient.

Word choice is important for the orthodontist in discussing the type of surgery required. Terms such as *reposition, lengthen,* or *shorten* should be used when describing the surgical procedures. The final and more detailed explanation of the surgery should be left to the surgeon.

Treated cases with similar problems may be used to demonstrate specific treatment objectives. For most patients the treatment time is extremely important, but it is preferable not to give a specific length of time. It is important, however, to give the patient a general idea of the length of treatment and a treatment profile explaining various phases of the treatment, the sequence of the stages, and the time each phase could take. The patient should be alerted to factors—such as bone density, periodontal disease, patient cooperation, age, and tooth extractions—that might influence the treatment time and surgical precision. It is also important at this stage to inform the patient about the cost of the orthodontic part of the treatment.

Explanation of typical treatment profile

The author explains to patients that a typical treatment profile consists of six stages:

1. *Placement of orthodontic bands on the teeth.* Any necessary extraction of teeth (including third molars) is done at this stage, and usually 2 or 3 weeks later the orthodontic bands are fitted.
2. *Preoperative/preparatory orthodontic phase (9 to 18 months, on average).* The teeth will now be aligned in their optimal positions in each arch. When the orthodontist is satisfied that this preparation is complete, the patient is referred back to the surgeon.
3. *Surgical phase and healing time (4 to 6 weeks).* The surgeon surgically repositions the jaw or jaws into their most favorable relationship to establish a good occlusion (bite) and balanced facial proportions. After a short healing period, the patient returns to the orthodontist for the final correction of the bite. It is very important that the patient see the orthodontist 2 to 3 weeks after surgery for postoperative orthodontic control.
4. *Postoperative orthodontic phase to perfect the bite (3 to 6 months).* The purpose of orthodontics after the surgery is to refine the bite. It usually involves minor tooth movement to finalize the occlusion and achieve a satisfactory result.
5. *Removal of orthodontic bands.*
6. *Retention phase (6 to 12 months).* When orthodontic treatment has been completed, the teeth that have been moved through bone need to be stabilized in their new positions for a time. The orthodontist manufactures and fits a retention appliance, which must be worn by the patient as instructed by the orthodontist.

First surgical consultation

The initial surgical consultation includes a general discussion of the basic principles of combined orthodontic and surgical treatment and of why surgery is necessary. The importance of a comprehensive treatment plan developed by both the orthodontist and surgeon is explained. At this consultation a systematic patient evaluation is conducted and records obtained (if duplicate records are not available).

Definitive surgical consultation

The definitive surgical consultation is conducted once the orthodontist and surgeon have finalized a treatment plan. The need for orthodontic preparation before surgery is confirmed. The basic principles of the specific surgical treatment, general sequence of events of the surgical phase of treatment, hospitalization time, time to recover, and the need for a soft food diet are discussed.

Treatment results of patients with similar dentofacial problems may be used to explain the surgical objectives. A patient information brochure is provided and the patient reassured that during the preoperative orthodontic phase, he or she is welcome to discuss with the surgeon any concerns regarding the planned surgery. The estimated costs, including costs of the planned surgery, hospitalization costs, and the anesthetization fee, should also be discussed at this stage.

Consultation with other disciplines

Consultation with practitioners in other disciplines may be needed in the treatment of patients with a dentofacial deformity.

Periodontic consultation

In general, most periodontal diseases should be treated prior to orthodontic banding. The teeth and periodontium should be sound before treatment. The importance of oral hygiene during the orthodontic treatment phase should be stressed and the possibility of periodontal treatment after debanding should be mentioned to the patient.

Prosthodontic consultation

Any work on fixed partial dentures preferably is performed after a period of orthodontic retention. However, it is often advantageous for the patient to consult with a prosthodontist before beginning treatment. The prosthodontist can contribute valuable insight into certain aspects of the surgical/orthodontic treatment and prosthodontic rehabilitation; eg, in a case with congenital absent lateral incisors, should the interdental spaces be closed, or should spaces be maintained and the missing teeth be replaced by implants or fixed partial dentures? For edentulous patients or patients with a limited number of teeth that would not require orthodontic treatment, the preoperative prosthodontic consultation is mandatory.

Implantology consultation

It is often possible to place required osseointegrated implants at the time of orthognathic surgery. It is important, however, to keep any postoperative orthodontic tooth movement in mind. Dental implants can often be placed more accurately after band removal and a short period of retention. The cost of a second surgery should be considered, however.

General practitioner consultation

Problems such as dental caries, fractures, and crowns with poor fit should be treated before treatment commences. The condition of certain teeth may influence the choice of tooth extraction for orthodontic reasons. The initial referral to the orthodontist or surgeon is often made by the general practitioner, and it is important to keep him or her abreast of the treatment plan and progress of the patient's treatment. Make the general practitioner part of the treatment team.

Importance of communication

Adequate communication between the orthodontist, patient, and surgeon about the patient's main complaint and concerns, dentofacial diagnosis, treatment possibilities, and treatment objectives is crucial (Fig 1-8). The confident sharing of information with the patient will build trust between patient and clinician. Remember, people want to know how much you care before they care how much you know.

No less important is the communication between the surgeon and the orthodontist. Lack of communication here not only hampers the development of an efficient and sound treatment plan but also generally leads to poor treatment results. Patients are extremely concerned about poor or lacking communication between the orthodontist and the surgeon, and it can lead to confusion. The development of a treatment plan has three advantages:

- It represents an agreement between the orthodontist and the surgeon on how the patient will be treated.
- The treatment plan and objectives can confidently be presented to the patient without contradictions.

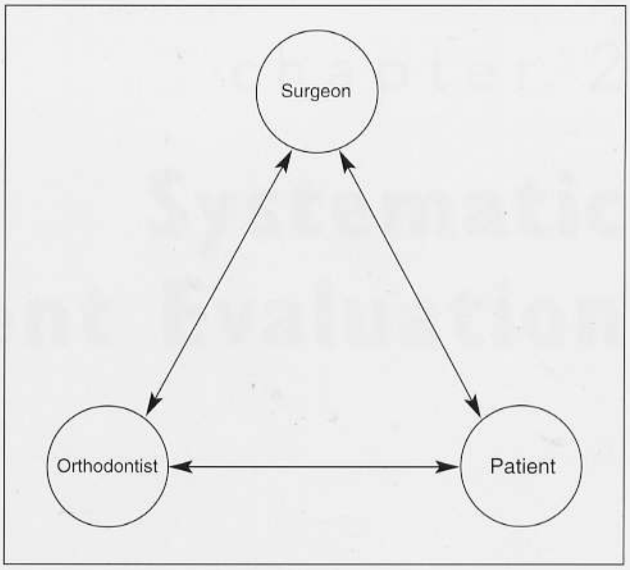

Fig 1-8 Kindness, communication, and free flow of information between the surgeon, orthodontist, and patient facilitate efficient and successful treatment and ensure patient confidence.

- Although the treatment plan may be changed when indicated, it serves as a solid guideline.

The treatment plan may need to be revised or changed after commencement of the preoperative orthodontic treatment. The reason for a change in treatment plan and the solution should be discussed by the orthognathic team. This will prevent any surprises at the immediate preoperative surgical consultation.

Superb orthodontic alignment of teeth and excellent surgical technique do not substitute for good clinical judgment, optimal decision making, proper communication, and empathy with patients.

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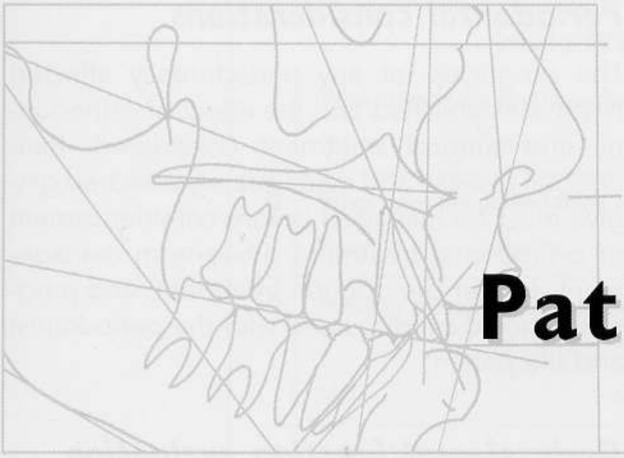


chapter 2

Systematic Patient Evaluation

The patient with a dentofacial deformity receives the best results from surgical therapy when there is clear and effective communication between the orthodontist and the maxillofacial surgeon from the outset of treatment. Through this close relationship, a full exchange of information and data can be made. Hence, in the following discussion no reference is made to "the orthodontist" or "the surgeon." Each should be familiar with the standard records required, and the data on the patient should be shared regardless of who actually carries out the investigations. Treatment should commence only after both the orthodontist and the surgeon have consulted with the patient and a treatment plan has been jointly prepared (records can be duplicated).

A systematic examination is necessary to adequately evaluate and plan treatment for patients with dentofacial deformities. In routine cases this evaluation includes the following:

A. General patient evaluation
   1. Medical history
   2. Dental evaluation
      a. History
      b. General evaluation
      c. Periodontal considerations
      d. Occlusal–oral function evaluation
B. Sociopsychologic evaluation
C. Esthetic facial evaluation
   1. Frontal analysis
   2. Profile analysis
D. Radiographic evaluation
   1. Lateral cephalometric evaluation
   2. Posteroanterior cephalometric evaluation
   3. Full-mouth periapical evaluation
   4. Panoramic evaluation
E. Occlusion and study cast evaluation
   1. Intra-arch relationship
   2. Interarch relationship
F. Temporomandibular joint evaluation

General Patient Evaluation

Medical history

The patient's medical history can be obtained by means of a questionnaire that the patient fills out at the first consultation. The questionnaire's coverage should be thorough so that no important areas are overlooked. The data are used to focus follow-up questions. Existing medical problems must be further evaluated and discussed with the appropriate physician or specialist. The potential for these medical problems to complicate general anesthesia or reconstructive surgery must be evaluated. Risk management and potential complications related to any medical problem should be discussed with the patient and carefully documented. It is also important to look for and recognize congenital syndromes, since these patients may have unusual growth patterns and may respond unpredictably to orthodontic or surgical treatment.

Dental evaluation

History

Previous restorative, orthodontic, periodontal, and facial pain treatment should be reviewed. The dental history is often an important barometer of the patient's probable commitment to future treatment.

General evaluation

Oral hygiene and previous dental treatment are good indications of the patient's "dental IQ" and motivation for future treatment. Caries, periodontal and periapical pathology, and the presence of unerupted and/or impacted teeth should be noted. The need for implants should be evaluated for possible integration into the final treatment plan. Final prosthetic decisions are deferred, however, until completion of surgical orthodontic treatment.

Periodontal considerations

The prognosis for any periodontally affected teeth is established and the effect of orthodontic and surgical treatment considered. Periodontal disease and inadequately attached gingiva must be managed before commencement of orthodontic treatment. Long-term management, further periodontal treatment, and prognosis should be discussed with the periodontist and the patient.

Occlusal–oral function evaluation

Mastication, swallowing, mouth breathing, modified eating habits, and maximum mouth opening are documented. The effect of the dentofacial deformities on speech should be noted and the patient referred for pretreatment speech evaluation. Tongue thrust, thumb sucking, and lip-biting habits should be noted and their effect on the deformity evaluated.

Sociopsychologic Evaluation

Evaluation of the patient's sociopsychologic makeup is often neglected. It is important to consider the patient's motives for treatment and to determine the patient's expectations from treatment. There are two basic causes of patient dissatisfaction with the treatment outcome: *(1)* failure of the clinician to inform the patient clearly of realistic and probable treatment results (especially esthetic results) and *(2)* overoptimistic expectations of the patient regarding the results of treatment.

At the first consultation, the patient should be introduced to the concept of surgery to the jaw(s) gently but confidently. It is imperative that the clinician immediately provide the patient with a realistic and understandable overview of orthognathic treatment principles and general treatment possibilities in relation to the patient's specific dentofacial problem. Understanding the patient's concerns, motivations, and expectations will provide insight into the patient's psychologic health.

Sociopsychologic Evaluation

1	**Who attends the first consultation?**									
	Patient		Father		Mother		Spouse			Friend
2	**What does the patient think is wrong?**									
	Function		Esthetics		Pain		Speech			None
3	**Patient's perception of esthetic severity:**									
	1	2	3	4	5	6	7	8	9	10
	Mild				Moderate					Severe
4	**Patient's perception of functional severity:**									
	1	2	3	4	5	6	7	8	9	10
	Mild				Moderate					Severe
5	**Patient's ability to define problem:**									
	1	2	3	4	5	6	7	8	9	10
	Poor				With assistance					Good
6	**Expectations of treatment:**									
	1	2	3	4	5	6	7	8	9	10
	Unrealistic				Unclear					Realistic
7	**Motivation**									
	1	2	3	4	5	6	7	8	9	10
	Low				Moderate					High

Fig 2-1 Sociopsychologic evaluation form.

The clinician should refrain from overwhelming the patient with overt enthusiasm about the benefits of treatment, but rather should allow the patient to make his or her own decision. Some patients may need time to discuss future treatment with family or friends. Further counseling about realistic treatment expectations may be necessary, and treatment may even best be delayed until, through psychologic guidance, the patient can cope with treatment realities.

The perception of one's own appearance is often the "motor" behind direction in life. Surgical-orthodontic change of facial appearance inevitably has an effect on this motor. The following are some relevant questions for the patient to consider:

1. What does the patient (and/or the patient's parents) think is wrong?
2. Why is treatment required?
3. Why is treatment required now?
4. What is expected from treatment?

Figure 2-1 shows a sociopsychologic evaluation form, which should give the clinician an overview of the patient's sociopsychologic status and an indication of any existing problems.

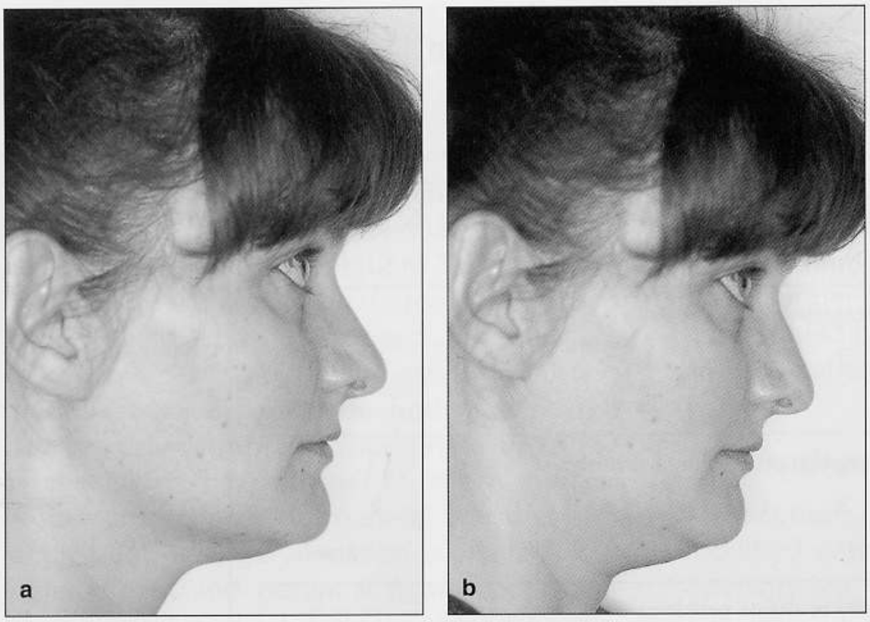


Fig 2-2 Clinical assessment of the chin and throat area is possible only when the head is in natural posture. Note the differences in natural head posture *(a)* versus posture with the head tilted down *(b)*.

Esthetic Facial Evaluation

The clinical assessment of the face is probably the most valuable of all diagnostic procedures. The esthetic facial evaluation should be performed in a systematic fashion with the patient standing or seated comfortably. Primary emphasis should be placed on frontal esthetics, since that is how people see themselves. Data should be recorded on a special form, which also can serve as a checklist. Only abnormal and pertinent data should be recorded. *Balance and proportion between the various facial structures in the individual are more important than numeric values.* It is also important to compare the facial proportions with the patient's general build and posture.

The clinical examination of the face should always be done with two questions in mind:

1. Would orthodontic-surgical treatment be able to correct the dental, skeletal, and soft tissue structure diagnosed as abnormal?
2. How would the orthodontic-surgical correction of the abnormal structures influence the facial structures considered to be normal?

The patient should be examined in natural head posture, with the teeth in centric occlusion and the lips relaxed. Natural head posture is the position in which the patient orientates his or her head and which feels most natural. Figure 2-2 illustrates the profound effect a change in head posture may have, for example, on chin position, chin-throat angle, and chin-throat length. Skeletal and soft tissue changes can therefore only be planned with the head in natural posture and the lips relaxed to ensure appropriate soft tissue changes.

Orthodontic and surgical treatment are planned to produce ideal function in centric occlusion. All examination data should therefore be recorded in centric occlusion. However, patients with vertical maxillary deficiency and severely closed bites are an exception to this rule. Because of the inadequate height of the maxilla, these patients' bites are overclosed, leading to distortion of their lips. To accurately evaluate these patients' lips and maxillary incisor–upper lip relationships, they should be evaluated in an open bite posture. A wax bite can be placed between the teeth to increase the vertical dimension until the lips just part. The lack of tooth exposure, lip shape and thick-

Fig 2-3 Individual with vertical maxillary deficiency. Note the change in the shape of the lips and lower facial height with the teeth in occlusion *(a)* and with the mandible rotated open until the lips just part *(b)*.

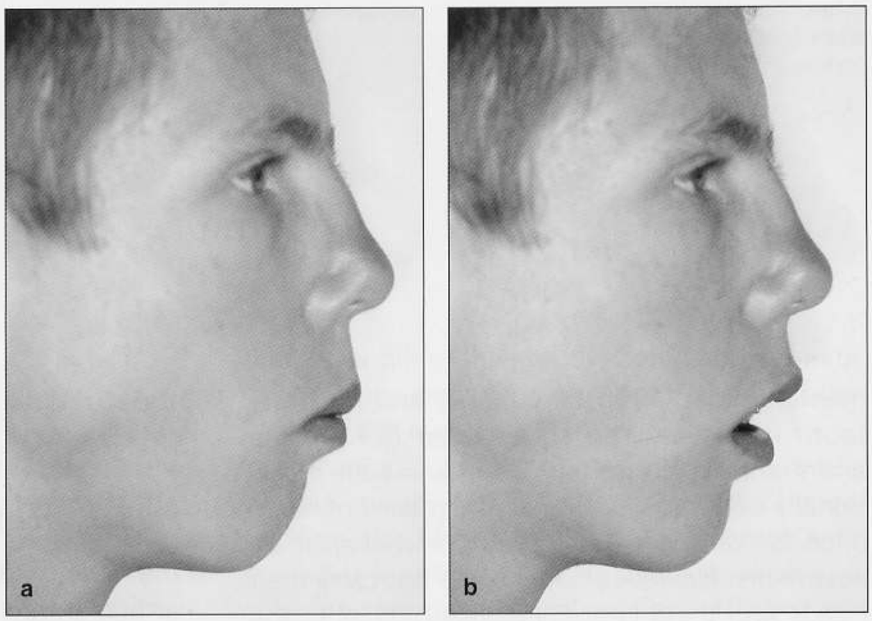


Fig 2-4 The lower-third profile is profoundly different when the lips are forced together *(a)* versus in repose *(b)*.

ness, anteroposterior position of the chin, labiomental fold, upper lip length, nasolabial angle, and soft tissue thickness can now be assessed more meaningfully. Figure 2-3 illustrates the profound changes in soft tissue characteristics in a patient with vertical maxillary deficiency in centric relation and in the open bite position.

It is imperative that the patient be examined with the lips in a relaxed position, as it is impossible to assess the soft tissue relationship to the hard tissue when the lips are forced together. The effect of muscular compensation on the lips and chin is demonstrated in Fig 2-4. Note the change in the interlabial gap, labio-

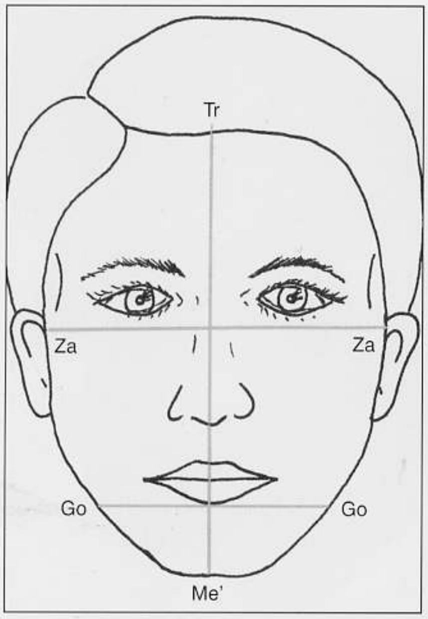


Fig 2-5 Facial form. The facial height (trichion [Tr]–soft tissue menton [Me']):bizygomatic width (Za-Za) should be 1.3:1 (females) and 1.35:1 (males). The bigonial width (Go-Go) should be approximately 30% less than the bizygomatic width.

Fig 2-6 In this individual, the bigonial width is greater than the bizygomatic width because of bilateral masseter muscle hypertrophy.

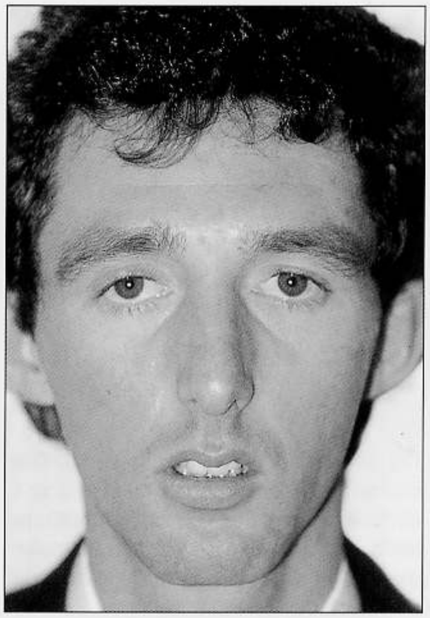


Fig 2-7 Individual with a long, narrow face. The bizygomatic width is more than 30% greater than the bigonial width.

mental fold, chin and lip shape, and maxillary tooth exposure. The sella-nasion (S-N) plane and Frankfort horizontal (FH) plane have traditionally been used as horizontal planes of reference for various cephalometric and clinical assessments. However, patients do not carry their heads with the S-N or FH planes parallel to the floor. Cephalometric landmarks should not dictate head posture used for facial assessment and treatment planning. The clinical evaluation should therefore be carried out with the head in the *natural* posture.

Frontal analysis

From the frontal view, it is particularly important to assess facial form; transverse dimensions; facial symmetry; the vertical relationship in the upper, middle, and lower thirds of the face; and the lips.

Facial form

The relationship between the facial width and vertical height has a strong influence on facial harmony. The height-to-width proportion is 1.3:1 for females and 1.35:1 for males. The bigonial width should be approximately 30% less than the bizygomatic dimension (Fig 2-5). Short, square facial types are often associated with a Class II deep bite malocclusion, vertical maxillary deficiency, masseteric hyperplasia, and macrogenia, while long, narrow facial types are often associated with vertical maxillary excess, a narrow nose, mandibular anteroposterior deficiency, microgenia, a high palatal vault, and an anterior open bite malocclusion (Figs 2-6 and 2-7).

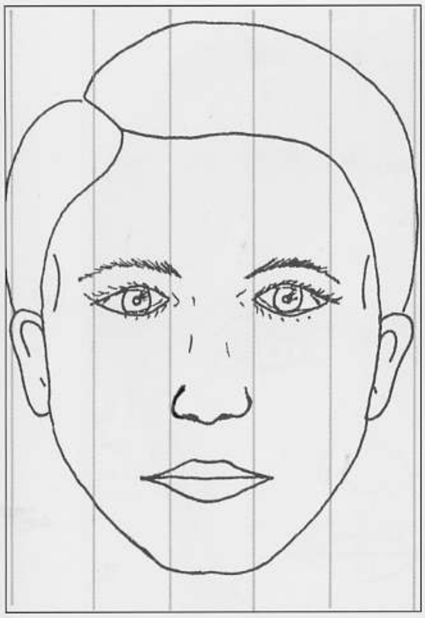


Fig 2-8 Transverse facial proportions.

Fig 2-9 The bigonial width is increased because of bilateral masseter muscle hypertrophy. The gonion falls lateral to a vertical line drawn through the outer canthus of the eye.

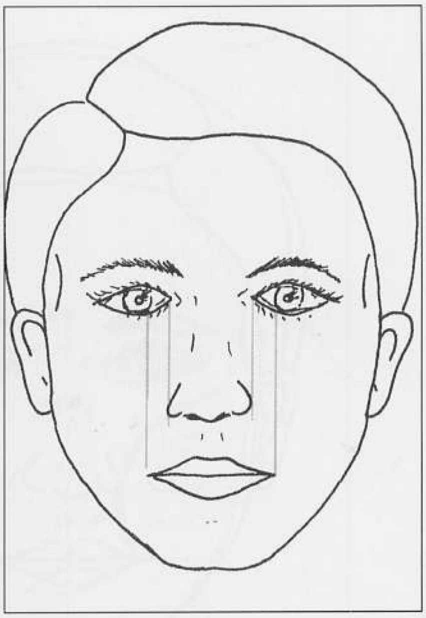


Fig 2-10 Vertical lines drawn through the medial canthi should coincide with the ala of the nose, while vertical lines drawn through the medial margins of the irides of the eyes should coincide with the corners of the mouth.

Transverse dimensions

The "rule of fifths" is a convenient method for evaluating transverse facial proportions. The face is divided into five equal parts—each the approximate width of the eye—from helix to helix of the outer ears (Fig 2-8). The outer fifth is measured from the center helix of the ears to the outer canthus of the eyes. Prominent ears may have a profound effect on facial proportions and can be corrected by otoplasty.

The medial two fifths of the face are measured from the outer to the inner canthus of the eyes. The outer border should coincide with the gonial angles of the mandible. In patients with masseter muscle hypertrophy, the gonial angles will fall well lateral to this line (Fig 2-9), while in patients with long faces there will be a tendency for the gonial angles to be medial to these lines. Within the medial fifths it should be noted that the width of the mouth should approximate the distance between the inner margins of the irides of the eyes (Fig 2-10).

The middle fifth is delineated by the inner canthus of the eyes. In patients with hypertelorism, this fifth will be out of proportion with the other four fifths. The ala of the nose should coincide with these lines (see Fig 2-10). For patients in whom maxillary advancement and/or superior repositioning is considered and the ala falls outside of the lines, control of alar width is indicated during surgery.

Facial symmetry

To assess facial symmetry, an imaginary line is drawn through the soft tissue glabella, pronasale, center of the filtrum of the upper lip and lower lip, and soft tissue pogonion (Fig 2-11). For more accurate assessment, these points

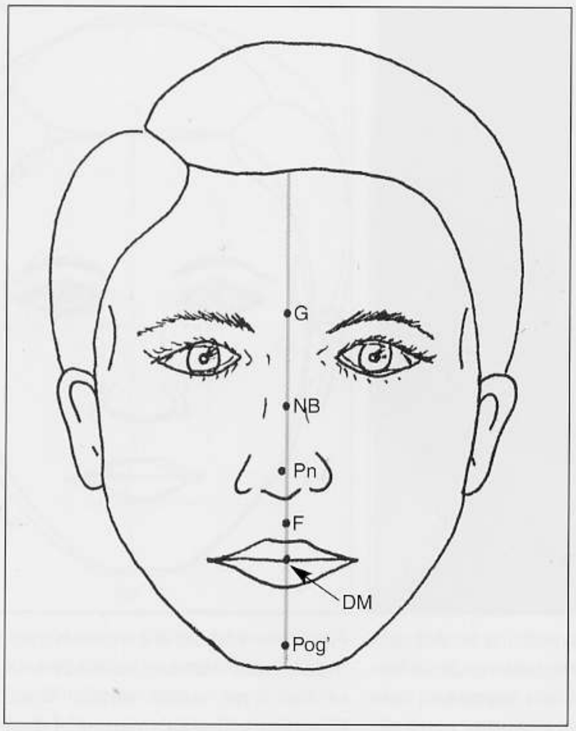


Fig 2-11 Facial symmetry. Important midline structures are the glabella (G), nasal bridge (NB), nasal tip (Pn), midpoint of the filtrum of the upper lip (F), dental midlines (DM), and midpoint of the chin (Pog').

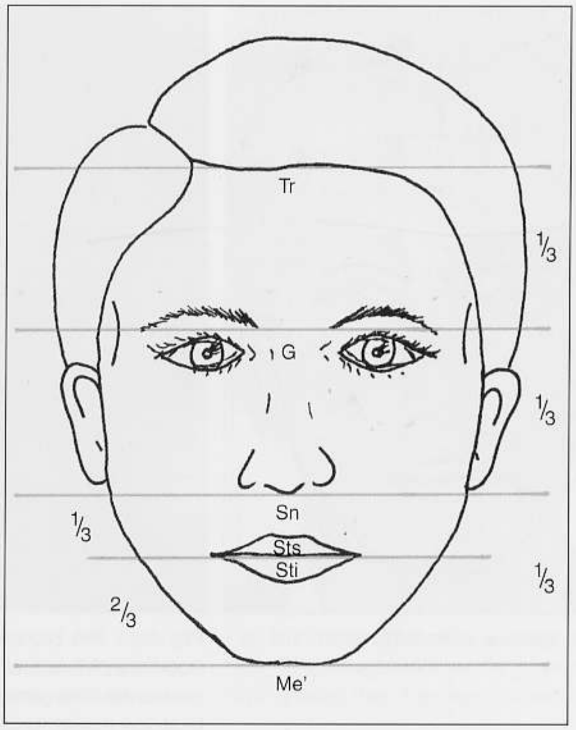


Fig 2-12 The face is divided into thirds by drawing horizontal lines through the trichion (Tr), glabella (G), subnasale (Sn), and soft tissue menton (Me'). The lower third can be divided into an upper third (from Sn to stomion superius [Sts]) and lower two thirds (from stomion inferius [Sti] to Me').

should be marked on the patient's face one at a time while other parts of the face are blocked out. The maxillary and mandibular dental midlines should be assessed in relation to the facial midline, as well as in relation to each other. These observations will play an important role in the decision-making process regarding surgical or orthodontic correction of dental midlines. It is also important to evaluate the mandibular dental midline in relation to the midline of the chin. This information will assist in treatment planning for correction of mandibular asymmetry by means of mandibular surgery, genioplasty, or both.

Certainly no face is perfectly symmetrical, yet the absence of any obvious asymmetry is necessary for good facial esthetics. Posteroanterior cephalometric radiography is indicated when a clinically significant asymmetry is present. This will allow the clinician to distinguish between bone, soft tissue, or a combination of the two as etiologic factors.

Vertical relationship

In the vertical dimension, the face can be divided into three equal parts (Fig 2-12): *(1)* upper third (hairline [trichion] to the glabellar area), *(2)* middle third (glabellar area to subnasale), and *(3)* lower third (subnasale to menton).

Upper third of the face

Fortunately, deformities that exist in the upper third of the face usually can be masked by an

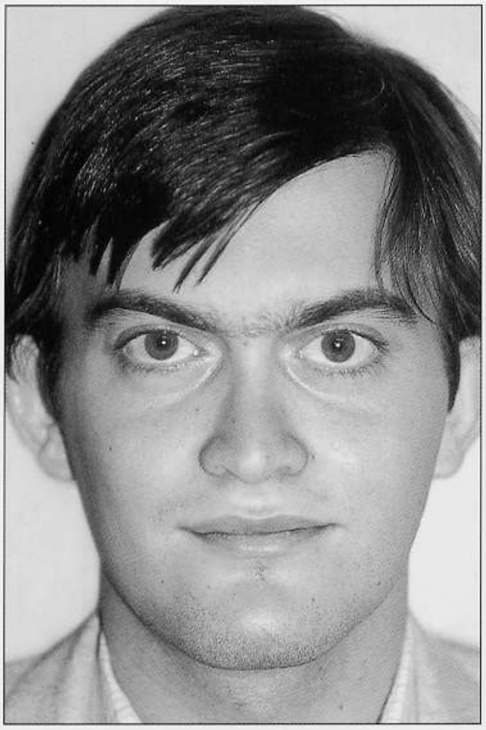


Fig 2-13 Sclera shows below the irides of the eyes in this individual with midface deficiency.

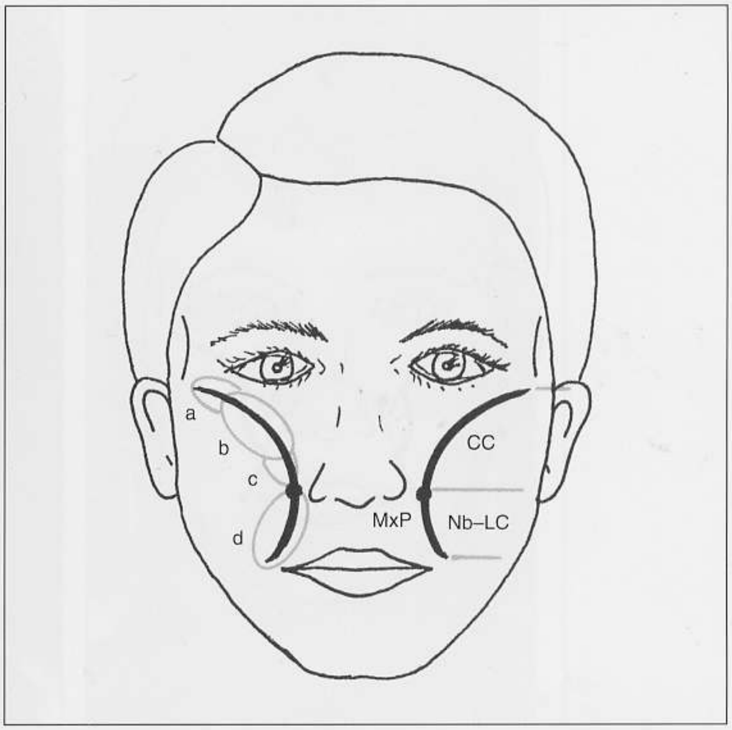


Fig 2-14 Cheekbone–nasal base–lip contour. The cheekbone area (CC) is divided into three parts: (a) zygomatic arch, (b) middle area, and (c) subpupillary area. The maxillary point (MxP) is the most medial point on the curve. The nasal base–upper lip contour (Nb–LC) extends inferiorly from MxP (d). The line should curve gently, without interruptions, ending lateral to the corner of the mouth.

appropriate hairstyle. However, it is important to record deformities in this area, since they may indicate craniofacial deformities.

Middle third of the face

The nose, center of the lips, and middle of the chin (in the lower third of the face) should fall along a true vertical line. Generally, no sclera is seen above or below the iris in a relaxed eyelid position with the patient looking straight ahead in natural head posture. Individuals with a midface deficiency tend to show sclera below the iris of the eye (Fig 2-13).

Sequential evaluation of the cheekbones, paranasal areas, alar eminences, and upper lip relation (in the lower third) should be performed. The cheekbone–nasal base–lip contour is a convenient contour line to evaluate the harmony of the structures of the midface (zygoma, maxilla, and nasal base) with the paranasal area and upper lip. This line starts just anterior to the ear, extends forward through the cheekbone, and then runs anteroinferiorly over the maxilla adjacent to the alar base of the nose, ending lateral to the commissure of the mouth. The line should form a smooth, continuing curve (Fig 2-14). An interruption of the curve may be an indication of an apparent skeletal deformity. Figure 2-15 illustrates a clear interruption of the line in the maxillary area, indicating maxillary anteroposterior deficiency. In Fig 2-16, the interruption is lower in the curve because of mandibular anteroposterior excess.

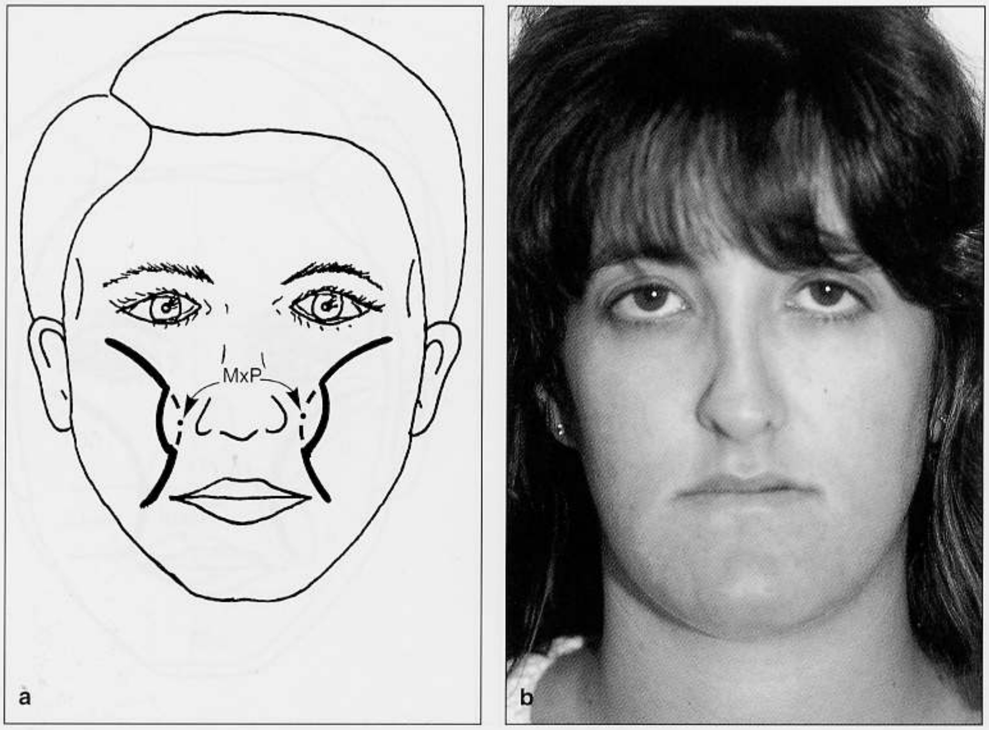


Fig 2-15 *(a)* Interruption of the curve at MxP. *(b)* Individual with maxillary anteroposterior deficiency. There is an interruption in the cheekbone–nasal base–lip contour at MxP.

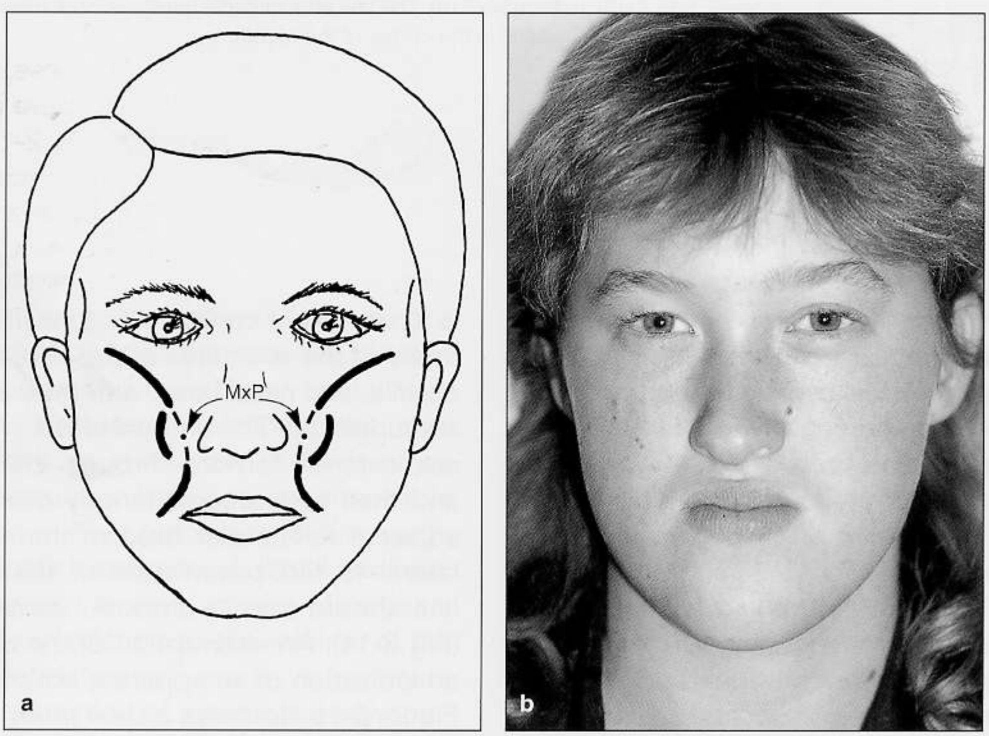


Fig 2-16 *(a)* Interruption of the curve at MxP and below MxP. *(b)* An individual with maxillary anteroposterior deficiency and mandibular prognathism. The cheekbone–nasal base–lip contour is interrupted with a double break, at MxP and also below MxP.

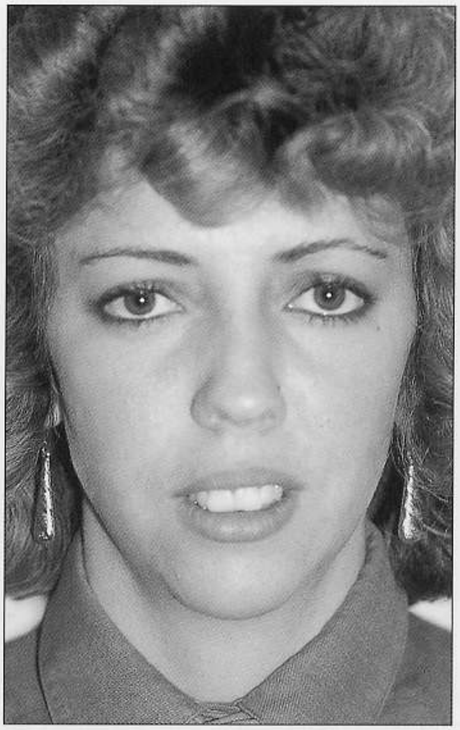


Fig 2-17 Excessive maxillary incisor exposure and increased interlabial gap. Normal maxillary incisor exposure under the upper lip is 1 to 4 mm. This measurement will be influenced by upper lip length, vertical maxillary length, lip thickness, and the angle and anteroposterior position of the maxillary incisors.

Lower third of the face

The middle third to lower third vertical height of the face should have a 5:6 ratio. The upper lip length (subnasale to stomion superius) should make up one third of the lower third facial height. The distance from stomion inferius to soft tissue menton should equal two thirds of the lower third face height (see Fig 2-12).

Normal upper lip length is 20 ± 2 mm for females and 22 ± 2 mm for males, measured from subnasale to upper lip inferior (stomion superius). If the upper lip is anatomically short, there is a tendency for the interlabial gap to be larger than normal and for increased maxillary tooth exposure with normal lower facial height. This should not be confused with skeletal vertical maxillary excess. Lower lip length is 40 ± 2 mm for females and 44 ± 2 mm for males, measured from lower lip superior (stomion inferius) to soft tissue menton. The lower lip may often appear short because of posture caused by upper incisor interference in deep bite cases. The upper lip length should be related to lower anterior dental height.

With the patient's lips in repose, the amount of maxillary incisor tooth exposure beneath the upper lip should be noted (Fig 2-17). For individuals in whom the maxillary incisors are not visible under the upper lip, the tooth-lip relation should be evaluated with the mandible rotated open until the lips just separate (Fig 2-18). The relation of the dental midline to the facial midline is an important aspect to note, since dental midlines can be coordinated and/or corrected either orthodontically or surgically. The etiology of dental midline shifts may be dental or skeletal. Dental factors that may cause midline shifts include spaces; missing teeth; tooth rotations; malpositioned teeth; crowding, crowns, fixed partial dentures, fillings, or implants, which change the size of teeth; and tooth size discrepancy.

In faces with asymmetry involving the mandible, it is of critical importance to note the midline of the chin and its relation to the mandibular dental midline. The chin is evaluated for symmetry, vertical relation, and shape. The cant of the occlusal plane is evaluated, es-

Fig 2-18 Individual with vertical maxillary deficiency. *(a)* It is not possible to assess maxillary incisor/lip relationship with the teeth in occlusion. *(b)* The lack of maxillary incisor exposure is evident with the mandible rotated open until the lips just part.

pecially in individuals with facial asymmetry, by asking the patient to bite on a wooden spatula and then relating the occlusal plane to the interpupillary plane (Fig 2-19). The maxillary dental arch level (between the maxillary canine tips) must be distinguished from the mandibular dental arch level (between the mandibular canine tips). However, with this assessment it is necessary to make sure that the orbits are on a horizontal plane, as there may be an orbital deformity influencing this observation. Patients who present with facial asymmetry and a cant in the occlusal plane will require an anteroposterior cephalometric radiograph for further analysis.

The amount of gingiva exposed during smiling is also noted. The ideal tooth exposure with the smile is the full tooth crown to 2 mm of gingiva, females more than males. When examining the smile it should be kept in mind that the amount of tooth exposure is influenced by *(1)* the vertical length of the maxilla, *(2)* lip length, *(3)* maxillary incisor crown length, *(4)* amount of lip action with smile, and *(5)* shape of Cupid's bow of the lip.

Surgical superior repositioning of the maxilla is indicated only when excessive gingival exposure is found in combination with an increased interlabial gap, increased maxillary incisor exposure, and increased vertical height of the lower third of the face. The amount of surgical superior repositioning will be dictated by amount of tooth exposure, lip length, crown length, and gender.

Keep in mind that superior repositioning of the maxilla will tend to shorten the upper lip. The upper lip will lengthen with age, especially in males. If necessary, err on the long side, as overcorrection gives the patient a toothless and aged look.

One should never plan treatment from the smile pattern. Individuals may exhibit a normal maxillary tooth–lip relationship (1 to 4 mm); however, when smiling, a large amount (eg, 7 mm) of gingiva is exposed ("gummy smile"). If superior repositioning is planned according to

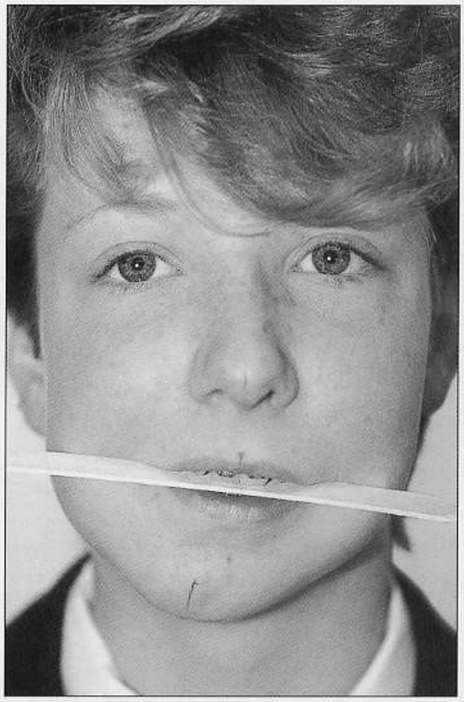


Fig 2-19 The cant in the occlusal plane can be evaluated in relation to the interpupillary line by asking the patient to bite on a wooden spatula. During this assessment, make sure that the interpupillary line is parallel to the floor.

the amount of gingiva exposed during smiling, the maxilla will need to be superiorly repositioned by 6 mm to establish the ideal full tooth exposure, resulting in no tooth exposure and a toothless look in repose.

Lips

The lips are extremely critical to overall esthetics. Lip symmetry should be evaluated; if asymmetry exists, its etiology should be determined (eg, cleft lip, facial nerve dysfunction, underlying dentoskeletal asymmetry, scarring due to previous trauma, or congenital unilateral microsomia or macrosomia).

The lower lip generally exhibits 25% more vermilion than the upper lip, and the lips should be 0 to 3 mm apart in repose. There are specific racial differences in lip thickness and shape that one must bear in mind for treatment-planning purposes. In patients with closed bites, the lips and tooth-lips relation should be evaluated with the lips relaxed and the jaws moved apart until the lips just part (closed bites may be due to maxillary vertical deficiency or severe deep bites). Accentuation of Cupid's bow of the upper lip may lead to exposure of only the maxillary central incisors.

Profile analysis

Upper third of the face

The supraorbital rims normally project 5 to 10 mm beyond the most anterior projection of the globe of the eye. Frontal bossing, supraorbital hypoplasia, exophthalmos, or enophthalmos should be distinguished.

Middle third of the face

It is helpful to examine the middle and upper thirds of the face in isolation, and masking the lower third with a card eliminates any undue influence that this third may have on the perceptions of the face as a whole. The nose, cheeks, and paranasal areas are sequentially evaluated.

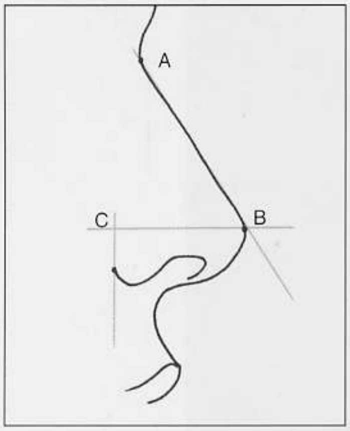


Fig 2-20 The nasal tip projection is evaluated by the method of Goode. If BC is greater than 55% to 60% of AB, the nasal tip usually appears disproportionately overprojected.

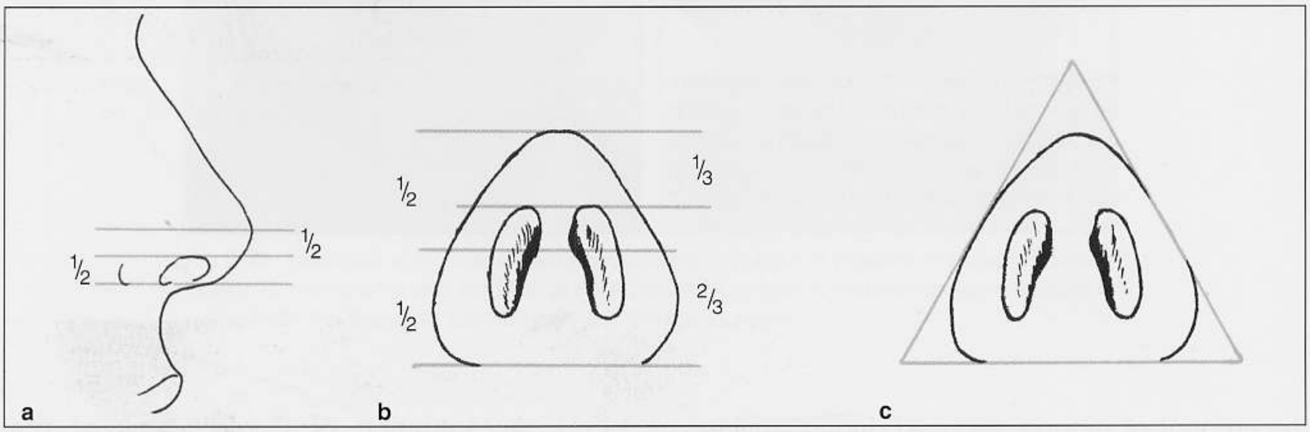


Fig 2-21 *(a)* Vertical ala–columella relationship. *(b)* Columella–lobule relationship with a ratio of approximately 2:1. *(c)* The general shape of the alar base should resemble an isosceles triangle, with the lobule neither too broad nor too narrow.

Nose

The shape of the dorsum is noted as normal, convex, or concave. The projection of the nasal bridge should be anterior to the globes (5 to 8 mm). The appearance of the nasal tip is evaluated for the presence of a supratip break and for tip definition and projection (Fig 2-20). It is important to distinguish between a dorsal hump and a turned-down tip, since the implications for treatment are entirely different. The possible effect of maxillary surgery on the nose should be kept in mind when evaluating the proportions of the base of the nose (Fig 2-21).

Cheeks

The globes generally project 0 to 2 mm ahead of the infraorbital rims, while the lateral orbital rims lie 8 to 12 mm behind the most anterior projection of the globes (Fig 2-22). The cheeks should exhibit a general convexity from cheekbone apex to the commissure of the mouth. This line of convexity, called the *cheekbone–nasal base–lip curve contour,* requires simultaneous frontal and profile examination. This line starts just anterior to the ear, extending forward through the cheekbone, then anteroinferiorly over the maxilla adjacent to the alar base of the

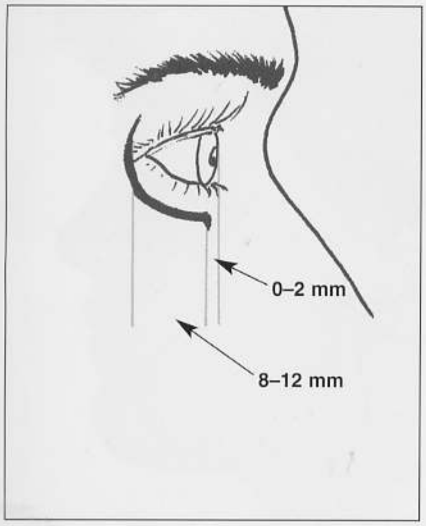


Fig 2-22 The lateral orbital rim lies 8 to 12 mm behind the globe, while the globe projects 0 to 2 mm ahead of the infraorbital rim.

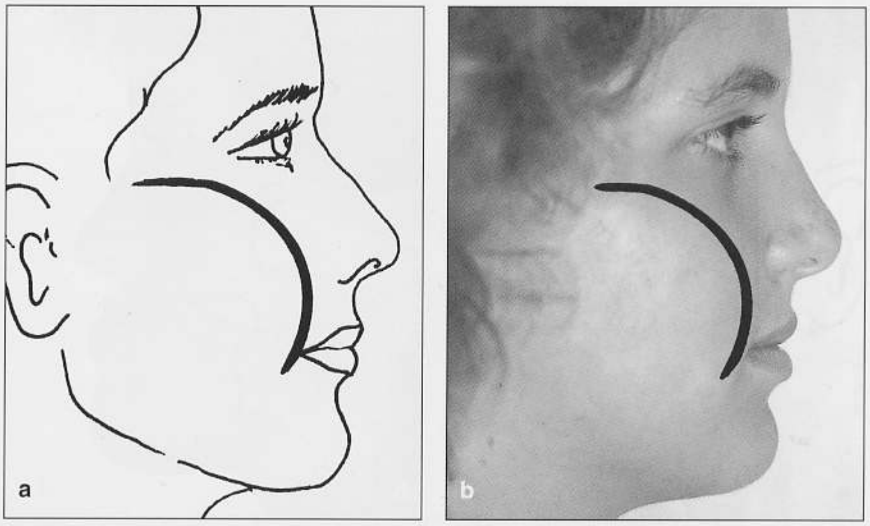


Fig 2-23 *(a)* Cheekbone–nasal base–lip curve contour. *(b)* Note the smooth, uninterrupted curve of the contour line in an individual with good facial proportions.

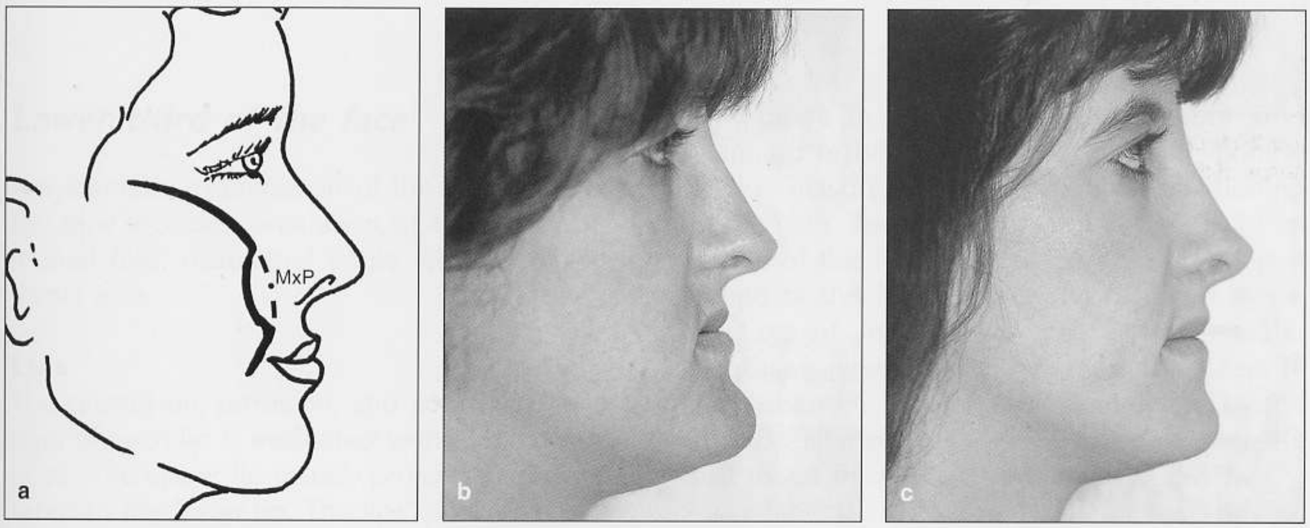


Fig 2-24 *(a and b)* An interruption in the curve of the contour line at MxP, indicating maxillary anteroposterior deficiency. *(c)* An improvement in the curve after advancement of the maxilla.

nose, and ending lateral to the commissure of the mouth (Fig 2-23). The line should form a smooth, continuing curve with no interruptions. An interruption of the curve may indicate an apparent skeletal deformity. Figure 2-24 illustrates a clear interruption of this line in the maxillary area, indicating maxillary anteroposterior deficiency. In Fig 2-25 the interruption in the line is in the maxillary area, indicating maxillary anteroposterior deficiency, and inferior to the upper lip section, indicating mandibular anteroposterior excess.

Fig 2-25 *(a and b)* A double break in the contour line in an individual with maxillary anteroposterior deficiency and mandibular anteroposterior excess. *(c)* The curve in the contour line is more harmonious after surgical advancement of the maxilla and mandibular setback.

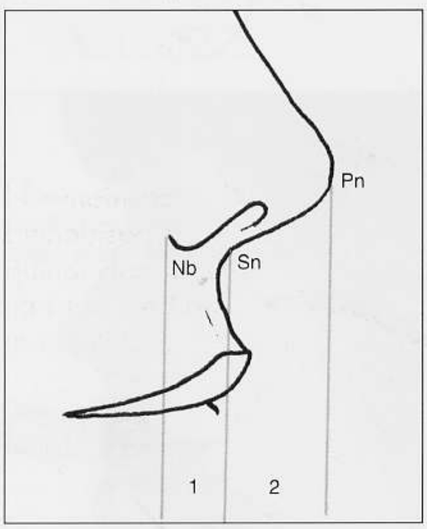


Fig 2-26 Nasal projection. The projection of the nose is measured horizontally from Pn to Sn and is normally 16 to 20 mm. The ratio of Pn-Sn to Sn–Nb should be 2:1.

Paranasal areas

The clinician should carefully assess the paranasal area because it plays an important role in distinguishing between middle third deficiency and mandibular anteroposterior excess. The ratio of the linear distance (horizontally) from nasal tip to subnasale and from subnasale to alar base crease is normally 2:1 (Fig 2-26). A closer ratio than 1:1 indicates maxillary anteroposterior deficiency. An increased ratio indicates decreased nasal projection. All other factors being equal, patients with a Class III malocclusion, decreased nasal projection, and a short nose should be treated by mandibular setback rather than maxillary advancement.

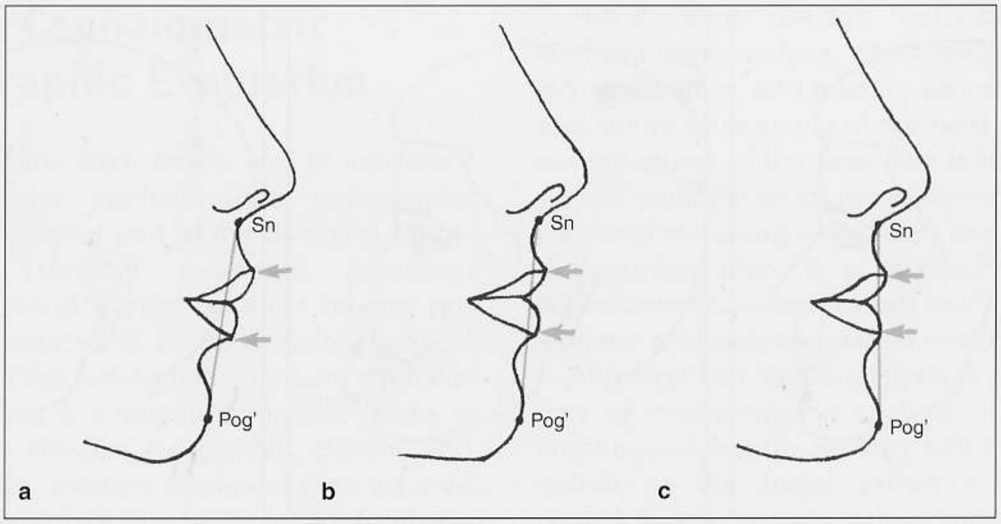


Fig 2-27 Effect of the chin position on the subnasale-pogonion line (Sn-Pog'). *(a)* Effect in an individual with mandibular anteroposterior deficiency (lips ahead of the line). *(b)* With the chin in normal horizontal relationship to the maxilla, the uppper lip should be 5.5 mm and the lower lip 2.5 mm ahead of Sn-Pog'. *(c)* Effect in an individual with mandibular prognathism (lips on the line). In all three cases, the upper lip position has not changed; however, a change in Pog' position results in a change in the lip position relative to the Sn-Pog' line.

Lower third of the face

A systematic examination of the lower third of the face includes evaluation of the lips, labiomental fold, nasolabial angle, chin, and chin-throat area.

Lips

The protrusion, retrusion, and soft tissue thickness of each lip is evaluated with the lips in repose. The upper lip usually projects slightly anterior to the lower lip. The lips' positions relate to the underlying dental position, such as maxillary dental protrusion or lack of upper lip support caused by, for example, Class II, division 2 malocclusion or excessive orthodontic retraction of maxillary incisors. An individual with an excessive increase in lower lip vermilion and a deep labiomental fold often also has a Class II, division 1 malocclusion.

The anteroposterior lip position may be assessed with the help of the E-line or S-line as guidelines (see the following sections on cephalometrics). The subnasale-pogonion line, also called the *lower facial plane,* is an important guide in assessing the lip position and planning orthodontic and surgical positioning of the incisors, as well as surgical positioning of the chin. The upper lip should be 3 ± 1 mm ahead of this line and the lower lip 2 ± 1 mm ahead of this line. Extractions followed by retraction of incisors behind the subnasale-pogonion line should be avoided. Keep in mind that this assessment is influenced by the anteroposterior position of the chin and the soft tissue thickness of the lips (Fig 2-27).

Labiomental fold

The lower lip–chin contour should have a gentle S-curve, with a lower lip–chin angle of at least 130 degrees (Fig 2-28). The angle is often acute in cases of Class II mandibular anteroposterior deficiency because of impingement of the maxillary incisor on the lower lip or macrogenia. The angle is flattened in individuals with microgenia or lower lip tension caused by Class III malocclusion. The surgeon considering genioplasty should assess not only the anteroposterior position of the pogonion but also the chin shape and the labiomental fold.

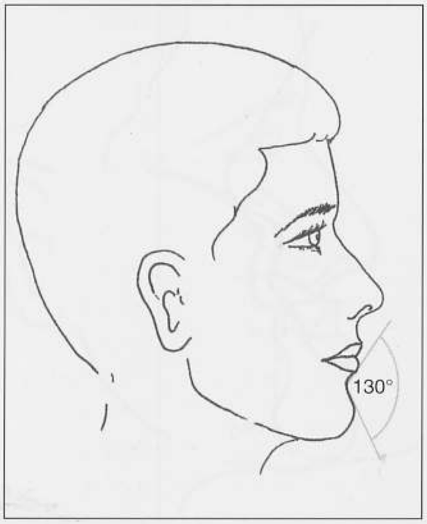


Fig 2-28 Labiomental fold.

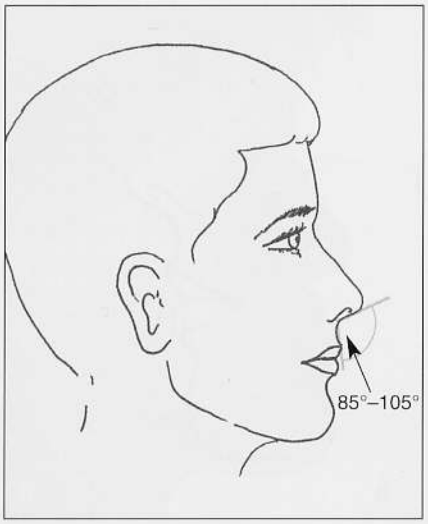


Fig 2-29 The nasolabial angle, measured between the columella of the nose and the upper lip (Sn–Ls), should be 85 to 105 degrees.

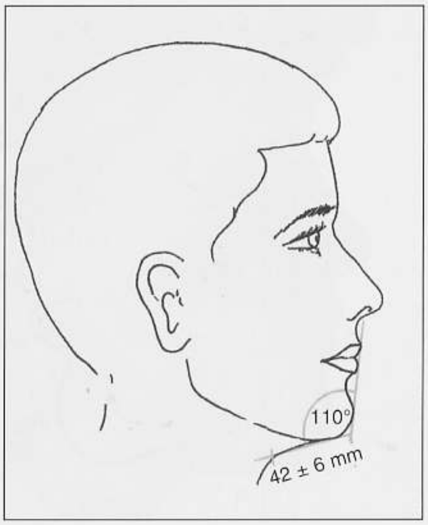


Fig 2-30 Chin-throat angle and length.

Nasolabial angle

The nasolabial angle, which is measured between the inclination of the columella and the upper lip (Fig 2-29), should be in the range of 85 to 105 degrees. In females a slightly larger angle is acceptable, while a smaller angle is considered esthetically pleasing in males. Patients with mandibular anteroposterior deficiency have increased nasolabial angles, while this angle is usually acute in individuals with Class III relations. Surgical or orthodontic retraction of maxillary incisors should be avoided in individuals with large nasolabial angles. Where crowding necessitates tooth extraction, the nasolabial angle should influence the decision to extract first versus second premolars. Surgical repositioning of the maxilla also affects the nasolabial angle. In general, the maxilla should never be moved posteriorly, especially in combination with superior repositioning. This surgical movement leads to loss of lip support, increase in nasolabial angle, increase in nasal projection, and flattening of the nasal base. These changes result in poor esthetics and a premature aging effect. The maxilla should be moved posteriorly only in individuals with true maxillary protrusion, which occurs very rarely.

Chin

Chin projection should be in good balance with the entire profile. At this stage, the middle third should be masked and the chin's relation to the rest of the facial structures evaluated. Various soft tissue cephalometric analyses are available to assist in clinical evaluation of the anteroposterior chin position. The chin should, however, be evaluated in all three dimensions. The width of the chin should be assessed in relation to the overall facial shape. A narrow chin often has a knobby appearance, and if surgical advancement of the chin is planned, widening of the chin should be contemplated. The labiomental fold, chin shape, relation to the dental midline, symmetry, and cant of the lower border should be considered.

Chin-throat area

The presence of a "double" chin and adipose tissue should be noted. The chin-throat angle (normally 110 degrees) provides chin definition (Fig 2-30). The distance from the neck-throat angle to the soft tissue pogonion should be approximately 42 mm. These observations are pertinent when considering mandibular setback or advancement procedures, genioplasty (advancement or reduction), or submental liposuction.

Lateral Cephalometric Radiographic Evaluation

The information from lateral and (if indicated) posteroanterior cephalometric radiographs forms an important part of the database for orthognathic surgical treatment planning. Although clinical evaluation must be the primary diagnostic tool in determining surgical treatment of the orthognathic patient, cephalometric analysis is a helpful diagnostic guide. It enables the clinician to quantify, classify, and communicate; create a treatment plan via a visual treatment objective; help plan for tooth extractions; monitor progress during treatment; study specific changes during and after treatment to evaluate treatment results; and study facial growth.

The cephalometric radiograph should be taken with the patient's head in a natural posture, the teeth in centric occlusion, and the lips in repose. The only three exceptions follow:

1. Where there is a clinically significant difference between the centric occlusion and centric relation, a second radiograph should be taken in centric relation.
2. In patients with maxillary vertical deficiency, a second radiograph should be taken with the mandible rotated open until the lips just part. The maxillary incisor–upper lip relationship, upper lip length and shape, and the amount of maxillary downgraft can be more accurately evaluated on this radiograph.
3. In patients with severe Class III malocclusion and overclosed bites, it is difficult to assess the lips, tooth-lip relationship, and the relationship between the maxilla and mandible. A second radiograph should be taken with the mandible rotated until the lips just part.

The primary objective of treatment is not to make the patient's cephalometric measurements normal, but rather to make the facial appearance harmonious and occlusal function normal. In the majority of cases, function and esthetics go hand in hand.

The literature contains much discussion of cephalometric analysis, which involves measuring, comparing, and relating various linear and angular measurements of the hard and soft tissue structures of the face. The following analysis is a compilation of measurements found to be useful in making a diagnosis and developing a treatment plan. It is divided into lateral cephalometric analysis of soft tissue, hard tissue (skeletal analysis), and dental relations.

Although soft tissue analysis is discussed as part of cephalometric analysis, it should be emphasized that the primary soft tissue examination of the facial esthetics guided by cephalometric analytic values should be done clinically. A patient's cephalometric analysis and photographs should be part of the permanent records, but controlled, reliable records of the clinical examination are necessary for accurate diagnosis and correct treatment. The diagnosis should not be based only on the examination of photographs and cephalometric analysis.

Soft tissue analysis

Soft tissue landmarks

Lateral soft tissue landmarks, shown in Fig 2-31, include the following:

Soft tissue glabella (G'): The most anterior point of the forehead

Soft tissue nasion (N'): The deepest point of concavity in the midline between the forehead and the nose

Pronasale (Pn): The most anterior point of the nose

Subnasale (Sn): The point at which the columella of the nose merges with the upper lip in the midsagittal plane

Labrale superior (Ls): The mucocutaneous border of the upper lip vermilion

Stomion superius (Sts): The lowest point of the vermilion of the upper lip

Stomion inferius (Sti): The uppermost point of the lower lip vermilion

Labrale inferior (Li): The mucocutaneous border of the lower lip

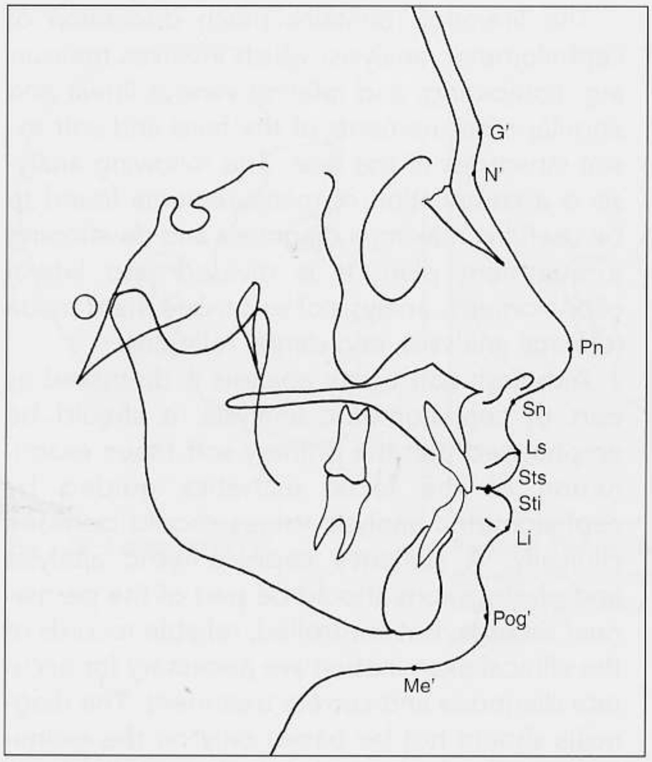


Fig 2-31 Soft tissue cephalometric landmarks.

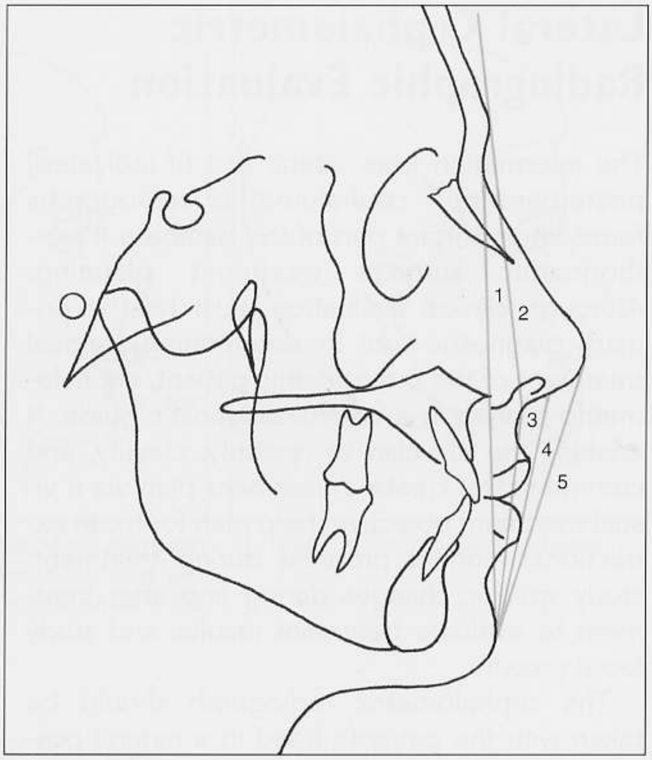


Fig 2-32 Soft tissue planes. (1) Facial plane. (2) Upper facial plane. (3) Lower facial plane. (4) S-line. (5) E-line (esthetic plane).

Soft tissue pogonion (Pog'): The most anterior point of the chin in the midsagittal plane

Soft tissue menton (Me'): The lowest point on the contour of the soft tissue chin, found by dropping a perpendicular line from a horizontal line through skeletal menton

Soft tissue planes

Soft tissue planes are shown in Fig 2-32 and include the following:

Facial plane: Extends from nasion to pogonion (N'-Pog')

Upper facial plane: Extends from soft tissue glabella to subnasale (G'-Sn)

Lower facial plane: Extends from subnasale to soft tissue pogonion (Sn-Pog')

S-line: Formed by connecting soft tissue pogonion to a point midway between pronasale and subnasale

E-line (esthetic plane): Extends from the tip of the nose (pronasale) to soft tissue pogonion (Pn-Pog')

Soft tissue vertical evaluation

Relationship of middle to lower facial third height

The distance from G' to Sn (middle facial third height, or MFH) and from Sn to Me' (lower facial third height, or LFH) is measured. The ratio should be approximately 1:1.

In most orthognathic surgical patients, abnormalities are in the lower third of the face (Sn-Me'). In cases where the lower third of the face is increased in relation to the upper third, either vertical maxillary excess or an increase in the vertical anterior height of the mandible should be expected (Fig 2-33). A decrease in lower vertical height could be caused by either vertical maxillary deficiency, vertical defi-

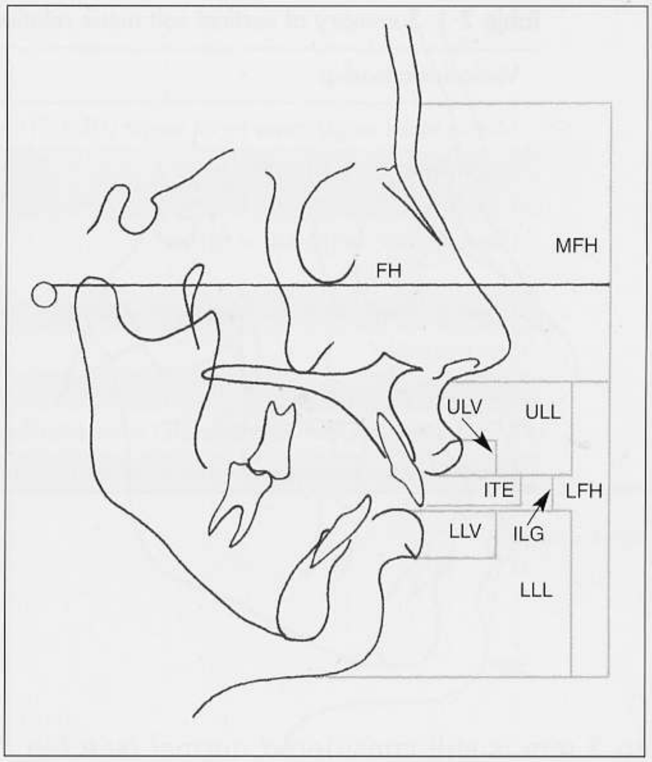


Fig 2-33 Soft tissue vertical evaluation. Vertical measurements are made perpendicular to the Frankfort horizontal plane.

ciency of the anterior mandible or an overclosed bite.

Upper lip length

Upper lip length (ULL) is measured from Sn to Sts and should be 22 ± 2 mm for males and 20 ± 2 mm for females (see Fig 2-33). Patients with relatively long upper lips tend to have less maxillary incisor exposure, while individuals with short upper lips tend to have an increased interlabial gap with increased maxillary incisor exposure. When vertical repositioning of the maxilla is contemplated, the above should be considered to plan the correct amount of superior repositioning of the maxilla for each individual.

Lower lip/chin length

The lower lip/chin length (LLL) is measured from Sti to Me′ and should be 44 ± 2 mm for males and 40 ± 2 mm for females (see Fig 2-33). An increase in the vertical dimension may indicate an increased anterior vertical height of the mandible, while a decrease may indicate a short anterior mandibular height. This dimension may also be short in individuals with both deep bites and everted lower lips.

Ratio of upper lip length to lower lip/chin length

The upper lip length (ULL, or Sn–Sts) should be approximately half the length of the lower lip and chin (LLL, or Sti–Me′) (see Fig 2-33). A decrease in the vertical relation indicates either a long upper lip or a vertical deficiency of the anterior mandibular height. An increase in the ratio may be due to either a short upper lip or a vertical excess of the anterior mandible.

Interlabial gap

When the lips are relaxed, they should just be touching, although an interlabial gap (ILG) of 1

Table 2-1 Summary of vertical soft tissue relationships

Vertical relationship	Normal value
Middle facial height:lower facial height (MFH:LFH) = G′-Sn:Sn-Me′	1:1
Upper lip length (ULL) = Sn–Sts	20 ± 2 mm (females) 22 ± 2 mm (males)
Lower lip/chin length (LLL) = Sti–Me′	40 ± 2 mm (females) 44 ± 2 mm (males)
Upper lip length:lower lip/chin length (ULL:LLL) = Sn–Sts:Sti–Me′	1:2
Sn–LLV:LLV–Me′	1:0.9
Interlabial gap (ILG)	0 to 3 mm
Maxillary incisor tooth exposure (ITE) = Sts–Maxillary incisor tip	1 to 4 mm
Upper lip vermilion:lower lip vermilion (ULV:LLV) = Ls–Sts:Sti–Li	3:4

to 3 mm is still considered normal (see Fig 2-33). An increased interlabial gap (larger than 4 mm) is usually an indication of lip incompetence due to vertical maxillary excess. Patients with a short upper lip, however, also tend to have an increased interlabial gap.

Maxillary incisor tooth exposure

When the patient's lips are relaxed, 1 to 4 mm of maxillary incisors should be visible under the upper lip. Lack of tooth exposure (ITE) may be an indication of maxillary vertical deficiency, while more than 4 mm of tooth exposure may indicate vertical maxillary excess (see Fig 2-33). The upper lip length should be kept in mind with this assessment.

Patients with relatively normal upper lips and excessive incisor exposure under the upper lip will have vertical maxillary excess. This assessment can be made only with lips in repose. Lack of tooth exposure under a normal-length upper lip is an indication that the maxilla is vertically deficient. Vertical maxillary deficiency can be assessed only with the bite opened until the lips just part.

Upper and lower lip vermilion height

The upper lip vermilion height (ULV) should be 25% less than the lower lip vermilion height (LLV). In short, Ls–Sts:Sti–Li = 3:4 (see Fig 2-33).

Vermilion heights are race specific, a fact that should be kept in mind during evaluation. Increased lower lip vermilion exposure may be due to lower lip eversion caused by lip incompetence in patients with vertical maxillary excess. The lower lip is also often everted in Class II deep bite cases or Class II, division 1 cases where the lower lip is rolled outward by the maxillary incisors.

Table 2-1 summarizes the vertical soft tissue relationships.

Soft tissue anteroposterior evaluation

Nasolabial angle

The nasolabial angle is formed by a line tangent to the columella and a line tangent to the upper lip. A value of 85 to 105 degrees is considered normal. In males the angle is usually more acute, while in females a more obtuse angle is considered to be attractive (Fig 2-34).

The nasolabial angle is influenced by the position of the upper lip supported by the maxillary incisors and the inclination of the columella of the nose. Excessive orthodontic retraction of the maxillary incisors will undermine upper lip support, leading to an unattractive increase of

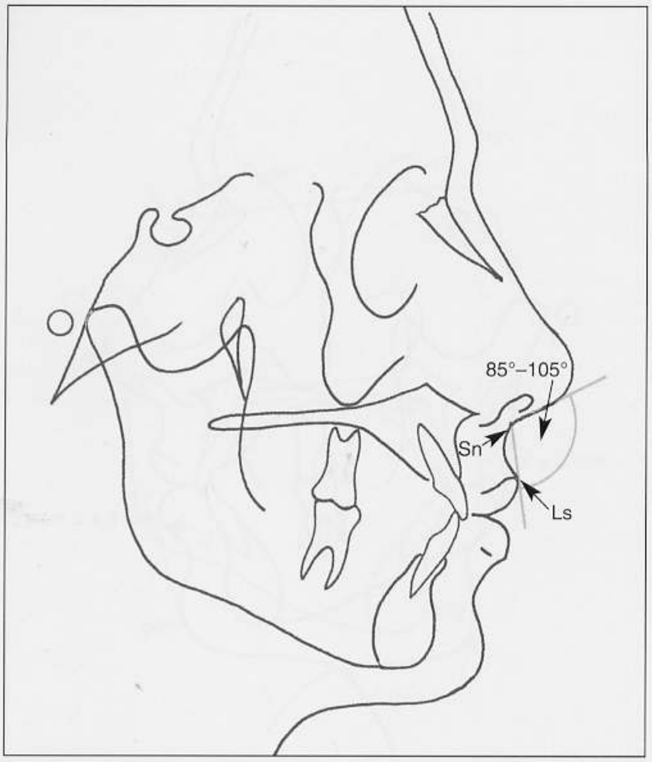


Fig 2-34 Nasolabial angle.

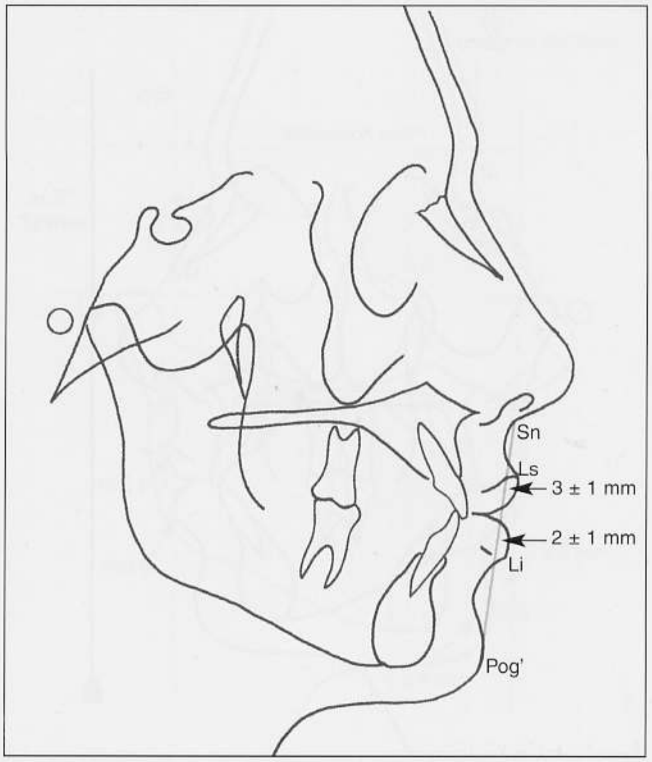


Fig 2-35 The distance of the upper lip (Ls) and lower lip (Li) to the lower facial plane (Sn-Pog') is measured. Ls to LFP: 3 ± 1 mm. Li to LFP: 2 ± 1 mm.

the nasolabial angle. The angle is more acute in Class III cases and more obtuse in Class II cases. The following factors that may influence the nasolabial angle should be considered during treatment planning:

- *Existing maxillary incisor–upper lip relationship (lip support).*
- *Lip strain.* Strained lips tend to move posteriorly once tension has been released. Tense lips, however, move less anteriorly with tooth or bone movement.
- *Lip thickness.* Thin lips respond more readily than thick lips to tooth movement.
- *Magnitude of the overjet, if orthodontic retraction of maxillary incisors is contemplated.* The larger the overjet, the more retraction of maxillary incisors will be necessary. This may lead to an increase in the nasolabial angle and loss of lip support.

The final anteroposterior position of the maxillary incisors and anteroposterior lip position are affected by interdental crowding or spaces in the anterior maxilla, tooth size discrepancies (maxillary versus mandibular), extraction versus nonextraction, extraction pattern (first versus second premolars), and existing tooth angulation.

Lip prominence

A line is drawn from subnasale to soft tissue pogonion (lower facial plane). The perpendicular distance of the upper lip (Ls) ahead of this line should be 3 ± 1 mm, while the lower lip (Li) should be 2 ± 1 mm anterior to the Sn-Pog' line (Fig 2-35).

The anteroposterior position of the upper lip is an indication of soft tissue support by the maxillary incisors and plays an important role in orthodontic or surgical positioning of the maxillary incisors. Thus, it should be kept in mind during treatment planning. The labrale inferior tends to be further ahead of this line (Sn-Pog') in Class II cases (with Pog' posteriorly situated) and to be behind the line in Class III cases (with Pog' anteriorly situated).

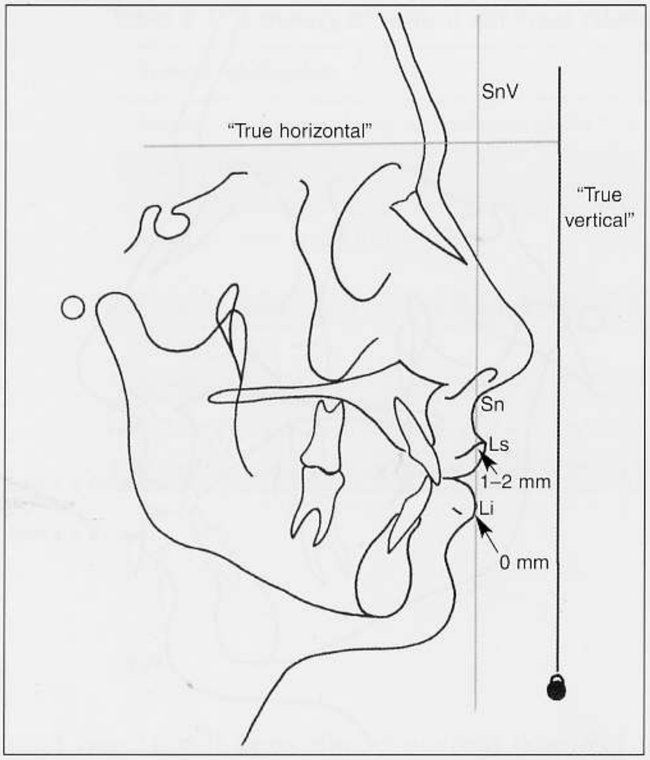


Fig 2-36 A line (SnV) is drawn parallel to true vertical through the subnasale (Sn), and the distance of the upper lip (Ls) and lower lip (Li) is measured to this line. Ls to SnV: 1 to 2 mm. Li to SnV: 0 mm.

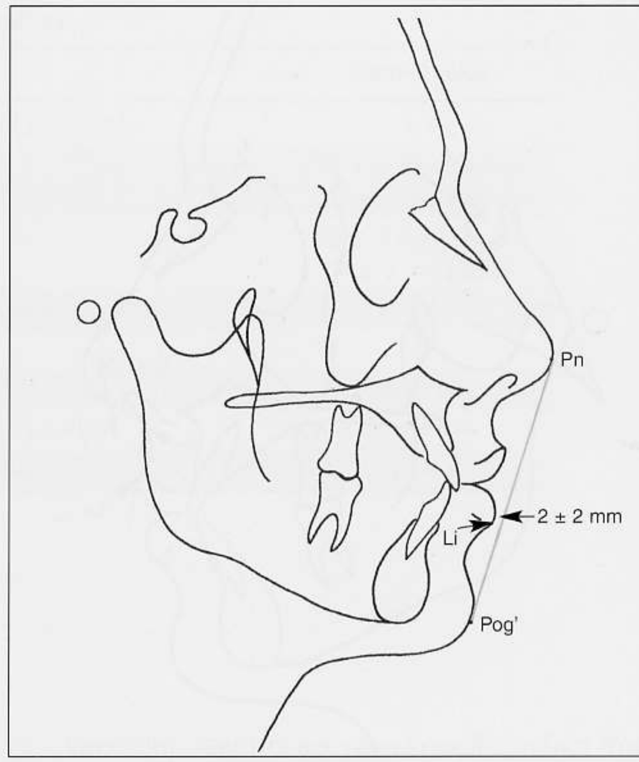


Fig 2-37 Lip prominence in relation to the E-line (Pn-Pog'). Li should be 2 ± 2 mm behind the E-line.

If a vertical line is drawn through the subnasale perpendicular to "true horizontal," the upper lip should be 1 to 2 mm ahead of this line (called the subnasale vertical, or SnV). The lower lip should be on, or just posterior to, SnV (Fig 2-36).

In cases of mandibular anteroposterior deficiency, the lower lip tends to be more than 1 mm posterior to the subnasale vertical. In patients with mandibular anteroposterior excess and/or maxillary anteroposterior deficiency, the lower lip will be anterior to the subnasale vertical. The distance of the most prominent part of the lower lip is measured to the esthetic line (E-line; Pn-Pog'). The lower lip should be 2 ± 2 mm behind this line (Fig 2-37).

This evaluation is influenced by the nose and chin prominence and could also be used for planning the final chin position. The lower lip would tend to be ahead of this line in individuals with Class II mandibular anteroposterior deficiency where Pog' is situated posteriorly and the lower lip everted.

Maxillary and mandibular anteroposterior position

A vertical line perpendicular to the constructed horizontal (cHP) is drawn through G'. Pog' should be 1 to 4 mm behind the line. For maxillary anteroposterior assessment, Sn should be 6 ± 3 mm ahead of this line (Fig 2-38).

In cases of maxillary anteroposterior deficiency, Sn will be less than 3 mm ahead of the line or, in severe cases, even behind the line. Pog' ahead of the line indicates possible mandibular anteroposterior excess, while in mandibular anteroposterior deficiency Pog' will

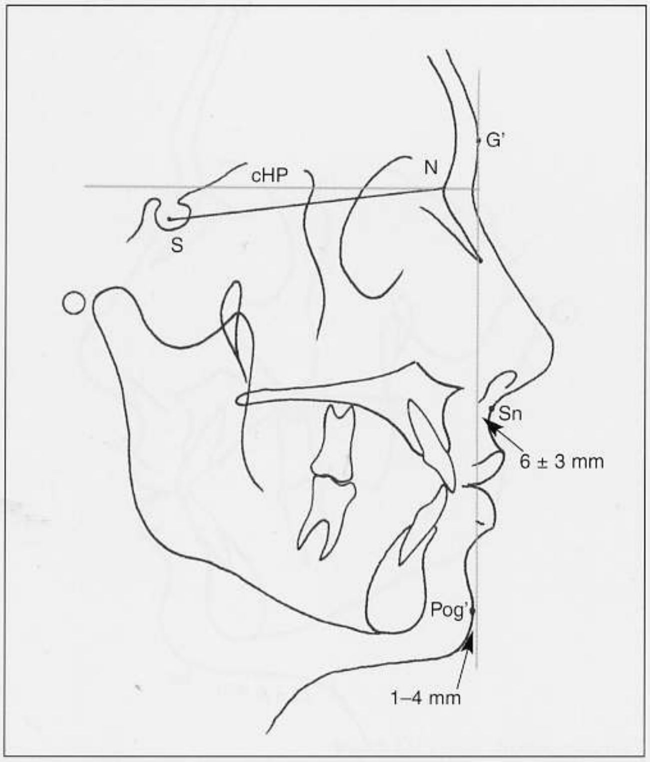


Fig 2-38 Maxillary and mandibular anteroposterior position. Sn should be 6 ± 3 mm ahead of, and Pog' should be 1 to 4 mm behind, the vertical line drawn through the glabella (G').

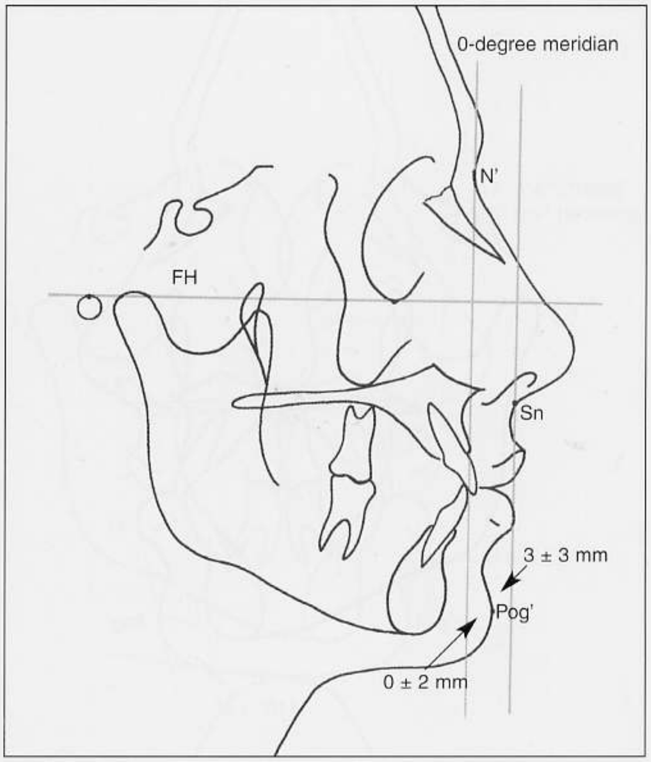


Fig 2-39 Chin prominence: anteroposterior evaluation of the chin to the 0-degree meridian and to a line perpendicular to the Frankfort horizontal (FH) through the subnasale (Sn). Pog' should be 0 ± 2 mm ahead of the 0-degree meridian and 3 ± 3 mm behind the Sn vertical line.

be more than 4 mm behind the line. It is important, however, to evaluate the anteroposterior position of the chin in conjunction with other features (particularly the shape of the chin) to distinguish among microgenia, macrogenia, and mandibular anteroposterior deficiency.

Chin prominence

Soft tissue chin prominence can be evaluated by measuring the distance to a line drawn through N' perpendicular to the FH. This line is also known as 0-degree meridian; Pog' should be 0 ± 2 mm ahead of it (Fig 2-39). A more prominent chin would be more than 2 mm ahead of the 0-degree meridian, while a horizontally deficient chin would be more than 2 mm posterior to the line.

Another vertical line that is helpful in assessing the horizontal prominence of the chin is a line drawn perpendicular to FH through Sn. Pog' should be 3 ± 3 mm behind this line (see Fig 2-39). A horizontally excessive chin would be on or ahead of the vertical line, while a deficient chin would be more than 6 mm posterior to this line.

It is extremely important, however, to use the above measurements only as a guide when assessing chin position. Chin prominence must be evaluated in conjunction with other factors, such as chin shape, depth of the labiomental fold, microgenia, macrogenia, lower lip position, and mandibular anteroposterior excess or deficiency.

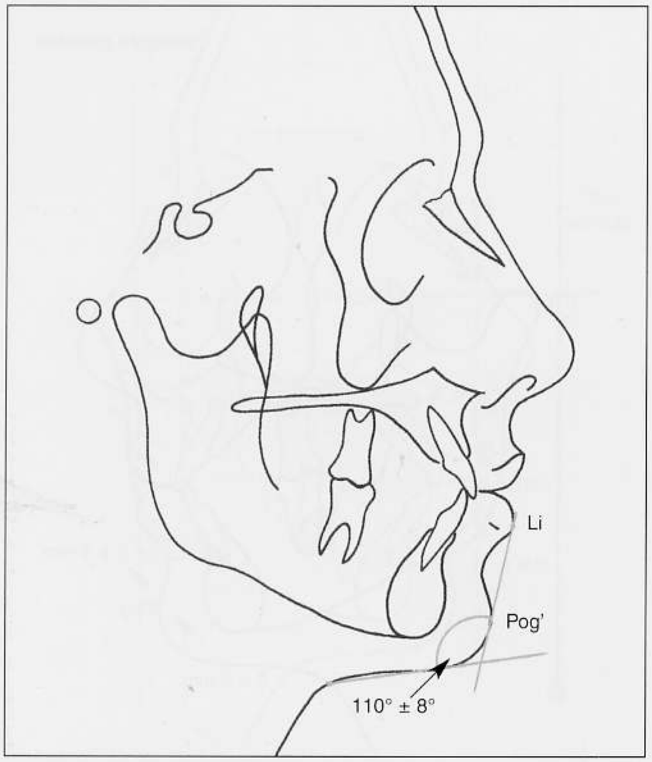


Fig 2-40 Lower lip–chin–throat angle.

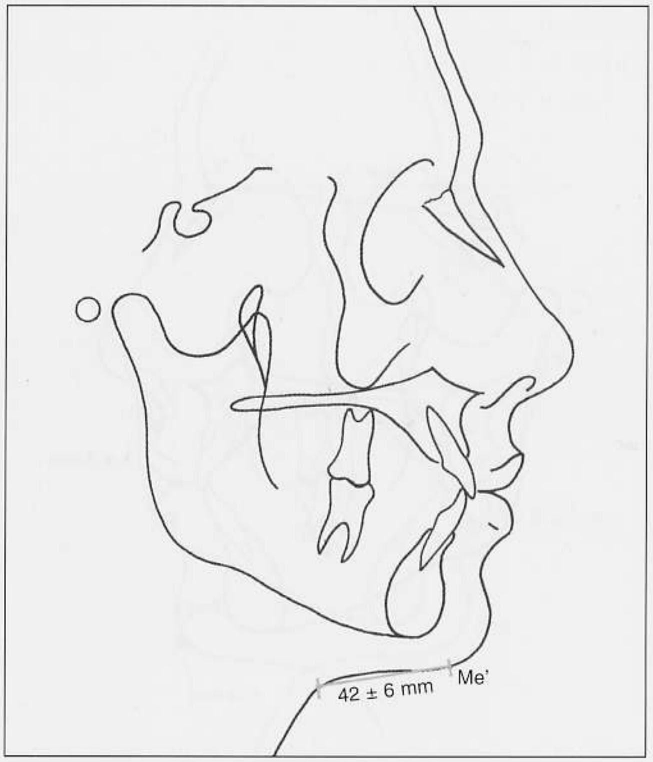


Fig 2-41 Chin-throat length.

Lower lip–chin–throat angle

The lower lip–chin–throat angle is contained between a line drawn from Li to Pog' and a submental tangent line. An angulation of 110 ± 8 degrees is considered normal. For this assessment, the radiograph must be taken in natural head posture (Fig 2-40).

This angle will be more acute in patients with mandibular anteroposterior excess and/or macrogenia. It will be more obtuse in cases of mandibular anteroposterior deficiency and/or microgenia.

Chin-throat length

The chin-throat length is measured from the angle of the throat to Me' (Fig 2-41). A distance of 42 ± 6 mm is considered normal. This measurement is only meaningful with the patient's head in natural posture.

The distance will be excessive in individuals with mandibular prognathism and short in mandibular recessive cases. This measurement is significant in differentiating between mandibular anteroposterior excess and maxillary deficiency. Mandibular setback would obviously reduce this length.

Facial contour angle

The angle of facial convexity is formed by lines drawn from G' to Sn and from Sn through Pog'. The line from G' to Sn is also called the *upper facial plane* (UFP), while the lower facial plane (LFP) is formed by the line from Sn to Pog'. The mean angulation is estimated to be −12 degrees. A clockwise angle is expressed as positive, while a counterclockwise angle is negative. Males tend to have a straighter profile (−11 ± 4 degrees), while a slightly more convex profile is considered esthetically pleasing for females (−13 ± 4 degrees) (Fig 2-42). It is important, however, to differentiate among the various facial deformities that may produce the same facial contour angle. The measurement of the angle does not reveal the localization of the deformity.

In Fig 2-43, both individuals have normal anteroposterior relations according to the facial con-

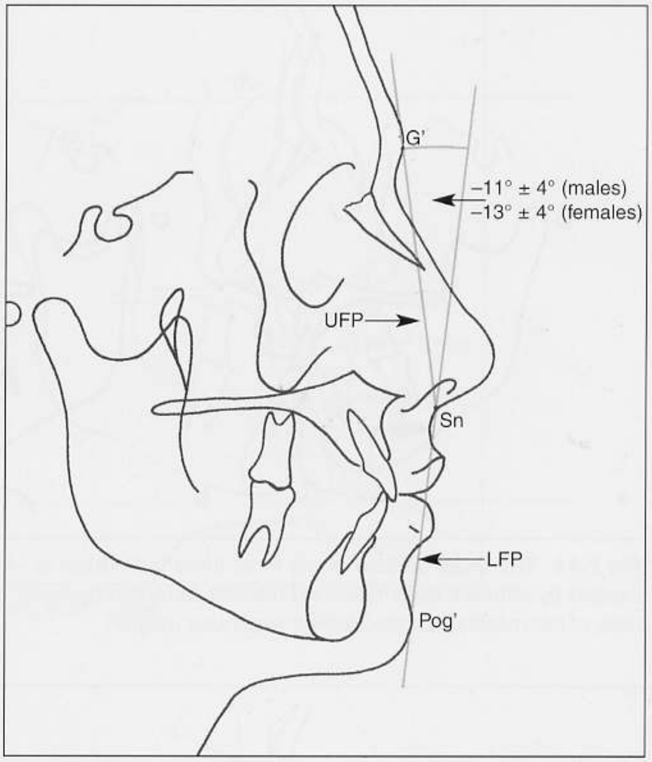


Fig 2-42 Facial contour angle.

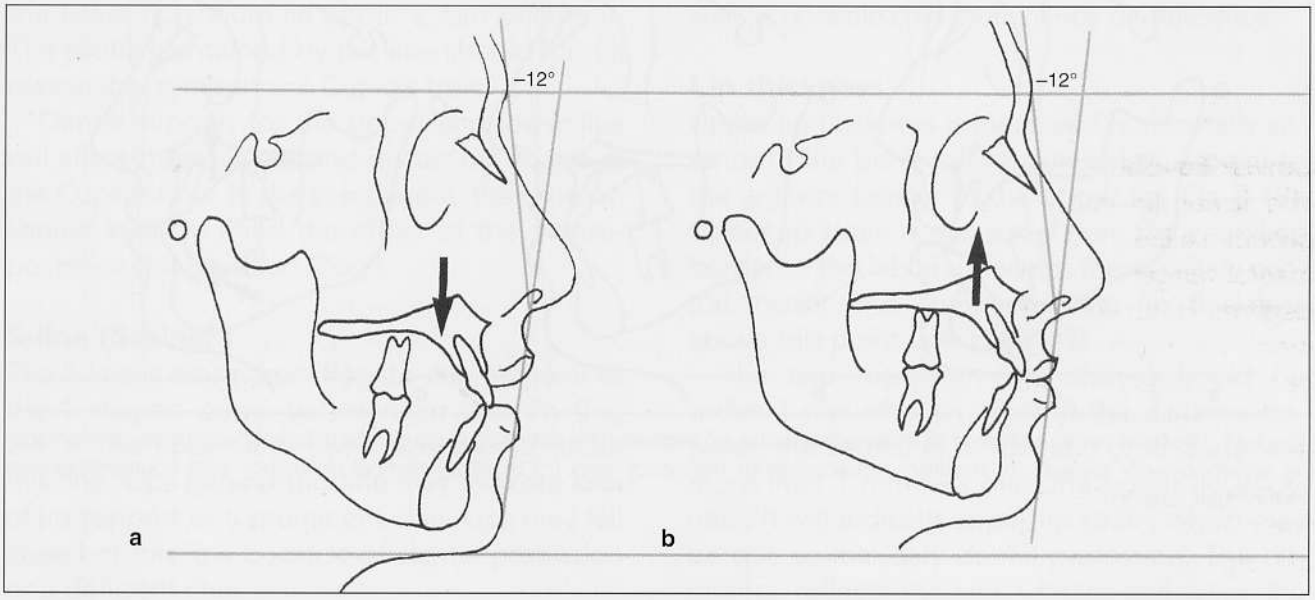


Fig 2-43 Both individuals have a facial contour angle of −12 degrees, but they have different vertical deformities. *(a)* Vertical maxillary excess. *(b)* Vertical maxillary deficiency.

tour angle (−12 degrees). However, the vertical height of one is long (Fig 2-43a), and the mandible has rotated clockwise; the other has a short vertical height (Fig 2-43b) due to maxillary anteroposterior deficiency with the mandible rotated counterclockwise. In Fig 2-44 all three patients have a Class II malocclusion and an increased facial contour angle (−20 degrees). Their identical facial contour angles, however, are produced by entirely different skeletal patterns. The patient in Fig 2-44a

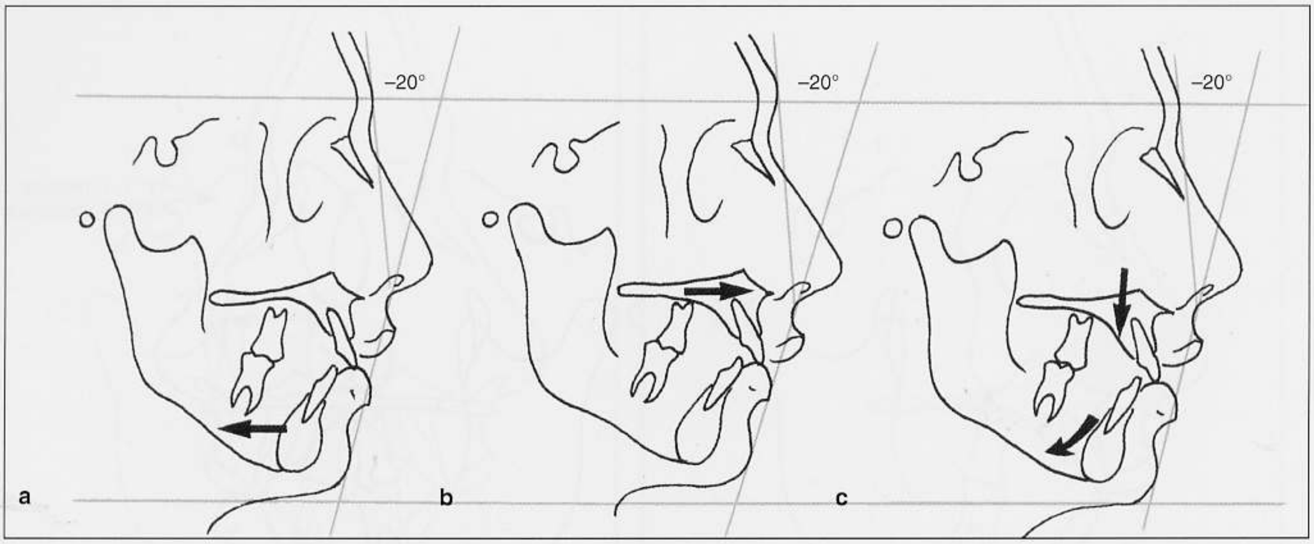


Fig 2-44 The facial contour angle in all three individuals is -20 degrees, indicating a convex profile. The convexity, however, is caused by different deformities: *(a)* mandibular anteroposterior deficiency, *(b)* maxillary anteroposterior excess, and *(c)* vertical excess of the maxilla with clockwise mandibular rotation.

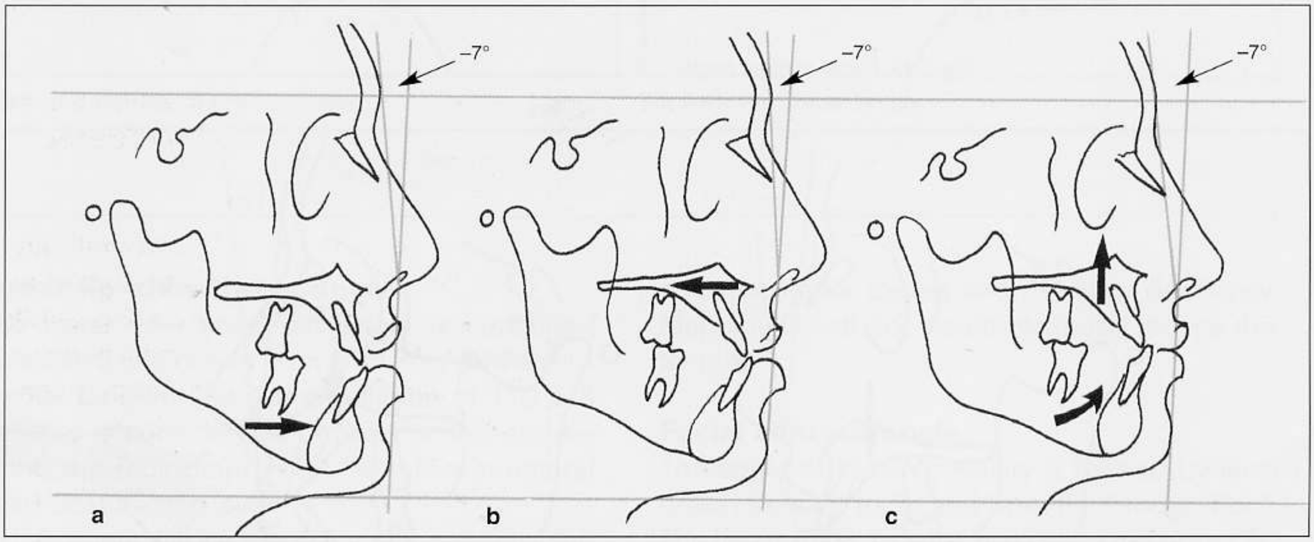


Fig 2-45 The facial contour angle in all three individuals is -7 degrees. This concavity is caused by different deformities: *(a)* mandibular anteroposterior excess, *(b)* maxillary anteroposterior deficiency, and *(c)* maxillary vertical deficiency with counterclockwise mandibular rotation.

has mandibular anteroposterior deficiency. Fig 2-44b shows a patient with maxillary anteroposterior excess, and Fig 2-44c shows an individual with vertical maxillary excess, with clockwise (backward) rotation of the mandible.

Figure 2-45 shows Class III malocclusion and a more concave profile with decreased facial contour angle (–7 degrees) produced by three entirely different skeletal patterns. The patient in Fig 2-45a has mandibular anteroposterior excess. Figure 2-45b shows a maxillary anteroposterior deficiency, and Fig 2-45c shows a maxillary vertical deficiency with counterclockwise (forward) rotation of the mandible.

E-line (Ricketts)

The E-line (esthetic plane) is drawn from nasal tip (Pn) to Pog' (Fig 2-46). The upper lip should

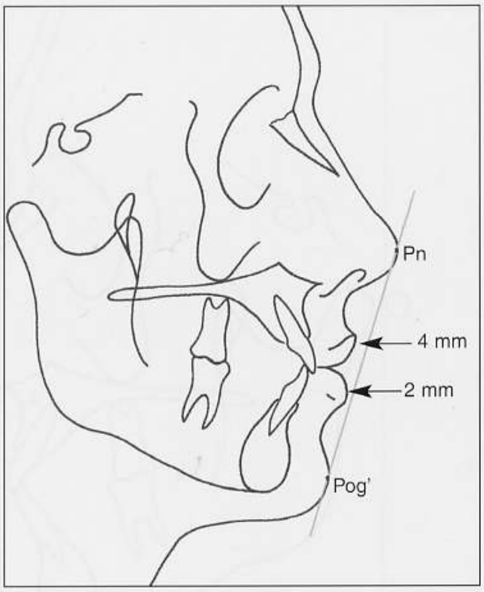


Fig 2-46 E-line (esthetic plane).

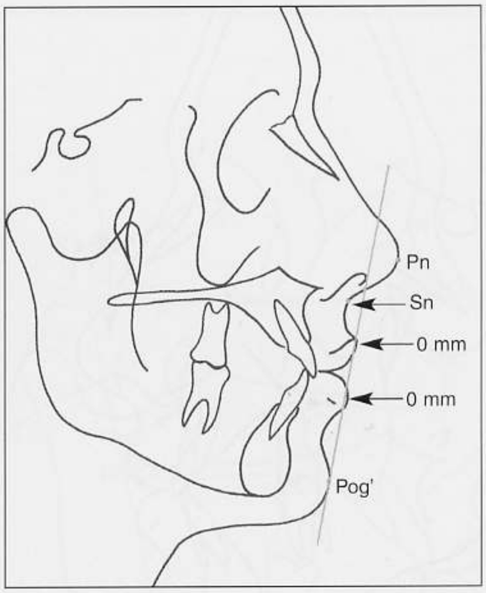


Fig 2-47 S-line.

be approximately 4 mm behind the line, while the lower lip should lie about 2 mm behind it. The profile contained by this line should form a reasonably symmetrical Cupid's bow.

Dental support for the upper and lower lips will affect these values and distort the shape of the Cupid's bow. In the assessment, the clinician should keep in mind the effect of the anteroposterior chin position (Pog').

S-line (Steiner)

The S-line is drawn from Pog' to the midpoint of the S-shaped curve between Sn and Pn (Fig 2-47). The upper and lower lips should touch this line. Lips behind this line may indicate lack of lip support or a prominent chin. Lips may fall ahead of this line because of dental protrusion or a deficient chin.

Z-angle (Merrifield)

Merrifield's Z-angle is formed by the intersection of FH and a line connecting Pog' and the most protrusive lip point (upper or lower) (Fig 2-48). The average Z-angle is 80 ± 9 degrees. An angle greater than 80 degrees is indicative of mandibular anteroposterior excess, while an angle of less than 80 degrees suggests an anteroposterior deficiency of the mandible. The Z-angle also indicates the relationship of the lips to the chin, as well as possible chin prominence or deficiency.

Lip thickness

Upper lip thickness is measured horizontally anterior to the bone from 2 mm below A-point to the anterior border of the upper lip (Fig 2-49). Upper lip strain is measured from the vermilion border to the labial surface of the maxillary central incisor and compared with lip thickness above this point (see Fig 2-49).

The two measurements above should be within 1 mm of each other. If the distance between the vermilion border and tooth surface is more than 1 mm less than the upper lip thickness, it will indicate upper lip strain, which may be due to maxillary dental protrusion. The difference reflects the strain factor and gives the clinician an indication of how far the incisors would have to be retracted before the lip would assume normal form and thickness and start responding to incisor retraction by moving posteriorly. Thin lips would respond more readily than thick lips to orthodontic tooth movements. Racial differences in facial soft tissue thickness should be taken into account.

Anteroposterior soft tissue relationships are summarized in Table 2-2.

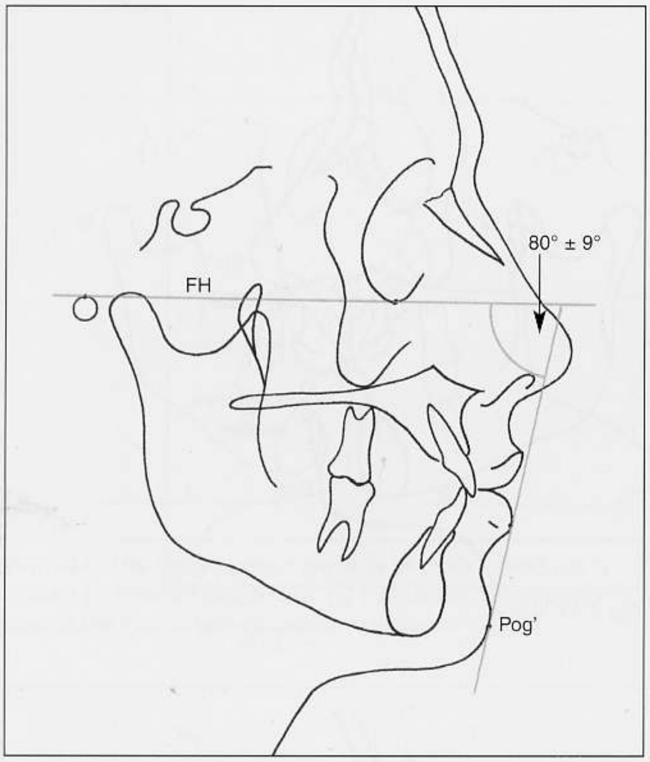


Fig 2-48 Merrifield's Z-angle is formed by the intersection of FH and a line connecting Pog' and the most protrusive lip point (upper or lower).

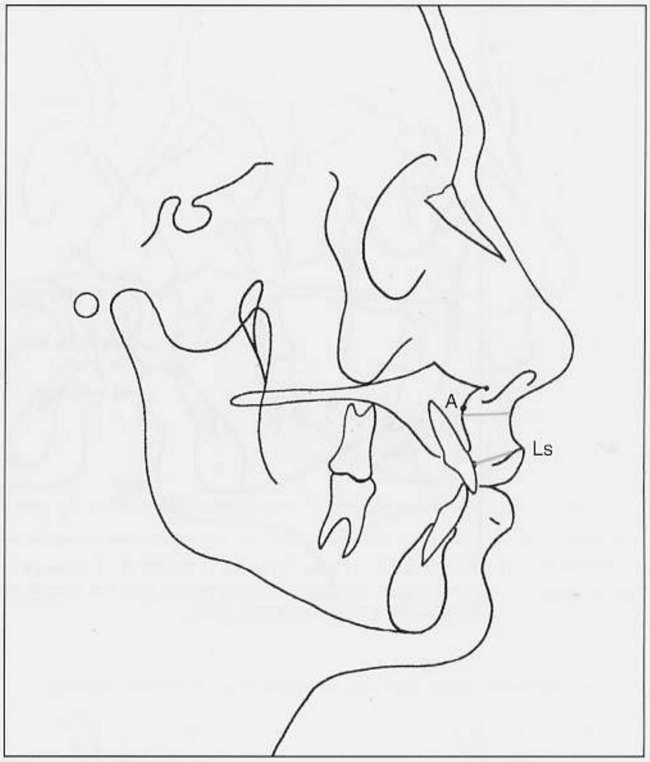


Fig 2-49 Soft tissue thickness of the upper lip.

Table 2-2 Summary of anteroposterior soft tissue relationships

Anteroposterior relationship	Normal value
Nasolabial angle	85 to 105 degrees
Lip prominence:	
Ls to Sn-Pog'	3 ± 1 mm ahead
Li to Sn-Pog'	2 ± 1 mm ahead
Ls to SnV	1 to 2 mm ahead
Li to SnV	0 mm
Chin prominence:	
Pog' to 0-degree meridian	0 ± 2 mm ahead
Pog' to Sn (perpendicular to FH)	3 ± 3 mm behind
Lower lip-chin-throat angle	110 ± 8 degrees
Chin-throat length	42 ± 6 mm
Facial contour angle	−11 ± 4 degrees (males) −13 ± 4 degrees (females)
E-line to Ls	−4 mm
E-line to Li	−2 mm
S-line to Ls	0 mm
S-line to Li	0 mm
Z-angle	80 ± 9 degrees

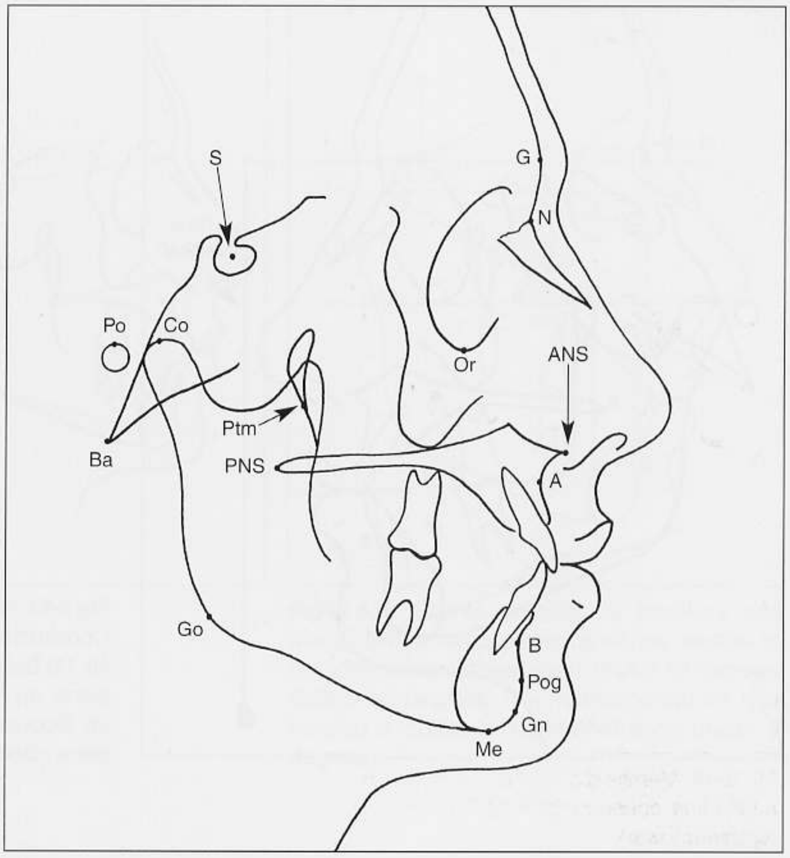


Fig 2-50 Hard tissue cephalometric landmarks.

Skeletal analysis

Hard tissue landmarks

Hard tissue landmarks, shown in Fig 2-50, include the following:

Glabella (G): The most anterior point of the frontal bone

Nasion (N): The most anterior point on the frontal nasal suture in the midsagittal plane

Orbitale (Or): The lowest point on the inferior orbital rim

Sella (S): The center of the sella turcica, as on the lateral cephalogram, which is located by inspection

Pterygomaxillare (Ptm): The apex of the teardrop-shaped pterygomaxillary fissure (lowest point of the opening)

Basion (Ba): The point where the median sagittal plane of the skull intersects the lowest point in the anterior margin of the foramen magnum

Anterior nasal spine (ANS): Anterior tip of the nasal spine

Posterior nasal spine (PNS): The most posterior aspect of the palatal bone

A-point, or subspinale: The most posterior midline point in the concavity where the lower anterior edge of the anterior nasal spine meets the alveolar bone overlying the maxillary incisors

B-point, or supramentale: The most posterior midline point in the concavity of the mandible between the alveolar bone overlying the mandibular incisors (infradentale) and the pogonion

Pogonion (Pog): The most anterior point of the chin

Gonion (Go): The point defined by using two lines, one tangent to the inferior border of the mandible and the other tangent to the posterior border of the ramus; found by bi-

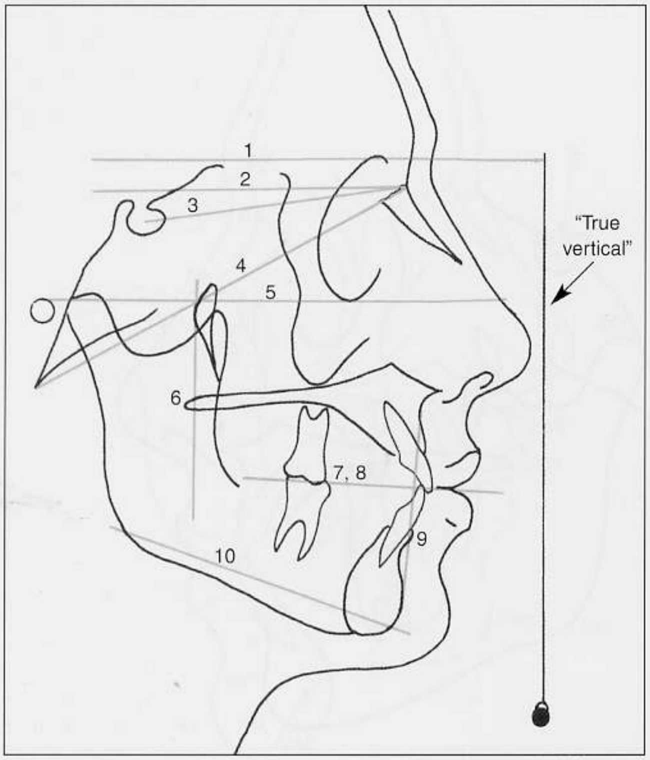


Fig 2-51 Hard tissue planes. (1) "True horizontal" plane (HP). (2) Constructed horizontal plane (cHP). (3) Anterior cranial base (S-N). (4) Basion-nasion (Ba-N) plane. (5) Frankfort horizontal (FH) plane. (6) Pterygoid vertical (Ptv). (7) Functional occlusal plane. (8) Occlusal plane. (9) Dental plane (A-Pog). (10) Mandibular plane (Go-Gn).

secting the angle formed by the two lines and extending the bisector through the curvature of the mandible

Gnathion (Gn): The lowest, most anterior midline point on the symphysis of the mandible (midway between the menton and the pogonion)

Menton (Me): The most inferior point on the symphysis of the mandible in the midline

Porion (Po): The most superior point of the external auditory meatus (anatomic point); the machine porion is the uppermost point on the outline of the rods of the cephalometer

Condylion (Co): The most posterosuperior point on the head of the condyle

Hard tissue planes

Hard tissue planes, shown in Fig 2-51, include the following:

"True horizontal" plane (HP): A line perpendicular to a plumb line on the radiograph will be the HP for a specific patient.

Constructed horizontal plane (cHP): A horizontal plane constructed by drawing a line through nasion at an angle of 7 degrees to S-N (see point 2 in Fig 2-51). This plane tends to be close to true horizontal.

Anterior cranial base (S-N): Formed by a line drawn from sella to nasion

Basion-nasion (Ba-N) plane: Extends between basion and nasion and divides the face and the cranium

Frankfort horizontal (FH) plane: Extends from porion to orbitale

Pterygoid vertical (Ptv): A vertical line perpendicular to the Frankfort horizontal plane and drawn through the distal outline of the pterygomaxillary fissure

Functional occlusal plane: A line through the cusp contacts of the molars and premolars defines this plane

Occlusal plane: Formed by a line drawn through the mesial cusp contact of the molars and dividing the incisor overbite

Dental plane: Extends between A-point and pogonion

Mandibular plane: Extends from gonion to gnathion

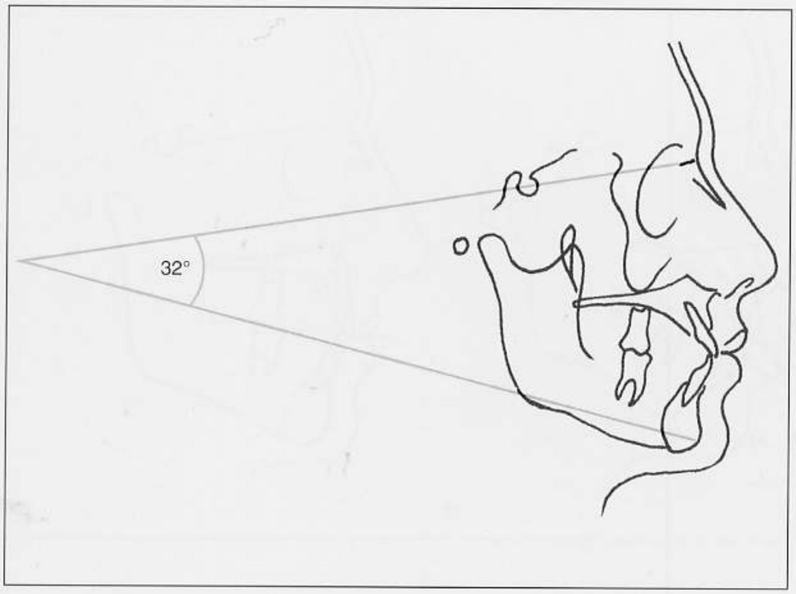


Fig 2-52 Mandibular plane angle.

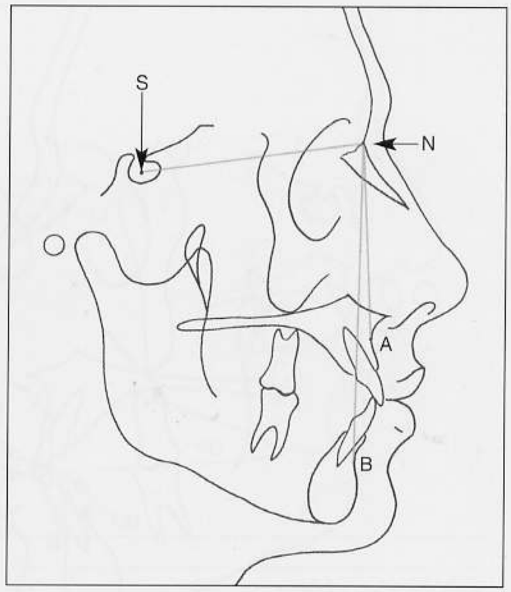


Fig 2-53 Steiner analysis for maxillary and mandibular anteroposterior positions relative to the anterior cranial base (S-N). SNA is 82 degrees. SNB is 80 degrees. The maxillomandibular relationship is indicated by the ANB angle (mean, 2 degrees).

Skeletal anteroposterior relationships

Mandibular plane angle (Steiner)

The mandibular plane is drawn between Go and Gn. The mandibular plane angle is formed between the mandibular plane and the anterior cranial base (S-N). Its mean is 32 degrees (Fig 2-52).

This angle interprets the difference between anterior and posterior facial heights. Individuals with high mandibular plane angles tend to have Class II malocclusions, vertical maxillary excess, and anterior open bites. Patients with low mandibular plane angles tend to be vertically deficient and to have deep bites.

SNA angle (Steiner)

The SNA angle is formed between the anterior cranial base (S-N) and a line drawn through N and A-point. Its mean is 82 degrees (Fig 2-53).

The SNA angle gives an indication of the anteroposterior position of the maxilla relative to the anterior cranial base. An angle less than 82 degrees is indicative of maxillary anteroposterior deficiency, while an increased angle may indicate maxillary protrusion.

SNB angle (Steiner)

The SNB angle is formed between the anterior cranial base (S-N) and a line drawn through N and B-point. Its mean is 80 degrees (see Fig 2-53).

The angle gives an indication of the anteroposterior position of the mandible relative to the anterior cranial base. Patients with mandibular anteroposterior excess will have an angle greater than 80 degrees, while those with mandibular deficiency will have a decreased angle.

ANB angle (Steiner)

The ANB angle is formed between A-N and N-B. Its mean is 2 degrees (see Fig 2-53). The angle provides an idea of the anteroposterior discrepancy between the maxilla and the mandible. In Class III cases, the angle is less than 2 degrees or even negative, while in Class II cases the angle is increased.

In spite of its shortcomings, Steiner analysis continues to be a popular method of evaluating the anteroposterior relationship of the maxilla and mandible. However, this analysis should not be used to make an absolute diagnosis of sagit-

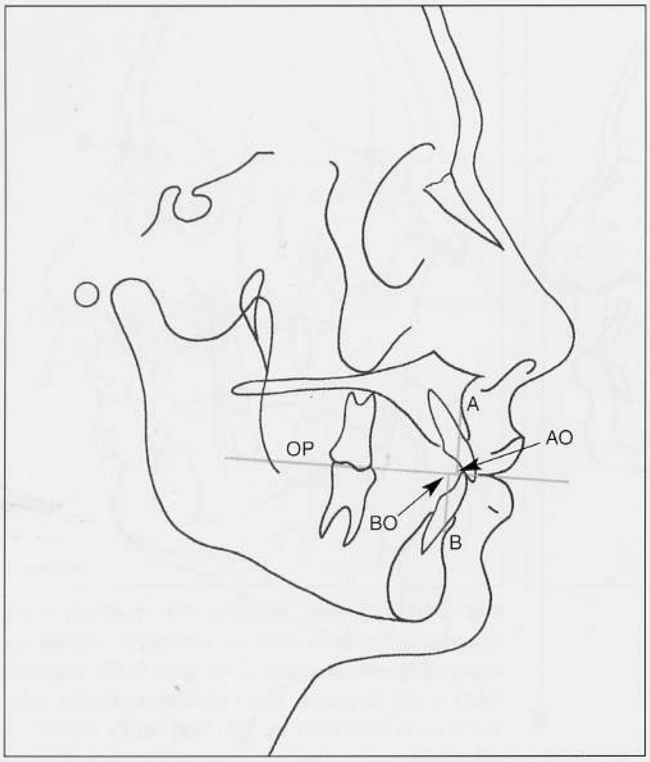


Fig 2-54 Wits appraisal. Vertical lines are drawn perpendicular to the occlusal plane (OP) from A-point and B-point. The points of contact on the occlusal plane are labeled AO and BO, respectively.

tal skeletal disharmony, since vertical and rotational jaw dimensions relative to the anterior cranial base often have a significant effect on the measurements (see the next section).

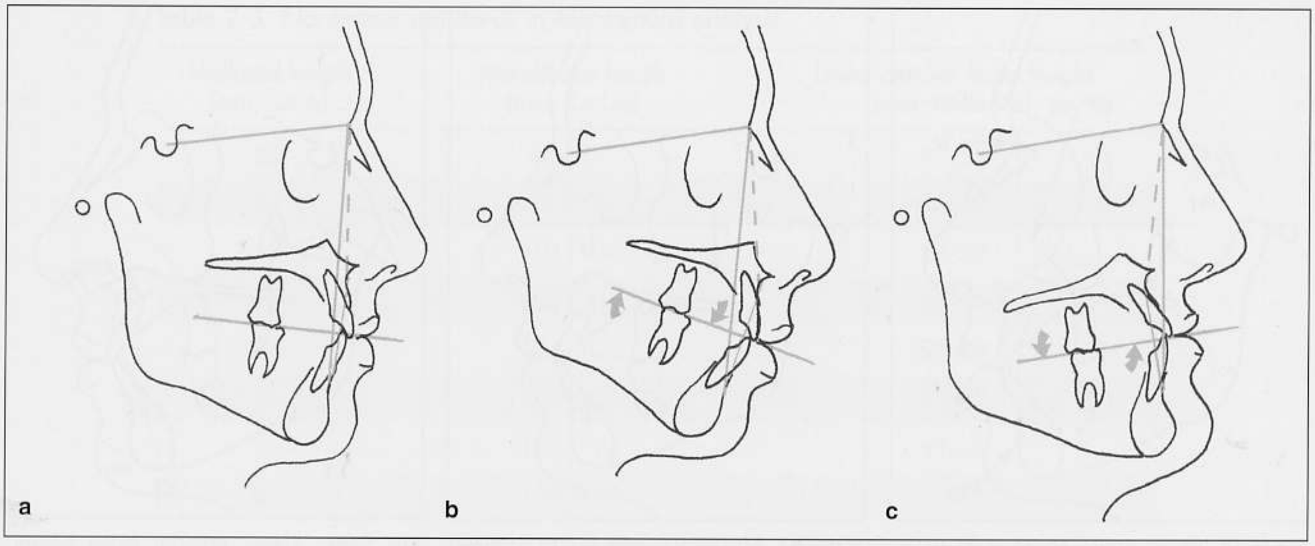
Wits appraisal

Most cephalometric analyses, like Steiner analysis, relate the maxillary and mandibular anteroposterior position to the cranium. Measurements from the cranial base, however, do not always provide a reliable expression of the anteroposterior relationship between the maxilla and mandible. The Wits appraisal is a linear measurement between the maxilla and mandible and is not influenced by the cranium.

Points BO and AO are established by dropping perpendicular lines from the A-point and B-point, respectively, onto the occlusal plane (OP) (Fig 2-54). The mean in males is BO 1 mm ahead of AO. In females, BO and AO coincide.

The measurement between BO and AO indicates the anteroposterior discrepancy between the maxilla and mandible. A small discrepancy may indicate that a case can be treated orthodontically, while a large discrepancy may indicate that surgical correction will be required.

Clockwise or counterclockwise rotations of the maxillomandibular complex relative to the anterior cranial base do not affect the Wits appraisal measurements. These rotations, however, do affect Steiner analysis significantly. This is a good example of how two cephalometric analyses may render quite contradictory measurements; however, the observations assist in treatment planning. Figures 2-55a to 2-55c illustrate three cases with the same Wits measurements (0 mm), but ANB angles of +2, +8, and –5 degrees and very different facial profiles. Surgical rotation of the maxillomandibular complex may be indicated for correction in the cases depicted in Figs 2-55b and 2-55c. The case in Fig 2-55d has an ANB angle of –1 degree, indicating a mild Class III discrepancy between the jaws. The Wits appraisal for this case, however, is 8 mm, indicating a substantial jaw discrepancy; the patient could not be treated by orthodontic means alone.



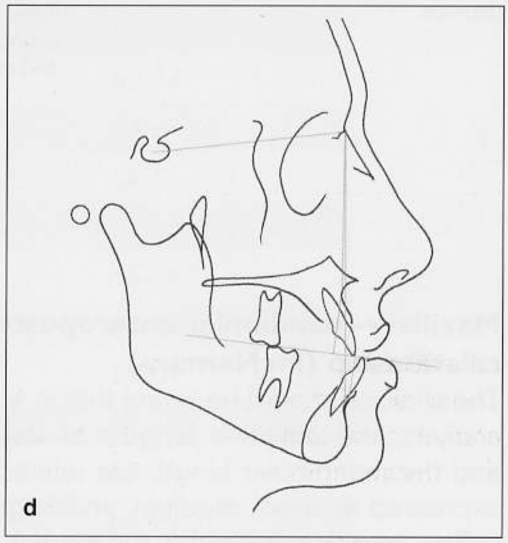


Fig 2-55 The effect of rotation of the maxillomandibular complex relative to the anterior cranial base and the ANB angle. *(a)* Normal relation: ANB angle is +2 degrees. *(b)* Counterclockwise rotation resulting in an ANB angle of +8 degrees. *(c)* Clockwise rotation with an ANB angle of −5 degrees. In all three cases, the Wits appraisal indicates a normal relationship (0 mm) between the maxilla and mandible. *(d)* An ANB angle of −1 degree indicates a mild Class III jaw relationship (Steiner). According to the Wits appraisal, the discrepancy between maxilla and mandible is severe (8 mm).

Facial angle (Downs)

The facial angle is the inferior inside angle in which the facial line (N-Pog′) intersects the FH. Its mean is 82 to 95 degrees (Fig 2-56). The facial angle indicates the relative anteroposterior position of the mandible to the cranium.

Maxillary depth (McNamara)

The maxillary depth is the linear distance between N perpendicular to FH and A-point (Fig 2-57). Its mean is 0 mm. A-point anterior to the line is expressed as a positive value, posterior to the line as a negative value. The maxillary depth is an indication of the anteroposterior position of the maxilla in relation to the cranium.

Anteroposterior and vertical relationships (McNamara)

The lower anterior facial height (LAFH) is measured from ANS to Me, and the midfacial length is measured from Co to A-point. The distance from Co to Gn constitutes the mandibular length (Fig 2-58). There should be a correlation between the LAFH (ANS–Me), the length of the midface (Co-A), and the mandibular length (Co-Gn). The correlations are listed in Table 2-3.

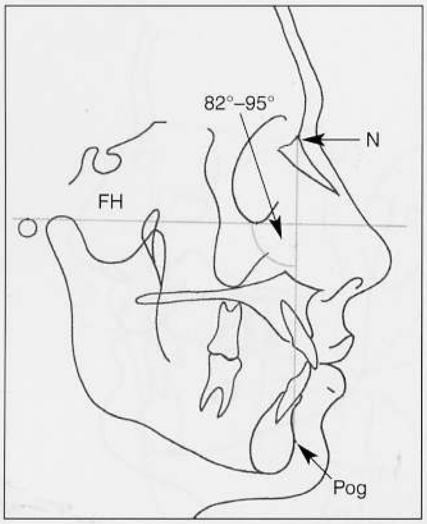


Fig 2-56 Facial angle. Mean is 82 to 95 degrees.

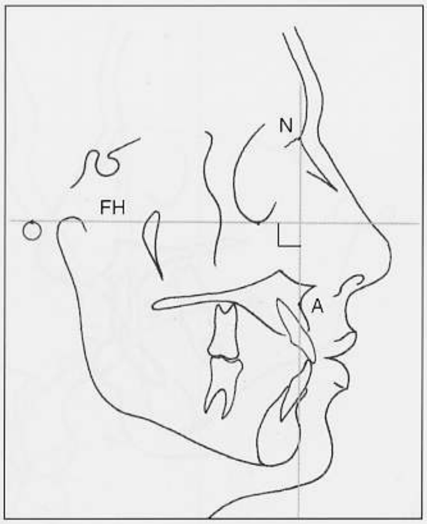


Fig 2-57 Maxillary depth. A line is drawn through N perpendicular to FH. A-point is expressed as positive anterior to the line and as negative posterior to the line.

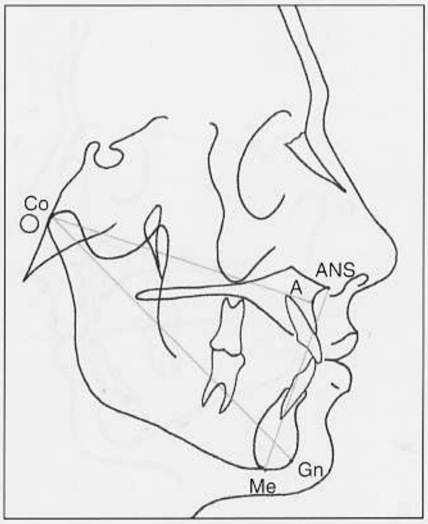


Fig 2-58 Lower anterior facial height: ANS–Me. Midfacial length: Co-A. Mandibular length: Co-Gn.

Maxillary-mandibular anteroposterior relationship (McNamara)

The clinician should be aware that in McNamara analysis, the effective lengths of the midface and the mandibular length are related and are expressed as *small*, *medium*, and *large*.

The maxillomandibular differential is determined by subtracting the midfacial length from the mandibular length. In small individuals (mixed dentition stage), the difference should be 20 to 23 mm. In medium-sized individuals, there should be a difference of 27 to 30 mm, while in large individuals the difference should be 30 to 33 mm (Fig 2-59).

The graph in Fig 2-60 illustrates the relationship between midfacial length, mandibular length, and lower anterior facial height. A discrepancy greater or smaller than the normative values would indicate a disharmonious relationship between the maxilla and mandible. Alternative analysis should be used to identify which jaw is at fault. The midfacial length is measured from Co to A-point, while the mandibular length is measured from Co to the anatomic Gn. The linear relationship between the midfacial length and the length of the mandible is called the *ratio of effective maxillary to mandibular length*. Any specific maxillary (midfacial) length will correspond to a specific mandibular length within a given range (see Table 2-3). The normal adult ratio should be maxilla (Co-A):mandible (Co-Gn) = 1:1.3.

During normal growth, the ratio decreases from 1:1.25 for an 8-year-old to the adult value. The effective mandibular length increases faster than the length of the maxilla, at the rate of 0.005 per year (1:1.26 at 10 years of age, 1:1.27 at 12 years, 1:1.28 at 14 years, and 1:1.29 at 16 years). The clinician should be aware that a change in this value may indicate disproportionate growth, but it does not indicate which jaw is at fault.

The esthetic effect of the effective maxillary and mandibular lengths is closely related to the anterior facial height and, therefore, the angle formed between A-point, Co, and Gn. This angle normally decreases with age (Fig 2-61).

Skeletal anteroposterior relationships are summarized in Table 2-4.

Table 2-3 Normative standards in McNamara analysis

Midfacial length (mm; Co-A)	Mandibular length (mm; Co-Gn)	Lower anterior facial height (mm; ANS–Me)
80	97–100	57–58
81	99–102	57–58
82	101–104	58–59
83	103–106	58–59
84	104–107	59–60
85	105–108	60–62
86	107–110	60–62
87	109–112	61–63
88	111–114	61–63
89	112–115	62–64
90	113–116	63–64
91	115–118	63–64
92	117–120	64–65
93	119–122	65–66
94	121–124	66–67
95	122–125	67–69
96	124–127	67–69
97	126–129	68–70
98	128–131	68–70
99	129–132	69–71
100	130–133	70–74
101	132–135	71–75
102	134–137	72–76
103	136–139	73–77
104	137–140	74–78
105	138–141	75–79

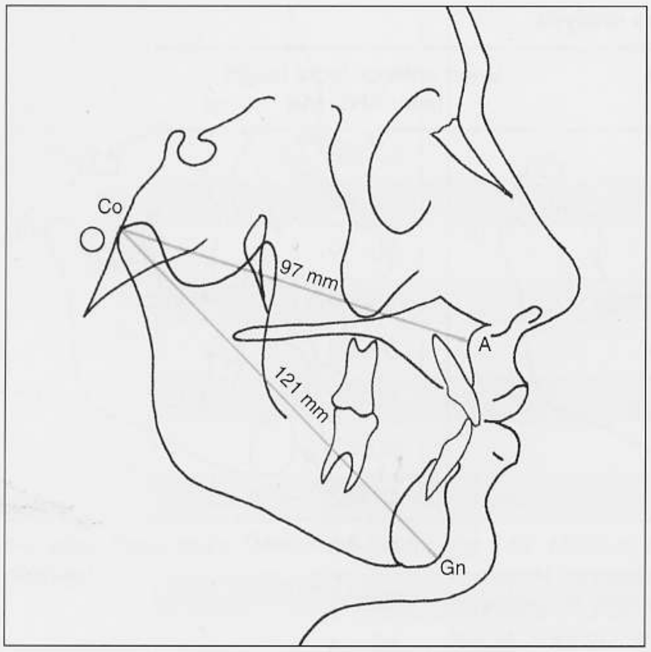


Fig 2-59 Maxillomandibular anteroposterior relationship. The maxillomandibular differential of 24 mm shown here would be ideal for a small to medium individual. The maxillomandibular ratio of 1:1.24, however, indicates a discrepancy in the relationship between the jaws. According to McNamara's normative standards (see Table 2-3), a midfacial length of 97 mm would be better related to a mandibular length of 126 to 129 mm. This may indicate a slight anteroposterior deficiency of the mandible.

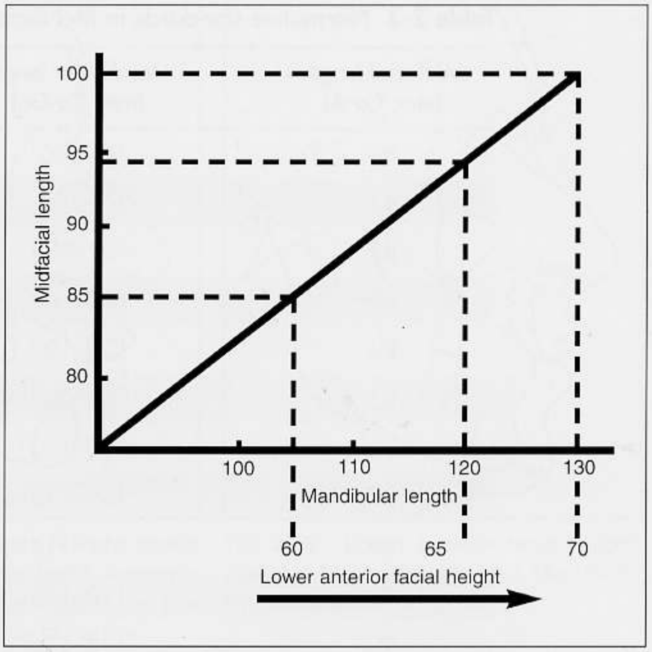


Fig 2-60 The relationship between midfacial (maxillary) length and mandibular length is generally linear and dependent on size, rather than on age or sex. An individual with a maxillary length of 100 mm should have an effective mandibular length of 130 mm. The difference between the maxillary and mandibular lengths in this instance would be 30 mm. (Adapted from McNamara and Brudon, 1993 with permission).

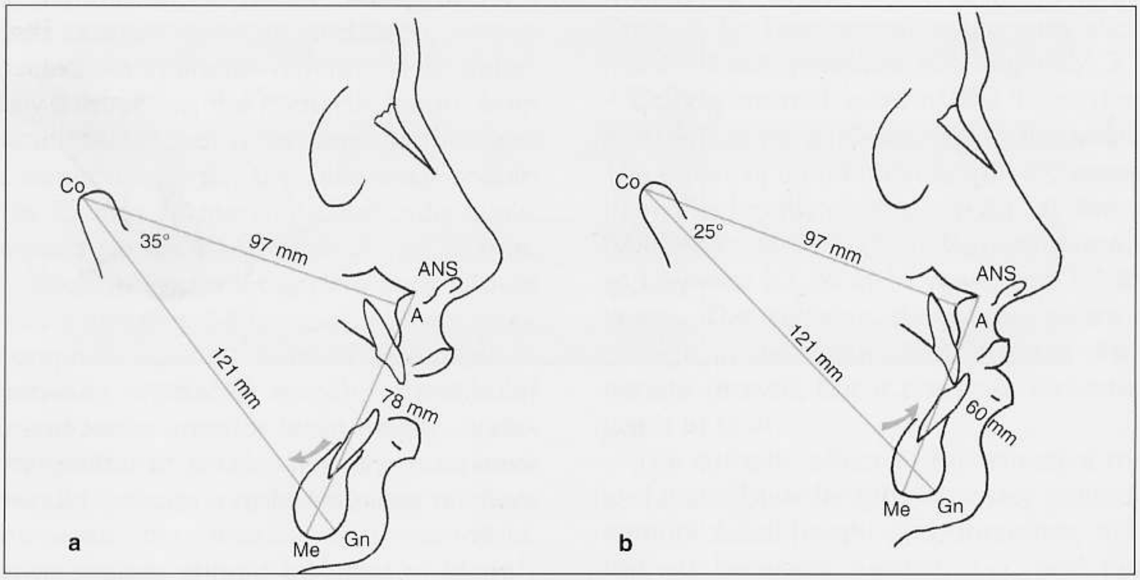


Fig 2-61 The esthetic effect of the change in lower anterior facial height and backward *(a)* and forward *(b)* rotation of the chin. In both *(a)* and *(b)*, the midfacial lengths (97 mm) and mandibular lengths (121 mm) are the same. In *(a)* the lower anterior facial height (ANS–Me) is 78 mm, while in *(b)* it is 60 mm. The angle between Co-A and Co-Gn in *(a)* is 35 degrees, while in *(b)* it is 25 degrees.

Table 2-4 Summary of skeletal anteroposterior relationships

	Anteroposterior relationship	Normal value
Maxilla		
	To anterior cranial base (SNA)	82 degrees
	To mandible (ANB)	2 degrees
	To mandible (Wits appraisal)	AO 1 mm behind BO (males) AO and BO coincide (females)
	Maxillary depth: A-point to N perpendicular to FH	0 mm
	To mandibular length: Co-A:Co-Gn	1:1.3
Mandible		
	Mandibular plane angle S-N to Go-Gn	32 degrees
	To anterior cranial base (SNB)	80 degrees
	To maxilla (ANB)	2 degrees
	To maxilla (Wits appraisal)	BO 1 mm ahead of AO (males) BO and AO coincide (females)
	To maxillary length: Co-Gn:Co-A	1.3:1

Skeletal vertical relationships: Midface to lower face skeletal height

Skeletal vertical relationships are measured from N to ANS and from ANS to Me. A vertical line is drawn perpendicular to the FH anterior to the face. In turn, perpendicular lines are drawn to the vertical line from N, ANS, and Me, and the distance is measured from N to ANS and from ANS to Me (Fig 2-62). The normal values are 53 mm from N to ANS and 65 mm from ANS to Me. However, the relationship between the vertical heights is more important than the measurement. A ratio of 5:6 is normal. In most individuals with vertical dentofacial deformities, the lower measurement (ANS–Me) will be affected, which in turn will affect the relationship with the upper measurement (N–ANS). The ANS–Me distance will be increased in individuals with vertical maxillary excess, vertical mandibular excess, and open bites. The lower measurement (ANS–Me) will be decreased in individuals with vertical maxillary deficiency, closed bites, deep bites, and vertical mandibular deficiency.

Analysis of dental relationships

Maxillary incisor evaluation

Maxillary incisor position

Steiner analysis According to Steiner analysis, the relative location of the maxillary incisor is determined by relating the incisor's angulation to the N-A line. The most anterior point of the maxillary incisors should be 4 mm ahead of N-A, with an axial inclination of 22 degrees to this line (Fig 2-63).

The linear relationship of the incisor tip to N-A provides information on the anteroposte-

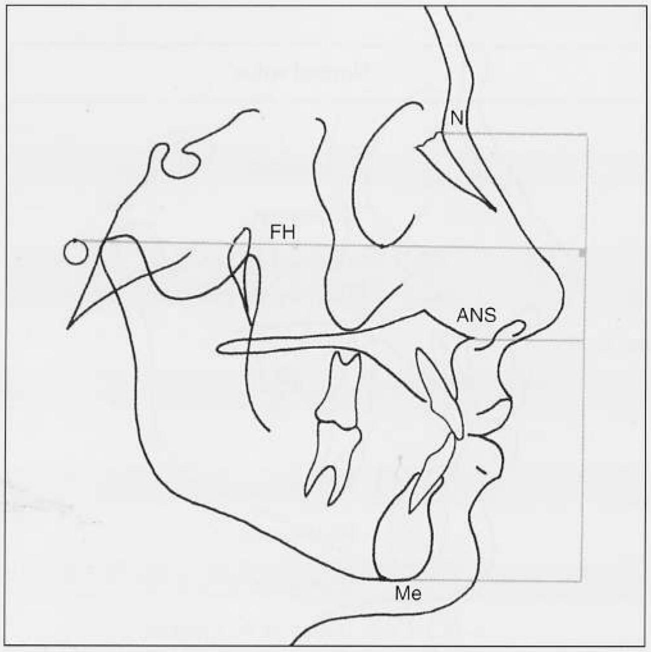


Fig 2-62 Midface and lower face skeletal heights. N–ANS: ANS–Me = 5:6.

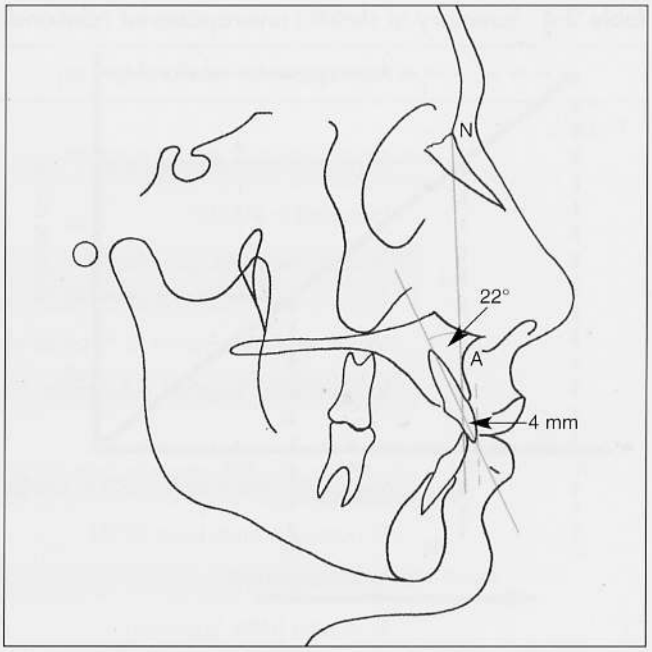


Fig 2-63 Maxillary incisor position (Steiner): 22 degrees to N-A, 4 mm ahead of N-A.

rior position of the incisor to the maxilla, but not to the whole facial complex. In orthognathic cases this measurement can be helpful in determining the preoperative positioning of the tooth if the maxilla's relation to the skull base is also considered. In individuals with dentofacial deformities, the N-A line is often not a reliable basis for assessment of the incisor position because of the skeletal disharmony between skull base and maxilla. In these cases, a vertical line through A-point should be substituted for N-A (Fig 2-64). A helpful additional measurement is the angulation between a line through the maxillary incisor (apex to incisor tip) and a line through the anterior skull base (S-N), which should be 106 ± 4 degrees (see Fig 2-64).

McNamara analysis An important relationship, especially in orthognathic patients, is that of the incisors to the underlying basal bone of each jaw. In McNamara analysis, the position of the maxillary incisors to their respective bone bases is determined by drawing a vertical line through A-point parallel to N and perpendicular to FH. The facial surface of the maxillary incisor should be 4 to 6 mm ahead of the line (Fig 2-65).

In maxillary dental protrusion cases, the incisor will be more than 6 mm ahead of the vertical line through A-point and will be an indication for orthodontic retraction. Where the maxillary incisors are upright (eg, in Class II, division 2 malocclusions), the incisor tip will be less than 4 mm ahead of, or even behind, this line.

Mandibular incisor evaluation

Mandibular incisor position

Steiner analysis The relative location of the mandibular incisors is determined by its relation to the N-B line (Fig 2-66). According to Steiner analysis, the mandibular incisor angulation to the N-B line should be 25 degrees, while the most labial portion of the tooth crown should be 4 mm anterior to the line. The N-B line, however, often is not a reliable basis for assessing the lower incisor position in patients with dentofacial deformities because of a lack of harmony between the mandible and the skull base.

The angular and linear measurements give an indication of the mandibular incisors' relationship to the mandible. In individuals with Class III

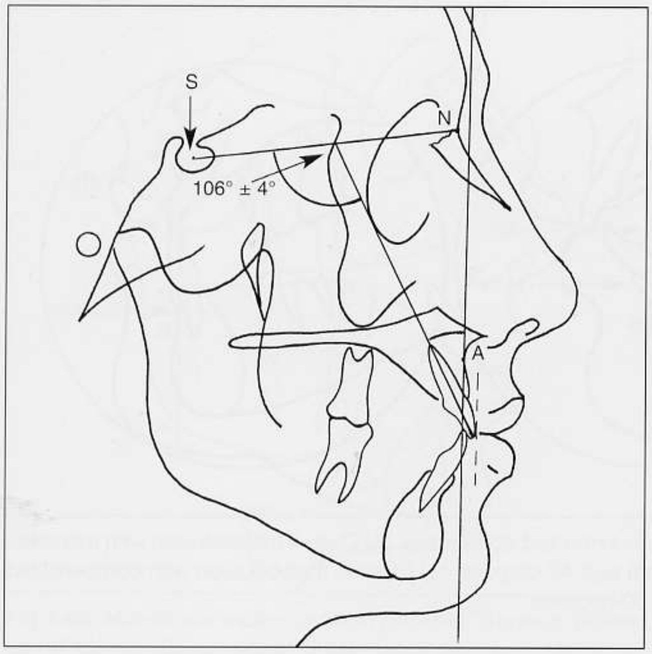


Fig 2-64 An alternative measurement of maxillary incisor angulation. The angle between the skull base (S-N) and maxillary incisor (apex to incisor tip) should be 106 ± 4 degrees.

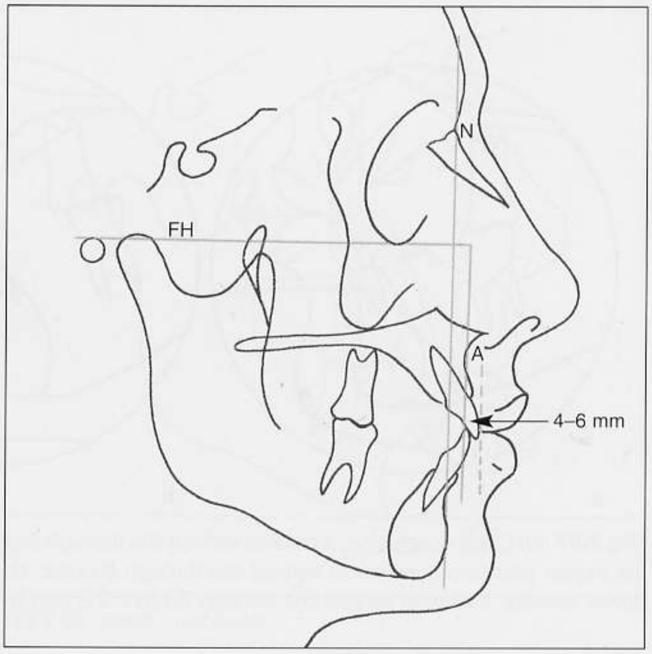


Fig 2-65 Maxillary incisor position (McNamara). The labial surface of the incisor should be 4 to 6 mm ahead of the vertical line through A-point.

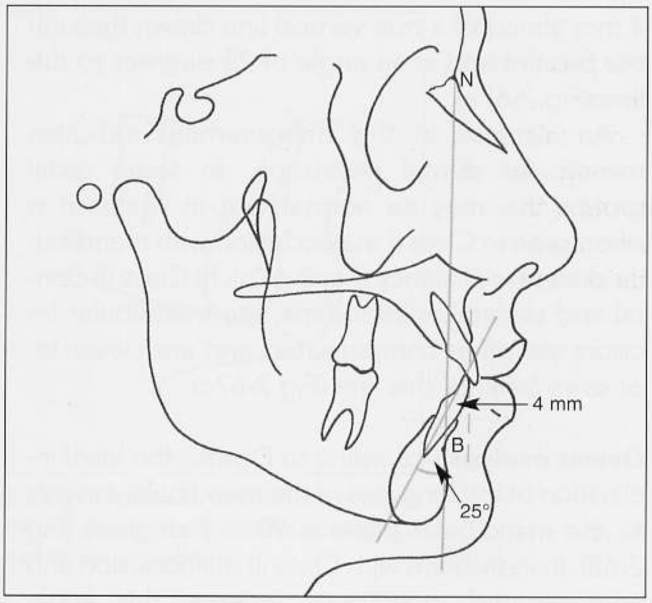


Fig 2-66 Mandibular incisor position (Steiner): 25 degrees to N-B line, and 4 mm ahead of N-B.

malocclusions and compensated incisors, the angle will be smaller and the incisor tip closer to, or even behind, the N-B line. Protrusive incisors would produce a larger angle, and the labial surface would be more than 4 mm ahead of N-B. These measurements can also serve as a guide in planning for extractions and preoperative orthodontic positioning of the mandibular incisor teeth.

McNamara analysis As in the maxilla, in the mandible it is important to determine the relationship of the mandibular incisors to the mandibular bony base. According to McNamara,

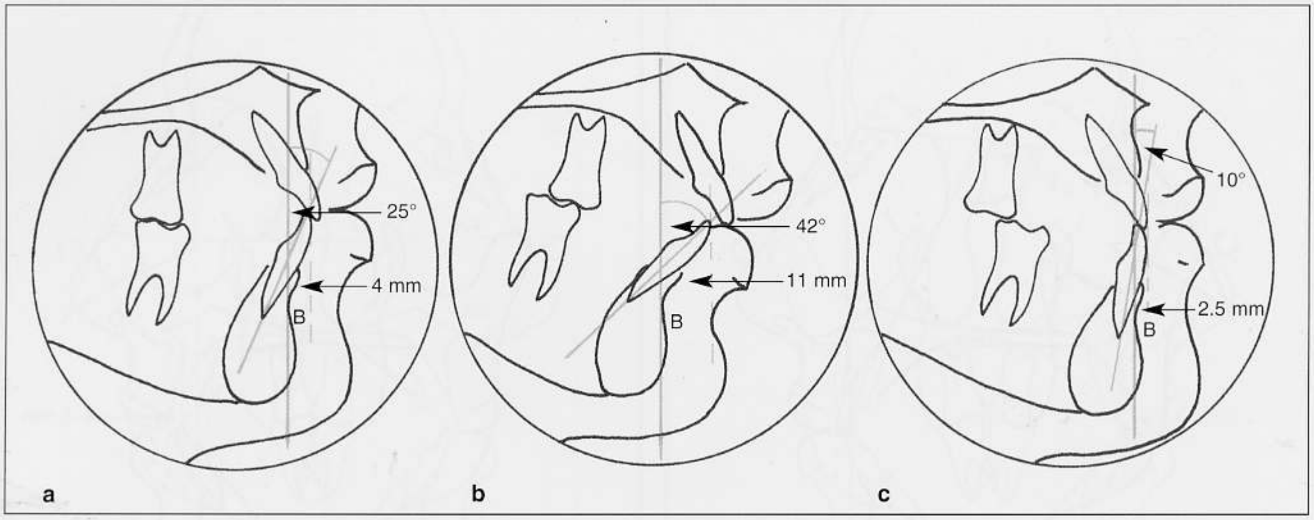


Fig 2-67 *(a)* Class I occlusion; incisor to vertical line through B-point: 4 mm and 25 degrees. *(b)* Class II malocclusion with mandibular incisor protrusion; incisor to vertical line through B-point: 11 mm and 42 degrees. *(c)* Class III malocclusion with compensated lower incisors; incisor to vertical line through B-point: 2.5 mm and 10 degrees.

the labial surface of the lower incisors should be 4 mm ahead of a true vertical line drawn through the B-point and at an angle of 25 degrees to the line (Fig 2-67a).

An increase in this measurement indicates mandibular dental protrusion. In some racial groups this may be normal, but in whites it is often seen in Class II malocclusion with mandibular skeletal deficiency (Fig 2-67b). In Class III dental and skeletal relationships, the mandibular incisors are often compensated and are closer to, or even behind, this line (Fig 2-67c).

Downs analysis According to Downs, the ideal inclination of the long axis of the mandibular incisors to the mandibular plane is 90 ± 7 degrees (Fig 2-68). In individuals with Class III malocclusion and compensated mandibular incisors, this angle tends to be small. It tends to be larger when the lower incisors are protrusive (eg, in bimaxillary protrusion or Class II, division 1 malocclusion).

Interincisal angle (Downs)

The interincisal angle is formed by a line through the incisal edge and the apex of the root of the maxillary and mandibular central incisors (130 ± 6 degrees) (Fig 2-69). The more protrusive the incisors, the smaller the angle. Low angles indicate protrusion of the incisors and are often associated with Class II, division 1 malocclusions, while high angles are frequently associated with Class II, division 2 deep bites.

Maxillary molar to pterygoid vertical (Ricketts)

The distance from the pterygoid vertical (back of the maxilla) to the distal surface of the maxillary first molar (Fig 2-70) should be equal to the patient's age + 3 mm. For example, a 12-year-old has a norm of 15 mm; an 18-year-old adult, 21 mm; and a 21-year-old adult, 24 mm.

This measurement helps determine whether a malocclusion is due to the maxillary or mandibular molar position. It is also useful in deciding whether extractions or headgear may be indicated and is indicative of the anteroposterior position of the maxilla. A small value indicates that the molar is too far distal, and thus headgear and distalization should be avoided, while large values indicate the opposite. This measurement is influenced by previous maxillary tooth extractions allowing mesial drifting of the molar.

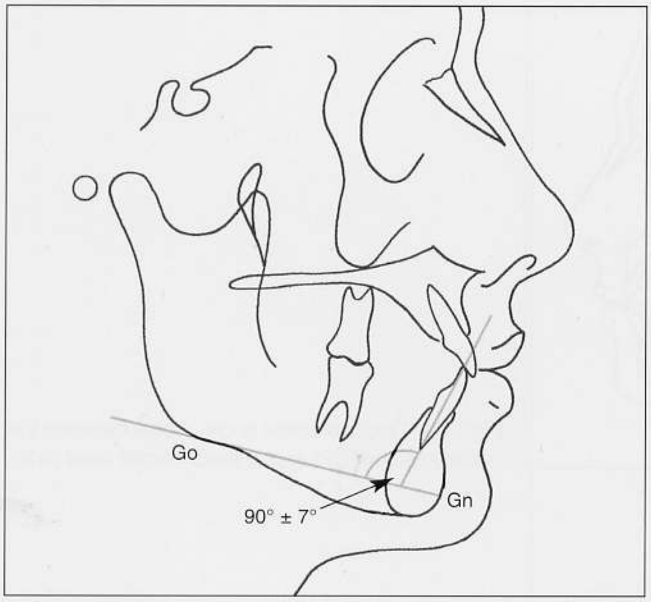


Fig 2-68 Mandibular incisor position (Downs). The axial inclination of the mandibular incisor to the mandibular plane (Go-Gn) is 90 ± 7 degrees.

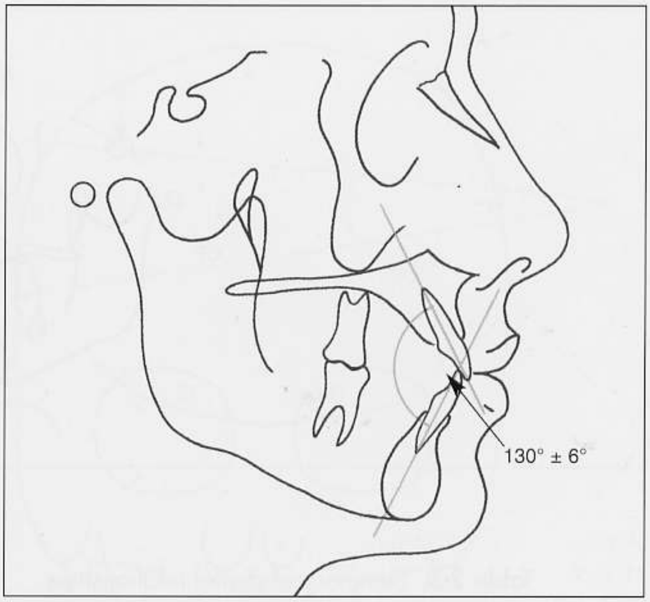


Fig 2-69 Interincisal angle.

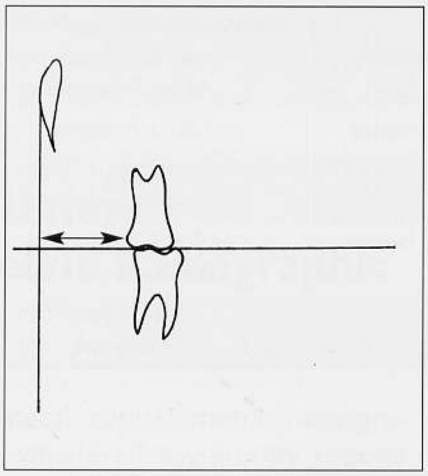


Fig 2-70 Maxillary molar position. The distance from Ptv to the first molar should be the patient's age + 3 mm.

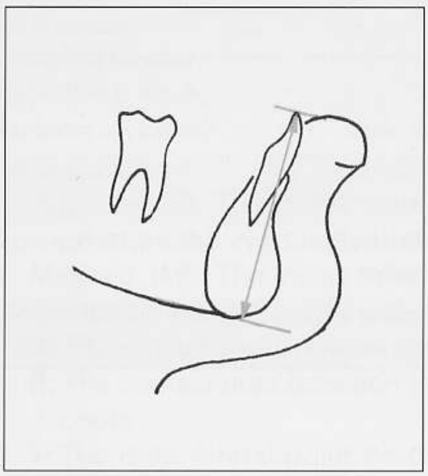


Fig 2-71 Mandibular anterior dental height: 44 ± 2 mm for male patients and 40 ± 2 mm for female patients.

Mandibular anterior dental height

Mandibular anterior dental height is measured from mandibular incisor tip to the inferior border of the mandible. The average mandibular dental height for males is 44 ± 2 mm and for females, 40 ± 2 mm (Fig 2-71).

An increase in the mandibular vertical height of the face in a patient with normal upper lip length and normal maxillary incisor exposure may be caused by the anterior vertical height of the mandible. In this case, vertical reduction genioplasty may be indicated.

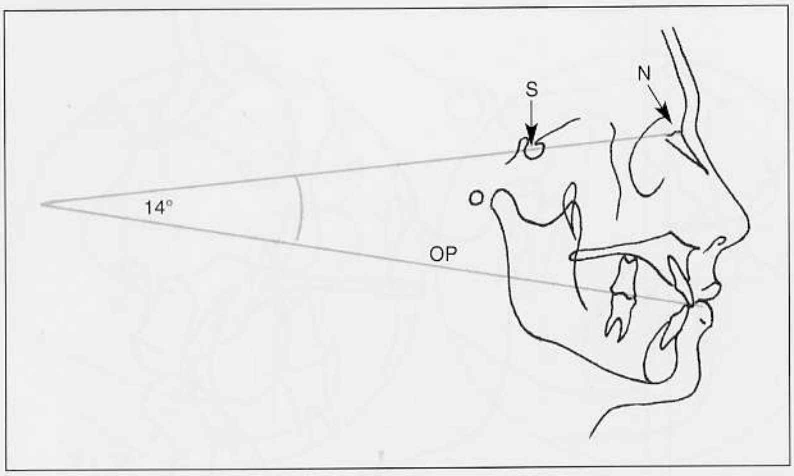


Fig 2-72 Occlusal plane angle. Angle between the occlusal plane (OP) and anterior cranial base (S-N).

Table 2-5 Summary of dental relationships

	Dental relationship	Normal value
Maxillary incisor	Angle to N-A Distance to N-A Distance to A-point vertical	22 degrees 4 mm ahead 4 to 6 mm ahead
Mandibular incisor	Angle to N-B Distance to N-B Distance to B-point vertical Angle to mandibular plane	25 degrees 4 mm ahead 4 mm ahead 90 ± 7 degrees
Interincisal angle	Maxillary to mandibular incisor	130 ± 6 degrees
Maxillary first molar	Molar to Ptv	Patient's age + 3 mm in growing individuals
Mandibular anterior dental height	Incisor tip to mandibular border	44 ± 2 mm (males) 40 ± 2 mm (females)
Occlusal plane angle	OP to S-N OP to FH	14 degrees 9 degrees

Occlusal plane angle

According to Steiner analysis, the occlusal plane angle is formed between a line drawn through the region of the overlapping cusps of the first premolar and first molar bisecting the incisal overbite (the occlusal plane) and the anterior cranial base (S-N). The mean angle is 14 degrees (Fig 2-72). According to Downs, the angle is measured between the occlusal plane and the Frankfort plane and should be 9 degrees.

The occlusal, palatal, and mandibular plane angles are often used in describing an individual as "high angle" or "low angle." High-angle individuals tend to have relatively long anterior facial heights, while low-angle individuals tend to be vertically short in anterior facial height.

The numeric values of tooth positions given in Table 2-5 should be considered a guide to diagnosing abnormal tooth positions and to determining final dental, skeletal, and soft tissue positions. The clinician must subjectively evaluate the positioning of the teeth to determine whether they are positioned in the central trough of bone.

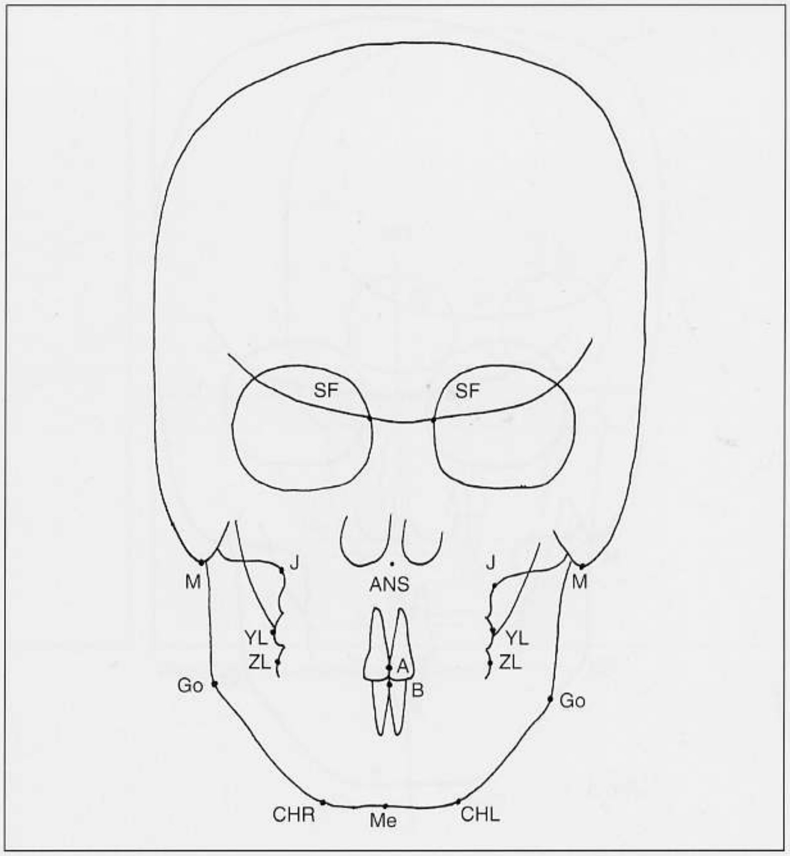


Fig 2-73 Posteroanterior hard tissue cephalometric landmarks.

Posteroanterior Cephalometric Radiographic Evaluation

In addition to lateral cephalometric radiography, individuals with facial asymmetry require posteroanterior radiographic evaluation of the facial bones.

Hard tissue cephalometric landmarks

Posteroanterior hard tissue landmarks, shown in Fig 2-73, include the following:

SF: Where the smaller wing of the sphenoid bone crosses the medial orbital ridge

Anterior nasal spine (ANS): The center point at the base of the nose

Jugulare (J): The most superior and medial point on the zygomatic buttress

Mastoid (M): The most inferior point on the mastoid bone

A: The contact area between the maxillary incisors

B: The contact area between the mandibular incisors

Y: The most lateral point on the buccal surface area of the first maxillary molar, with *YL* designating the left Y and *YR*, the right Y.

Z: The most lateral point on the buccal surface area of the first mandibular molar, with *ZL* designating the left Z and *ZR*, the right Z.

Gonion (Go): The most inferior posterior point at the angle of the mandible

Menton (Me): The most inferior point at the anterior mandibular area

CH: The most inferior lateral point on the anterior inferior border of the mandible, with *CHL* designating the left CH and *CHR*, the right CH

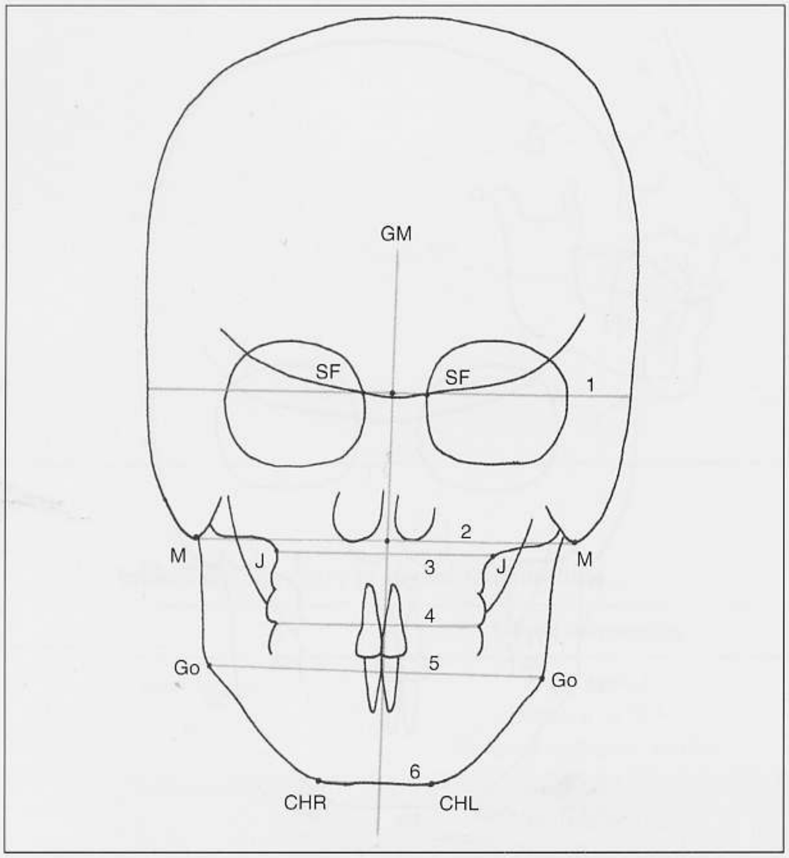


Fig 2-74 Transverse posteroanterior and vertical planes. (1) Cranial base plane. (2) Mastoid plane. (3) J-plane. (4) Occlusal plane. (5) S-plane. (6) Chin plane.

Transverse posteroanterior cephalometric planes

Transverse posteroanterior cephalometric planes, shown in Fig 2-74, include the following:

Cranial base plane (C-plane): A horizontal line connecting the left and right SF points and extending laterally to the cranium
Mastoid plane (D-plane): A line connecting the left and right mastoid points
S-plane: The connecting line between the left and right Go of the mandible
J-plane: A line drawn from the left J-point to the right J-point, which is divided into two halves (IR and IL) by the geometrically constructed vertical axis (GM)
Occlusal plane (OP): A plane formed by a line connecting the occluding points of the maxillary and mandibular buccal cusps left and right
Chin plane (CHP): A line drawn on the inferior border of the chin at maximum bone contact, through Me

Vertical posteroanterior cephalometric line

The vertical cephalometric line is called the geometrically constructed vertical axis (GM) (see Fig 2-74). It is constructed by dividing the C-plane and the D-plane, connecting these two midpoints, and extending this line to the chin.

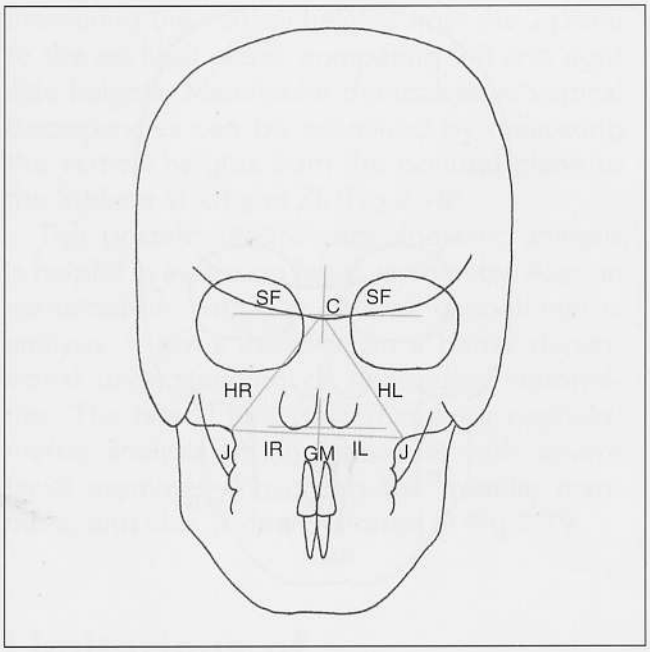


Fig 2-75 The maxillary triangle.

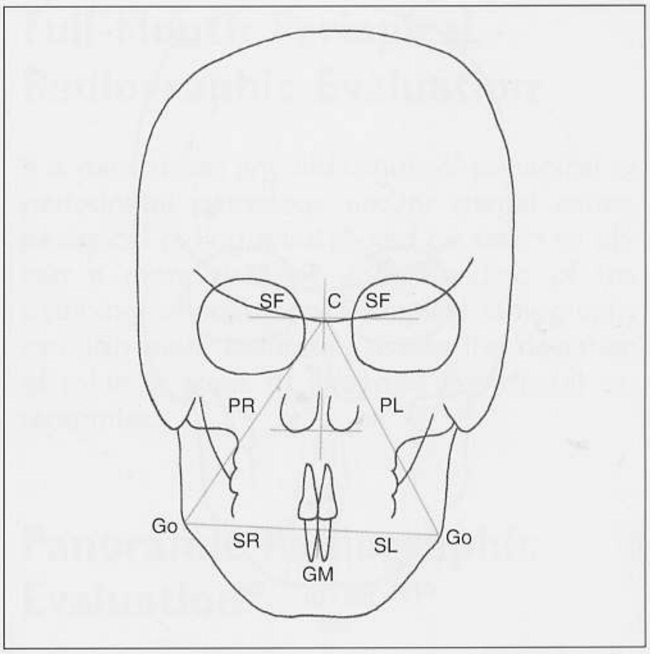


Fig 2-76 The mandibular triangle.

Triangular analysis

Triangles are constructed for evaluation of the symmetry of the maxilla, mandible, and chin. The maxillary triangle is constructed by connecting the midpoint of the C-plane (C-point) with points J on either side of GM. These connecting lines are called the *HR line* and the *HL line*. The base of the triangle is divided in two halves, IR and IL, by GM (Fig 2-75).

The mandibular triangle is constructed by connecting C-point with Go bilaterally using lines PR and PL. The base of the mandibular triangle is halved into SR and SL by GM (Fig 2-76).

The chin triangle is constructed by connecting the C-point with CHR and CHL; the long legs of the triangle are called KR and KL. A line is drawn from B-point perpendicular to CHP to evaluate the mandibular incisor midline in relation to the midline of the chin. The base of this triangle is divided into two halves, GR and GL, by GM (Fig 2-77).

By measuring the long legs of the triangles, cants in the maxilla, mandible, and chin can be evaluated in relation to the cranial base, as well as to each other. By comparing the left and right sides of the bases of the triangles, transverse discrepancies on rotations can be assessed. Midline asymmetries of the nasal spine, menton, and dental midlines can be evaluated. Any discrepancy between the mandibular dental midline and the midpoint of the chin can be evaluated by the vertical line perpendicular to CHP (see Fig 2-77).

Vertical and transverse dentoalveolar assessment

The vertical relationship between the basal bones and the dental and alveolar structures are evaluated by dropping perpendicular lines from the J-plane at YR and YL to the occlusal plane and from the S-plane to the occlusal plane at ZR and ZL. Transverse discrepancies are assessed by measuring the distances both from YR and YL and from ZR and ZL to the GM line. Vertical discrepancies are assessed by

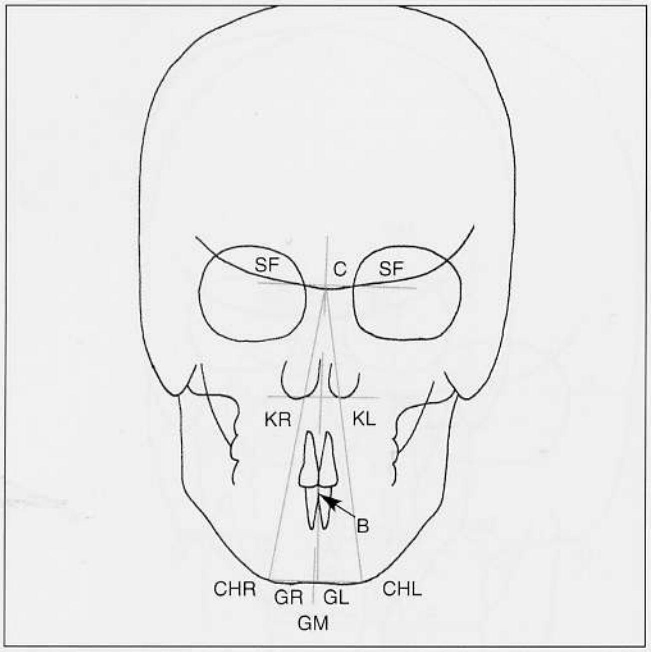


Fig 2-77 The chin triangle and vertical line through B-point perpendicular to CHP.

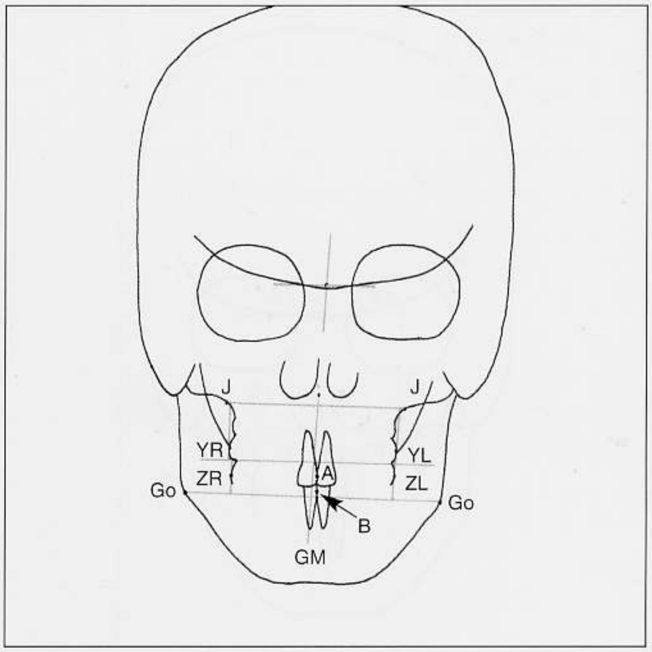


Fig 2-78 Vertical dentoalveolar assessment.

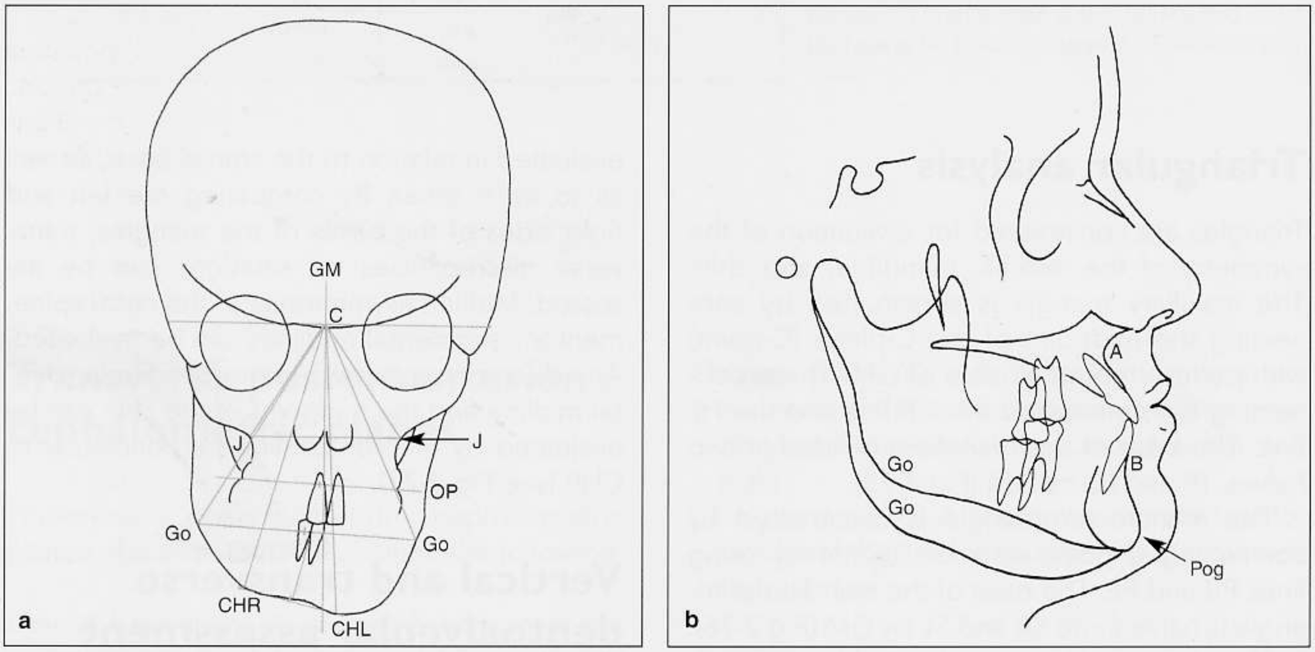


Fig 2-79 *(a)* Severe facial asymmetry. Note the severe rotation of the triangles. *(b)* The severe asymmetry is also evident on the lateral cephalometric tracing. The three-dimensional nature of the facial asymmetry, a common finding in such cases, is well demonstrated.

measuring the vertical heights from the J-plane to the occlusal plane, comparing left and right side heights. Mandibular dentoalveolar vertical discrepancies can be examined by measuring the vertical heights from the occlusal plane to the S-plane at ZR and ZL (Fig 2-78).

The posteroanterior cephalometric analysis is helpful in assessing facial asymmetry. Also, in combination with the lateral cephalometric analysis, it gives the clinician a better dimensional understanding of dentofacial deformities. The lateral and posteroanterior cephalometric analysis of an individual with severe facial asymmetry involving the maxilla, mandible, and chin is demonstrated in Fig 2-79.

Limitations of Cephalometric Analysis

Although cephalometric analysis is important in both diagnosis and development of a treatment plan, it has the following limitations:

1. Most individuals with dentofacial deformities have anatomic variations in the location of the cephalometric landmarks used as a baseline in many analyses, such as sella, nasion, and orbitale. This often results in incorrect conclusions from the analysis.
2. The clinician must not base interpretations on single cephalometric measurements.
3. The clinician must recognize the limitations, as well as the advantages, of cephalometry and be sure to integrate measurements with clinical findings.
4. The art of cephalometric interpretation lies in understanding abnormal findings and identifying the etiologic factors behind these cephalometric abnormalities in patients with dentoskeletal deformities.
5. Although cephalometric analysis forms an important part of the database for diagnosis and treatment planning, it should not take precedence over the clinical evaluation of the patient.

Full-Mouth Periapical Radiographic Evaluation

If a patient has any indication of periapical or periodontal pathology and/or dental caries, periapical radiographs should be taken to obtain a more detailed understanding of the pathological condition. Periapical radiography can also more accurately assess the deviation of roots in areas of intended interdental osteotomies.

Panoramic Radiographic Evaluation

Panoramic radiography is an excellent means to establish an overview of the paranasal sinuses, bony temporomandibular joint, periapical and periodontal pathology, dental caries, position of the inferior alveolar canal, position of the lingula, position of the mental foramen, tooth root lengths in relation to the maxillary sinus, and mandibular symphysis. In addition, it can detect root deviations in areas of intended interdental osteotomies (although not as accurately as can a periapical radiograph), unerupted and/or impacted teeth, and previously undetected pathological conditions. The information obtained is valuable not only in the pretreatment assessment but also in the determination of the relative position of anatomic structures, which is important during the actual surgical procedure. Figure 2-80 shows a panoramic radiographic evaluation form. It is essential that an immediate preoperative panoramic radiograph is available at the time of surgery because it gives the surgeon a valuable overview of anatomic structures relevant in most orthognathic surgical procedures (eg, position of the inferior alveolar canal, mental foramen, tooth roots, impacted third molars [if present], and maxillary sinuses).

Panoramic Radiographic Evaluation

Absent teeth		
Unerupted teeth		
Impacted teeth		
Dental caries		
Periodontal pathology		
Maxillary sinus pathology	Left:	Right:
Temporomandibular joint pathology	Left:	Right:
Bone pathology	Maxilla:	Mandible:

Fig 2-80 Panoramic radiographic evaluation form. This evaluation should be used during the pretreatment assessment, at the presurgical examination, and at the time of surgery.

Occlusion and Study Cast Evaluation

Occlusal functional evaluation

The basic aims of occlusal functional evaluation are to determine the compatibility of centric occlusion (CO) and centric relation (CR); to note the difference between CO and CR, if present; to note any bite of convenience or occlusal slide; and to note interocclusal rest space. Figure 2-81 is a sample functional evaluation form.

Study cast analysis

Intra-arch relationship

In the study cast analysis, arch form and symmetry, missing teeth, tooth rotations, and overerupted teeth are noted. Maxillary and mandibular occlusal curves are studied. Crowding and the need for extractions are determined. Bolton discrepancies of tooth sizes are studied.

Functional Evaluation	
Difference between centric occlusion and centric relation	
Premature contact	
Occlusal slide	
Freeway space	
Tooth attrition	
Bite of convenience	

Fig 2-81 Functional evaluation form.

Interarch relationship

The study cast analysis also includes examination for incisor overjet and overbite, as well as angle classification for molars and canines. The clinician evaluates coordination of dental midlines and crossbites while moving the dental casts into a Class I malocclusion to get an idea of general arch compatibility.

If the possibility of establishing an acceptable occlusion, accommodating the teeth, or providing for tooth size discrepancies is at all questionable, a Kesling diagnostic setup should be used. This setup can also be used to test for various extraction patterns.

If a crossbite exists with the teeth in centric occlusion and it is corrected when the dental casts are moved into a Class I malocclusion, the crossbite is considered *relative*. If the crossbite still exists after the dental casts have been positioned in a Class I relationship, the crossbite is considered *absolute*.

A sample form for study cast analysis is presented in Fig 2-82.

Study Cast Analysis Evaluation

Intra-arch evaluation:

Arch form: Maxilla		
Mandible		
Missing teeth		
Impacted/unerupted teeth		
Occlusal plane cant		
Occlusal curve		
Crowding: Maxillary arch	mm:	
Mandibular arch	mm:	
Tooth rotations		
Overeruption of teeth		

Interarch relations:

Molar	Left:	Right:
Canine	Left:	Right:
Overjet	mm:	
Open bite	mm:	
Maxillary-to-mandibular dental midline	mm:	
Crossbite	Absolute:	Left:
	Relative:	Right:
Location of crossbite		
Tooth size discrepancy		

Fig 2-82 Study cast analysis form.

Temporomandibular Joint Evaluation

Maximal mouth opening	mm:	
Deviation on mouth opening	Left:	Right:
Maximal protrusion	mm:	
Deviation on protrusion	Left:	Right:
Temporomandibular joint signs:		
Clicking/popping	Left:	Early (< 10 mm) Late (> 10 mm)
	Right:	Early (< 10 mm) Late (> 10 mm)
Pain	Left:	Joint: Muscle(s):
	Right:	Joint: Muscle(s):
Crepitations	Left:	Right:
Previous treatment		

Fig 2-83 Temporomandibular joint evaluation form.

Temporomandibular Joint Evaluation

The temporomandibular joint is an important component of the orthognathic mechanism and should be examined with care. Pathologic conditions may be present in the joint at the outset, develop during treatment, or even develop long after treatment. Therefore, the clinician should diagnostically and prognostically evaluate the joint before orthodontic-surgical treatment begins. A basic temporomandibular joint examination evaluates three areas: *(1)* mandibular movements, *(2)* temporomandibular joint symptoms and signs, and *(3)* mouth opening and deviations.

Careful documentation of temporomandibular joint pretreatment status is very important (Fig 2-83). The correct positioning of the condyle in the fossa is a critical part of the orthognathic surgical procedure, and information gathered at the pretreatment evaluation may be useful during surgery. The patient should also understand that correction of the dentofacial deformity and malocclusion will not necessarily correct a temporomandibular joint problem.

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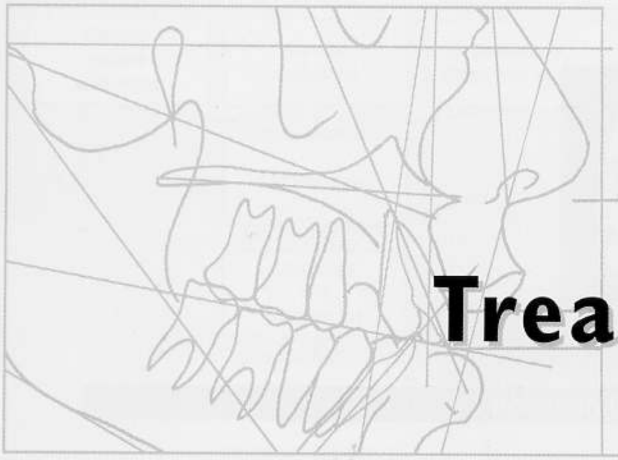


chapter 3

Diagnosis and Treatment Planning

The information from the systematic patient evaluation forms a database that the practitioner can use in compiling a short problem list, which in turn leads to an initial diagnosis of the patient's dentofacial deformity. Careful assessment and consideration of soft tissue, skeletal, and dental positions are necessary to differentiate among various dentofacial deformities that can have similar patterns. For example, a patient with a Class III malocclusion may have the skeletal characteristics of anteroposterior deficiency of the maxilla, anteroposterior excess of the mandible, maxillary vertical deficiency with overclosure of the mandible, or any combination of the above. Figure 3-1 provides a schematic guide to the differential diagnosis of various dentofacial deformities and their interrelationships. Figure 3-2 illustrates the treatment pathway—starting at the gathering of information, followed by the recording of a database, which leads to a problem list and diagnosis, and ending with the development of a treatment plan.

The following section uses a specific case to demonstrate systematic evaluation, the formation of a database, the diagnostic process, and the treatment planning pathway. Although the specific treatment of cases has not yet been discussed in the text, the visual treatment objectives, treatment, and posttreatment results of this case are included here to give the reader an idea of where the cumbersome initial stages of examination and treatment planning are leading.

Case Overview

General patient evaluation

Name: LM

Age: 16 years

Medical history: Not pertinent

Dental history: Orthodontic treatment by her general practitioner for 18 months; currently wearing a fixed lingual retention appliance in the mandibular incisor area. Four impacted third molars are present.

Main complaints: She finds it increasingly difficult to bite through food with her incisors. Her left mandibular lateral incisor is malpositioned. She feels she has a "toothy" look. She has to strain to get her lips together.

Motivation: Internal (self).

Psychologic assessment: Good parental support; low self-confidence.

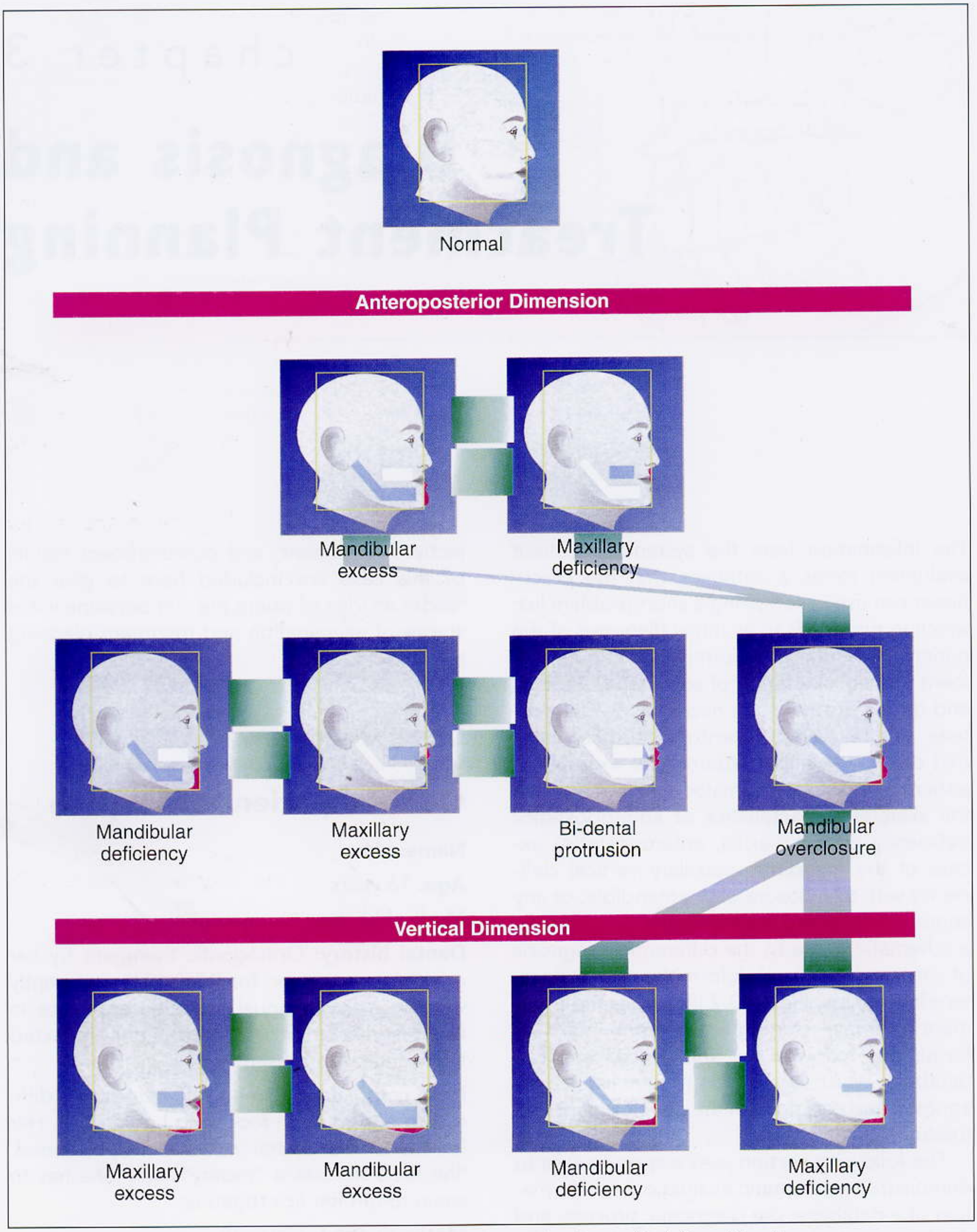


Fig 3-1 A schematic guide to the differential diagnosis of dentofacial deformities and their interrelationships.

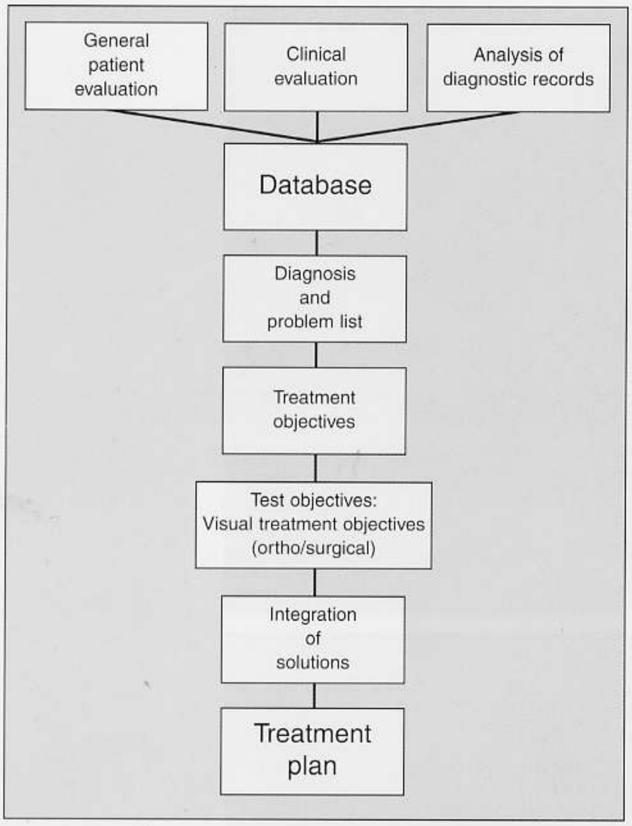


Fig 3-2 Flowchart illustrating the systematic gathering of data leading to a diagnosis and, finally, the development of a treatment plan.

Clinical evaluation

A. Extraoral examination
  1. Frontal view (Figs 3-3a and 3-3b)
    a. Increased lower facial height
    b. Increased interlabial gap
    c. Excessive maxillary incisor exposure
    d. "Gummy smile"
    e. Slightly flattened paranasal areas
    f. Narrow alar base
    g. Excessive lower lip vermilion exposure
    h. Mandible asymmetrical to the left
  2. Profile view (Fig 3-3c)
    a. Convex profile
    b. Anteroposterior chin deficiency
    c. Anteroposterior mandibular deficiency
    d. Everted lower lip
    e. Increased interlabial gap
    f. Increased lower facial height
  3. Three-quarters view (Fig 3-3d)
    a. Paranasal flattening
    b. Ill-defined chin
    c. Narrow alar base
    d. Poor nasal tip definition

B. Intraoral examination (Figs 3-3e to 3-3g)
  1. Mandibular arch
    a. Crowding in the incisor area
    b. Incisor protrusion
    c. Serrated incisor edges
    d. Narrow area of attached gingiva in the incisor area
  2. Maxillary arch
    a. Incisor protrusion
    b. Slight crowding
  3. Interarch area
    a. Class I malocclusion
    b. Anterior open bite
    c. Bi-dental protrusion
    d. Mandibular dental midline 1.5 mm to the left

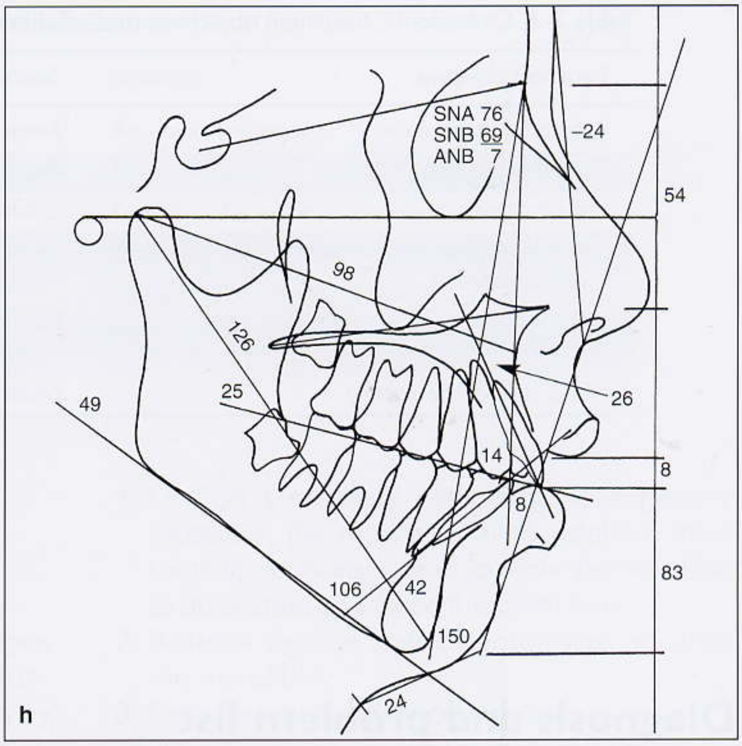
C. Other
  1. Slight marginal gingivitis in the incisor areas
  2. Mouth breathing

Special investigations

Radiographic evaluation

A. Cephalometric analysis
  1. Soft tissue analysis (Fig 3-3h)
    a. Increased facial contour angle (–24 degrees)
    b. Increased interlabial gap (8 mm)
    c. Increased maxillary incisor exposure (8 mm)
    d. Increased lip-chin-throat angle (150 degrees)
    e. Decreased chin-throat length (24 mm)
  2. Skeletal analysis (see Fig 3-3h)
    a. Increased ANB angle (7 degrees)
    b. Increased mandibular plane angle (49 degrees)
    c. Increased vertical height (83 mm [midface, 54 mm])
    d. Decreased mandibular length (126 mm [maxilla, 98 mm])
    e. Mandible rotated clockwise
  3. Dental analysis
    a. Maxillary incisor protrusion (26 degrees)

Fig 3-3 Preoperative evaluation for patient LM. *(a)* Frontal view. *(b)* Frontal view, smile. *(c)* Profile view. *(d)* Three-quarters view. *(e)* Occlusion, right. *(f)* Occlusion, middle. *(g)* Occlusion, left.



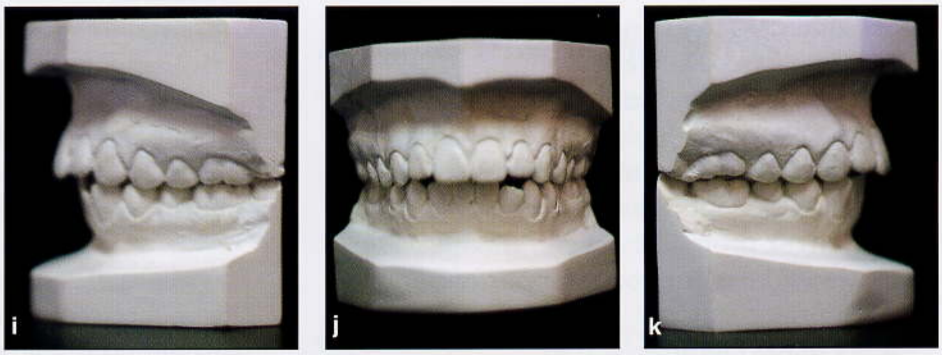


Fig 3-3 *Continued (h)* Pretreatment cephalometric analysis. *(i to k)* Study cast: left *(i)*, middle *(j)*, and right *(k)*.

  b. Mandibular incisor protrusion (42 degrees, 14 mm)
  c. Anterior open bite
B. Panoramic evaluation: Impacted third molars
C. Posteroanterior cephalographic analysis
  1. Mandibular asymmetry to the left
  2. Mandibular dental midline to the left
D. Dental radiographic analysis: No relevant findings
E. Occlusal plane radiographic analysis: No relevant findings
F. Other: No relevant findings

Dental cast analysis

The cast analysis (Figs 3-3i to 3-3k) confirms the clinical assessment.

Table 3-1 Orthodontic treatment objectives and solutions

Treatment objective	Solutions
Reduce lip prominence	Retract maxillary and mandibular incisors
Correct bimaxillary protrusion	Retract incisors
Reduce crowding	Extract premolars
Facilitate surgical advancement of the mandible	Extract maxillary second premolars and slightly retract maxillary incisors
	Extract mandibular first premolars, retract incisors, and increase overjet
Ensure orthodontic stability	Make no attempt to close open bite orthodontically

Diagnosis and problem list

A. Skeletal diagnosis and problems
   1. Vertical maxillary excess
   2. Mandibular anteroposterior deficiency
   3. Microgenia
   4. Mandibular asymmetry to the left

B. Soft tissue diagnosis and problems
   1. Convex profile
   2. Mandibular anteroposterior deficiency
   3. Deficient chin
   4. Increased interlabial gap
   5. Everted lower lip

C. Dental diagnosis and problems
   1. Crowding in both arches
   2. Bi-dental protrusion
   3. Impacted third molars
   4. Mandibular dental midline toward the left

D. Other diagnoses and problems
   1. Mouth breathing

Treatment objectives

A. Soft tissue treatment objectives
   1. Correct facial convexity
   2. Improve chin prominence
   3. Create lip seal
   4. Reduce lip prominence slightly

B. Skeletal treatment objectives
   1. Reduce vertical maxillary excess
   2. Advance mandible
   3. Advance chin

C. Dental treatment objectives
   1. Correct bimaxillary protrusion
   2. Correct anterior open bite
   3. Reduce crowding

Testing objectives

The clinician should now move on to set specific treatment objectives for the case. When considering the final treatment plan, three basic questions should be kept in mind:

1. What are the esthetic objectives, and which surgical procedures are indicated?
2. What specific orthodontic treatment is required to facilitate the proposed surgery?
3. What is the best sequence of treatment—taking into account dental, periodontal, prosthodontic, and orthodontic treatment; surgical needs; and other requirements—to obtain the desired result in the shortest time?

Orthodontic treatment objectives and possible solutions are shown in Table 3-1. Surgical treatment objectives and possible solutions are shown in Table 3-2.

Table 3-2 Surgical treatment objectives and solutions

Treatment objective	Solutions
Correct facial convexity	Advance the mandible
Improve chin prominence	Advance the chin
Reduce vertical maxillary excess	Reposition the maxilla superiorly
Correct open bite	Reposition the posterior maxilla superiorly
Creat a lip seal	Reposition the maxilla superiorly
Correct mandibular asymmetry	Reposition the mandible to the right

Treatment plan

Preoperative orthodontics

The expected dental and soft tissue changes to be effected by the preoperative orthodontic treatment are predicted and illustrated by the cephalometric tracing and orthodontic visual treatment objective (Figs 3-4a and 3-4b).

In the maxillary arch:

1. Surgically remove both third molars and extract both second premolars.
2. Retract the incisors slightly, and maintain upper lip support.
3. Align the arch, and close the extraction spaces.
4. Establish a good arch form to be compatible with the mandibular dental arch.

In the mandibular arch:

1. Surgically remove both third molars and extract both first premolars.
2. Retract the incisors to increase the overjet and create a Class II malocclusion.
3. Level and align the arch, and establish a good arch form to be compatible with the maxillary arch.
4. Make no attempt to close the open bite by extrusion of incisors or intrusion of molars.

Surgery

The surgical visual treatment objectives, outlined here, are shown in Fig 3-4c:

1. Le Fort I maxillary osteotomy to superiorly reposition the maxilla both to establish ideal tooth-lip relationship and to allow the mandible to autorotate and close the open bite
2. Bilateral sagittal split osteotomy to advance the mandible
3. Genioplasty to advance the chin

Postoperative orthodontics

1. Light 3.5-oz quarter-inch elastics with slight Class II vector to guide the occlusion
2. After 3 to 4 weeks, heavier up-down elastics (6-oz, quarter-inch elastics)
3. Finalization of the occlusion

Retention

1. Mandibular fixed intercanine retainer
2. Removable maxillary appliance

Results

The achievement of the preoperative orthodontic goals is illustrated in Fig 3-5. The end result of treatment is demonstrated in Fig 3-6.

This case demonstrates a systematic approach, which is achieved by listing the problems under the following categories: soft tissue, skeletal, dental, and other. Successful treatment planning must also consider the interaction of the specific solutions, the sequence of the various steps, and the impact the steps are likely to have on one another.

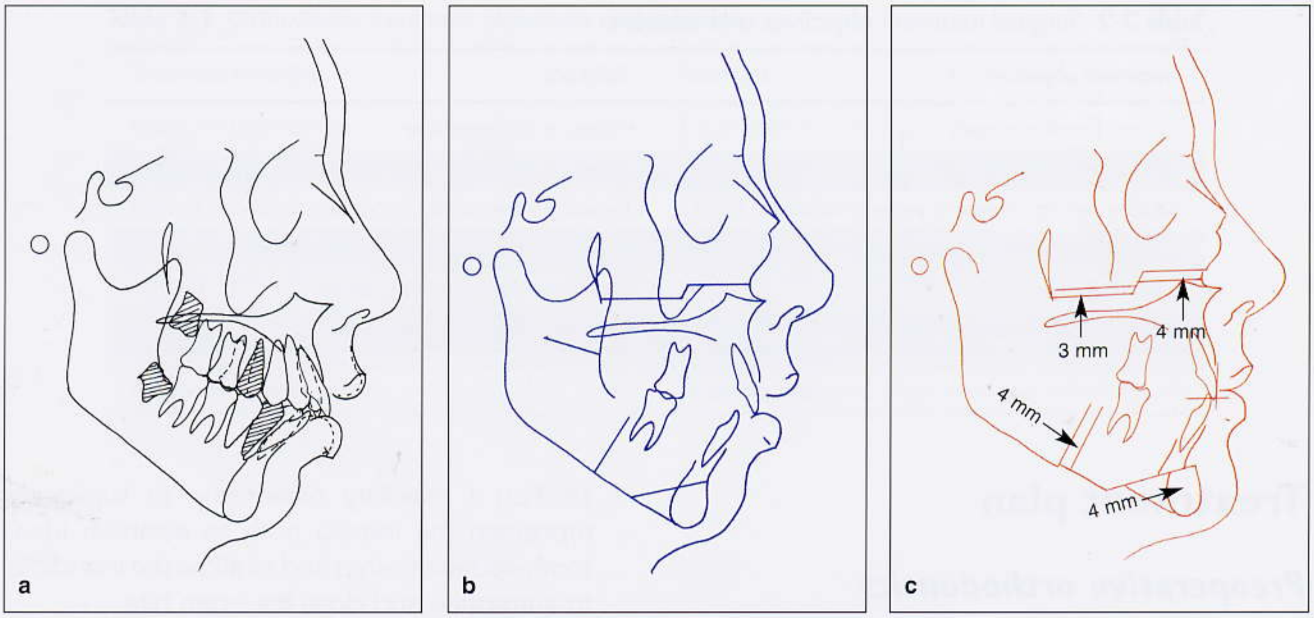


Fig 3-4 Patient LM. *(a)* Orthodontic visual treatment objective: surgical removal of all four third molars and extraction of both maxillary second premolars and both mandibular first premolars. Retraction of incisors and creation of a Class II malocclusion. *(b)* Visual treatment objective of completed preoperative orthodontics. *(c)* Surgical visual treatment objective: superior repositioning of the maxilla (4 mm anterior and 3 mm posterior), advancement of the mandible (4 mm), and advancement of the chin (4 mm).

Fig 3-5 Immediate preoperative views of Patient LM. *(a)* Frontal view. *(b)* Profile view. *(c)* Occlusion, right. *(d)* Occlusion, center. *(e)* Occlusion, left.

Fig 3-6 Patient LM, end result of treatment. *(a)* Frontal view. *(b)* Profile view. *(c)* Three-quarters view. *(d)* Frontal view, smile. *(e)* Occlusion, right. *(f)* Occlusion, center. *(g)* Occlusion, left. *(h)* Pretreatment and posttreatment composite cephalometric tracing illustrating the soft tissue, skeletal, and dental changes.

Facial Changes Associated with Skeletal Repositioning

The correction of a dentofacial deformity with orthognathic surgery will result in altered facial esthetics. To decide on the correct surgical procedure and be able to predict the soft tissue changes, the clinician must have an in-depth knowledge of the soft tissue reactions subsequent to the different surgical movements of the jaws. The basic reactions are summarized in the following outline.

A. Mandibular advancement
  1. Frontal changes
    a. Induces a vertical increase in lower-third face height (more in cases with a high mandibular plane angle than in low-angle cases)
    b. Reduces lower lip eversion (effect of maxillary incisor on lower lip reduction)
    c. Reduces labiomental fold (lower lip rolls back)
    d. Improves neck-chin definition
  2. Profile changes
    a. Increases chin prominence
    b. Decreases lower vermilion exposure (lower lip rolls back)
    c. Increases lower lip fullness
    d. Decreases chin-throat angle
    e. Decreases labiomental fold
B. Mandibular setback
  1. Frontal changes
    a. Decreases mandibular prominence
    b. Makes upper lip vermilion more prominent
    c. Decreases lower-third face height (more in cases of high mandibular plane angle than in low-angle cases)
  2. Profile changes
    a. Decreases mandibular anteroposterior prominence
    b. Reduces lower lip vermilion exposure
    c. Reduces chin-throat length
    d. Increases chin-throat angle
C. Maxillary advancement
  1. Frontal changes
    a. Increases alar base width (controllable)
    b. Increases upper lip fullness
    c. Increases upper lip vermilion exposure
    d. Increases paranasal fullness
  2. Profile changes
    a. Increases paranasal area fullness
    b. Elevates nasal tip (controllable)
    c. Increases upper lip fullness
    d. Decreases prominence of chin and nose (relative)
D. Maxillary superior repositioning
  1. Frontal changes
    a. Reduces maxillary incisor exposure
    b. Reduces upper lip vermilion exposure
    c. Reduces interlabial distance
    d. Reduces upper lip length (controllable)
    e. Reduces lower-third face height
    f. Reduces gingival exposure when smiling
    g. Increases alar base width (controllable)
  2. Profile changes
    a. Elevates nasal tip (controllable)
    b. Reduces lower-third face height
    c. Reduces interlabial distance
    d. Increases mandibular anteroposterior prominence (autorotation)
    e. Increases paranasal fullness
E. Maxillary inferior repositioning
  1. Frontal changes
    a. Increases lower-third face height
    b. Increases upper lip length
    c. Increases upper lip vermilion exposure
    d. Increases maxillary tooth exposure
  2. Profile changes
    a. Increases upper lip prominence
    b. Makes nasolabial angle more obtuse
    c. Makes mandible less prominent anteroposteriorly (autorotation)

Esthetic Objectives and Surgical Indications

The choice of surgical procedure is dictated by the esthetic goals, which are determined by the patient's main complaint and the facial examination (examination of both hard and soft tissues). Attainment of the esthetic goals can be determined by developing the orthodontic and surgical visual treatment objectives. Close collaboration between the orthodontist and the surgeon is necessary for effective planning and successful execution of the treatment plan.

Consider a case with the esthetic requirement of increasing the mandibular prominence. The *shape* of the chin, however, plays an important role in the decision-making process. Chin surgery is indicated only in cases where the chin is too flat (microgenia) and there is an obtuse labiomental fold.

The possible surgical solutions for increasing chin prominence are *(1)* surgical advancement of the chin, *(2)* surgical advancement of the mandible, and *(3)* surgical advancement of chin and mandible. The choice of surgery is influenced by the dental occlusion, mandibular skeletal base position, and chin shape. The following discussion illustrates how these variables influence treatment possibilities in various scenarios.

Class II malocclusion

Scenario 1

The patient has a Class II malocclusion, mandibular anteroposterior deficiency, and good chin shape. The solution is orthodontic alignment of the teeth and making the malocclusion more Class II, if necessary. Surgical advancement of the mandible is then performed.

Scenario 2

In this scenario, the patient has a Class II malocclusion, mandibular anteroposterior deficiency, and microgenia (flat chin). The solution is orthodontic alignment of the teeth, along with surgical advancement of the mandible and chin. Alternatively, the clinician could decide to accept the Class II malocclusion and recommend surgical advancement of the chin.

Class I malocclusion

Scenario 1

This patient has a Class I malocclusion, mandibular anteroposterior deficiency, and good chin shape. The solution is to use orthodontics to create a Class II malocclusion, along with surgical advancement of the mandible.

Scenario 2

In this scenario, the patient has a Class I malocclusion, mandibular anteroposterior deficiency, and microgenia. One solution would be to advance the chin. A second solution, which would be useful in more severe cases, would be to use orthodontics to create a more Class II malocclusion and then surgically advance the mandible and chin.

Specific Orthodontic Treatment Required to Facilitate Surgery

It is as important for the surgeon to understand the orthodontic decision-making process as it is for the orthodontist to have a good understanding of the presurgical orthodontic requirements. Knowledgeable practitioners not only have good interprofessional communication but also have improved treatment results.

The preoperative positioning of the teeth dictates the nature and extent of the surgical procedure and influences the final esthetic result. Poor orthodontic preparation, dental compensation for a skeletal discrepancy, or failure to follow the treatment plan will lead to surgical compromise (Fig 3-7). It may also force the surgeon to perform adjunctive procedures, such as segmental surgery or genioplasty, that were not initially part of the surgical treatment plan in an attempt to achieve a more acceptable functional and esthetic result. The treatment result is usually a compromise rather than an ideal solution.

The orthodontic treatment objectives, extraction patterns, and mechanics used in surgical-orthodontic cases often differ or may be opposite to those used in nonsurgical orthodontic cases. When developing an orthodontic treatment plan for the surgical-orthodontic correction of a dentofacial deformity, a few basic surgical treatment scenarios should be consid-

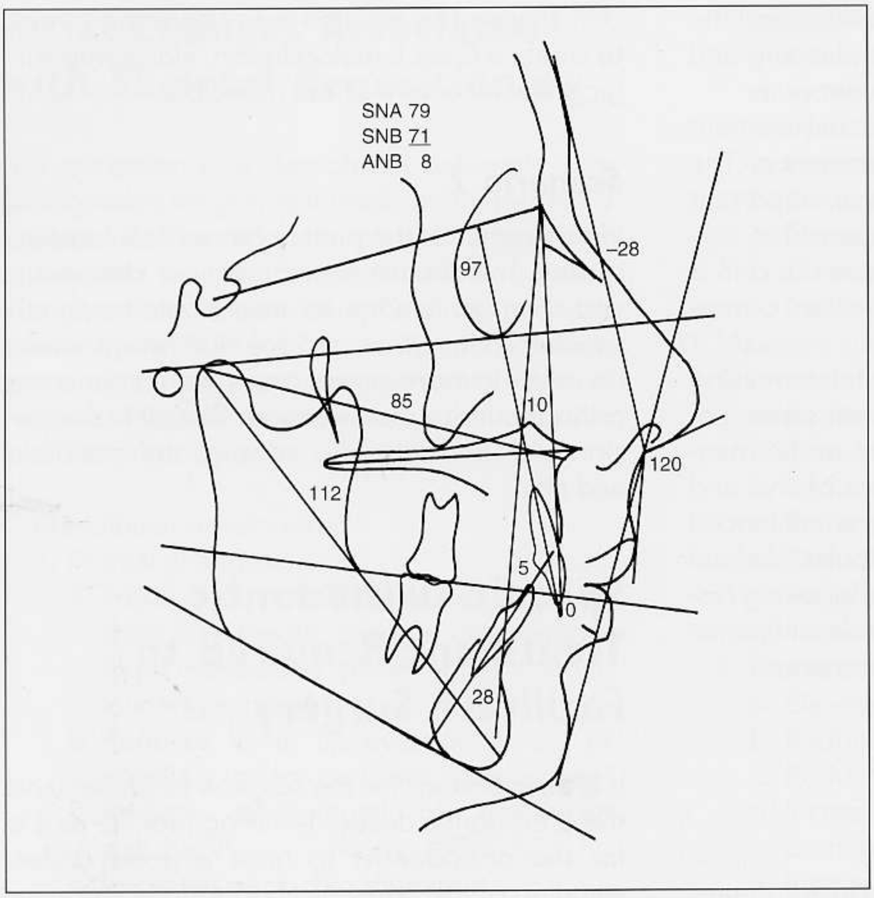


Fig 3-7 Cephalometric analysis of a patient with a Class II malocclusion and mandibular anteroposterior deficiency. The first premolars have been removed and the maxillary incisors retracted excessively, decreasing upper lip support and overjet. This will limit the surgical advancement of the mandible and result in a compromised esthetic result. The favorable shape of the chin and normal labiomental fold do not allow the surgeon to perform a genioplasty without making the chin too prominent and accentuating the poor lip support.

ered. Guidelines to assist in the orthodontic and surgical decision-making process are presented here in various treatment scenarios involving one or both jaws. When surgical correction requires repositioning of only one jaw, the dentition of the unoperated jaw will determine the final position of the jaw to be repositioned.

Single-jaw surgery with mandibular repositioning

The maxillary dentition, especially the incisors, will determine the new vertical, anteroposterior, and transverse positions of the mandible (Fig 3-8). The anteroposterior and vertical positions of the chin may be altered by means of a genioplasty. These positions will be influenced by the prominence and shape of the chin, as well as the labiomental fold.

For example, when a patient has a Class II malocclusion and mandibular anteroposterior deficiency combined with microgenia, the chin should be advanced by means of a genioplasty (Fig 3-9).

A second example is a patient with a Class II malocclusion who has either a mandibular dentoalveolar process that is anteroposteriorly deficient (Fig 3-10a) or macrogenia. The surgeon should consider two alternatives:

1. Advancement of the mandible by means of a bilateral sagittal split osteotomy combined with a reduction genioplasty (Fig 3-10b)
2. A total subapical mandibular osteotomy with advancement of the dentoalveolar process (Fig 3-10c)

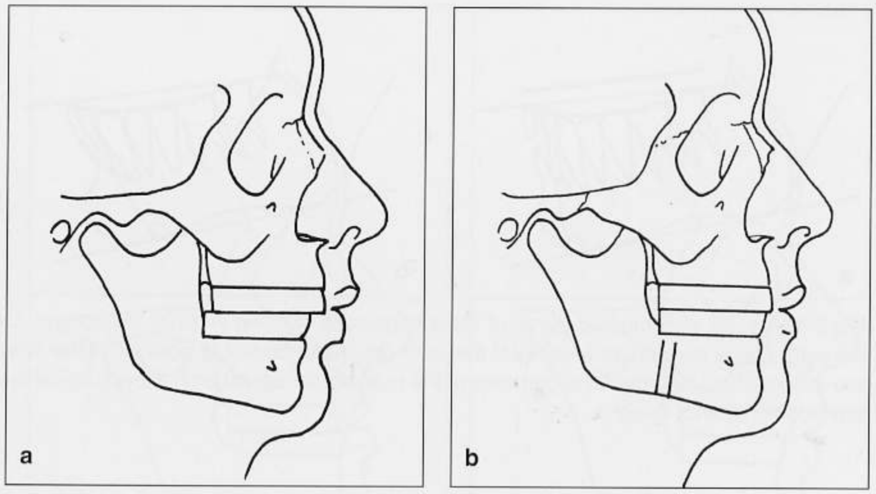


Fig 3-8 *(a)* Class II malocclusion and mandibular anteroposterior deficiency. *(b)* The orthodontically prepared maxillary arch and favorable position of the mandibular incisors allow the surgeon to advance the mandible into a Class I malocclusion and an ideal esthetic position.

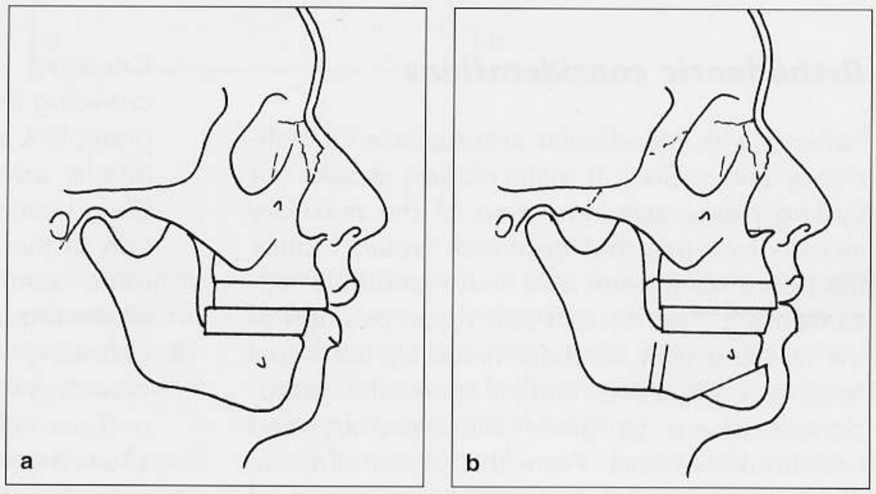


Fig 3-9 *(a)* Diagnosis: Class II malocclusion, mandibular anteroposterior deficiency, and microgenia. *(b)* The esthetic requirements demand a surgical advancement of the mandible and chin.

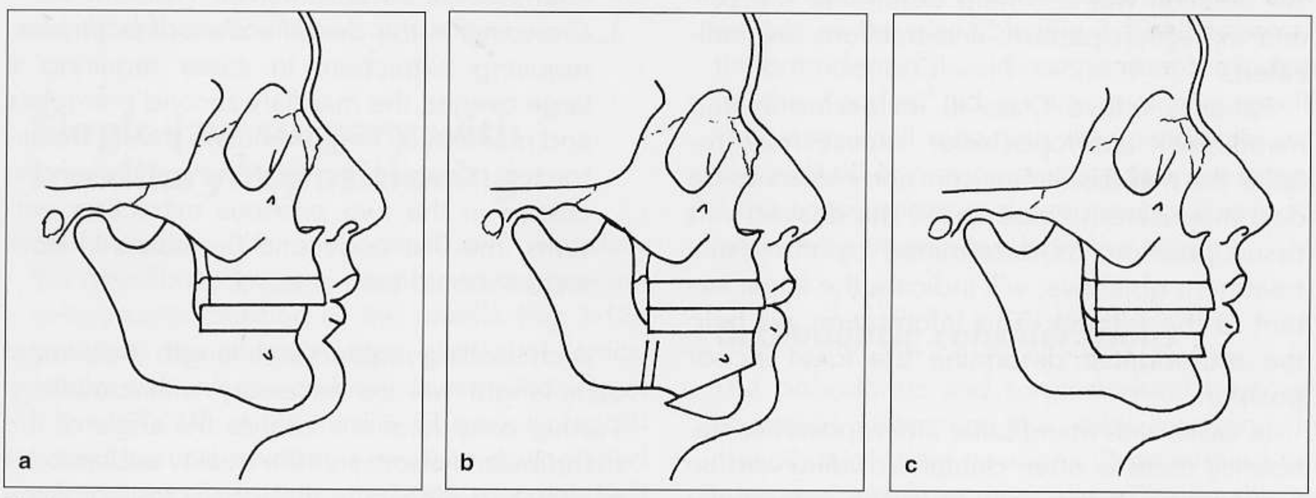


Fig 3-10 *(a)* Dentoalveolar anteroposterior deficiency. *(b)* Surgical advancement of the mandible combined with reduction genioplasty. *(c)* Advancement of the dentoalveolar part of the mandible by means of total subapical osteotomy. In both surgical options, the maxillary incisors determine the amount of surgical advancement and final esthetic shape of the chin area (either by the amount of chin reduction necessary or the amount of lower lip advancement resulting from the advanced dentoalveolar segment).

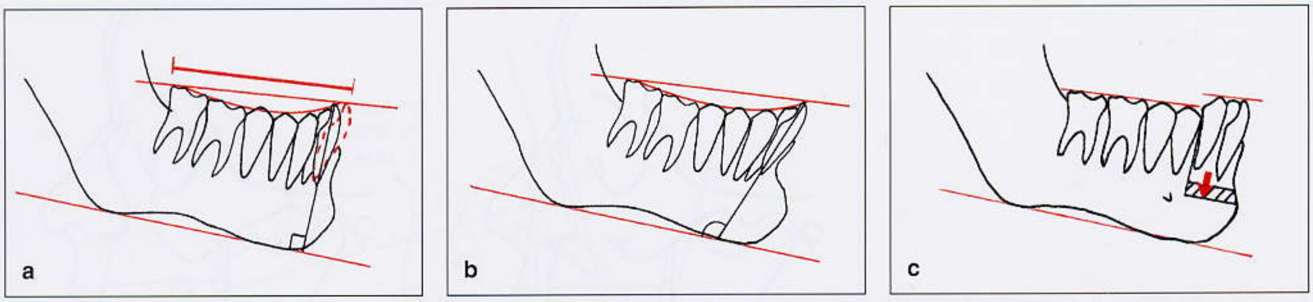


Fig 3-11 *(a)* An accentuated curve of Spee is present, and the incisors are upright. Labial movement of the incisors would create the extra space needed for leveling of the arch. *(b)* The unfavorable position of the incisors does not allow arch leveling. Extractions are indicated. *(c)* Segmental alignments of the mandibular dental arch allow surgical leveling as an alternative. This does not require any additional arch length.

Orthodontic considerations

Patients with mandibular anteroposterior deficiency and a Class II malocclusion should not undergo excessive retraction of the maxillary incisors because that approach would reduce the upper lip support and limit mandibular advancement. The desired soft tissue position of the lips and chin, as determined by the visual treatment objective, should show the orthodontist where to place the maxillary and mandibular incisors. From this placement, the orthodontist can deduce the linear extent of the mandibular advancement. The desired incisor position will also help determine the correct extraction pattern, if extractions are indicated.

Patients with a Class III malocclusion and mandibular anteroposterior excess may require the mandibular incisors and molars to be decompensated. Once again, the desired soft tissue position, as determined by the visual treatment objective, will indicate the linear extent of the setback. This information will help the orthodontist determine the ideal incisor position.

In cases with mandibular anteroposterior deficiency there is often dental crowding and an accentuated curve of Spee in the mandibular arch, which are conditions requiring tooth extractions. Three extraction patterns may be implemented, depending on the conditions:

1. *Crowding in the anterior mandible and no crowding in the maxilla.* The mandibular first premolars should be extracted. After mandibular advancement, a Class III molar and Class I canine relationship will result. Extraction of the first premolars will also allow for more retraction of the mandibular incisors, where required.
2. *Crowding in the posterior mandible and no crowding in the maxilla.* The mandibular second premolars should be extracted. This will allow less retraction of the mandibular incisors. This extraction pattern will result in a Class III molar and Class I canine relationship after surgical advancement.
3. *Crowding in the dental arches of both jaws, requiring extraction.* In cases requiring a large overjet, the maxillary second premolars and mandibular first premolars should be extracted. Keeping in mind the principles discussed in the two previous extraction patterns, the first or second premolars in both arches should be extracted.

Arch leveling requires arch length. Additional arch length will be necessary with crowding. Further considerations include the angle of the mandibular incisors and the quality and amount of attached gingiva in the incisor region. If the mandibular incisors are angled lingually, improving the angulation by labial movement would create space needed for arch leveling

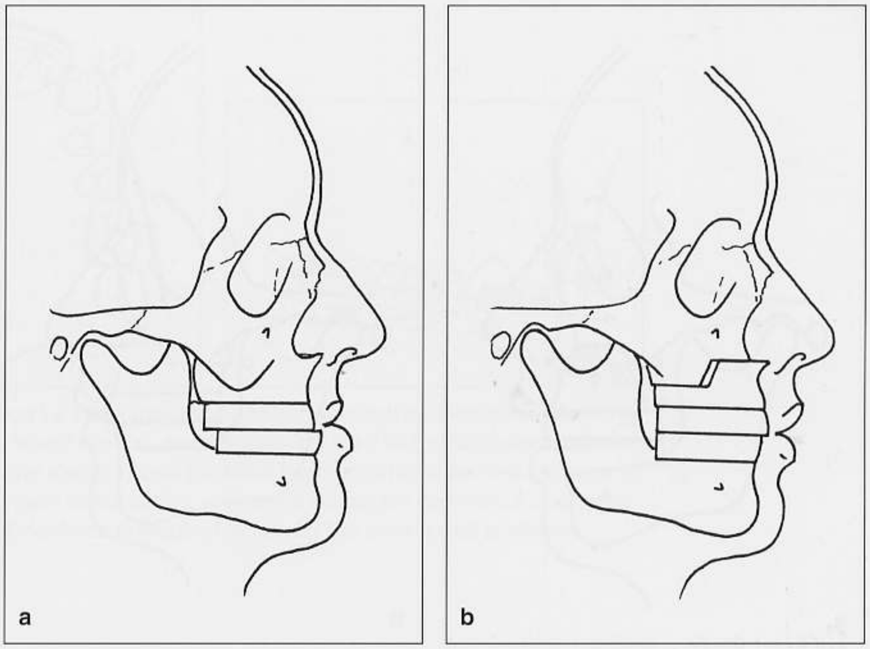


Fig 3-12 *(a)* Anteroposteriorly deficient maxilla with a Class III dental relationship. *(b)* The maxilla will be advanced to a Class I malocclusal relationship determined by the anteroposterior position of the mandibular incisors.

(Fig 3-11a). If the mandibular incisors are protrusive and crowding is present, extractions will be necessary (Fig 3-11b). The mandibular arch may be leveled surgically. This will not require additional arch length (Fig 3-11c).

Ensuring that the maxillary (unoperated jaw's) dental midline coincides with the facial midline is another orthodontic consideration. Finally, the maxillary arch should be leveled, and the dental arches should be compatible.

Single-jaw surgery with maxillary repositioning

The mandible (the unoperated jaw), especially the mandibular incisors, determines the new anteroposterior position of the maxilla (Fig 3-12). However, the surgeon may alter the vertical height with inferior or superior repositioning of the maxilla. When the maxilla is superiorly repositioned (vertical maxillary excess) or downgrafted (vertical maxillary deficiency), the mandible will autorotate around a point at the condyle. The anteroposterior position of the maxillary incisors is determined by the anteroposterior position of the mandibular incisors after autorotation. Transverse discrepancies (narrowing or widening), vertical occlusal plane discrepancies (open bites), and interdental spaces in the maxillary arch may be corrected by segmental surgery.

When the maxilla is also vertically excessive, superior repositioning of the maxilla will result in some advancement due to the anterior rotation of the mandibular incisors caused by the autorotation of the mandible (Fig 3-13). If necessary, the orthodontist should compensate the incisors for this "added" advancement of the maxilla. This may entail retracting the mandibular incisors slightly or may necessitate two-jaw surgery if the anteroposterior discrepancy becomes too large to be treated by single-jaw surgery.

Orthodontic considerations

The orthodontic and surgical visual treatment objectives determine the ideal maxillary and mandibular incisor positions. Bear in mind that autorotation of the mandible will alter the anteroposterior position of the incisors.

Maxillary anteroposterior deficiency often results in crowding in the maxillary dental arch,

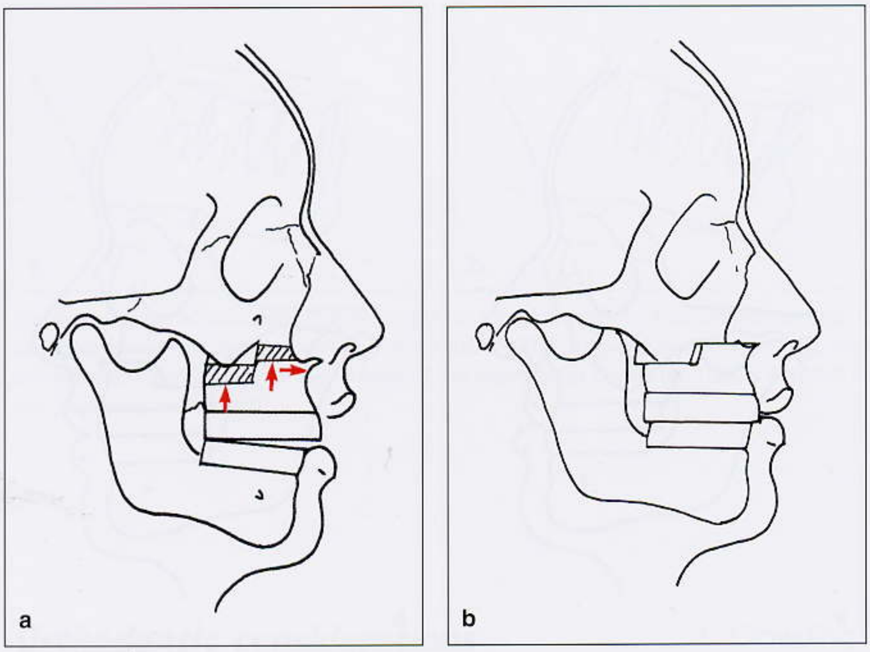


Fig 3-13 *(a)* Vertical maxillary excess and an anterior open bite malocclusion. *(b)* The bite is closed by surgical superior repositioning of the maxilla with autorotation of the mandible. Because of the anterior component of the autorotation, the maxilla needs to be advanced as well.

and extractions may be necessary to accommodate all the teeth. Three extraction patterns may be implemented, depending on the conditions:

1. *Crowding in the anterior maxillary arch and no crowding in the mandibular arch.* Extraction of the maxillary first premolars will result in a Class II molar and Class I canine relationship after surgery. Extraction of the first premolars will also allow more retraction of the maxillary incisors.
2. *Crowding in the posterior maxillary arch and no crowding in the mandibular arch.* Extraction of the maxillary second premolars will also result in a Class II molar and Class I canine relationship after surgery.
3. *Crowding in both arches.* The principles described in the two previous extraction patterns also apply here. Additionally, where a large overjet is required, the maxillary first premolars and mandibular second premolars should be extracted.

In cases where segmental surgery of the maxilla is planned—eg, for the surgical correction of open bites—extraction of the first premolars is preferred because it makes the orthodontic segmental alignment easier. The interdental osteotomy may be placed in one of two positions: between the deviated roots of the lateral incisors and canines or between the deviated roots of the canines and first premolars.

Placing the osteotomy between the deviated roots of the lateral incisors and canines has significant advantages (Fig 3-14). The surgeon has control over the intercanine width, which ensures a good Class I canine relationship. Furthermore, before surgery, the canine root is deviated distally, away from the interdental osteotomy site, achieving the distalized canine root angulation that most clinicians aim for in their completed cases. This is important in the postsurgical orthodontic phase because a large canine root that requires distal movement can add many months to the finishing phase of orthodontics. Finally, with this method

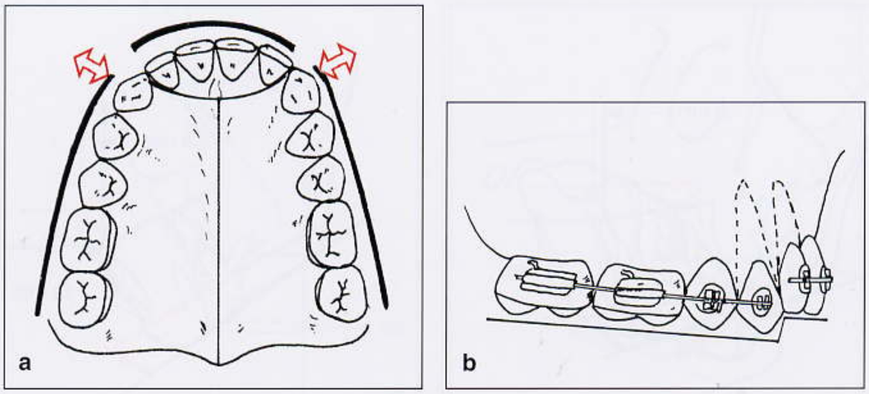


Fig 3-14 *(a)* Three-piece Le Fort I maxillary osteotomy, with the interdental osteotomy between the maxillary lateral incisors and canines. *(b)* Step in the occlusion between the anterior segment (the incisors) and posterior segments (canines through second molars bilaterally). The roots of the canine and lateral incisor are deviated. A shorter period of postsurgical orthodontics is required to correct the canine root positions.

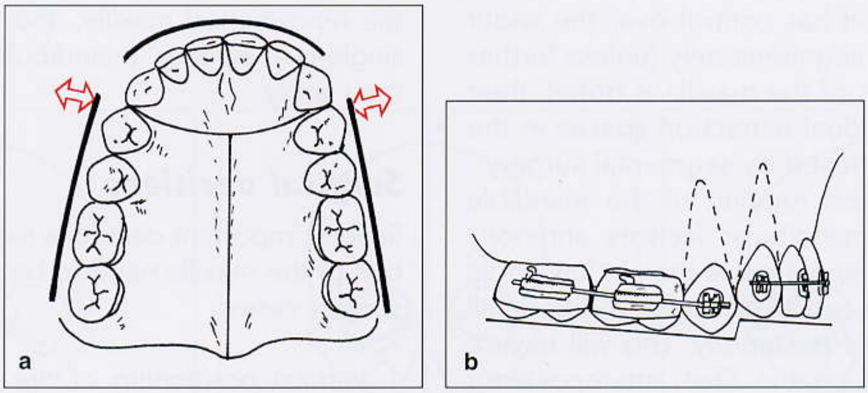


Fig 3-15 *(a)* Three-piece Le Fort I maxillary osteotomy with the interdental osteotomy between the canines and premolars. *(b)* Step in the occlusion between the anterior segment (canines and incisors) and posterior segments (second premolars through second molars). The roots of the canine and second premolar are deviated. A longer period of postsurgical orthodontics is required to move the large canine root into a more correct distal inclination.

the surgical site is more accessible and the interdental osteotomy is easier because the alveolar bone is thinner in this region.

Placing the osteotomy between the deviated roots of the canines and first premolars also has its advantages (Fig 3-15). This site is sometimes preferred when a natural step exists here in the pretreatment maxillary arch. Even though this site may be a more appropriate place for the segmental osteotomy, it necessitates significant postsurgical orthodontic work because the canine root must be tipped forward, away from the osteotomy site, and this root angulation then must be corrected. This site is also preferred when first premolar extraction spaces are to be closed surgically. The orthodontist must ensure that the intercanine dimensions are coordinated,

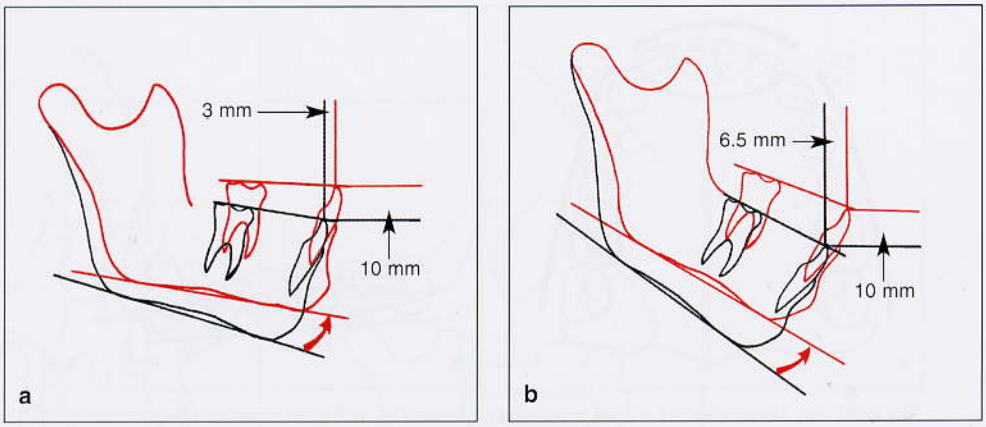


Fig 3-16 *(a)* Low-angle case with 10-mm superior repositioning of the maxilla. The mandible will rotate 10 mm superiorly and 3 mm anteriorly. *(b)* High-angle case. A 10-mm superior repositioning will result in a 6.5-mm anterior rotation of the mandibular incisors.

since the surgeon has control over the width of the posterior segments only (unless further segmentalization of the maxilla is done). Bear in mind that residual extraction spaces in the maxilla may be closed by segmental surgery.

Counterclockwise rotation of the mandible will rotate the mandibular incisors anteriorly (more so in high-angle cases than in low-angle cases) (Fig 3-16), while clockwise rotation will rotate the incisors posteriorly. This will have a significant effect on the final anteroposterior position of the maxilla.

The clinician must ensure that the mandibular dental midline (unoperated jaw) coincides with the facial midline. The maxillary dental midline can be corrected by the surgery.

Finally, when segmental surgery is indicated (for narrowing, widening, vertical change, or closure of interdental spaces), the roots of the teeth adjacent to the interdental osteotomy should be deviated.

Two-jaw surgery with maxillary and mandibular repositioning

When two-jaw surgery is performed, surgery on the maxilla is usually first. Therefore, the final position of the mandible will be determined by the repositioned maxilla, and the principles of single-jaw surgery (mandibular repositioning) then apply.

Surgical decisions

Several important decisions regarding the position of the maxilla need to be made in two-jaw surgery cases:

1. *Vertical positioning of the anterior maxilla.* This position is determined by the maxillary incisors–upper lip relationship (Fig 3-17).
2. *Vertical positioning of the posterior maxilla.* This position is determined by the mandibular molars after the mandible has autorotated *unless* rotation of the maxillomandibular complex is indicated (Fig 3-18).
3. *Vertical changes of the right and left sides of the maxilla.* These changes are relevant where a transverse maxillary cant exists (usually associated with facial asymmetry). The cant should be corrected, usually according to the interpupillary line. The interpupillary line, however, may not always be in the horizontal plane and should be noted. Keep the vertical maxillary incisor–lip relationship in mind with the correction (Fig 3-19). An alteration in the transverse cant of the occlusal plane in two-jaw surgery may have a profound effect on mandibular symmetry, and it

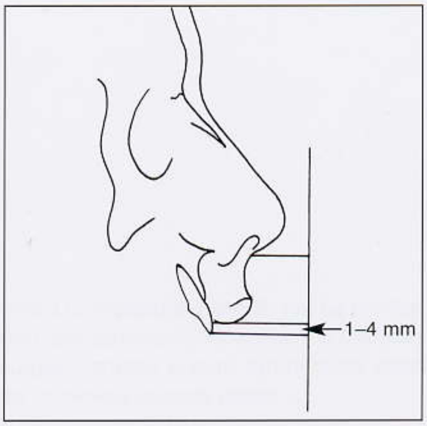


Fig 3-17 The ideal amount of maxillary tooth exposure under the relaxed upper lip should be 1 to 4 mm (less exposure in patients with long upper lips and more exposure in patients with short upper lips). Normal upper lip length in females is 20 ± 2 mm and in males, 22 ± 2 mm.

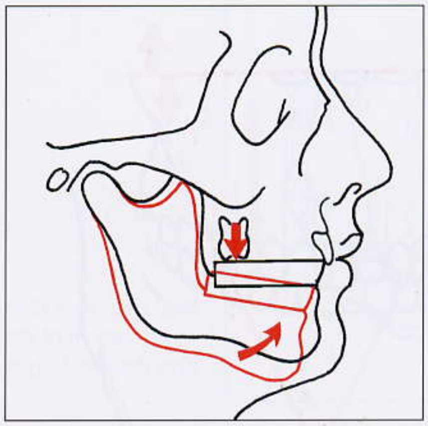
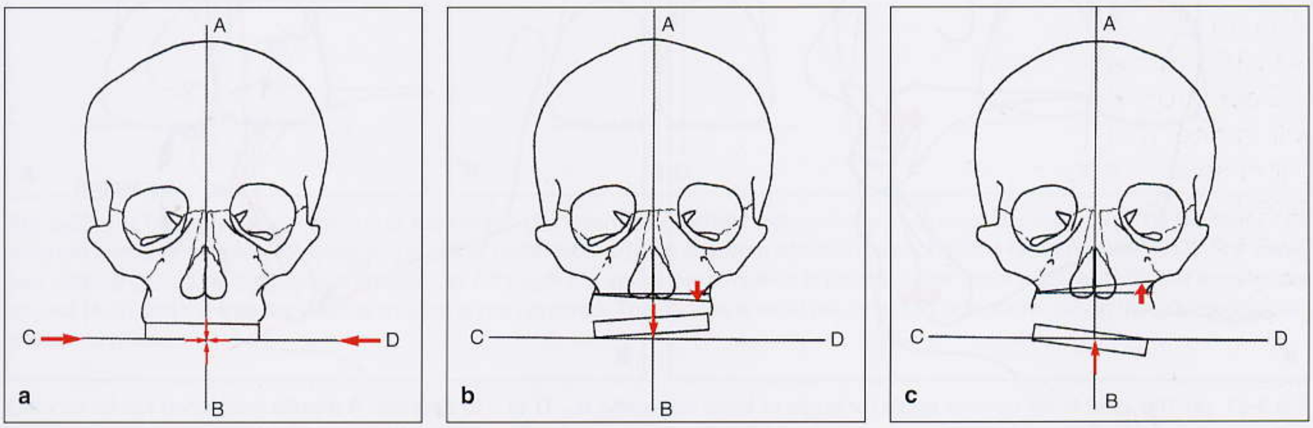


Fig 3-18 The final occlusal plane is determined by the mandibular occlusal plane once the vertical position of the anterior maxilla/mandible has been established. The vertical position of the posterior maxillary teeth will therefore be dictated by the posterior mandibular teeth (after autorotation).



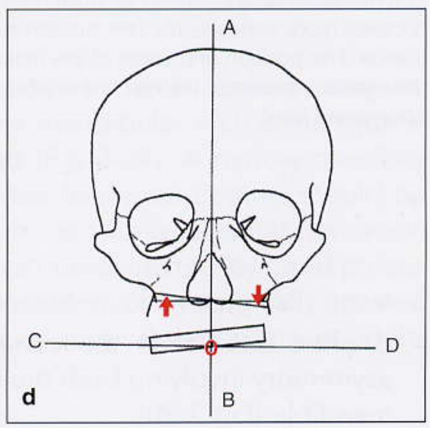


Fig 3-19 *(a)* Surgically correcting the transverse cant of the occlusal plane and, at the same time, ensuring ideal vertical and transverse position of the maxillary incisors. A-B represents the facial midline, while C-D indicates the ideal vertical height of the maxillary incisors. *(b)* The left side of the maxilla is downgrafted. *(c)* The left side of the maxilla is superiorly repositioned. *(d)* The left side of the maxilla is downgrafted, and the right side is superiorly repositioned.

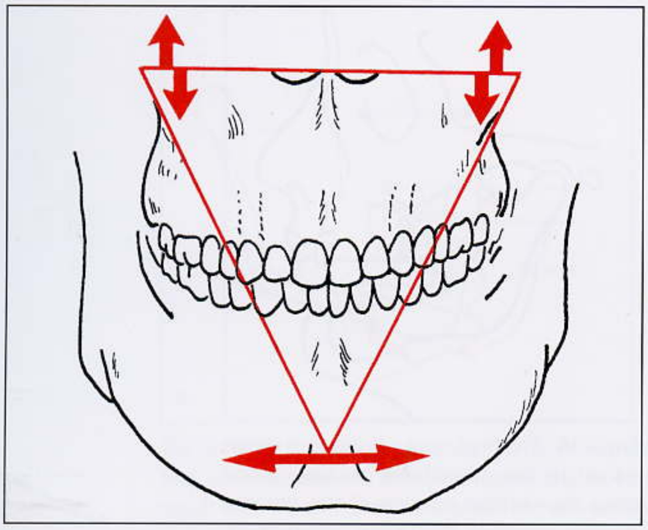


Fig 3-20 The constructed triangle illustrates the effect that change in the transverse occlusal cant may have on mandibular symmetry.

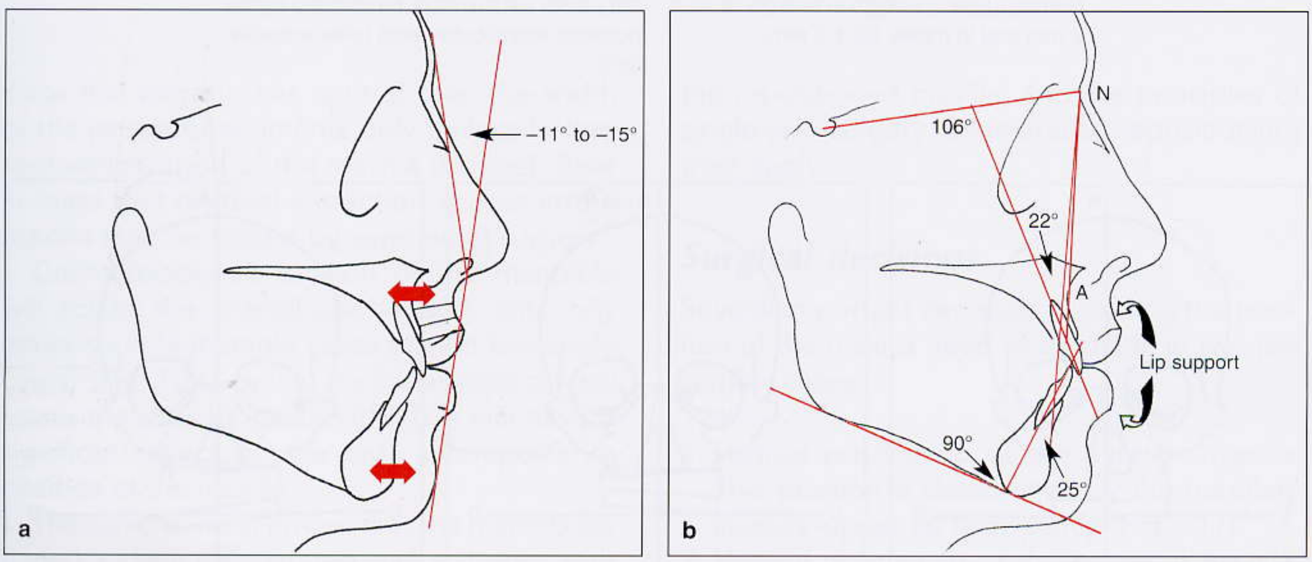


Fig 3-21 *(a)* The ideal facial contour angle (or angle of facial convexity) is −11 to −15 degrees. A maxilla positioned too far forward or a mandible positioned too far posteriorly would increase this angle and vice versa. Class II cases will be more convex, while Class III cases more concave. *(b)* The support rendered by the maxilla and maxillary incisors to the upper lip is mandatory for good esthetics. The position and angle of the maxillary incisors are also determining factors for the nasolabial angle. Normal angulation of the maxillary incisor to the N-A line is 22 degrees, with the incisal tip 4 mm ahead of N-A. A nasolabial angle of 90 to 110 degrees is considered ideal.

is often integral in the correction of facial asymmetry involving both the maxilla and the mandible (Fig 3-20).

4. *Anteroposterior position of the maxilla.* This position is determined by the maxillary incisor–lip relationship (lip support), paranasal form, and facial contour (Fig 3-21).
5. *Anteroposterior position of the left and right sides of the maxilla.* Any arch rotations will determine the changes in this dimension (Fig 3-22).
6. *Transverse position of the maxilla.* This position is determined by the midline of the face. In two-jaw surgery, the surgeon can position

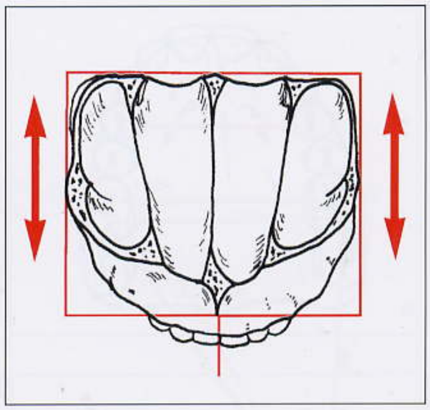


Fig 3-22 Arch relationships (compatibility) should not be confused with arch form, and both should be corrected orthodontically. However, the maxillary arch form may be altered surgically. The surgeon should ensure symmetrical positioning of the left and right sides of the maxilla in two-jaw surgery cases.

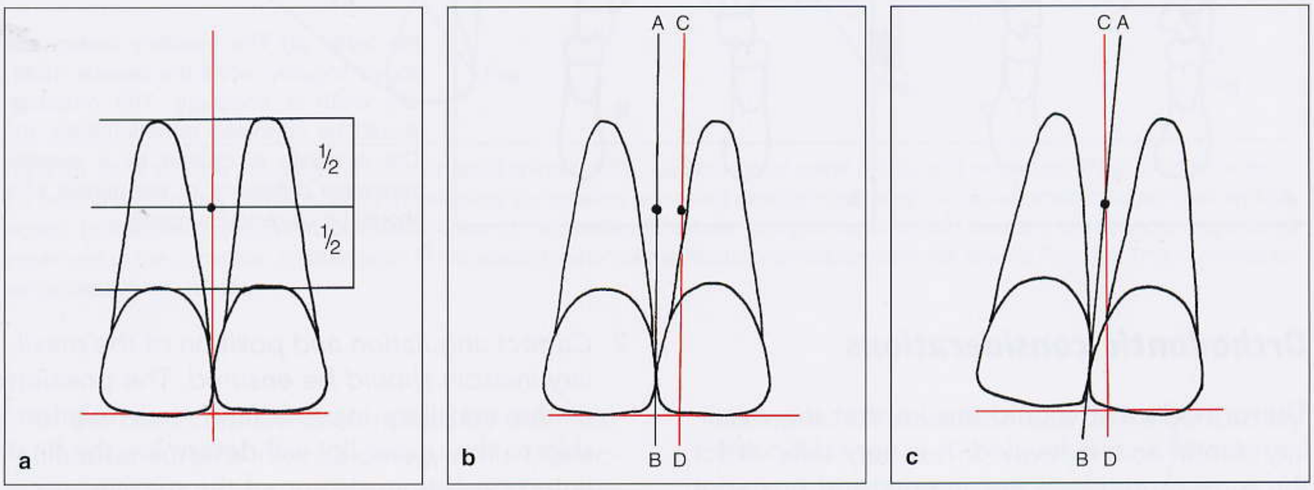


Fig 3-23 *(a)* The apical base midline is the central point vertically halfway between the central incisor roots. *(b)* The maxillary incisors are correctly angulated; however, the apical base midline (A-B) is asymmetrical in relation to the facial midline (C-D). The maxillary midline should be surgically corrected. *(c)* Although the apical base midline is central to the facial midline (C-D), the incisors are angled (A-B) and the maxillary dental midline is not centered. The midline should be corrected orthodontically in the preoperative orthodontic phase.

the dental midlines of both jaws and must ensure that the dental midlines and facial midlines coincide. The orthodontist, therefore, should not waste treatment time by correcting dental midlines. Keep in mind that in the mandible, the dental midline and the midline of the chin may not coincide, and genioplasty may have to be considered to correct the symmetry of the chin. In asymmetry cases, the clinician should distinguish between dental midline and apical base midline (Fig 3-23).

7. *Transverse dimension of the maxilla.* This dimension is determined by the width of the mandibular dental arch unless surgical change in the mandibular arch dimension is contemplated (Fig 3-24). A narrow maxillary dental arch due to dental tipping should be corrected orthodontically. Skeletal transverse deficiency must be corrected by rapid palatal expansion in children or by surgically assisted orthodontics or surgical expansion in adults (Fig 3-25).

Repositioning of the maxilla entails accurate planning and meticulously performed surgery to establish the basis for mandibular repositioning.

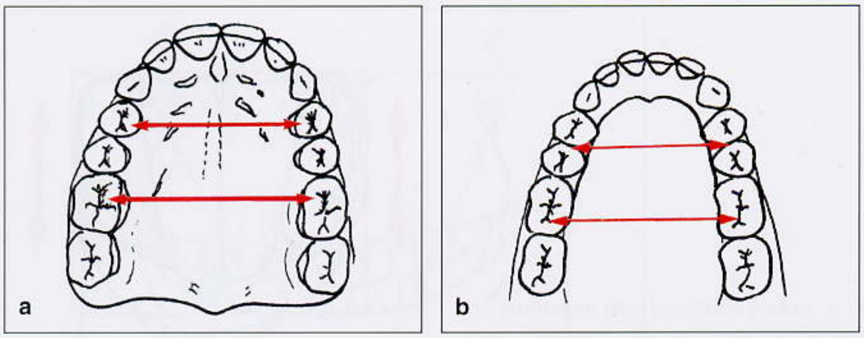


Fig 3-24 *(a and b)* Dental arch width may be assessed preoperatively by diagnostic casts or by measuring and comparing the distance between the mesiolingual cusps of the maxillary first molars versus the central fossae of the mandibular first molars and the distance between the lingual cusps of the maxillary first premolars versus the centers of the distal marginal ridges of the mandibular first premolars.

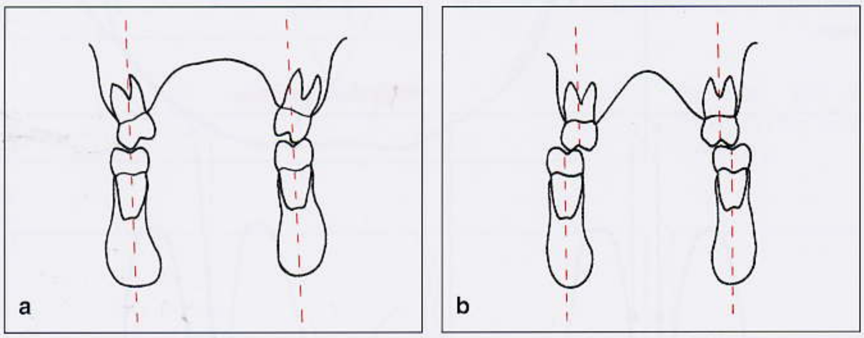


Fig 3-25 *(a)* The maxillary molars are tipped lingually, while the skeletal maxillary width is adequate. The crossbite should be corrected orthodontically. *(b)* The crossbite is caused by a skeletal transverse deficiency of the maxilla and should be corrected surgically.

Orthodontic considerations

The orthodontist should ensure that the maxillary dental arch is leveled. It is very difficult for the surgeon to place the anterior and posterior maxilla in the correct vertical position when there is an existing curve in the occlusal plane. However, the maxillary occlusal plane may be leveled surgically in some cases—eg, open bite cases where the maxillary arch has been orthodontically aligned in segments.

Tooth extraction patterns in two-jaw surgery are influenced by the following: crowding (anteriorly or posteriorly), the amount of incisor discrepancy (overjet or crossbite) required to obtain optimal esthetics, the need to place teeth in a stable position in the central trough of bone, the curve of Spee, and the possibility of surgically closing residual extraction spaces. Following are some basic rules regarding orthodontic procedures for two-jaw surgery.

1. *One should not attempt to level a transverse occlusal plane cant orthodontically in facial asymmetry cases.* The cant should be leveled surgically as part of the surgical correction of the facial asymmetry.
2. *Correct angulation and position of the maxillary incisors should be ensured.* The position of the maxillary incisors (and their relationship to the upper lip) will determine the final anteroposterior position of the maxilla.
3. *A good arch form should be established.* The orthodontist should not waste treatment time correcting anteroposterior and vertical discrepancies of the left or right side of the maxilla. These discrepancies can be corrected surgically.
4. *The maxillary dental midline can be corrected surgically.* As long as a good arch form exists, the maxillary dental midline should be corrected surgically.
5. *Transverse discrepancies involving dental tipping should be corrected orthodontically, while transverse skeletal discrepancies should be corrected surgically.* Any orthodontic expansion in the maxilla beyond the skeletal base will have a strong tendency to relapse. Because the maxillary dental arch width is determined by the mandibular arch width, it is necessary to establish the mandibular arch form before surgery (eg, by decompensation of anterior and posterior teeth). The anteroposterior, vertical, and transverse positions

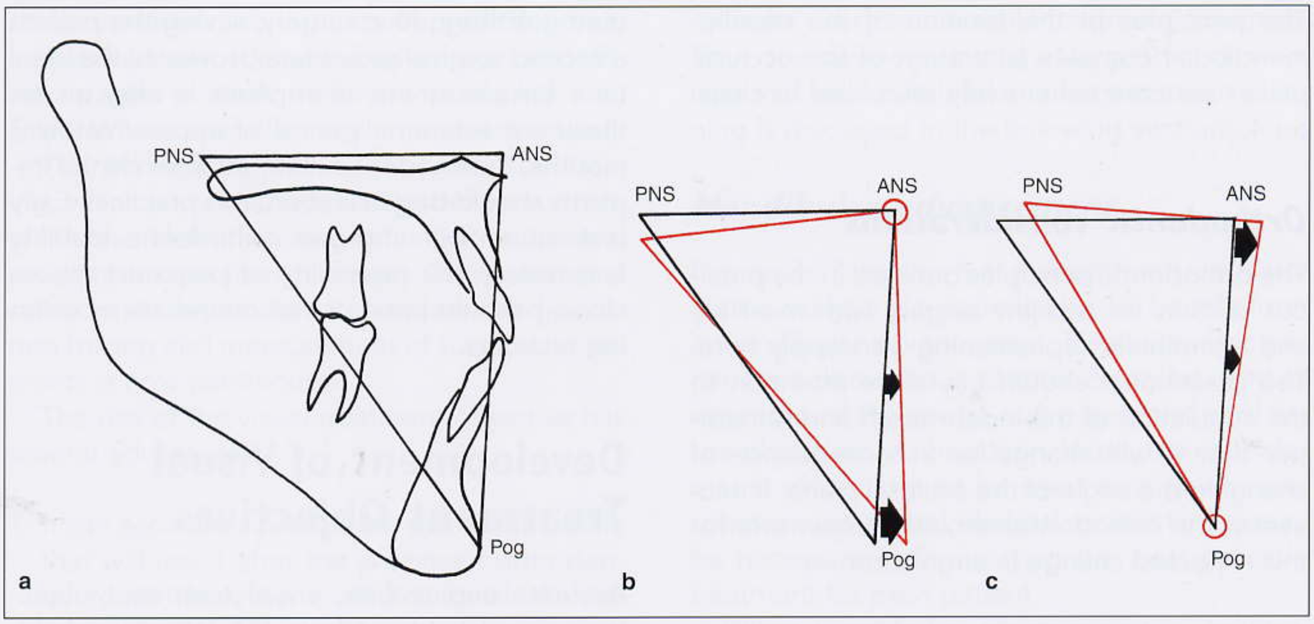


Fig 3-26 *(a)* A triangle involving the anterior nasal spine (ANS), posterior nasal spine (PNS), and pogonion (Pog) is constructed in the treatment-planning phase to assist in selecting the rotation point and developing a surgical cephalometric visual treatment objective. *(b)* Illustration of counterclockwise rotation of the maxillomandibular complex around ANS resulting in a pronounced anterior movement of the mandible. *(c)* Illustration of clockwise rotation of the maxillomandibular complex around Pog resulting in a large advancement of the maxilla.

of the mandible are determined by the maxilla after surgical repositioning, while the occlusal plane of the maxilla is dictated by the occlusal plane of the mandible after autorotation.

Two-jaw surgery with rotation of the maxillomandibular complex

Rotation of the maxillomandibular complex with consequent alteration of the angulation of the occlusal plane is a surgical treatment designed to achieve esthetic and functional results that cannot be achieved by conventional treatment. In this treatment scenario the occlusal plane of the mandible (after autorotation) will not be the final occlusal plane. The surgeon, therefore, has two more decisions to make before positioning the maxilla:

1. *The new occlusal plane angle and the direction of rotation of the maxillomandibular complex*. This decision will be influenced by the anteroposterior position of the chin, paranasal anatomy, and facial contour.
2. *The point around which the maxillomandibular complex will be rotated*. By constructing a triangle involving the anterior nasal spine (ANS), posterior nasal spine (PNS), and pogonion (Pog) and varying the point of rotation or the direction of rotation, functional and esthetic possibilities can be investigated (Fig 3-26a). The position of the rotation point will be determined by the surgical cephalometric prediction tracing and will be influenced by the following:
    a. The anteroposterior position of the chin (Pog). The higher and more anterior (ie, the closer to the anterior nasal spine) the point of rotation, the more pronounced the anteroposterior movement of the chin (Fig 3-26b).
    b. *Paranasal flattening*. The lower the rotation point (ie, the closer to Pog), the more pronounced the anteroposterior movement of the anterior nasal spine (Fig 3-26c).

The principles of the rotation of the maxillo-mandibular complex (alteration of the occlusal plane) are comprehensively discussed in chapter 4.

Orthodontic considerations

The orthodontic principles outlined in the previous section on two-jaw surgery with maxillary and mandibular repositioning also apply here. The practitioner should pay close attention to the angulation of the incisor teeth and remember that it will change as a consequence of changing the angle of the occlusal plane. If necessary, the orthodontist should compensate for this expected change in angulation.

Best Sequence of Treatment to Obtain the Desired Result

It is usually preferable to perform basic restorative dental and periodontal treatment before beginning the preoperative orthodontic phase. This sequence will ensure that the dentition and supporting dental tissues are sound. It is also preferable to remove any impacted teeth at this stage.

In general, the surgery should not be performed too early in the orthodontic phase for the following reasons:

1. Delaying surgery allows the surgeon to position the jaws more accurately at surgery.
2. Better interdigitation of the teeth, which improves stability, can be achieved if the arches are better prepared.
3. After surgery, the patient's appearance improves; as a consequence, motivation to have small orthodontic discrepancies corrected diminishes, and cooperation falters.

It is usually preferable not to extend the postoperative orthodontic treatment beyond 3 to 6 months.

In determining placement of dental implants, overall functional and esthetic results should be carefully considered. Implants can be placed during orthognathic surgery, saving the patient a second surgical procedure. However, the ideal time for placement of implants is after an orthodontic retention period of approximately 3 months. Prosthodontic restoration of dental implants should begin as soon as is practical. Early restoration will improve orthodontic stability and reduce the possibility of prepared spaces closing should patients not cooperate in wearing retainers.

Development of Visual Treatment Objectives

Accurate and realistic visual treatment objectives are developed from the lateral cephalometric radiograph tracing in combination with all the data obtained from the systematic patient evaluation. There are two types of visual treatment objectives: the pretreatment visual treatment objective and the immediate presurgical prediction tracing.

The pretreatment visual treatment objective is developed once the primary surgical procedure has been selected. The following questions are used in its development:

- Will the selected surgical procedure produce the required facial esthetic changes?
- Will it be physically possible to create the skeletal change within the biologic boundaries?
- Will it be possible to orthodontically produce the tooth movements called for by the proposed surgery?

The pretreatment visual treatment objective is used for overall treatment planning. It consists of *(1)* an orthodontic prediction tracing illustrating the desired presurgical orthodontic tooth movement and the resulting soft tissue changes and *(2)* a surgical prediction tracing predicting the surgical repositioning of the jaws and subsequent soft tissue changes. The magnitude of the surgical movements of the jaw(s) is not important at this stage as long as the procedure falls within the boundaries of good surgical technique. If more than one surgical or orthodontic option is under consideration, a series of prediction tracings should be made and all advantages and disadvantages of each treatment possibility analyzed. Where possible, simple treatment is best.

The immediate presurgical prediction tracing, which is created a few days before surgery, plans the definitive surgical movements and predicts the soft tissue changes. The presurgical orthodontic treatment is complete, and accurate tracing and measurement of surgical movements is now paramount.

The use of the visual treatment objective has several advantages:

1. It can accurately predict the soft tissue profile that will result after the proposed orthodontic tooth movements and surgical skeletal repositioning. The predicted soft tissue profile can be assessed and the treatment plan adjusted, if necessary.
2. It enables the orthodontist and surgeon to investigate treatment options and evaluate the advantages and disadvantages of each option before treatment starts.
3. It helps analyze the need for tooth extractions or which teeth to extract.
4. The need for adjunctive surgical procedures, such as genioplasty, can be assessed.
5. The progress of orthodontic treatment can be monitored using the orthodontic prediction.
6. The postsurgical skeletal movements can be assessed.
7. It acts as a communication medium between the orthodontist and the surgeon, as well as between the clinicians and the patient.

Orthodontic prediction tracing

The presurgical position of the teeth dictates the surgical movement of the jaws and, ultimately, the soft tissue facial balance. Correct planning of the orthodontic tooth positioning before surgery and accurate execution of the presurgical orthodontic plan will enhance the surgical potential and, hence, the esthetic result.

Because of the myriad treatment possibilities, it is impossible to discuss method and development for every conceivable treatment objective. Thus, the development of a few prediction tracings that will be helpful in most treatment planning is discussed in the following sections.

Mandibular advancement

Figure 3-27 shows the pretreatment cephalometric analysis of a patient who will benefit from a mandibular advancement. Cephalometric parameters discussed in chapter 2 may be used as indicators of the dental, soft tissue, and hard tissue objectives. As has been noted, the cephalometric values should be used as a guide, and compromise (dental, skeletal, or soft tissue) may be necessary in formulating the best possible treatment for each patient.

When mandibular advancement is contemplated, the shape of the chin should be assessed as part of the orthodontic treatment planning. Esthetic planning of the soft tissue of the chin should assess the horizontal position of the soft tissue pogonion (Pog'), but the actual shape of the chin is more important in the overall esthetics. The following factors should be considered in the assessment of chin esthetics (Fig 3-28): the vertical height of the chin, lower lip length, amount of lower lip vermilion exposed, depth of the labiomental fold, lower lip–chin–throat angle, chin-throat length, curvature of the chin, and horizontal relation of the labrale inferior (Li) and Pog'.

Figure 3-29 illustrates three patients with ideal incisal relationships and Pog' in the same horizontal position. Because of the variation in the shapes of their chins, however, they have different esthetic appearances.

Therefore, when there is a clear indication for genioplasty to improve the shape of the chin, it should be incorporated in the orthodontic prediction tracing so the presurgical orthodontic tooth positioning will allow for the correct amount of mandibular advancement and incorporate the planned amount of chin advancement for the best esthetic result.

Step 1

Create the original tracing by tracing the hard and soft tissue, without analysis lines, on a separate

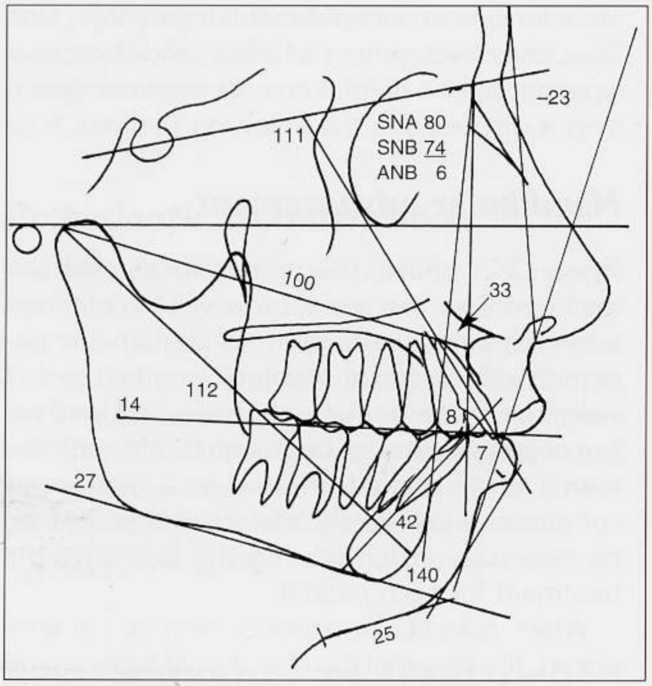


Fig 3-27 The pretreatment cephalometric analysis of a patient with the following diagnostic summary: A 17-year-old female patient whose main complaint is that her chin appears deficient. Skeletal: mandibular anteroposterior deficiency and microgenia. Dental: Class II, division 1 malocclusion; slightly narrow maxillary arch; slight maxillary incisor protrusion; mandibular incisor protrusion; and crowding in the mandibular incisor area. Soft tissue: convex profile, deficient chin, and short chin-throat length.

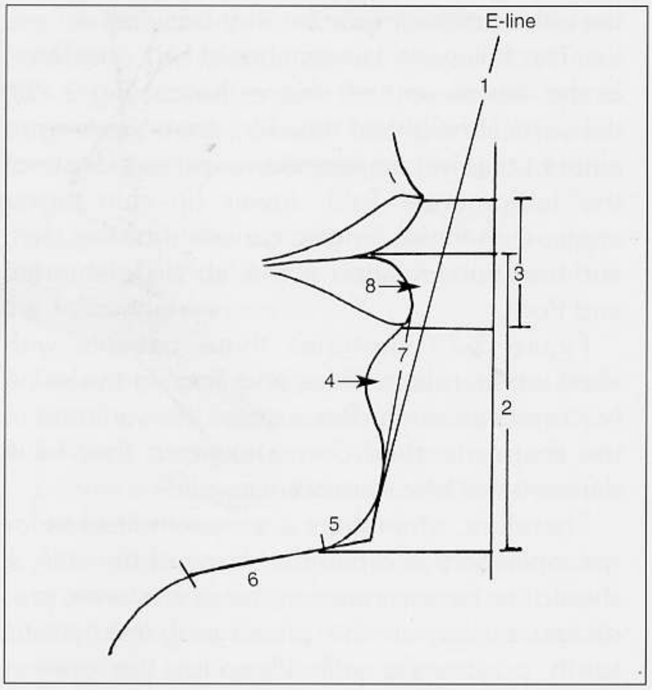


Fig 3-28 Parameters used in the evaluation of the overall esthetics of the chin. The esthetic line (E-line) (1) is drawn from nasal tip (Pn) to pogonion (Pog). The height of the chin (2) should be equivalent to two thirds of the lower third of the face (subnasale-stomion:stomion–soft tissue menton = 1:2). Also known as lower lip length, chin height should be 40 ± 2 mm (females) and 44 ± 2 mm (males). Vermilion exposure (3): lower lip exhibits approximately 25% more vermilion than the upper lip. Depth of the labiomental fold (4): the labiomental fold should have a smooth concave curve connecting the lower lip with the chin. Mandibular-prognathic cases often exhibit flat labiomental folds, while mandibular-deficient cases often have deep folds. Lower lip–chin–throat angle (5): 110 ± 8 degrees. This angle tends to be less than normal in mandibular prognathism and larger than normal in mandibular deficiency cases. Chin-throat length (6): normal, 42 ± 6 mm. An advancement genioplasty will clearly increase this distance, while the distance will decrease when the chin is set back. Curvature of the chin (7): the shape of the chin is enhanced if the profile forms a smooth S shape from stomion inferius to soft tissue menton. The lower lip should be 2 ± 2 mm behind the E-line (8).

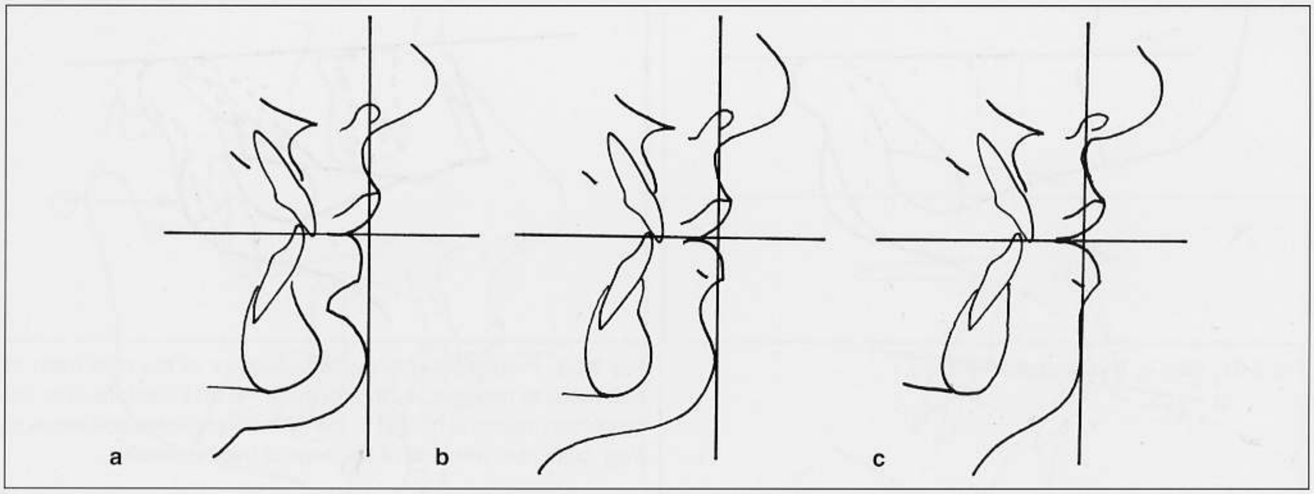


Fig 3-29 The fact that chin shape is more important than the horizontal position of Pog' in overall esthetics is demonstrated in individuals with the following characteristics: *(a)* a deep labiomental fold and a knobby chin, *(b)* an esthetically well-shaped chin, and *(c)* an obtuse labiomental fold that gives the chin a flat appearance. All three individuals have Pog' in exactly the same horizontal position.

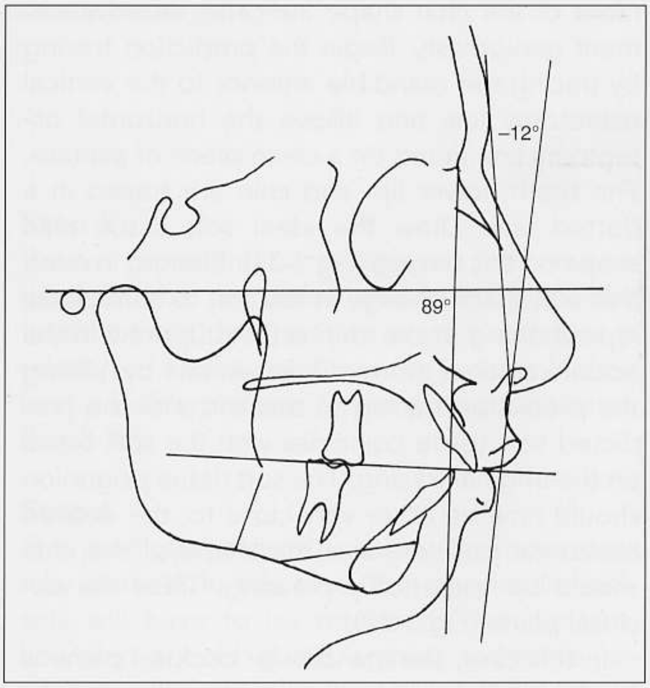


Fig 3-30 Step 1: The original tracing.

sheet of acetate. In this case, the facial depth angle and facial contour angle are used as indicators of the "ideal" hard and soft tissue positions, respectively. The facial depth angle is formed by passing a line from nasion (N) through A-point and the Frankfort horizontal (FH) plane (with the maxilla in good position: males, 90 degrees; females, 89 degrees). An extension of the N-A line should go through Pog'. The facial contour angle is formed between the upper facial plane (UFP) and lower facial plane (LFP) and should be –11 to –15 degrees for males and –13 to –17 degrees for females. Also, draw a vertical line on the mandible posterior to the second molar, representing the vertical osteotomy line of the sagittal split osteotomy; draw a horizontal line on the chin, representing the genioplasty osteotomy line (Fig 3-30).

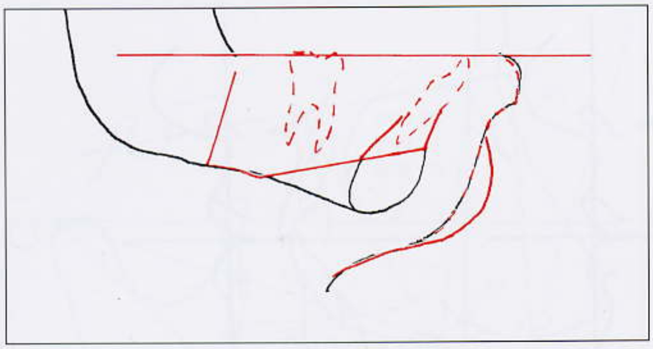


Fig 3-31 Step 2: The prediction tracing.

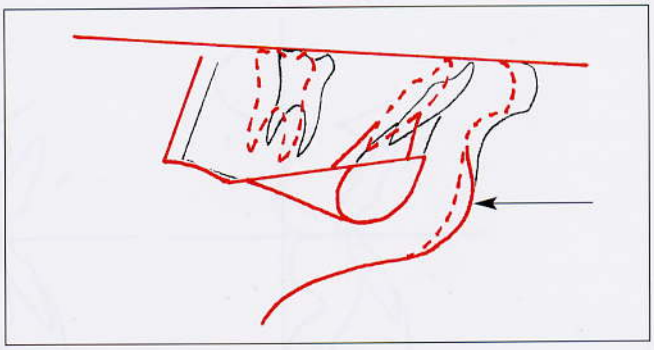


Fig 3-32 Prediction of bony advancement of the chin (ratio of soft tissue to hard tissue advancement = 0.9:1.0) is done after the prediction tracing is moved to the left until predicted soft tissue at Pog' coincides with that of the original tracing *(arrow)*.

Step 2

In this case, clinical and cephalometric assessment of the chin shape indicates an advancement genioplasty. Begin the prediction tracing by tracing the mandible anterior to the vertical osteotomy line and above the horizontal osteotomy line in red on a clean piece of acetate. The teeth, lower lip, and chin are traced in a dotted line. Draw the ideal soft tissue chin shape on this tracing (Fig 3-31). Bearing in mind that soft tissue change in relation to hard tissue repositioning of the chin is 0.9:1.0, draw in the actual required bony advancement by sliding the prediction tracing to the left until the predicted soft tissue coincides with the soft tissue on the original tracing. The soft tissue pogonion should now be at, or very close to, the desired horizontal position, and the shape of the chin should be esthetically pleasing. Trace the occlusal plane (Fig 3-32).

In this case, the mandibular occlusal plane is level. However, patients with Class II malocclusion often have deep bites with an accentuated curve of Spee. Preoperative versus postoperative leveling of the curve of Spee should be considered carefully because the choice affects facial esthetics, the amount of surgical advancement, and the need for genioplasty. An excessive curve of Spee should be leveled before surgery in the following cases:

1. When the chin needs to be advanced the same distance as the mandibular incisors.
2. When little vertical increase in the lower facial height is indicated. In high-angle cases, the vertical increase is slightly more than in low-angle cases because of the steepness of the occlusal plane.
3. When less decompensation of the incisors will be necessary to achieve the desired chin projection.

The curve of Spee should not be leveled prior to surgery in cases where a clockwise rotation of the distal portion of the mandible will be advantageous (Fig 3-33), for example:

1. Where the incisor teeth need to be advanced more than the chin
2. Where the anterior vertical height of the lower third need to be increased by the amount of excess of the overbite
3. Where a deep labiomental fold (usually present with deep bites) will improve because of the advancement of the mandibular incisors and downward rotation of the chin

Taking the above into account, the clinician should choose the plane of advancement. The mandible can be advanced along one of three occlusal planes (Fig 3-34): *(1)* the functional occlusal plane, *(2)* the molar-incisor plane of the maxilla, or *(3)* the molar-incisor plane of the mandible (in this case, all three planes are the same).

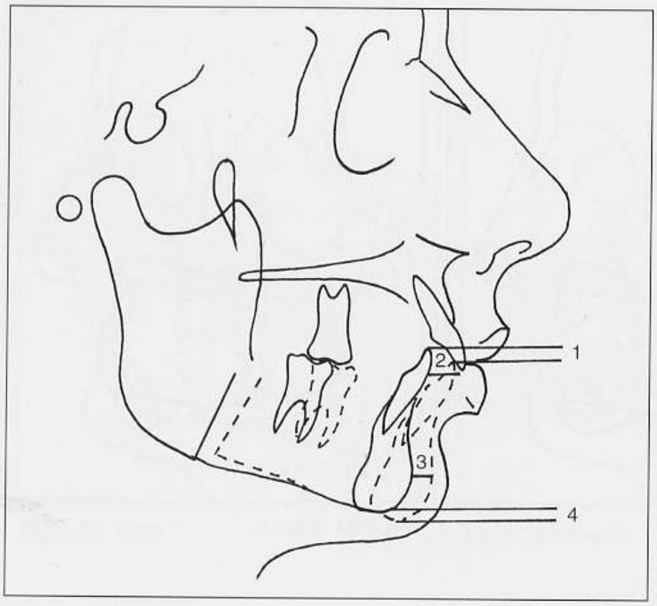


Fig 3-33 The curve of Spee is not leveled, and as the mandible is advanced, the mandible will rotate clockwise. The incisors will advance (2) more than Pog' (3), while the correction of the deep bite (1) will increase the vertical height of the chin (4) by the same amount.

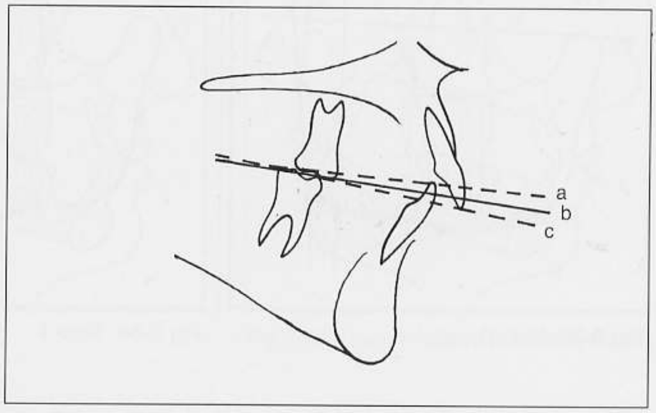


Fig 3-34 Three occlusal planes: the molar-incisor plane of the mandible (a), the functional occlusal plane (b), and the molar-incisor plane of the maxilla (c).

Step 3

Slide the prediction tracing to the right along the chosen occlusal plane (in this case, the functional occlusal plane), until the bony pogonion coincides with the facial depth line and the soft tissue pogonion coincides with the lower facial plane line (or best fit) (Fig 3-35). The soft tissue should take precedence, since it will determine the esthetic result.

Step 4

Trace the rest of the facial structures. The maxillary teeth are drawn in dotted lines (Fig 3-36). It is now clear that the mandibular advancement has resulted in an anterior crossbite. The question is, Can the teeth be orthodontically positioned in their ideal relationship to bone and to each other in the new jaw relationship? The clinician has various options:

1. Retraction of the mandibular incisors with or without extractions
2. Advancement of the maxillary incisors
3. Less advancement of the mandible and increasing the advancement of the chin.

Step 5

Various cephalometric parameters may now be used on the prediction tracing to place the teeth in their ideal position in each arch and in relation to each other. Draw the incisors in their best possible position on the prediction tracing (Fig 3-37).

Step 6

The predicted incisor positions are now carefully studied. In this case, the mandibular incisors will have to be retracted. The clinician, however, should guard against excessive retraction of the maxillary incisors, which would undermine the lip support and limit the mandibular advancement. The maxillary arch in Class II cases often needs some expansion to accommodate the mandibular arch after advancement. This expansion, in turn, often offers sufficient space for ideal positioning of the maxillary incisors. Extraction of premolars (first or second), however, may be indicated where crowding and an occlusal curve are present. Every 1 mm of arch leveling will increase the anteroposterior arch length by 1 mm. However,

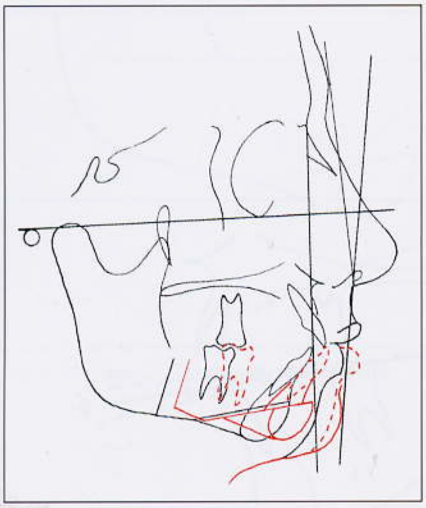


Fig 3-35 Step 3.

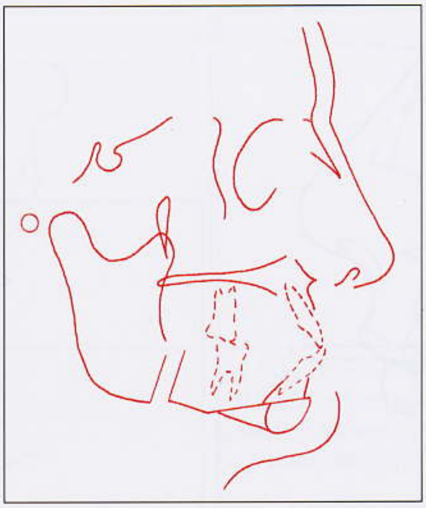


Fig 3-36 Step 4.

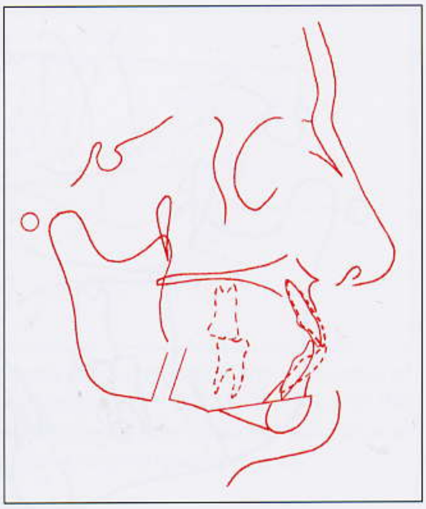


Fig 3-37 Step 5.

there will be an approximately 1-mm increase in arch length for every 1 mm of expansion of the arch at the canine area and a 4-mm increase for a 1-mm arch expansion in the molar area. Taking the following factors into account, the clinician can make a decision regarding tooth extraction (see pages 82 to 83):

1. Current incisor position
2. Required incisor position to facilitate the correct amount of mandibular advancement
3. Amount and area of crowding
4. Extent of the occlusal curve
5. Need for arch expansion
6. Possibility of interdental stripping

Step 7

The required arch length can now be established. If tooth extractions are indicated, the width of the teeth to be extracted should be subtracted from the existing arch length. The remainder of space (if any) can be closed by advancing the molars.

The feasibility of the predicted position of the incisors will now be evident. In some cases it may be necessary to make small dental compromises because of lack of arch length (even with tooth extractions), thin mandibular symphysis limiting tooth movement, or increase in treatment time. To achieve the amount of mandibular incisor retraction indicated on the prediction tracing in this case, two premolars should be extracted. The remaining space will be made up by advancing the molars.

The molar relationship can also be estabished. In this case, where extractions are not indicated in the maxillary arch, the maxillary molar will not move and is placed in a Class III relationship to the mandibular molar. The mandibular molar is advanced slightly to close the remaining extraction space once the incisor has been retracted sufficiently (Fig 3-38).

Step 8

The soft tissue profile prediction can now be completed. The upper lip will change very little because of the small amount of maxillary incisor retraction. The lower lip, however, will roll back subsequent to retraction (decompensation) of the mandibular incisors, as well as because of the elimination of the effect of the maxillary incisors on the lower lip. The rotation of the lower lip affects the soft tissue superior to the labiomental fold. Generally, the lower lip has the same thickness as the upper lip (Fig 3-39).

Figure 3-40 illustrates the completed prediction tracing (visual treatment objective stage). The tracing indicates the intended orthodontic tooth movement, the surgical repositioning of the mandible and chin, and the expected soft tissue result.

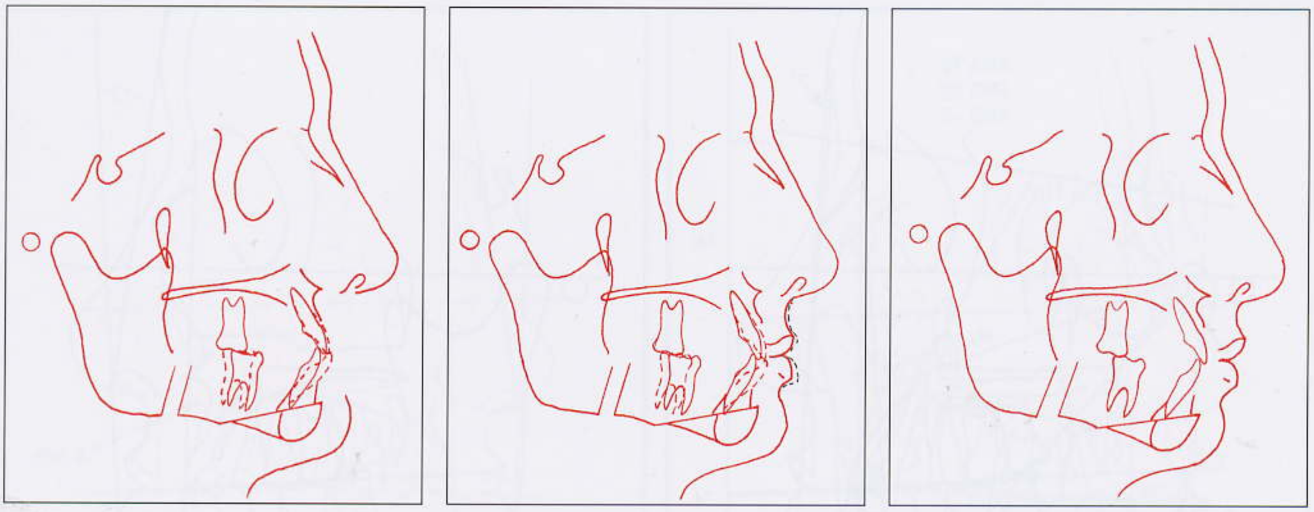


Fig 3-38 Step 7.

Fig 3-39 Step 8.

Fig 3-40 The completed prediction tracing.

Maxillary advancement

Figure 3-41 illustrates a cephalometric tracing and analysis of a patient who will benefit from a maxillary advancement procedure. Begin the original tracing by tracing all the relevant hard and soft tissues on a clean piece of acetate. Also trace all the teeth, since this will assist in the prediction of the orthodontic tooth movement. Draw the Le Fort I osteotomy line on the maxilla, as well as the mandibular occlusal plane. The following lines are drawn and angles constructed to assist in the ideal positioning of the teeth and in the surgical repositioning of the maxilla (Fig 3-42):

1. The facial depth line is drawn by dropping a line perpendicular to FH from N. The line should be tangent to A-point, as well as to Pog. In this case, however, the line is 5 mm ahead of the A-point, confirming the diagnosis of maxillary anteroposterior deficiency.
2. The ideal position of subnasale (Sn) is predicted by constructing the ideal facial contour angle for the patient. In this case, a facial contour angle of –13 degrees is chosen (the normal angle is –11 to –15 degrees for males and –13 to –17 degrees for females). The UFP and the LFP are drawn at an angle of 13 degrees with the help of a protractor. The glabella (G) and Pog' are static, while Sn is advanced.

Step I

Trace all the facial structures that will not be affected by the surgery on a clean piece of acetate. Trace the cranial base, soft tissue chin below the labiomental fold, hard tissue above the Le Fort I osteotomy line, mandible, mandibular occlusal plane, forehead, and soft tissue of the nose above the supratip break. The mandibular teeth (molar and incisor) are drawn in a dotted line. Trace the facial depth line and LFP in the midface region. The facial depth line is an indicator of the required A-point position on the maxilla, while the LFP indicates the required position of Sn. This tracing will develop into the prediction tracing (Fig 3-43).

This case will also benefit from a slight vertical increase of the maxilla. Draw a short horizontal line 2 mm below the mandibular occlusal plane in the incisor region. This line indicates the desired vertical position of the maxillary incisor tip (the 2 mm represents the incisor overbite) (see Fig 3-43).

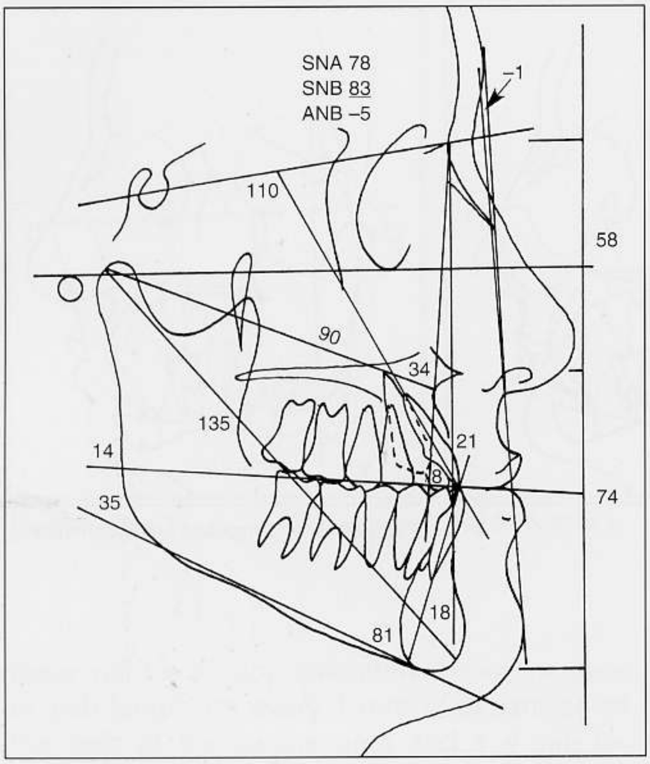


Fig 3-41 The cephalometric analysis of a patient with the following diagnostic summary: A 19-year-old male patient referred for the correction of a Class III malocclusion. Skeletal: maxillary anteroposterior deficiency and a tendency to vertical maxillary deficiency (clinically there is a 1-mm maxillary exposure under the upper lip with the lips slightly apart). Dental: Class II malocclusion, crowding in the maxillary arch (the maxillary canines are partially blocked out labially), and mandibular incisors slightly compensated. Soft tissue: lack of upper lip support, concave profile, and flat paranasal area.

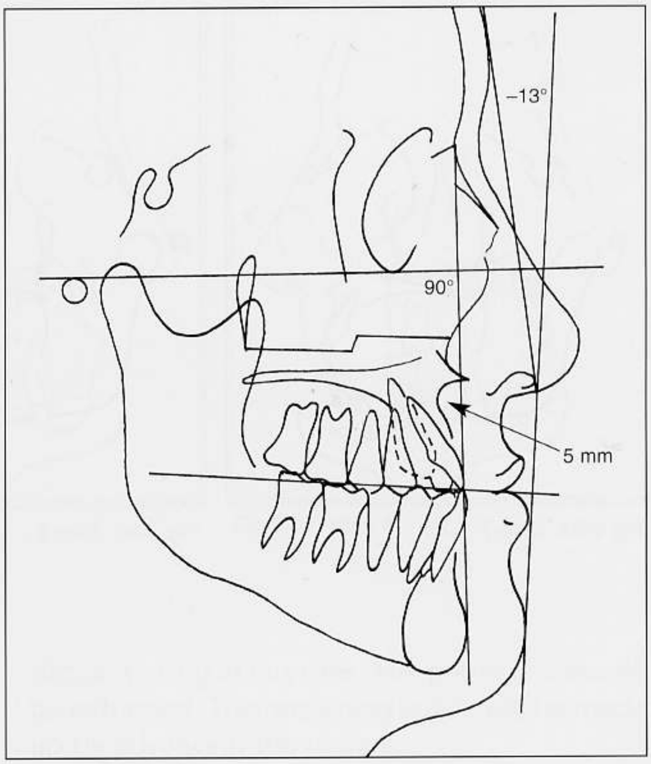


Fig 3-42 The facial depth line, facial contour angle, occlusal plane, and Le Fort I maxillary osteotomy line on the original tracing.

Step 2

Slide the prediction tracing to the left. The original tracing will move to the right, advancing the maxilla. Advance the maxilla on the original tracing until A-point is tangent to the facial depth line and Sn is tangent to LFP or best fit. In this case, A-point is moved just past the facial depth line, while Sn falls short of LFP. Place the maxillary incisor tip on the horizontal incisor line (Fig 3-44). Now draw the maxillary molars and incisors with dotted lines on the prediction tracing (Fig 3-45).

The prediction tracing can now be carefully studied and the following observations made:

1. An increased incisor overjet is present.
2. The maxilla is advanced by 6.5 mm.
3. The maxilla is inferiorly repositioned by 2 mm.
4. The molars are now in a Class II relationship.

The clinician has the following options:

1. Advance the maxilla less to get a better occlusal relationship, and retract the maxillary incisors. However, there is still crowding in the maxillary arch. A small advancement would compromise the esthetic result.
2. Extract the maxillary first premolars and retract the maxillary incisors, improving their angulation. The remaining space will be taken up by advancement of the molars. Decompensate the mandibular incisors. Keep the maxillary advancement at 6.5 mm.

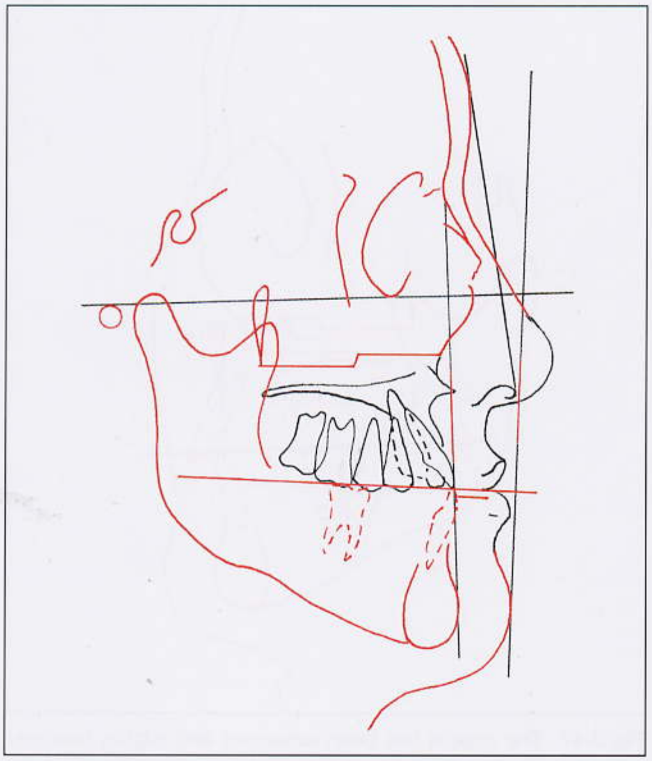


Fig 3-43 Step 1: The prediction tracing. All facial structures that will not be affected by the surgery are traced in red.

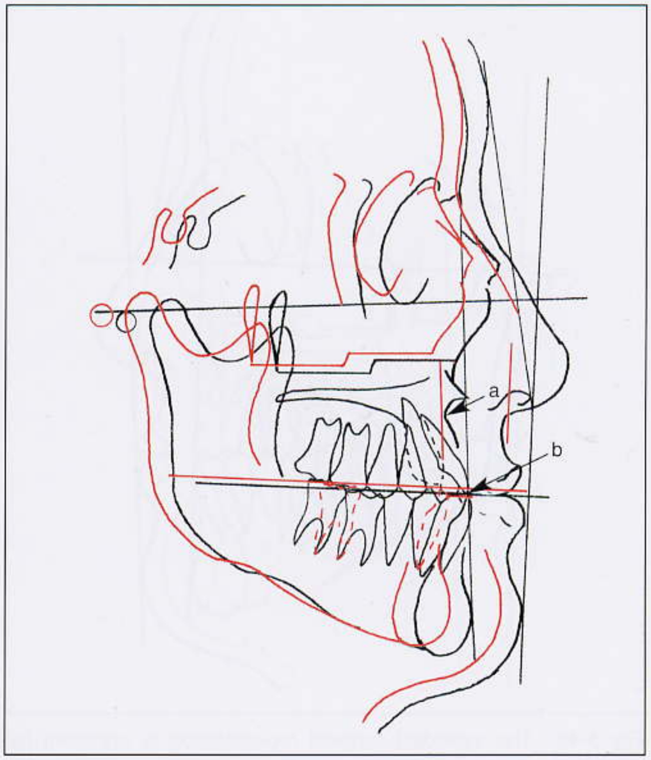


Fig 3-44 Step 2: The prediction tracing is moved to the left and slightly upward until A-point is just anterior to the facial depth line (a) and the maxillary incisor at the chosen vertical height (b).

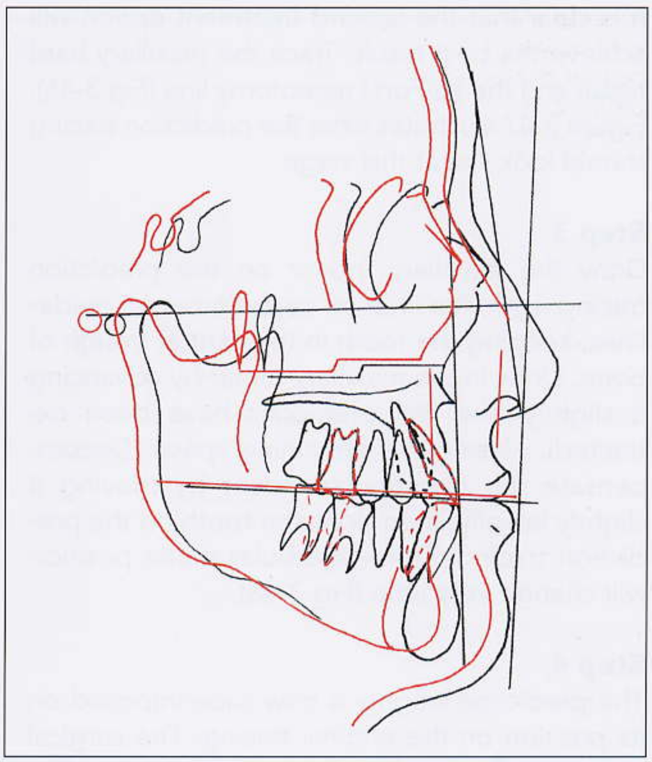


Fig 3-45 The treatment possibilities can be studied at this stage. Note the increased incisor overjet, amount of maxillary advancement (6.5 mm), amount of inferior repositioning of the maxilla (2 mm), and Class II molar relationship.

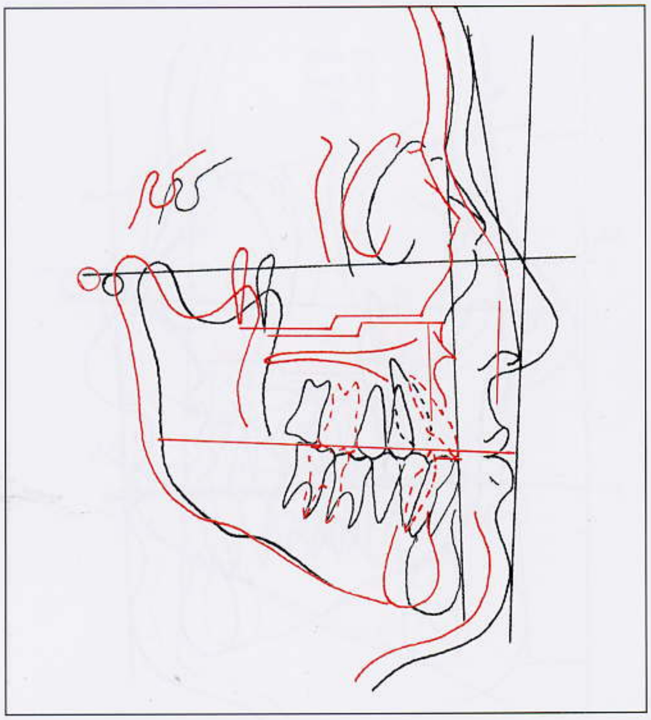


Fig 3-46 The intended surgical repositioning is apparent by comparing the Le Fort I osteotomy lines.

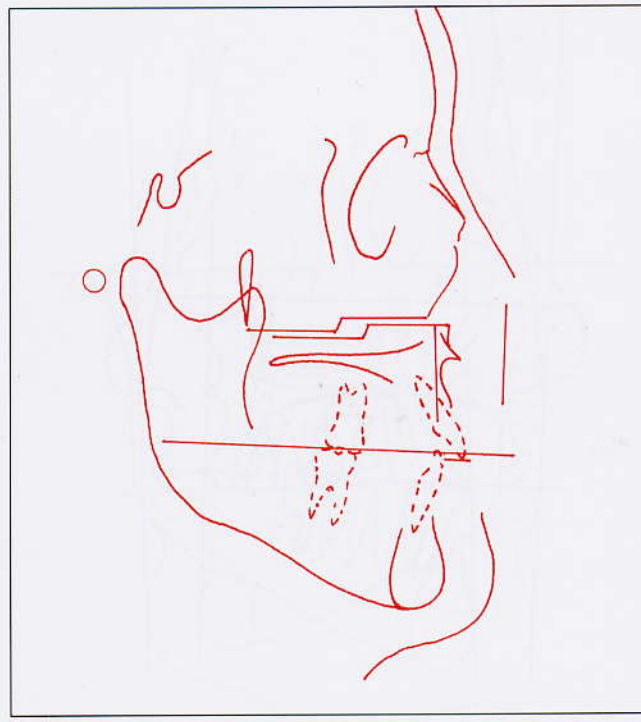


Fig 3-47 The maxilla has been advanced and slightly inferiorly repositioned. The dental and soft tissue prediction should be done now.

It is clear that the second treatment option will achieve the best result. Trace the maxillary hard tissue and the Le Fort I osteotomy line (Fig 3-46). Figure 3-47 illustrates what the prediction tracing should look like at this stage.

Step 3

Draw the maxillary incisor on the prediction tracing with the aid of cephalometric guidelines, keeping the tooth in the central trough of bone. Draw in the maxillary molar by advancing it slightly (the first premolars have been extracted), closing the remaining space. Decompensate the mandibular incisor by moving it slightly labially; then draw the tooth on the prediction tracing. The mandibular molar position will change very little (Fig 3-48).

Step 4

The prediction tracing is now superimposed on its position on the original tracing. The surgical change in the position of the maxilla is clear (Fig 3-49). The soft tissue changes subsequent to the repositioning of the maxilla can now be drawn in:

1. Vermilion (stomion superius): 50% to 75% of horizontal movement
2. Nasolabial angle: decreases 1 to 4 degrees per 1-mm advancement
3. Nasal tip: advances 30% (variable) and can be controlled

First, draw the predicted soft tissue change with a dotted line (Fig 3-50). When you are satisfied with the prediction, complete the line. Draw the soft tissue of the lower lip above the labiomental fold. Because of the effect of the upper lip on the lower lip, slight curling of the lower lip is expected (see Fig 3-50).

Step 5

Complete the visual treatment objective by measuring the horizontal and vertical change between the two Le Fort I maxillary osteotomy lines, and note the orthodontic tooth movements (Fig 3-51).

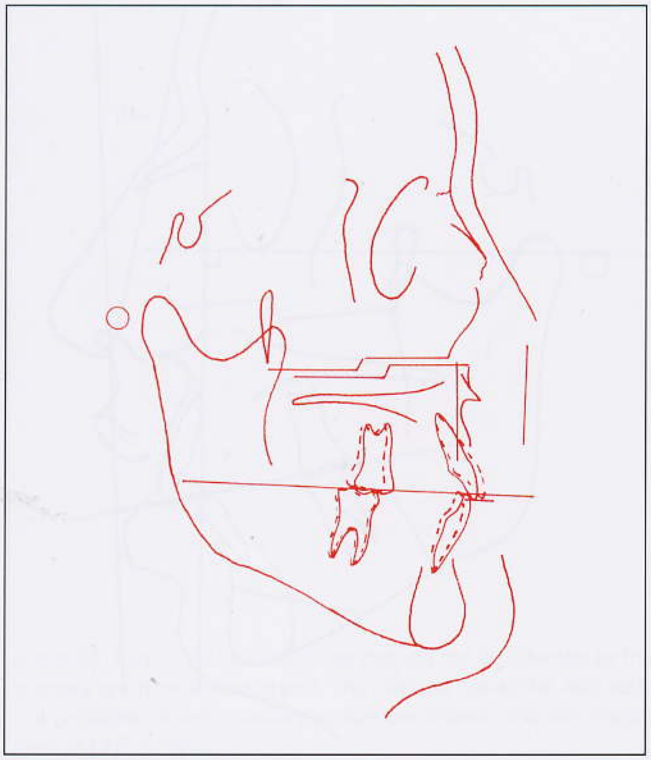


Fig 3-48 Step 3. Prediction of incisor and molar positions. Note the Class II molar relationship.

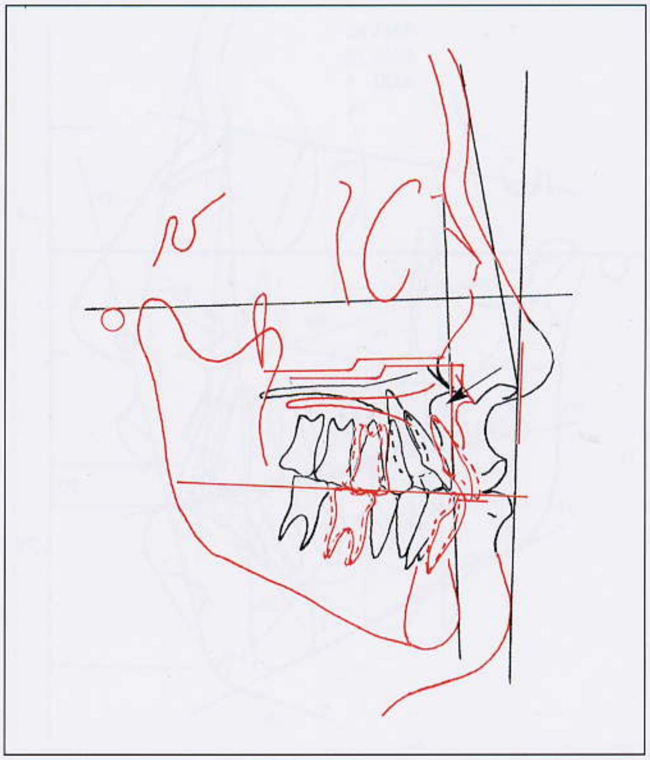


Fig 3-49 By comparing the position of A-point on the prediction tracing and the original tracing *(arrow)*, the amount of bone advancement can be seen (6.5 mm in this case).

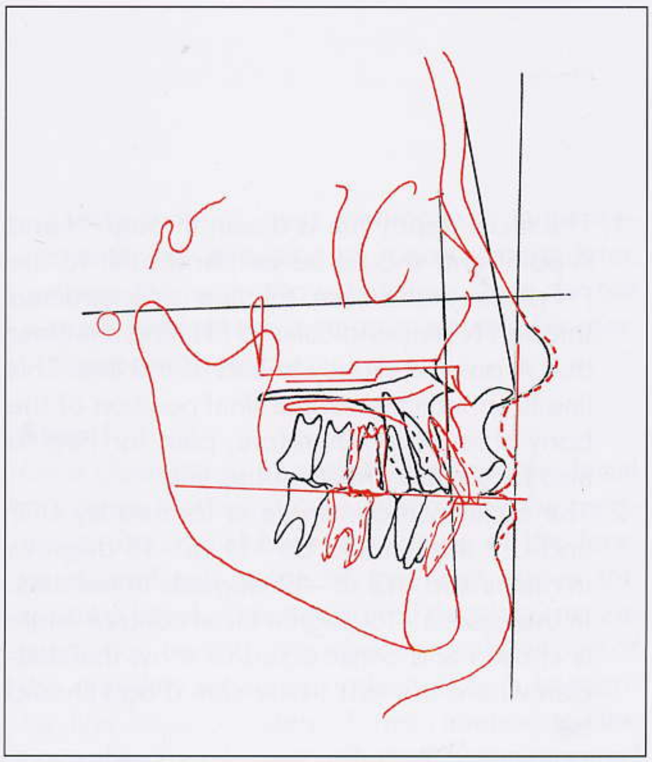


Fig 3-50 Soft tissue prediction.

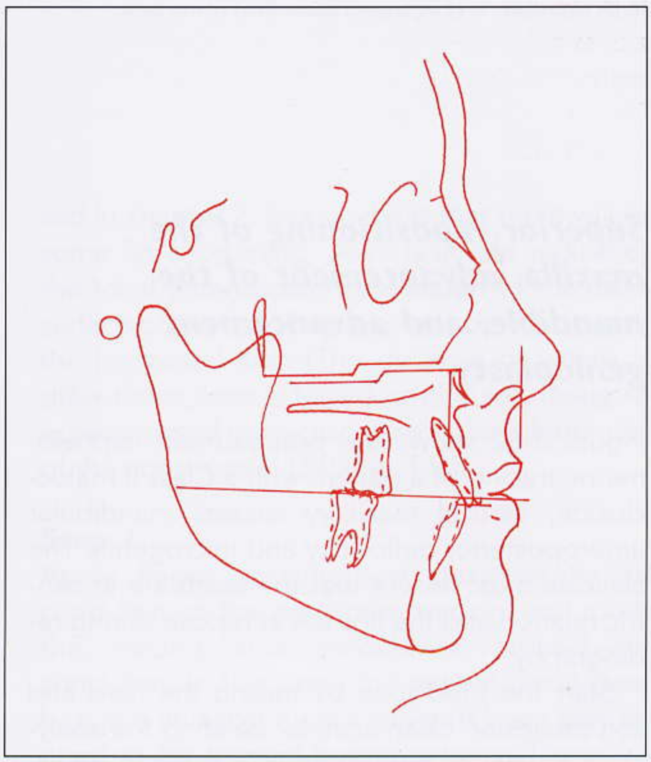


Fig 3-51 Completed pretreatment prediction.

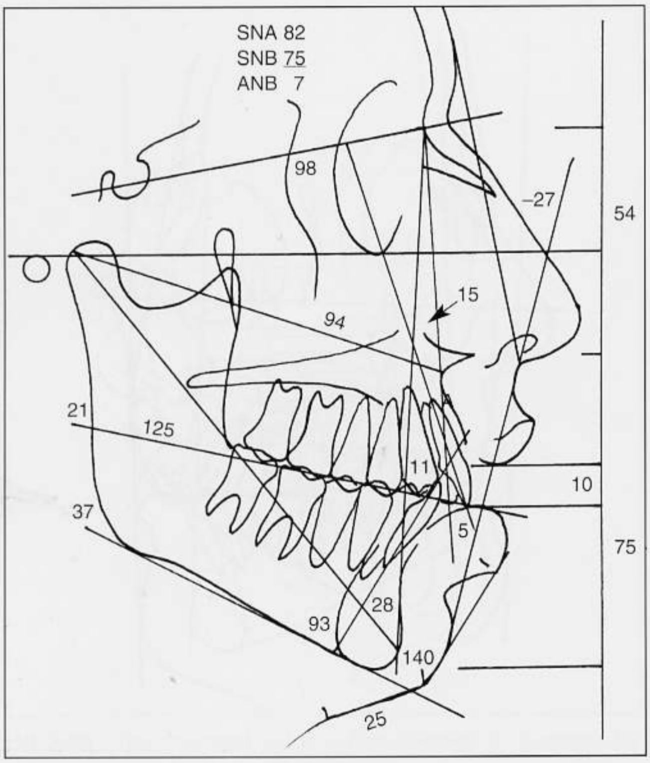


Fig 3-52 Pretreatment cephalometric tracing of a 16-year-old male patient with the following diagnostic summary. Skeletal: vertical maxillary excess and mandibular anteroposterior deficiency. Dental: Class II malocclusion and accentuated curve of Spee. Soft tissue: increased interlabial gap, excessive maxillary incisor tooth exposure, and increased lower third of the face.

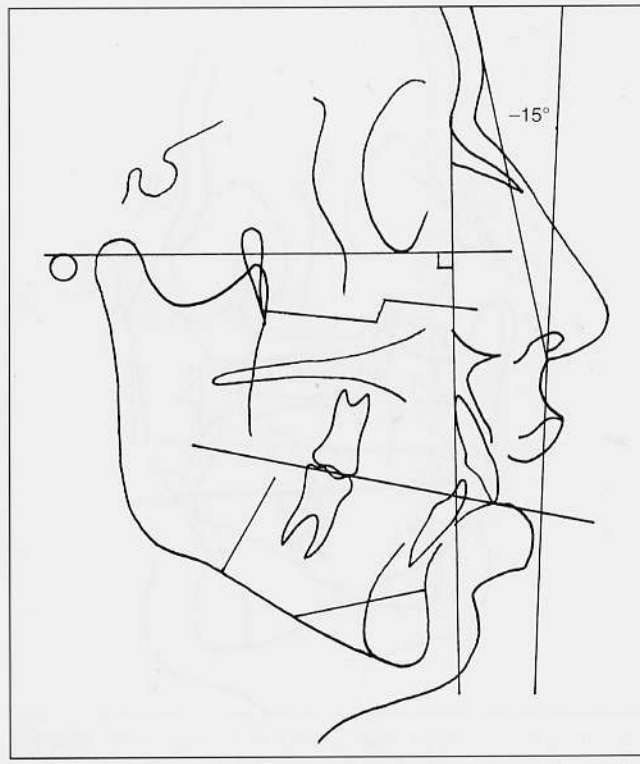


Fig 3-53 The facial depth line and the facial contour angle on the original tracing will act as cephalometric guidelines to evaluate the horizontal position of the maxilla and soft tissue pogonion and to plan the required position of A-point and the soft tissue of the chin, respectively.

Superior repositioning of the maxilla, advancement of the mandible, and advancement genioplasty

Figure 3-52 shows the pretreatment cephalometric tracing of a patient with a Class II malocclusion, vertical maxillary excess, mandibular anteroposterior deficiency and microgenia. The clinician must ensure that the teeth are in centric relation and the lips are in repose during radiography.

Start the prediction by tracing the hard and soft tissues on clean acetate, deleting the analysis lines (the original tracing). To assist in developing the prediction, construct the following lines and angles on the original tracing (Fig 3-53):

1. The facial depth line is drawn through N and A-point and should be perpendicular to the FH plane. In this case, the line is constructed through N perpendicular to FH, and it is clear that A-point is slightly ahead of the line. This line is an indicator of the final position of the bony chin (Pog). Therefore, plan for Pog to also be slightly ahead of this line.
2. The facial contour angle is formed by UFP and LFP and should be –11 to –15 degrees in males and –13 to –17 degrees in females. In this case, a –15-degree facial contour angle is chosen and constructed to show the clinician where the soft tissue chin (Pog') should be.
3. This case will benefit from a Le Fort I maxillary osteotomy (superior repositioning), a bilateral sagittal split mandibular osteotomy

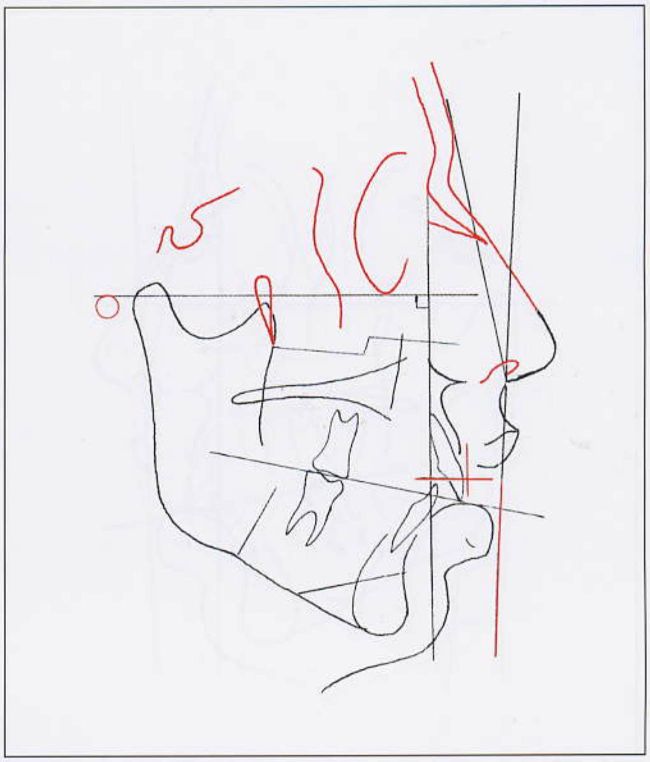


Fig 3-54 Step 1. All the structures that will not be affected by the surgery are now traced in red. The desired horizontal and vertical positions of the maxillary incisor are drawn, and the inferior part of LFP is traced.

(advancement), and genioplasty (advancement). For accuracy of measurement later, draw the osteotomy lines as close to the areas where the osteotomies will be performed as possible.

Step 1

On a clean piece of acetate, trace all the facial structures that will not be affected by the treatment: the cranial base, soft tissue of the forehead, and soft tissue of the nose above the supratip break. This tracing will develop into the prediction tracing. The ideal vertical position of the maxillary incisors is indicated by a horizontal line approximately 3 mm inferior to the upper lip. This decision is based on the required amount of incisor exposure under the upper lip after maxillary superior repositioning, as discussed in chapter 2. Bear in mind that there will be some lip shortening. A vertical line indicating the ideal anteroposterior position of the labial surface of the maxillary incisor is drawn crossing the horizontal line. (The decision of where to draw these lines is based on the soft tissue requirements of each case.) Trace the inferior part of the constructed LFP (Fig 3-54).

Step 2

Apply finger pressure just posterior to the condylion on the prediction tracing, and rotate the tracing counterclockwise around the condylion. In this case, the patient has a deep bite and an accentuated curve of Spee that will need to be leveled before surgery. Therefore, the maxillary occlusal plane will be the occlusal plane of choice.

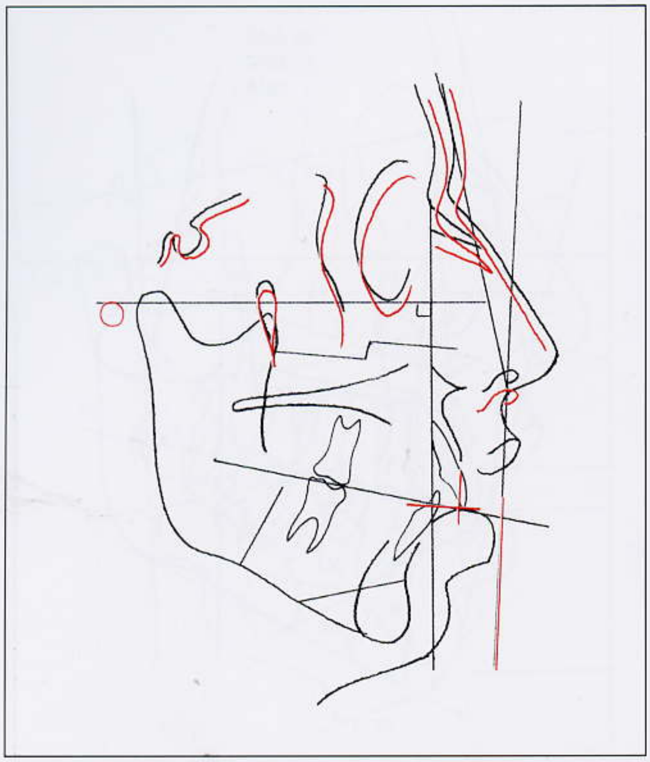


Fig 3-55 The maxillary incisor is now in the ideal vertical position; however, it is still slightly ahead of the chosen horizontal position.

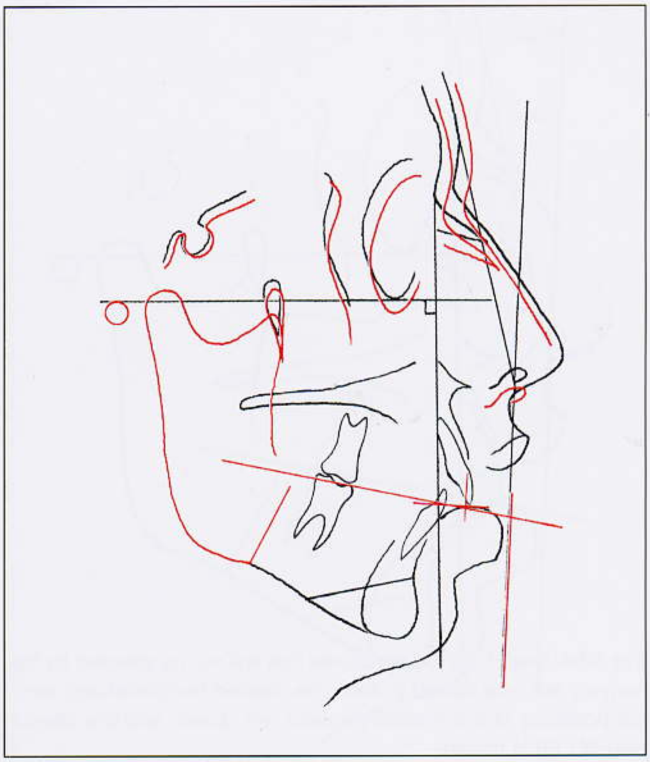


Fig 3-56 The mandibular ramus has autorotated and is traced in.

Rotate the tracing until the maxillary incisor is tangent to the horizontal line (Fig 3-55). Draw the mandibular ramus proximal to the vertical osteotomy line, as well as the maxillary occlusal plane (Fig 3-56).

Step 3

Slide the prediction tracing to the left along the occlusal plane until the soft tissue of the chin (Pog') is tangent to the predicted LFP. After careful study of the distal section of the mandible on the original tracing in relation to the prediction tracing, three observations can be made (Fig 3-57):

1. The mandibular incisor is ahead of the vertical line, indicating the desired labial surface of the maxillary incisor.
2. The mandibular incisor edge is 3 mm above the horizontal line, indicating the vertical position of the maxillary incisor edge.
3. The vertical osteotomy line is 8 mm ahead of the osteotomy line on the original tracing, indicating that an 8-mm surgical advancement is required to achieve the predicted chin position.

The clinician has the following options:

1. *Retraction of the mandibular incisors.* In this case, the angle of the mandibular incisors is acceptable. Any retraction will make the teeth very upright and require extraction of teeth.
2. *Leveling the curve of Spee.* This option will increase the mandibular arch length and thus necessitate slight advancement of the mandibular incisors. Extraction of teeth may be indicated.
3. *Less advancement of the mandible.* This option will compromise the esthetics.
4. *Less advancement of the mandible combined with an advancement genioplasty.* The patient has a small chin and a large, everted lower lip. An advancement of the chin will benefit the patient.

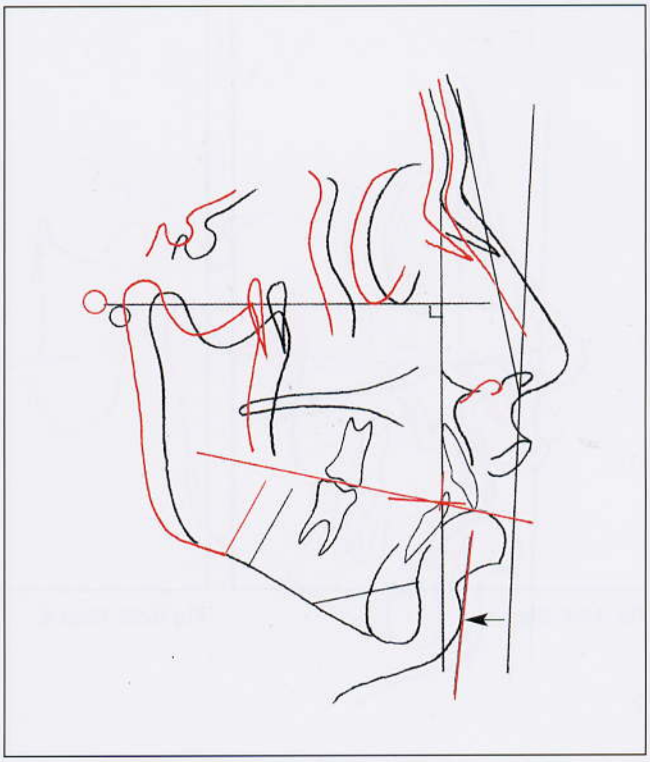


Fig 3-57 Step 3. The prediction tracing is moved to the left along the occlusal plane. Pog' is now tangent to the predicted LFP *(arrow)*. Note that the mandibular incisor is ahead of the vertical line, indicating the desired anteroposterior position of the maxillary incisor; the mandibular incisor is 3 mm above the horizontal line, indicating the desired vertical position of the maxillary incisor edge; and an 8-mm mandibular advancement is necessary to achieve the predicted chin position.

From the above considerations, it is clear that the best option is to level the mandibular arch without tooth extractions. The mandibular incisors will move slightly forward. Advance the mandible less, and combine the mandibular surgery with an advancement genioplasty. To test the decision, follow Steps 4 through 9.

Step 4

Lay a clean piece of acetate over the original tracing. Trace the distal part of the mandible anterior to the vertical osteotomy. Do not trace the mandible inferior to the genioplasty line. Trace the soft tissue chin below the depth of the labiomental fold using a dotted line. The curve of Spee will be leveled before surgery (for reasons discussed previously). Trace the maxillary occlusal plane. The first molar is extruded and the incisor intruded and moved slightly labially to facilitate leveling of the mandibular arch. This tracing is called the *mandibular tracing* (Fig 3-58).

Step 5

Superimpose the prediction tracing on the mandibular tracing, and slide the prediction tracing to the left along the occlusal plane until the mandibular incisors are positioned 1 mm to the left of the vertical line. This will allow the maxillary incisors to fit in between the mandibular incisor and the vertical line, indicating the labial surface of the maxillary incisor. The dotted line indicating the soft tissue of the chin is behind the predicted LFP, indicating the need for an advancement genioplasty (Fig 3-59).

Step 6

Trace the distal part of the mandible (the mandibular tracing) on the prediction tracing. The amount of surgical advancement is indicated by the distance between the two vertical osteotomy lines (Fig 3-60).

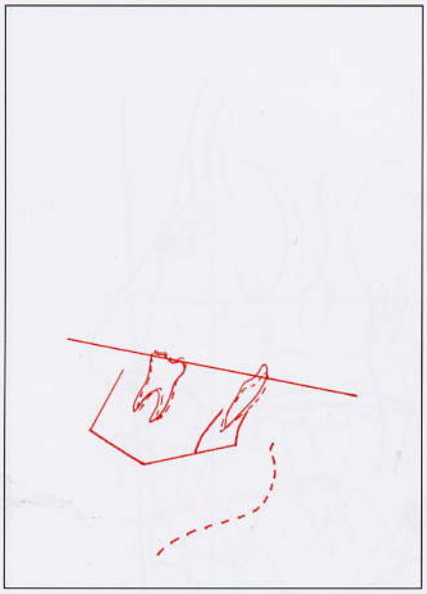


Fig 3-58 Step 4.

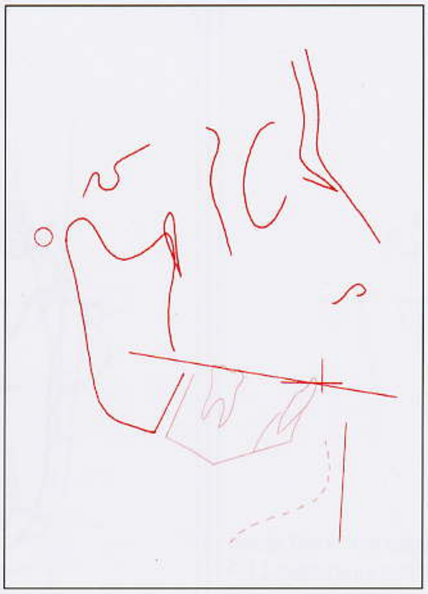


Fig 3-59 Step 5.

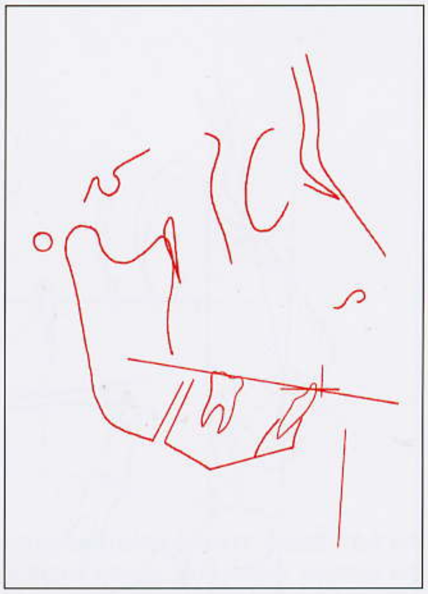


Fig 3-60 Step 6.

Step 7
Superimpose the prediction tracing on the original tracing with the occlusal planes coinciding and the first molars in a Class I relationship. The increased overjet of the incisors is clear (Fig 3-61). The clinician now must determine whether retraction of the maxillary incisors to achieve an ideal incisal relationship is possible. In this case, it was found to be a feasible option. Now trace the maxillary incisor in its ideal relationship to the mandibular incisor, then trace the Le Fort I osteotomy line (Fig 3-62). These two lines indicate the maxillary superior repositioning (it is typical that the superior movement is more in the anterior region than the posterior region). Figure 3-63 illustrates the prediction tracing at this stage, with no soft tissue prediction below the subnasale and the unfinished genioplasty. The LFP indicates the required anteroposterior position of the soft tissue chin.

Step 8
The next step is prediction of the upper lip and nasal tip. Superimpose the prediction tracing and the original tracing with unaffected tissues coinciding. Draw the upper lip using the original lip position as a guide, bearing in mind that there will be lip shortening (10% to 20% of total maxillary superior repositioning). The subnasale would move slightly forward, and the lip curve would fill out. The tip of the nose below the supratip break will advance slightly (Fig 3-64).

Step 9
To predict the hard and soft tissue chin and the lower lip, lay the prediction tracing over the original tracing with the mandibular skeletal tissues. Slide the prediction tracing to the left along the genioplasty osteotomy line until the soft tissue of the chin (dotted line) is tangent to the LFP line (Fig 3-65). Trace the soft tissue of the chin below the depth of the labiomental fold, as well as the hard tissue below the genioplasty osteotomy line. Draw the lower lip, bearing in mind that the effect of the maxillary incisors on the lower lip is eliminated. The lip will rotate backward, reducing the vermilion exposure (Fig 3-66).

Figure 3-67 illustrates the final visual treatment prediction of hard and soft tissue.

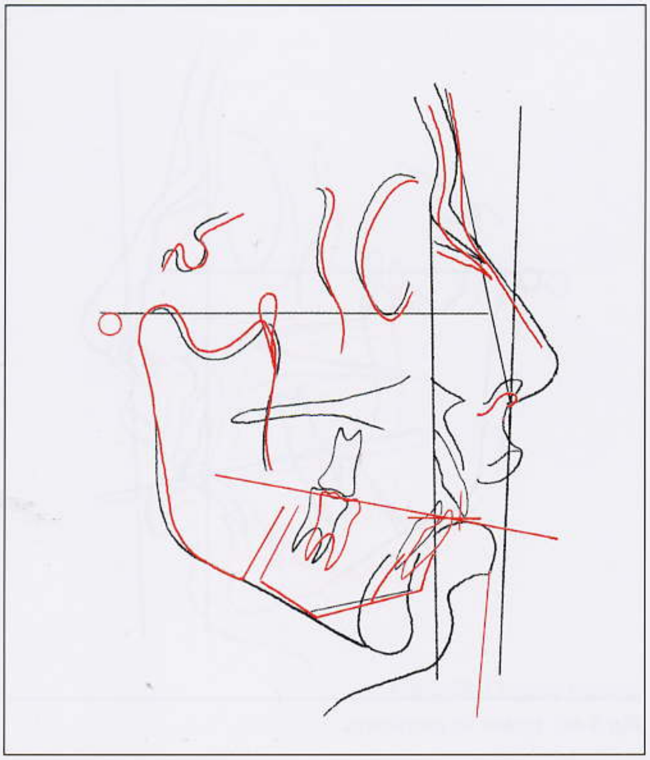


Fig 3-61 The maxillary incisor is 2 mm ahead of the vertical line.

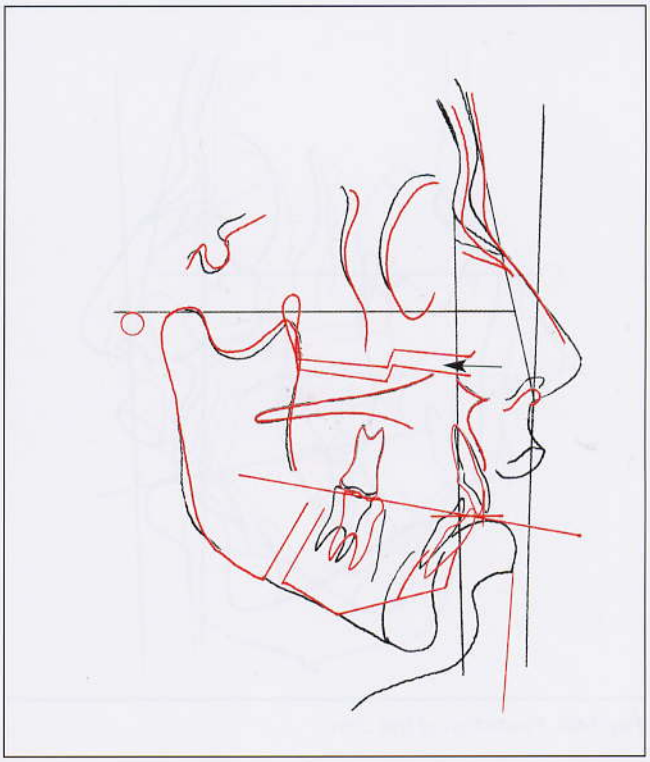


Fig 3-62 The amount of superior repositioning of the maxilla is indicated by the distance between the two Le Fort I osteotomy lines *(arrow)*.

Fig 3-63 The soft tissue of the nasal tip, the upper lip, the sliding genioplasty, and the soft tissue of the chin must still be predicted.

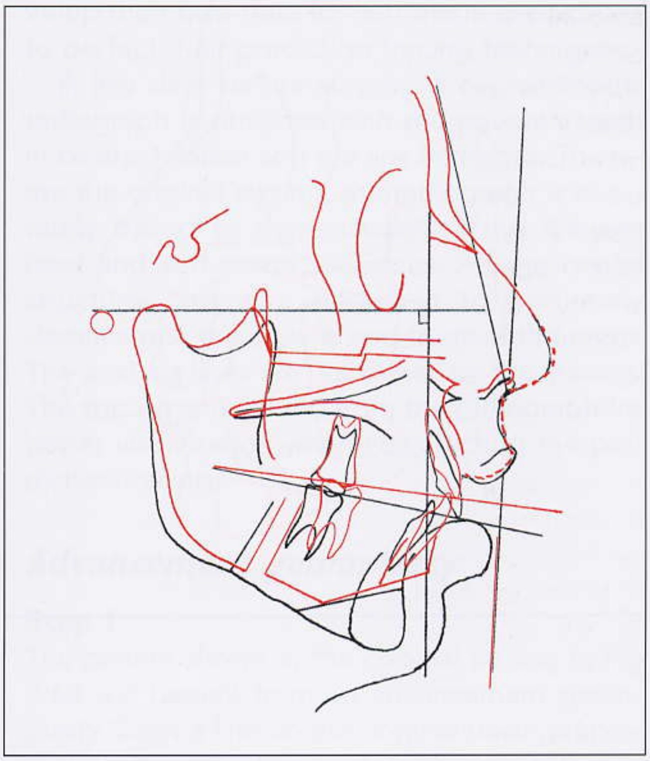


Fig 3-64 Prediction of the nasal tip and upper lip.

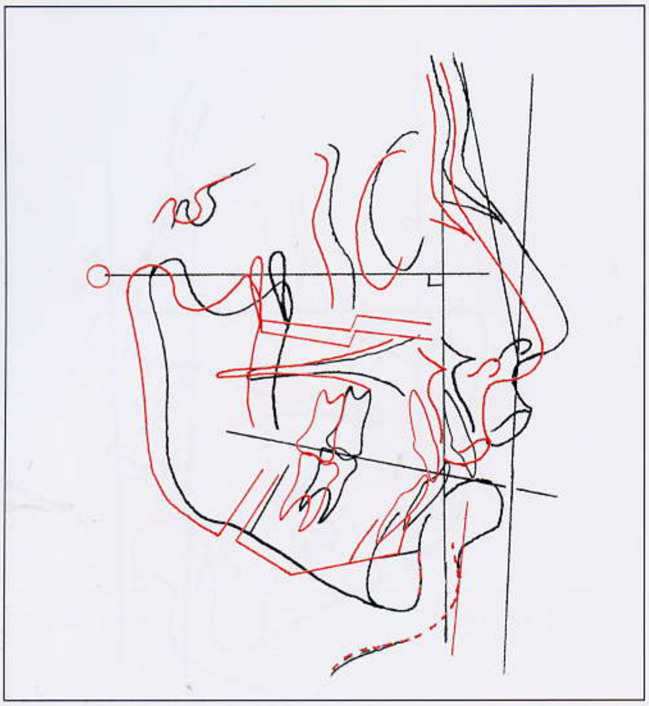


Fig 3-65 Prediction of the chin.

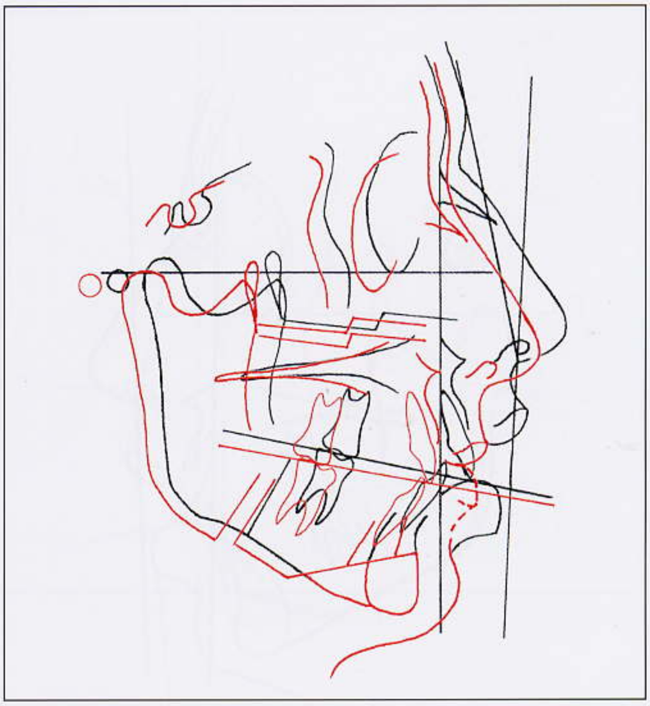


Fig 3-66 Lower lip prediction.

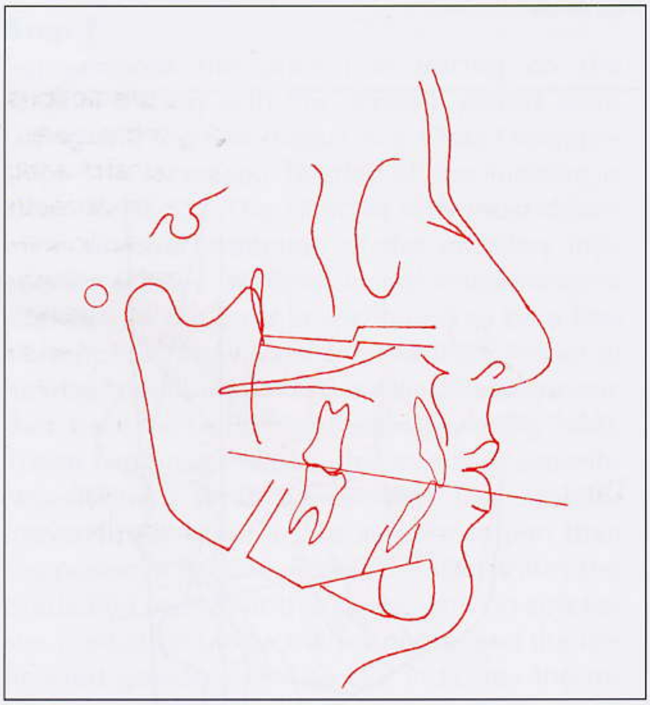


Fig 3-67 Completed treatment objective.

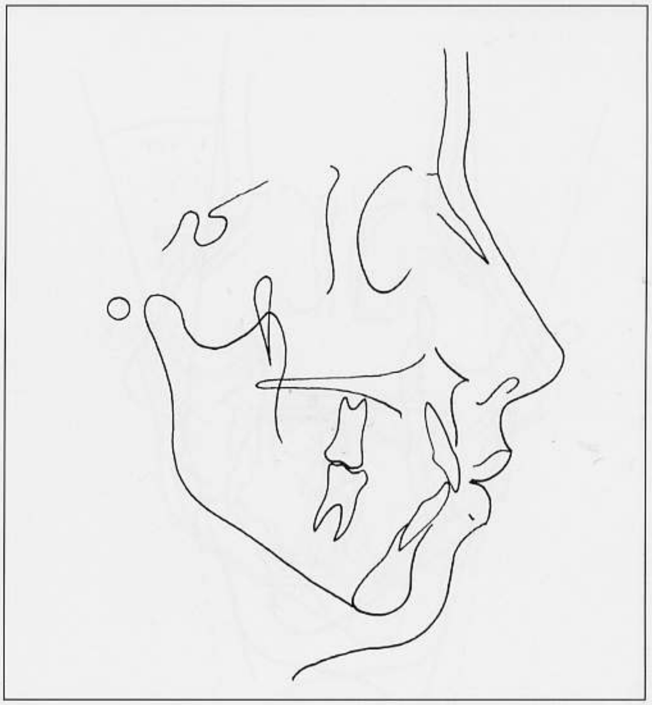


Fig 3-68 Original tracing.

Final surgical visual treatment prediction

The surgical visual treatment objective is based upon the immediate preoperative cephalometric radiograph (the preoperative orthodontic preparation is now completed) and will accurately determine the skeletal surgical movements necessary to achieve the functional and esthetic treatment goals. The visual treatment objective can also be used after surgery to check whether the predicted surgical results have been achieved.

Because of the extreme diversity of surgical procedures and the combination of procedures employed in the surgical correction of dentofacial deformities, it is impossible to illustrate the method of developing the cephalometric prediction tracing for every conceivable deformity. By creating the visual treatment predictions through trial and error and comparing the actual soft and hard tissue treatment results with the predicted results, surgeons will develop their own data for soft tissue predictions to perfect their prediction tracing techniques.

A few days before surgery, a cephalometric radiograph is obtained with the patient's teeth in centric relation and the lips in repose. To create the original tracing, the radiograph is accurately traced to demonstrate all the relevant hard and soft tissue structures. All the dental structures are also traced in to accurately demonstrate the crowns and roots of the teeth. The analysis lines are not drawn on this tracing. The tracing is removed from the radiograph for better visualization when constructing the prediction tracing.

Advancement genioplasty

Step 1
The patient shown in the original tracing in Fig 3-68 will benefit from an advancement genioplasty. Draw a line on the original tracing representing the osteotomy cut on the chin. Bear in mind anatomic structures, such as the mental foramen and roots of the teeth. Also remember

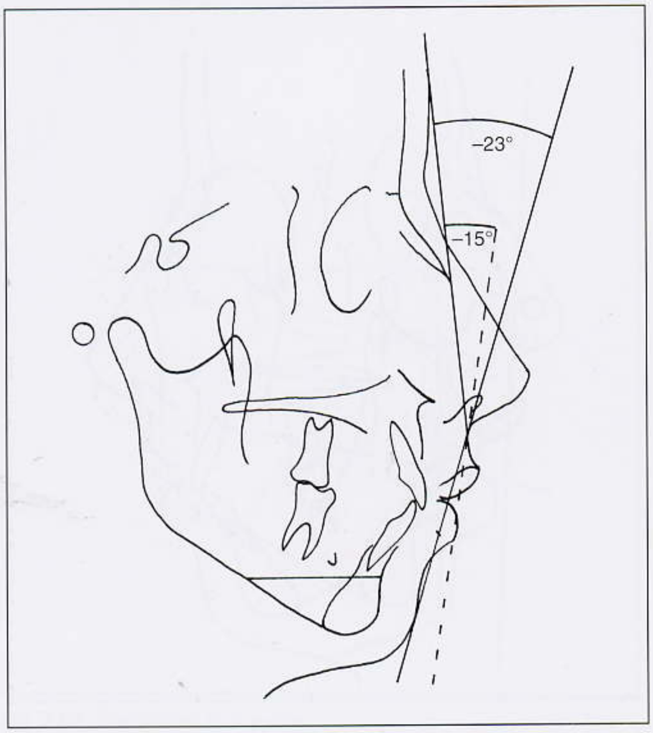


Fig 3-69 No vertical change of the anterior mandibular vertical height is required. The osteotomy for genioplasty is therefore made horizontal.

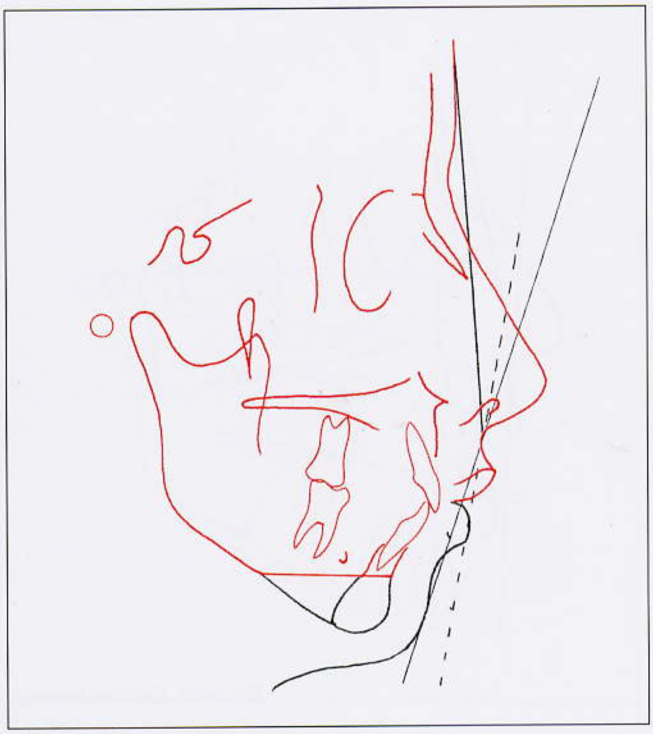


Fig 3-70 Step 2. All structures that will not be affected by the surgery are traced in red.

that the angle at which the osteotomy is performed will influence the vertical dimension of the chin as it is advanced (see chapter 5). Draw the facial contour angle formed by the upper and lower facial planes. Construct a predicted lower facial plane (in this case, an angle of –15 degrees to the upper facial plane is chosen) using dotted lines (Fig 3-69).

Step 2

Lay a clean sheet of acetate over the original tracing. Trace the osteotomy line and all skeletal and soft tissue structures that will remain unchanged by the surgical procedure—in this case, everything above the genioplasty line. This tracing is called the *prediction tracing* (Fig 3-70).

Step 3

The clinician, guided by all the available references for the ideal soft tissue position of the chin (in this case, the facial contour angle is used) and an artistic sensibility, draws the soft tissue chin on the prediction tracing (Fig 3-71).

Step 4

The prediction tracing is now moved toward the left until the original tracing's soft tissue chin line is tangent to, or just ahead of, the prediction tracing's soft tissue chin line (soft tissue change to hard tissue movement is 90% to 100%). Trace the skeletal change as superimposed on the original tracing (Fig 3-72). Vertical changes can now be made where indicated (eg, ostectomy to vertically shorten the chin, downgrafting for vertical increase, or changing the angulation of the osteotomy so that the chin will slide superiorly when advanced or slide more horizontally when reduced). The skeletal advancement can be measured and recorded on the completed prediction tracing (Fig 3-73).

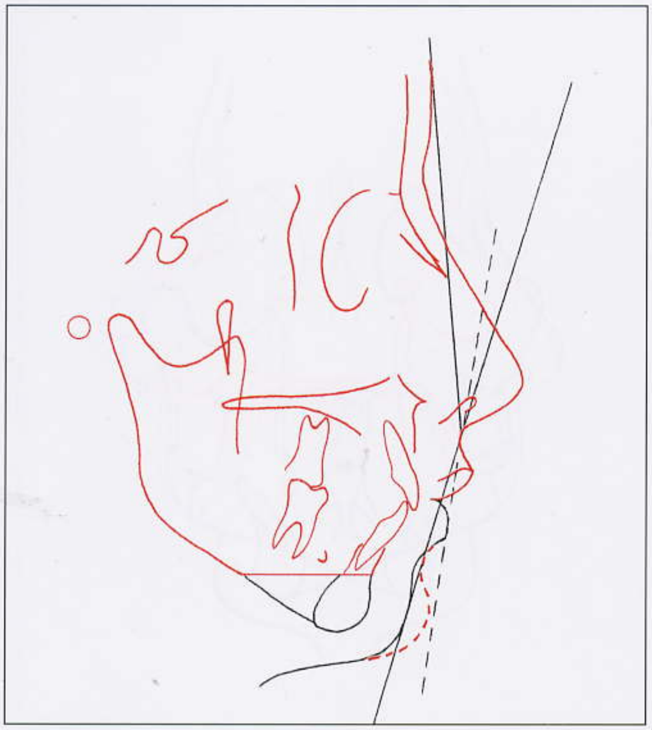


Fig 3-71 Step 3. Soft tissue prediction.

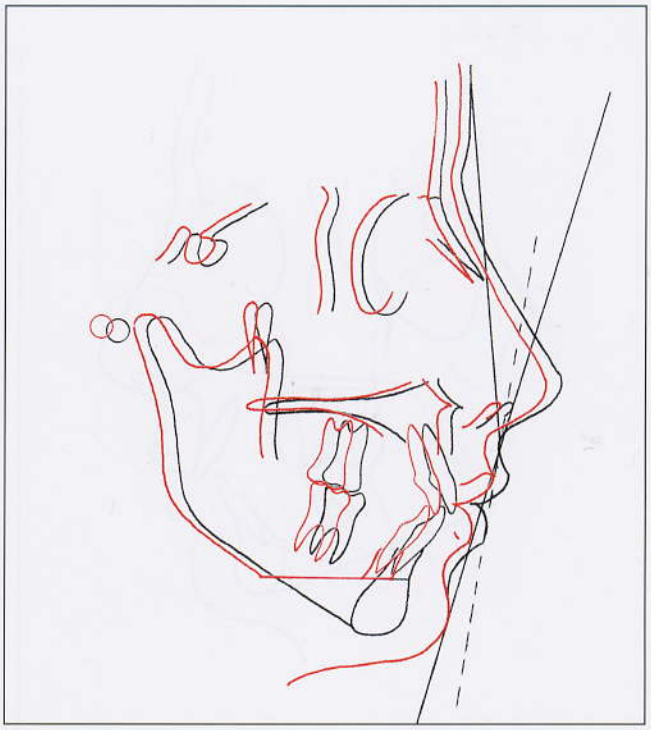


Fig 3-72 Step 4. Hard tissue prediction.

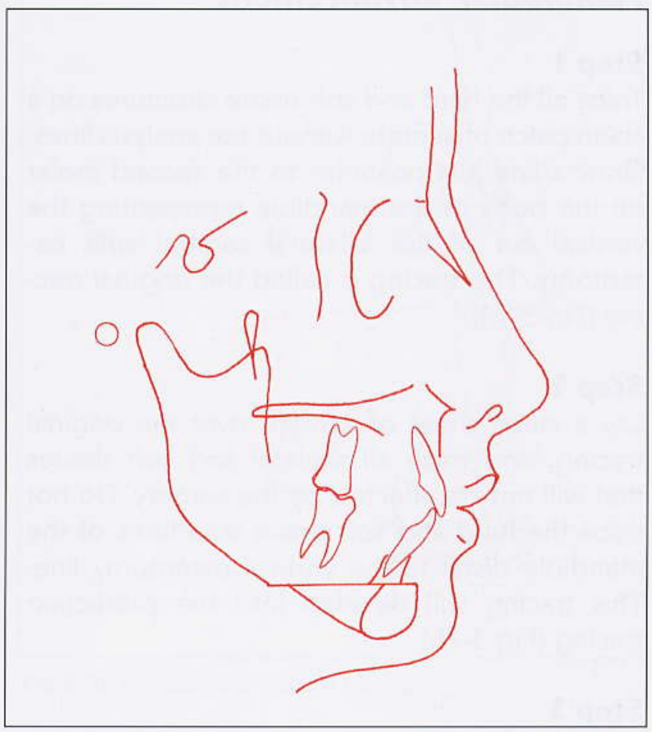


Fig 3-73 Completed prediction tracing.

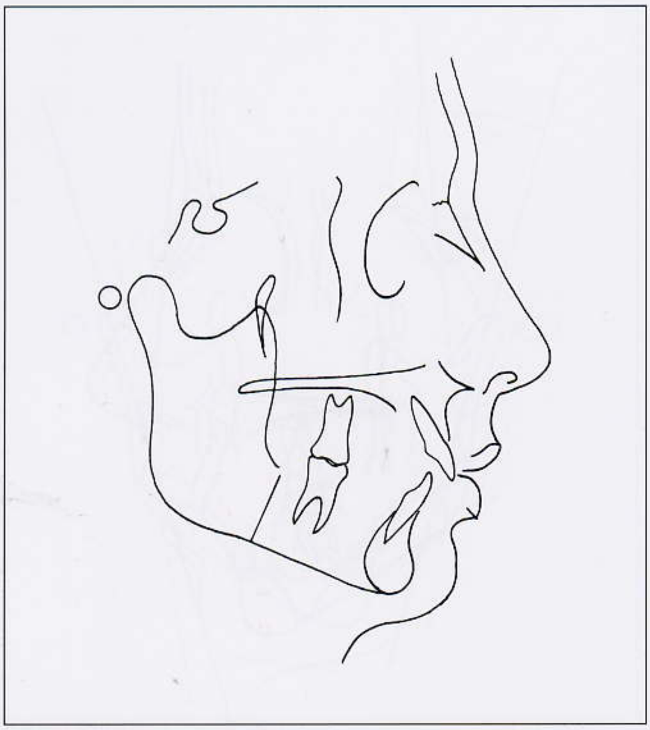


Fig 3-74 Original tracing of a patient requiring advancement of the mandible.

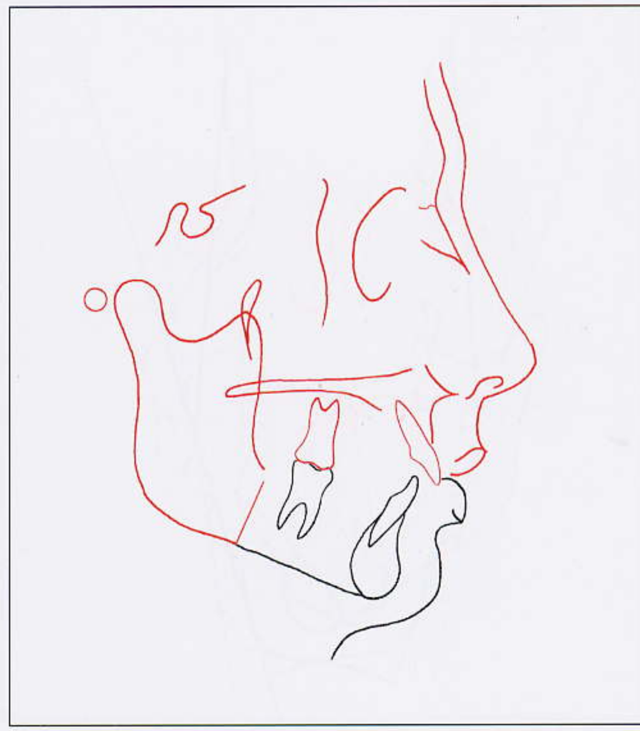


Fig 3-75 Step 2. All structures that will not be affected by the surgery are traced in red.

Mandibular advancement

Step 1

Trace all the hard and soft tissue structures on a clean piece of acetate without the analysis lines. Draw a line just posterior to the second molar on the body of the mandible representing the vertical cut of the bilateral sagittal split osteotomy. This tracing is called the *original tracing* (Fig 3-74).

Step 2

Lay a clean sheet of acetate over the original tracing, and trace all skeletal and soft tissues that will not be affected by the surgery. Do not trace the hard and soft tissue structures of the mandible distal to the vertical osteotomy line. This tracing will develop into the prediction tracing (Fig 3-75).

Step 3

Slide the prediction tracing to the left (the original tracing structures will move to the right). Position the mandibular teeth of the original tracing in the best interincisal and molar relationship with the maxillary teeth on the prediction tracing (Fig 3-76). Trace the mandibular skeletal structures and the teeth. Also trace the soft tissue of the chin below the labiomental fold (the pogonion response to hard tissue advancement is 0.9:1.0 to 1:1) (Fig 3-77).

Step 4

Now trace the lower lip. As a guide, use the available knowledge of the soft tissue response to hard tissue changes (Fig 3-78). The labiomental fold flattens. The lower vermilion advances 75% (66% to 100%) of horizontal skeletal movement. The effect of the maxillary incisor on the lower lip is now removed, and the lower lip will curl back, reducing the vermilion exposure. Figure 3-79 shows the completed prediction. The amount of mandibular advancement can be determined by measuring the distance between the two vertical osteotomy lines.

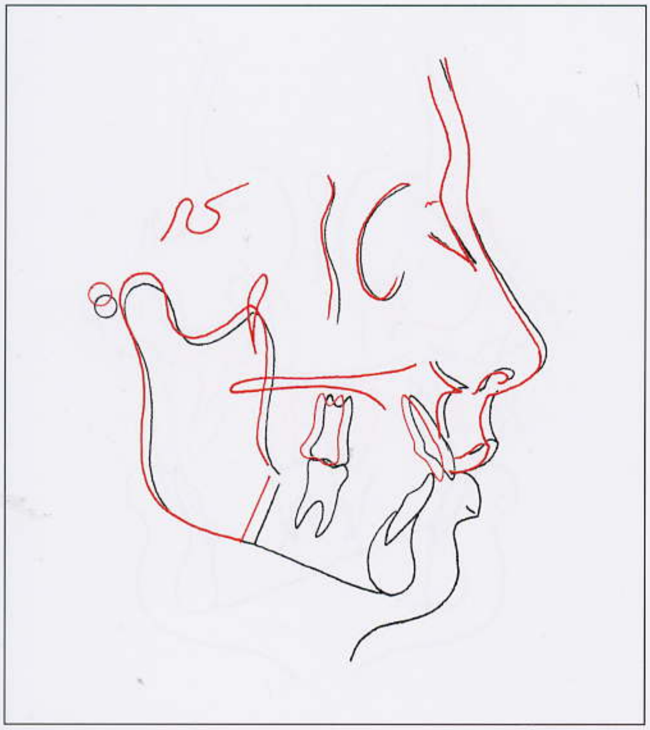


Fig 3-76 The mandibular teeth on the original tracing are now in a Class I molar relationship and in the ideal incisor overbite and overjet with the maxillary teeth on the prediction tracing.

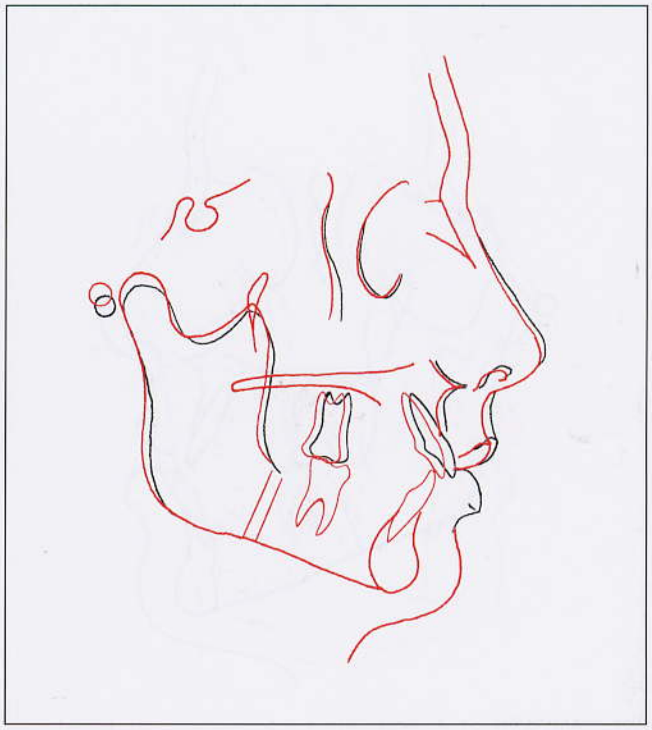


Fig 3-77 Step 3. The mandibular skeletal structures and teeth and the soft tissue of the chin below the labiomental fold are traced.

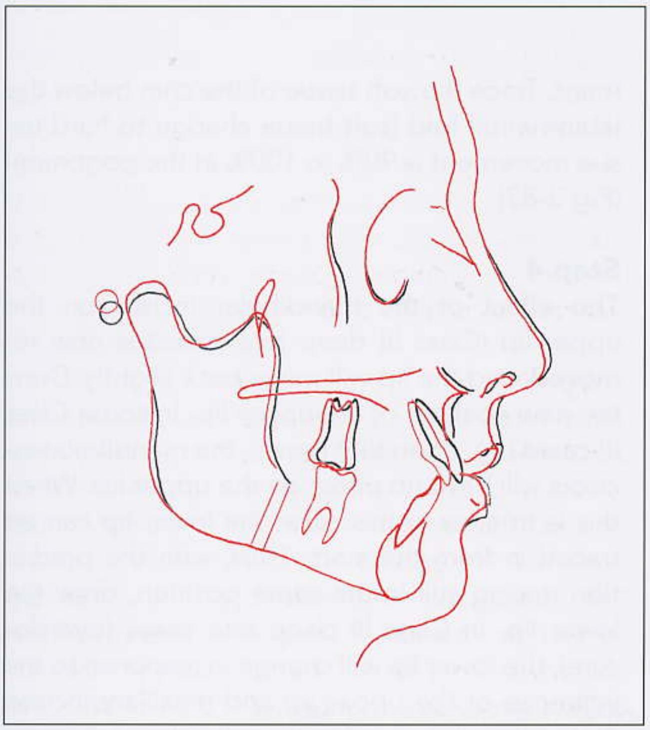


Fig 3-78 Step 4. The everted lower lip will rotate back as the effect of the maxillary incisor is eliminated.

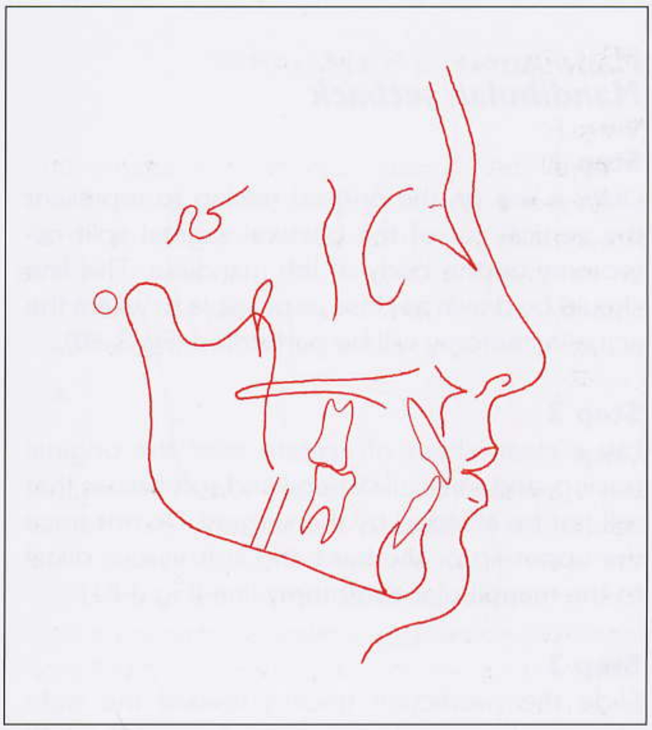


Fig 3-79 Completed prediction tracing.

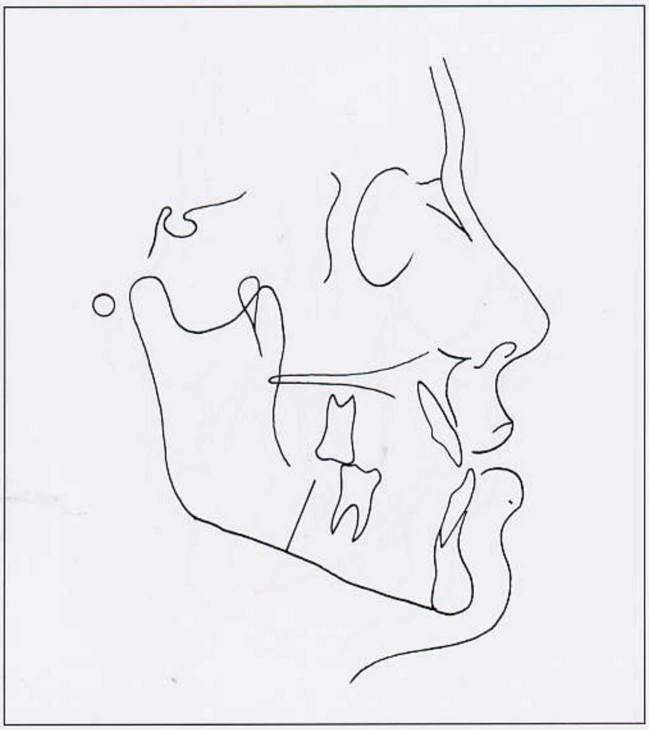


Fig 3-80 Original tracing of a patient with a Class III malocclusion. The surgical treatment plan consists of a mandibular setback procedure.

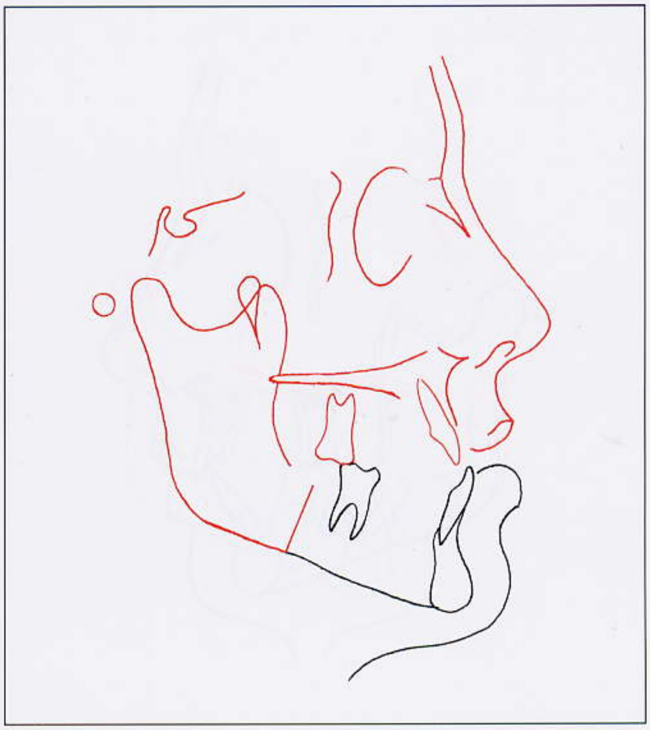


Fig 3-81 Step 2. All structures that will not be affected by the surgery are traced in red.

Mandibular setback

Step 1

Draw a line on the original tracing to represent the vertical cut of the bilateral sagittal split osteotomy on the body of the mandible. This line should be drawn as close as possible to where the actual osteotomy will be performed (Fig 3-80).

Step 2

Lay a clean sheet of acetate over the original tracing, and trace all skeletal and soft tissues that will not be affected by the surgery. Do not trace the upper lip or the hard and soft tissues distal to the mandibular osteotomy line (Fig 3-81).

Step 3

Slide the prediction tracing toward the right (the distal mandible will move toward the left) until the best interincisal and molar relationship is achieved (Fig 3-82). Trace the skeletal tissue, as well as the osteotomy line of the distal segment. Trace the soft tissue of the chin below the labiomental fold (soft tissue change to hard tissue movement is 90% to 100% at the pogonion) (Fig 3-83).

Step 4

The effect of the mandibular incisor on the upper lip (Class III deep bite cases) is now removed, and the lip will move back slightly. Draw the new position of the upper lip. In some Class III cases (eg, open bite cases), the mandibular incisors will have no effect on the upper lip. When this is true, as in this case, the lower lip can be traced in from the start. Thus, with the prediction tracing still in the same position, draw the lower lip. In Class III deep bite cases (overclosure), the lower lip will change in response to the influence of the upper lip and maxillary incisor. The amount of mandibular setback can now be determined on the completed prediction tracing by measuring the distance between the two vertical osteotomy lines (Fig 3-84).

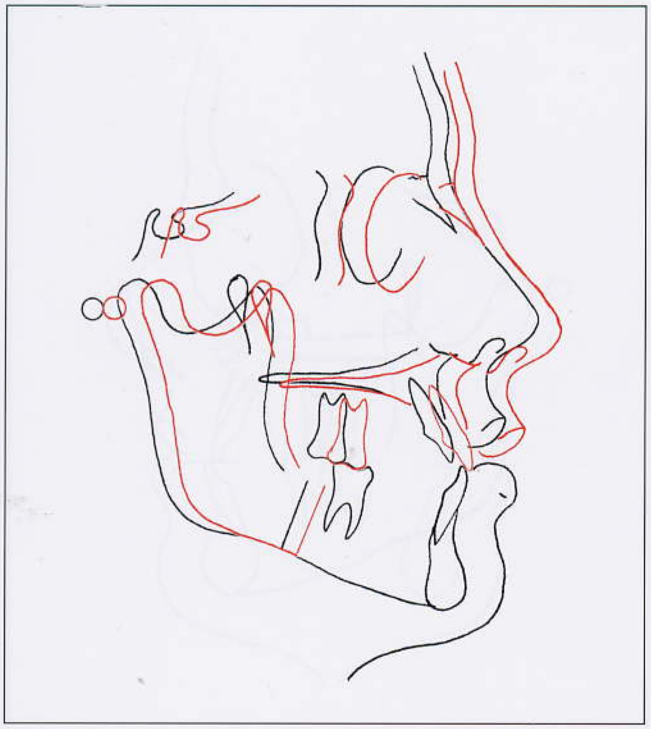


Fig 3-82 The mandibular teeth on the original tracing have a Class I molar relationship and ideal incisal relationship with the maxillary teeth on the prediction tracing.

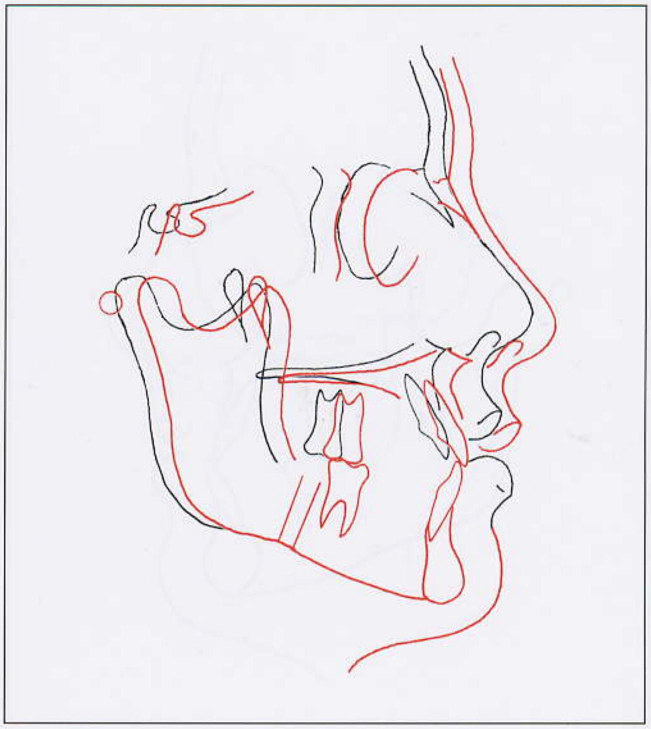


Fig 3-83 Step 3.

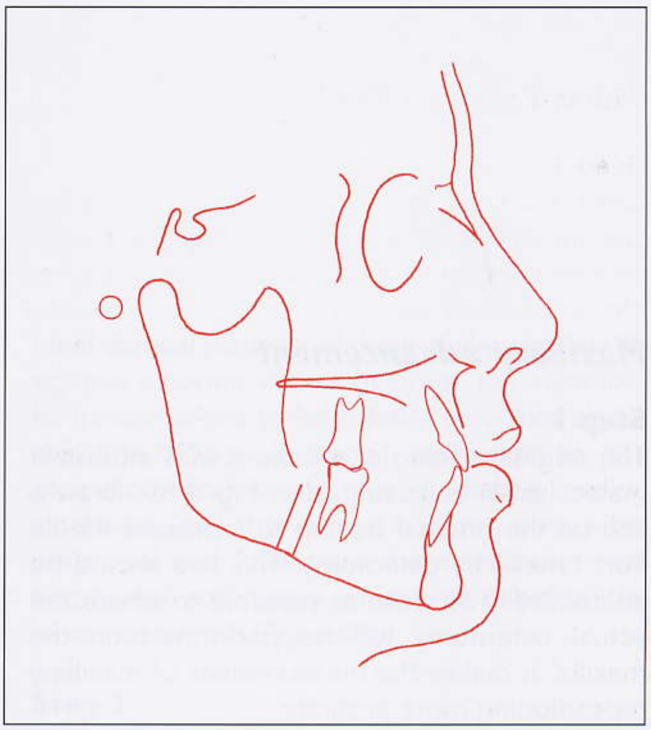


Fig 3-84 Completed prediction tracing.

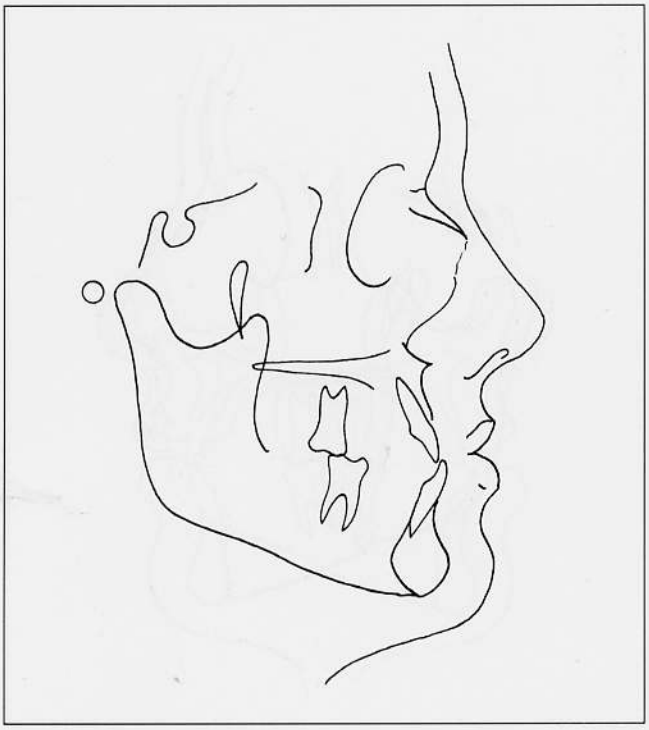


Fig 3-85 The original tracing of a patient who will benefit from an advancement of the maxilla for the correction of a Class III malocclusion.

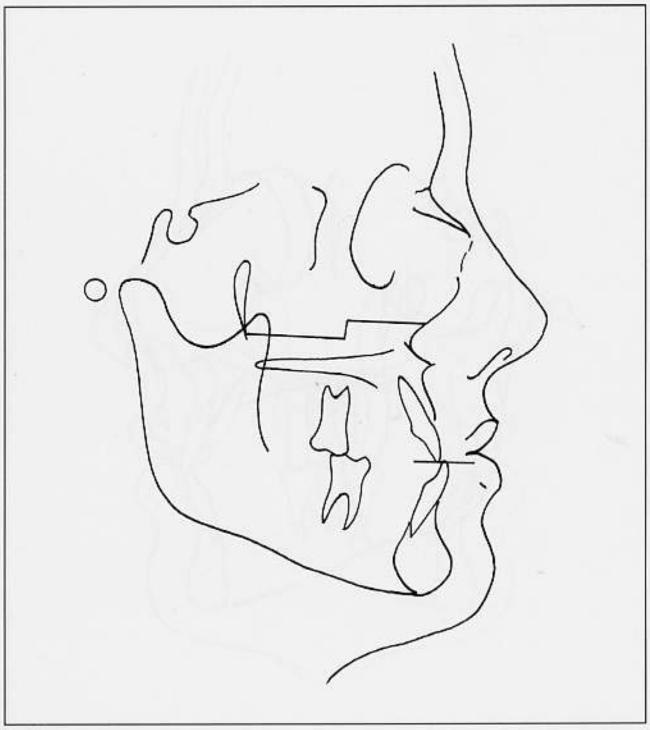


Fig 3-86 Step 1. The Le Fort I osteotomy line is drawn and the desired height of the maxillary incisor indicated.

Maxillary advancement

Step I

The original tracing of a patient with a Class III malocclusion is illustrated in Fig 3-85. Draw a line on the original tracing to represent the Le Fort I maxillary osteotomy. This line should be anatomically as close as possible to where the actual osteotomy will be performed on the maxilla. It makes the measurement of maxillary repositioning more accurate.

The line should be parallel to the occlusal plane of the maxilla so that the maxilla will be advanced along this plane. If the line is angled upward, the height of the maxilla will be reduced; if bone contact is maintained, the bite will open anteriorly. If the line is angled inferiorly, the maxilla will slide downward. In a Le Fort I advancement procedure, the final anteroposterior position of the maxilla is dictated by the mandibular dentition. However, the vertical position of the maxilla is controlled by the surgeon. The mandible will autorotate (clockwise subsequent to an increase in the maxillary height and counterclockwise subsequent to superior repositioning of the maxilla). The clinician can therefore decide on the final vertical position of the maxillary central incisor based on the ideal tooth-lip relationship. Draw a horizontal line in the incisor region indicating the ideal ver-

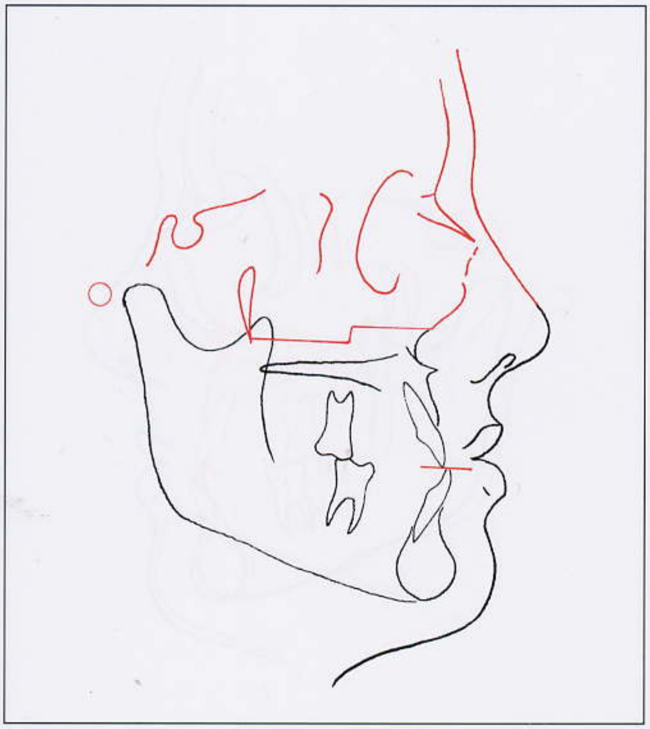


Fig 3-87 Step 2. All structures that will not be affected by the surgery are traced in red. The horizontal line representing the desired vertical position of the maxillary incisor edge is also drawn.

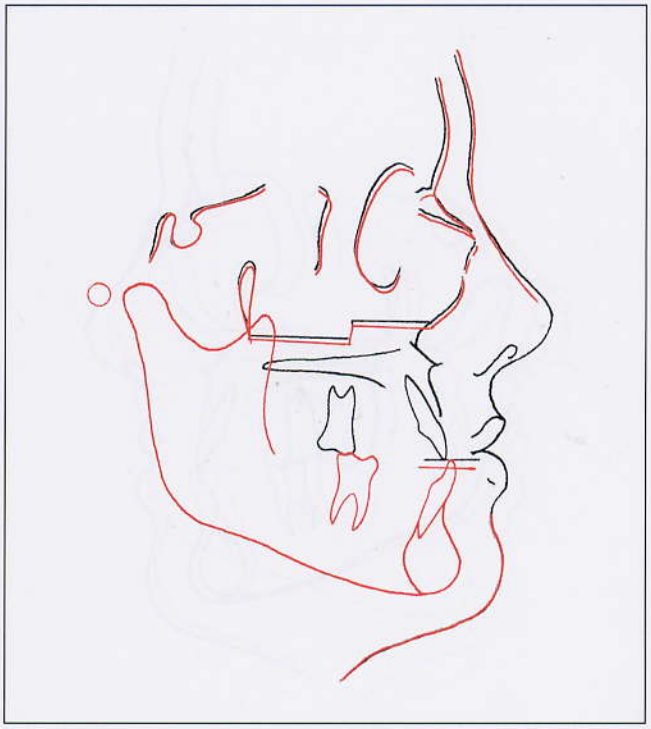


Fig 3-88 The prediction tracing is rotated around the condylion until the mandibular incisor edge is 2 mm above the horizontal line. This projection represents the incisor overbite.

tical position of the maxillary incisor. In this case, the existing height of the maxilla will be maintained (Fig 3-86).

Step 2

Lay a clean sheet of acetate over the original tracing. Trace all skeletal and soft tissue structures that will not be affected by surgery (Fig 3-87). Do not trace the bone and teeth of the maxilla below the osteotomy line or the soft tissue inferior to the supratip break of the nose, upper lip, and lower lip. The soft and hard tissues of the mandible are also not traced at this stage. In this case, it is clear that the mandibular incisor is tangent to the line indicating the ideal vertical position of the maxillary incisor. To achieve a normal incisor overbite, the mandibular incisor needs to be rotated to 2 mm above the line. Place a pencil posterior to the condylion, and rotate the prediction tracing clockwise until the incisor is 2 mm above the horizontal line. Now trace the mandibular hard tissue and soft tissue of the chin below the labiomental fold (Fig 3-88).

Step 3

Move the prediction tracing to the left (the original tracing structures will move to the right), and superimpose the skeletal tissue of the original tracing to establish the best interincisal and

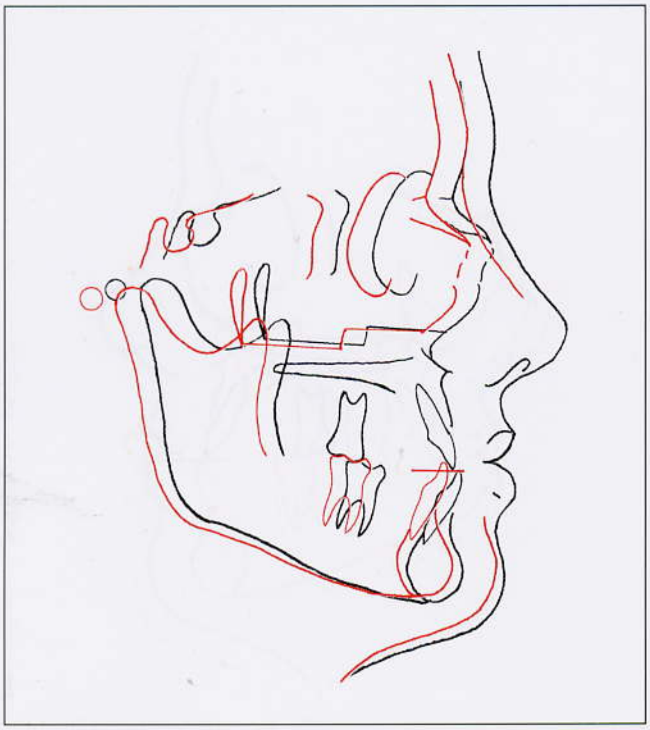


Fig 3-89 The maxillary teeth on the original tracing are now in occlusion with the mandibular teeth of the prediction tracing.

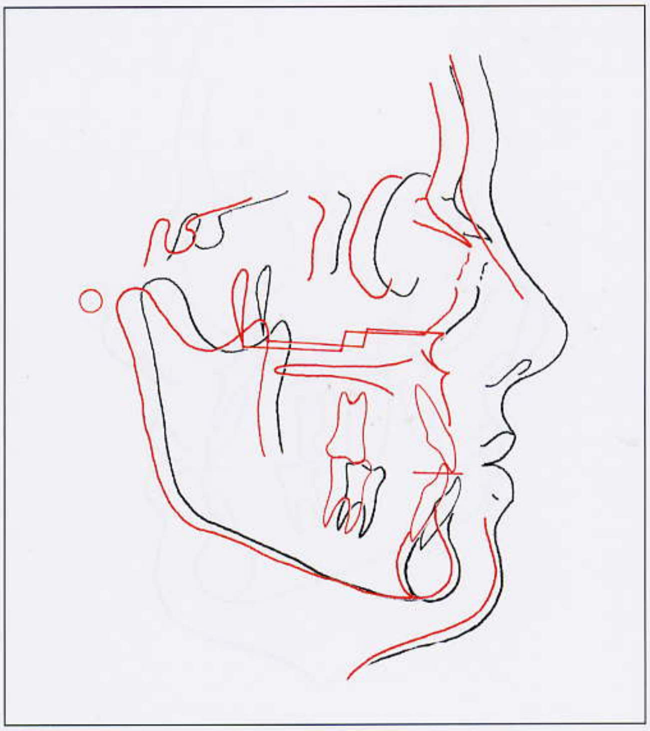


Fig 3-90 Step 3.

molar relationship with the teeth on the prediction tracing (Fig 3-89). Trace the skeletal tissues, as well as the osteotomy line (Fig 3-90).

Step 4

The soft tissue can now be drawn; bear in mind the soft tissue changes caused by maxillary advancement procedures. Lay the prediction tracing over the original tracing to superimpose the structures that did not move. The nose and upper lip changes are now predicted. Draw the soft tissue first in dotted lines until the prediction is satisfactory; then complete the lines of the nose and upper lip (Fig 3-91). Vermilion (stomion) movement will represent 50% to 75% of the horizontal movement. The nasolabial angle decreases 1 to 4 degrees per 1 mm of advancement. The nasal tip advances 30% (although this is variable) and can be controlled.

To predict the soft tissue change of the lower lip, superimpose the prediction tracing on the original tracing with the mandibular hard tissue and soft tissue chin coinciding. The new relationship between the upper and lower lips is evident. The upper lip will tend to push the lower lip slightly down, somewhat everting the lower lip. First draw the predicted change with a dotted line, and then finish the prediction tracing (Fig 3-92).

Figure 3-93 shows the completed tracing predicting the hard and soft tissue changes. The amount of surgical advancement can be measured by comparing the preoperative and postoperative osteotomy reference lines.

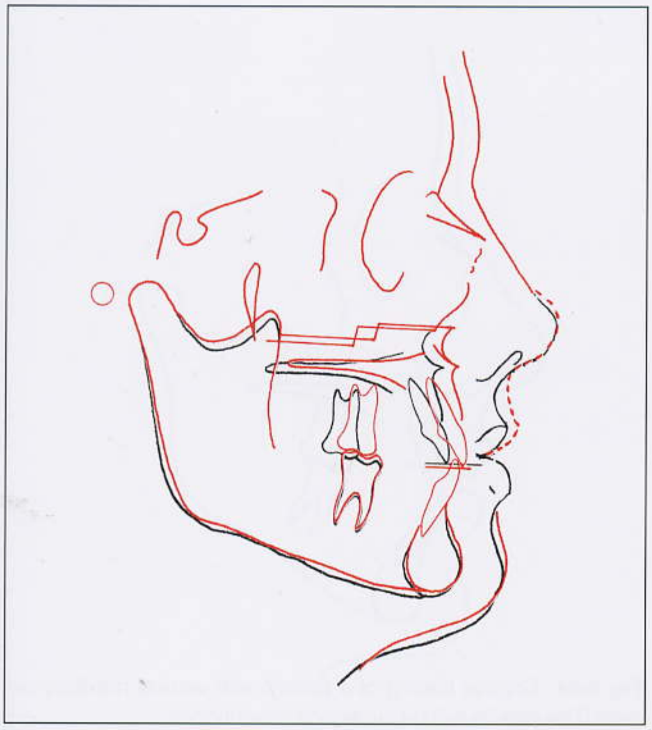


Fig 3-91 Soft tissue prediction of the tip of the nose and upper lip.

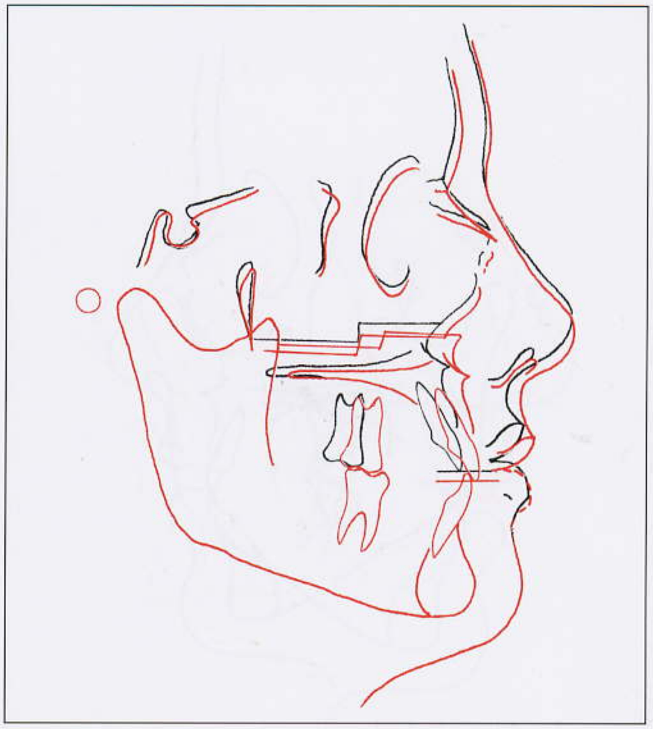


Fig 3-92 Prediction of the lower lip.

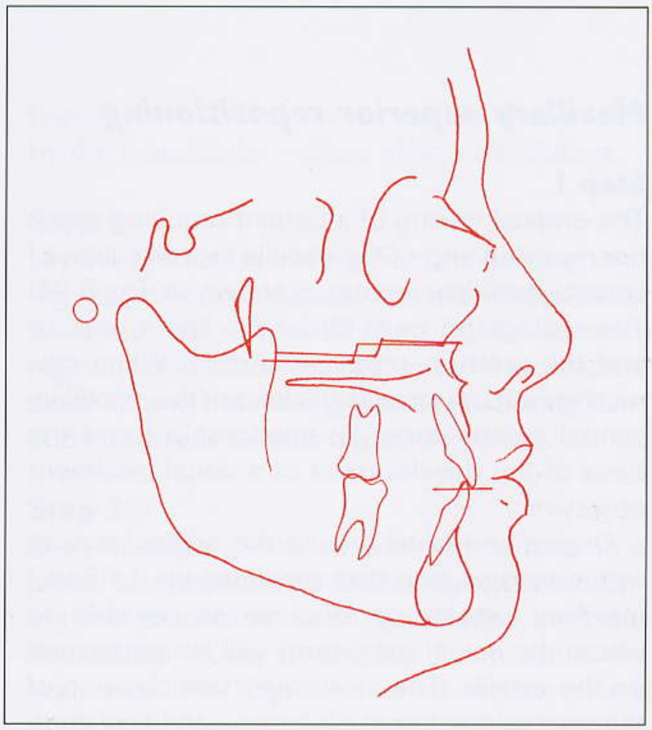


Fig 3-93 Completed prediction tracing.

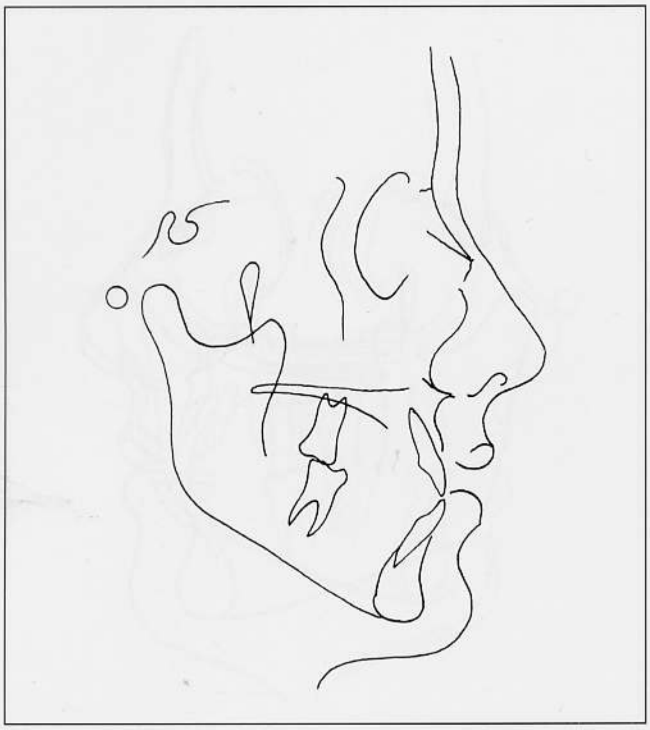


Fig 3-94 Original tracing of a patient with vertical maxillary excess. The maxilla will be superiorly repositioned.

Maxillary superior repositioning

Step I

The original tracing of a patient requiring superior repositioning of the maxilla for correction of vertical maxillary excess is shown in Fig 3-94. The radiograph must show the lips in repose and the teeth in centric occlusion. When correcting vertical maxillary excess, the maxillary central incisor–upper lip relationship forms the basis of the development of a visual treatment objective.

Draw a horizontal line on the original tracing with a vertical step that simulates the Le Fort I maxillary osteotomy as close as possible to where the actual osteotomy will be performed on the maxilla. The most important decision of the surgical treatment objective—*the final vertical position of the maxillary incisor tip*—must now be made. The decision is made with the aid of cephalometric guidelines, knowledge of soft tissue response to maxillary superior repositioning, clinical experience, and artistic sense. A few guidelines to assist in making this decision follow:

- Maxillary incisor exposure of 1 to 4 mm under the upper lip is considered normal.
- Less maxillary incisor will show under long upper lips, and more maxillary incisor will show under short upper lips.
- Never treat the "gummy smile." The smile may expose a larger amount of gingiva than the amount of superior repositioning indicated by the incisor exposure under the upper lip. Treatment of the "gummy smile" will lead to excessive superior repositioning of the maxilla, resulting in a toothless appearance.
- Superior repositioning of the maxilla combined with maxillary setback undermines soft tissue support of the upper lip and paranasal areas, leading to poor esthetic results.

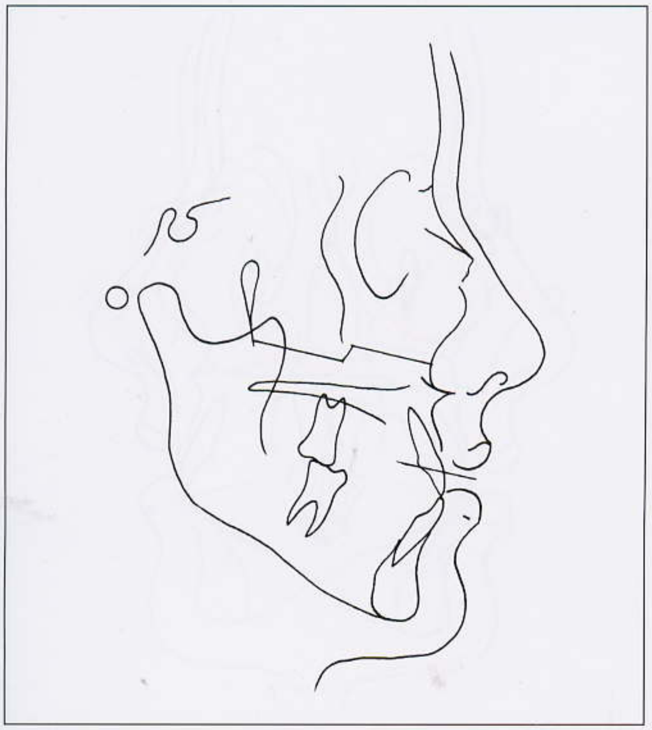


Fig 3-95 Step 1.

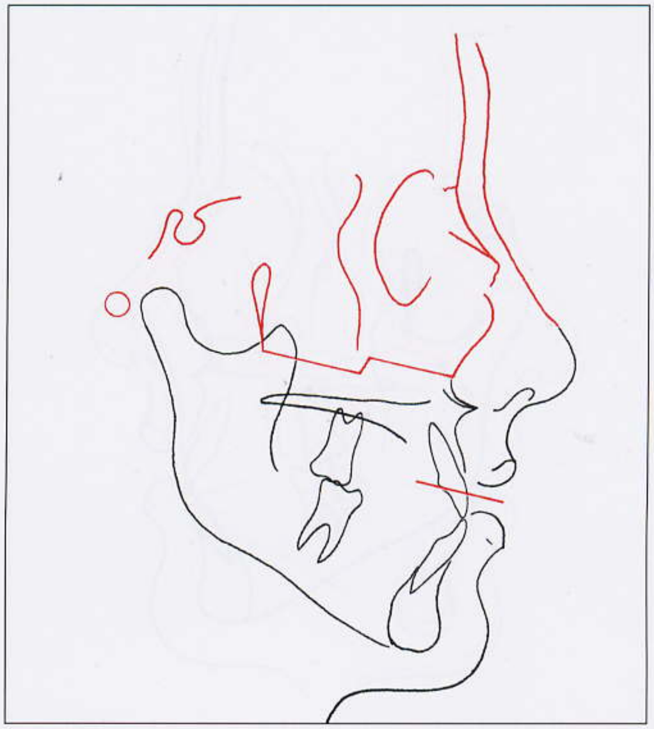


Fig 3-96 Step 2.

- Superior repositioning of the maxilla will lead to upper lip shortening (10% to 20% of the amount of superior repositioning).
- Never treat the interlabial gap. Correction of vertical maxillary excess and establishment of the ideal tooth-lip relationship will create lip seal in most cases. An interlabial gap of 1 to 3 mm is acceptable and often very attractive. The amount of superior repositioning should not be guided by the interlabial distance.
- The upper lip length, lip thickness, and overall esthetics are also influenced by the surgical technique (see chapter 5).
- Err on the long side rather than the short side in superior repositioning of the maxilla.

Consider these guidelines while drawing a horizontal line on the original tracing to indicate the required vertical position of the maxillary incisor edge (Fig 3-95). The anteroposterior position of the maxillary incisor will be determined by the mandibular incisors after autorotation.

Step 2

Lay the prediction tracing over the original tracing, and trace all skeletal and soft tissue structures that will not be affected by the superior repositioning of the maxilla. In other words, the nasal tip and the maxillary and mandibular hard and soft tissue are not traced (Fig 3-96).

Step 3

The mandible is now autorotated by placing a pencil just posterior to the condylion and rotating the prediction tracing clockwise until the mandibular incisor tip projects 2 mm above the horizontal line. The amount of incisor above the line represents the amount of overbite (Fig 3-97). Trace the mandibular hard tissue and soft tissue of the chin below the labiomental fold (Fig 3-98).

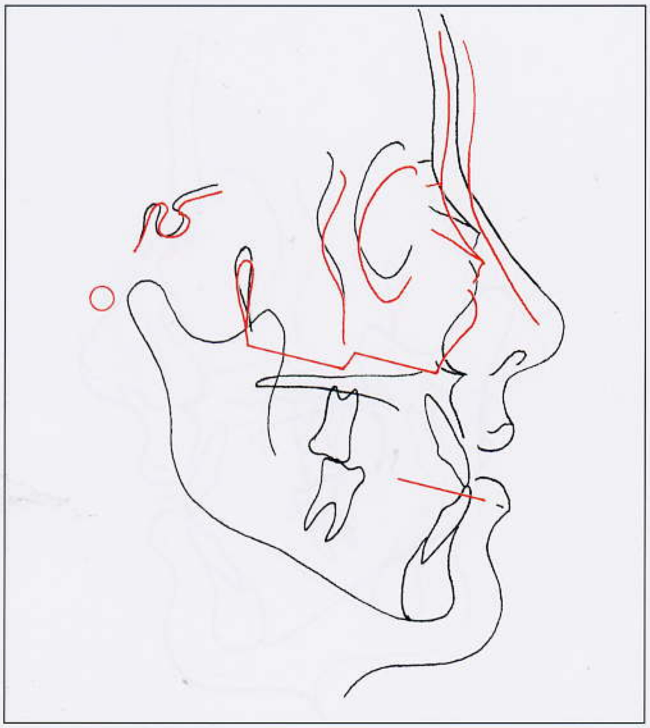


Fig 3-97 The mandible has been autorotated until the mandibular incisor projects 2 mm above the horizontal line.

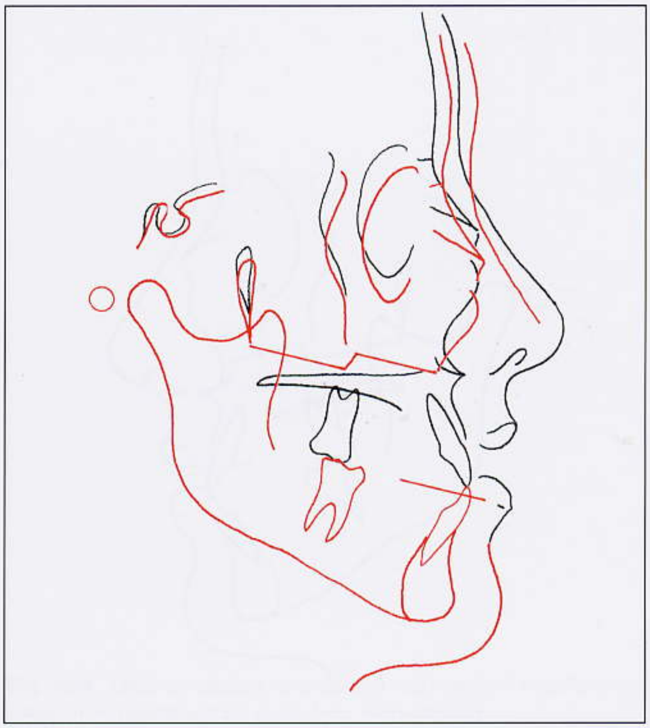


Fig 3-98 Step 3.

Step 4

Superimpose the mandibular teeth of the prediction tracing on the original tracing to obtain the best incisor and molar relationship. The anteroposterior position of the maxilla is dictated by the mandibular incisor position. The occlusal plane is dictated by the mandibular occlusal plane after autorotation (Fig 3-99). Trace the maxillary hard tissue, as well as the Le Fort I osteotomy reference line (Fig 3-100).

Step 5

Slide the prediction tracing on the original tracing to superimpose the structures that were not affected by the surgery. The superior repositioning of the maxilla is now apparent. The maxillary advancement subsequent to the counterclockwise rotation of the maxilla is also clearly visible. The expected soft tissue changes can be drawn in according to knowledge of soft tissue change in relation to skeletal repositioning. In Le Fort I superior repositioning, the vermilion (stomion) movement represents 10% to 20% of the vertical movement, and the nasolabial angle tends to decrease. In Le Fort I advancement, vermilion (stomion) movement represents 50% to 75% of the horizontal movement. The nasolabial angle decreases 1 to 4 degrees per 1 mm of advancement. The nasal lip turns upward (a change that is variable, but controllable).

First, draw the predicted soft tissue with a dotted line. When the prediction is satisfactory, the nasal tip and upper lip predictions can be drawn in (Fig 3-101).

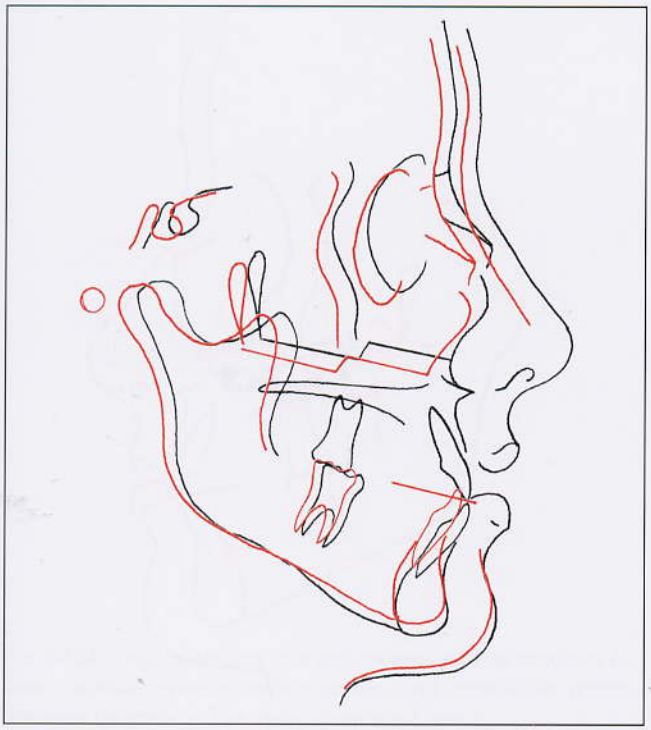


Fig 3-99 The mandibular teeth on the prediction tracing now occlude with the maxillary teeth on the original tracing.

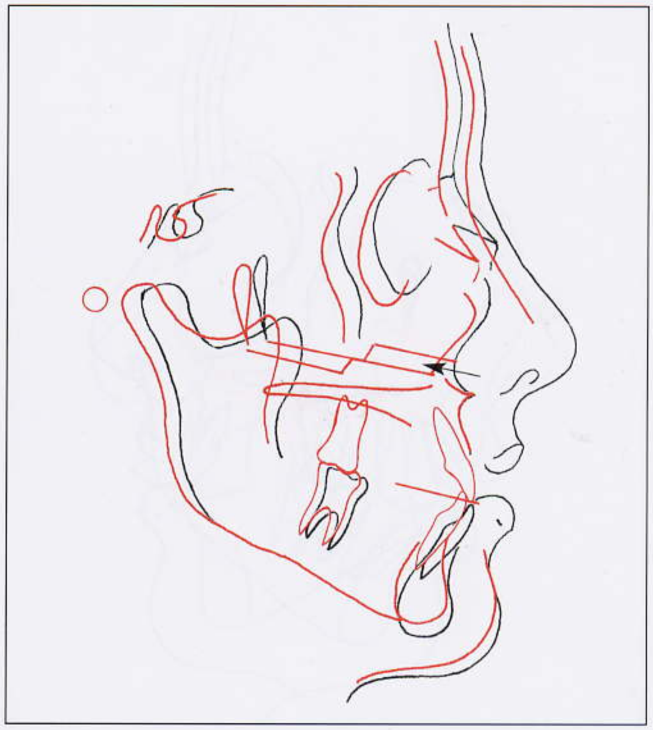


Fig 3-100 Step 4. The maxillary structures and the osteotomy line are traced to indicate the maxillary repositioning *(arrow)*.

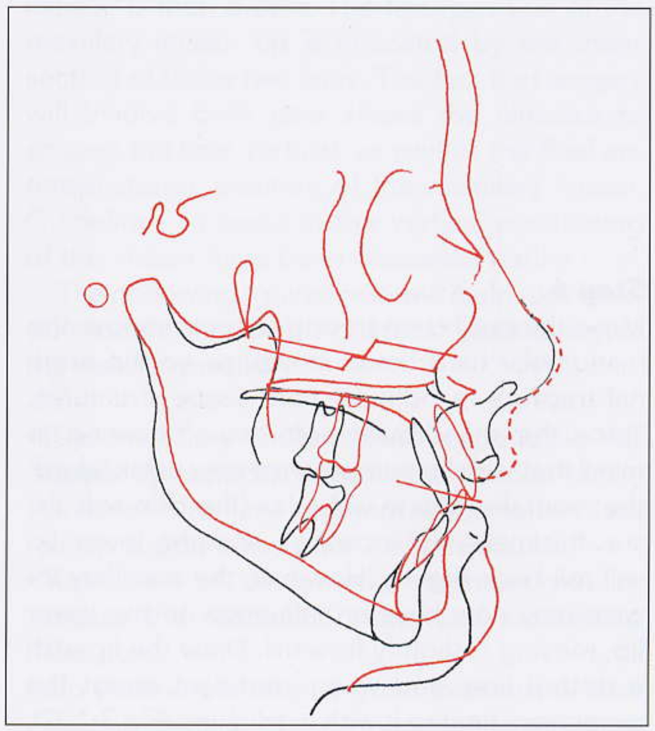


Fig 3-101 Soft tissue prediction of the nasal tip and upper lip.

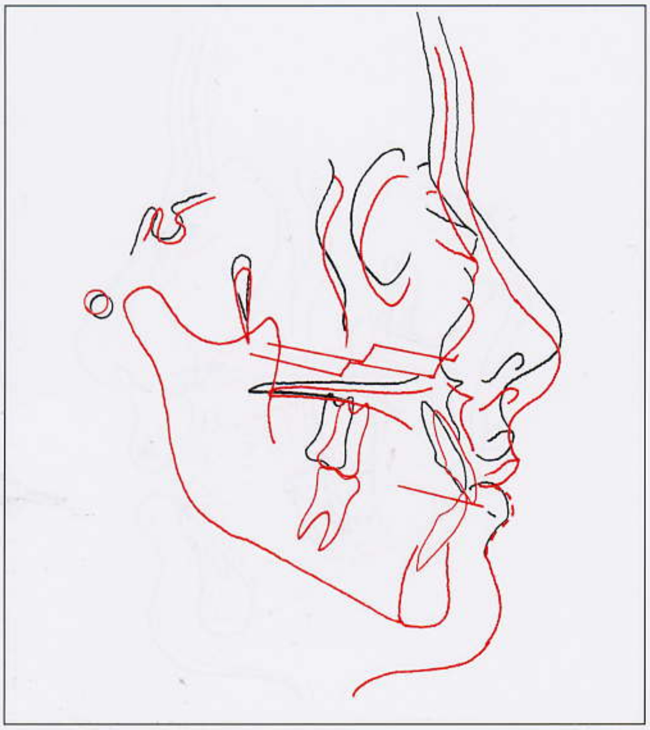


Fig 3-102 Prediction of lower lip change.

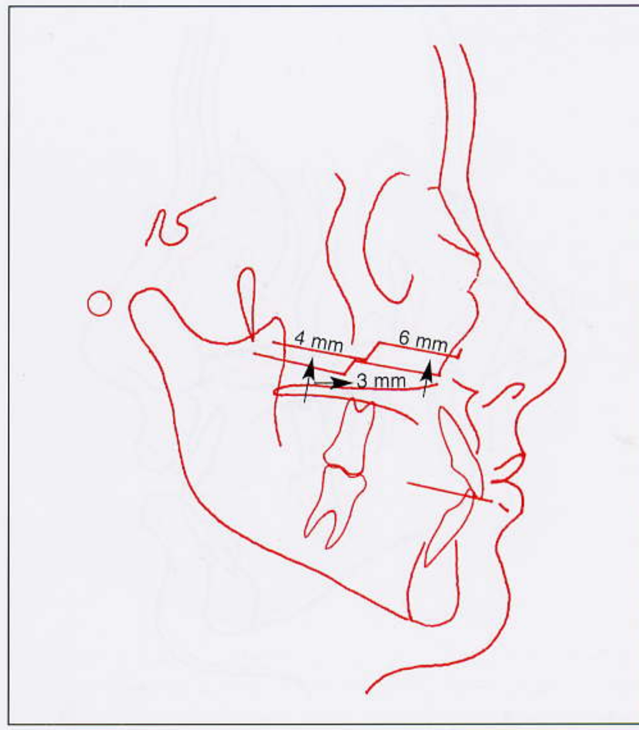


Fig 3-103 Completed prediction tracing. The maxilla is superiorly repositioned 4 mm in the posterior area and 6 mm in the anterior area. By following the forward rotation of the mandible, a 3-mm maxillary advancement is necessary.

Step 6

Move the prediction tracing to superimpose the mandibular hard tissue structures on the original tracing's mandibular hard tissue structures. Trace the mandibular soft tissue, bearing in mind that with lip competence now established, the mentalis muscle will relax (the chin soft tissue thickness will increase), and the lower lip will roll back slightly. However, the maxillary incisor may now have an influence on the lower lip, moving it slightly forward. Draw the lip with a dotted line, and when confident about the prediction, finalize it with a solid line (Fig 3-102).

By measuring the distance between the osteotomy lines on the original tracing and the prediction tracing, the actual skeletal movements can be recorded. The following facts are clear in the case demonstrated here (Fig 3-103):

1. The superior repositioning of the maxilla is less in the posterior area (4 mm) than in the incisor areas (6 mm). This is due to the fact that a severe anterior open bite is corrected, as well as to the fact that more superior repositioning was necessary in the molar area to allow for mandibular autorotation.
2. The anteroposterior position of the maxilla is determined by the mandibular incisor position after autorotation. As the mandible (the unoperated jaw) is rotated counterclockwise, it is also rotated forward. The maxilla, therefore, has to be advanced (3 mm in this case).

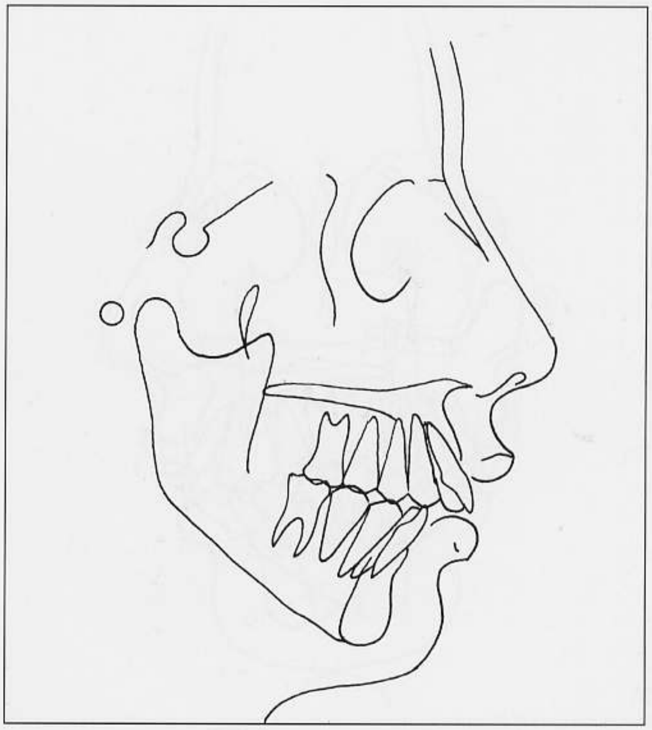


Fig 3-104 Original tracing of a patient with vertical maxillary excess, maxillary anteroposterior excess, and mandibular anteroposterior deficiency. The malocclusion is Class II.

Maxillary segmental superior repositioning with extraction of first premolars and advancement of the mandible

Step I

Begin the prediction by tracing the original tracing (Fig 3-104). Draw lines on the original tracing to simulate the osteotomies. A horizontal line with a step simulating the Le Fort I osteotomy is drawn as close as possible to the actual osteotomy on the maxilla. Two vertical lines indicating the limits of the interdental ostectomy are then drawn between the second maxillary premolar and the canine. The first premolars will be removed at the time of surgery and the space closed surgically.

The very important decision—the predicted vertical position of the maxillary incisor—is now made. Guided by the information on the ideal incisor–upper lip relationship discussed elsewhere, a horizontal line is drawn to indicate the vertical position of the maxillary incisor. A vertical line transecting this line, indicating the desired anteroposterior position of the maxillary incisor, is then drawn. The final position of the maxillary incisor tip is indicated by the intersection of these two lines. The fact that surgery will involve both jaws allows the clinician to choose the final vertical, as well as the final anteroposterior, position of the maxillary incisor. Guidelines to assist in the vertical positioning of the incisor have been discussed earlier.

The following guidelines will help the clinician locate the ideal horizontal positioning of the maxillary incisor:

- The maxillary incisors are responsible for upper lip support. Excessive retraction of the anterior maxillary segment will result in loss of lip support and poor esthetic results.
- Retraction of the anterior segment will increase the nasolabial angle and accentuate the nose.
- Lip thickness is often a good indicator of how much retraction of the anterior segment a patient will tolerate before the lip will react to the tooth movement. In general, the thickness of the upper and lower lips is equal.

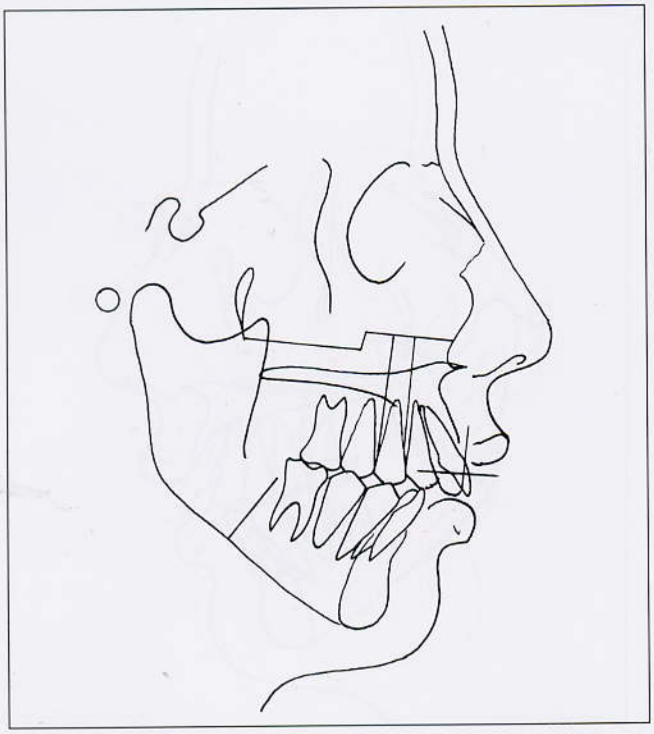


Fig 3-105 Step 1. The intended osteotomy lines, as well as the required vertical and horizontal positions of the maxillary incisor edge, are drawn on the original tracing. The first maxillary premolars will be removed at surgery and the space closed.

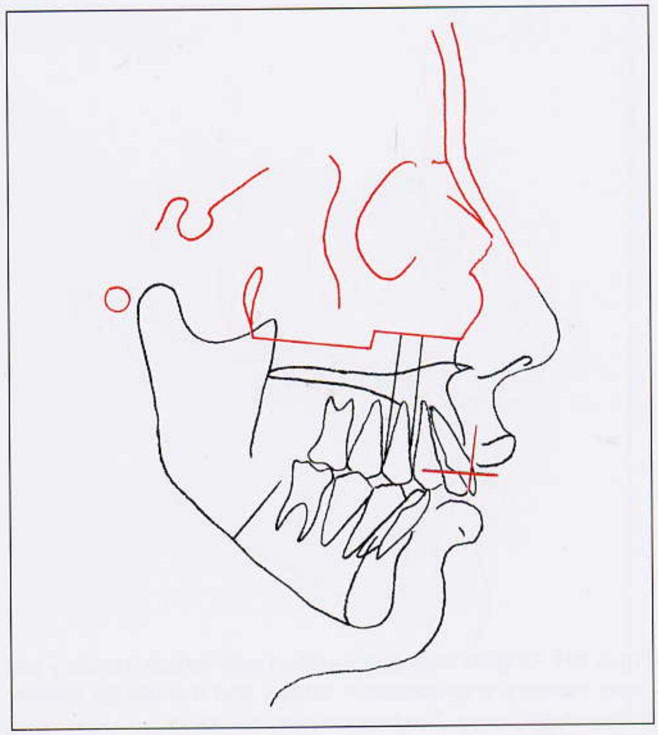


Fig 3-106 Step 2. All structures that will not be affected by the surgery are traced in red.

- Vermilion exposure of the upper lip will decrease after retraction of the anterior maxillary segment.
- Avoid excessive retraction of the anterior teeth. A fuller lip is esthetically more pleasing than a flat, unsupported upper lip.

A vertical line simulating the vertical osteotomy of the bilateral sagittal split osteotomy is drawn on the body of the mandible (Fig 3-105).

Step 2

Lay a clean sheet of acetate over the original tracing, and trace all hard and soft tissue structures that will not be affected by the surgery (Fig 3-106). The maxillary and mandibular skeletal structures, soft tissue of the nose below the supratip break, upper lip, and mandibular soft tissue structures are not traced.

Place a pencil just posterior to the condylion. Rotate the prediction tracing in a clockwise direction until the mandibular incisor projects approximately 2 mm above the horizontal line (the amount of mandibular incisor above the line indicates the desired overbite) (Fig 3-107). Next, trace the skeletal structure of the mandible, proximal to the vertical mandibular osteotomy line. The mandibular incisor is now a few millimeters behind the vertical line (Fig 3-108).

Step 3

Slide the prediction tracing to the left. The original tracing structures will move to the right. Superimpose the prediction tracing so that the mandibular incisor on the original tracing is 1 mm behind the vertical line (the amount of mandibular incisor behind the vertical line indicates the desired overjet) (Fig 3-109). The two vertical osteotomy lines on the mandibular body should be parallel, indicating that no rotational movements of the mandible have taken place. Trace the mandibular skeletal structures distal to the vertical line, as well as the soft tissue on the chin below the labiomental fold (pogonion 1:1 response) (see Fig 3-109).

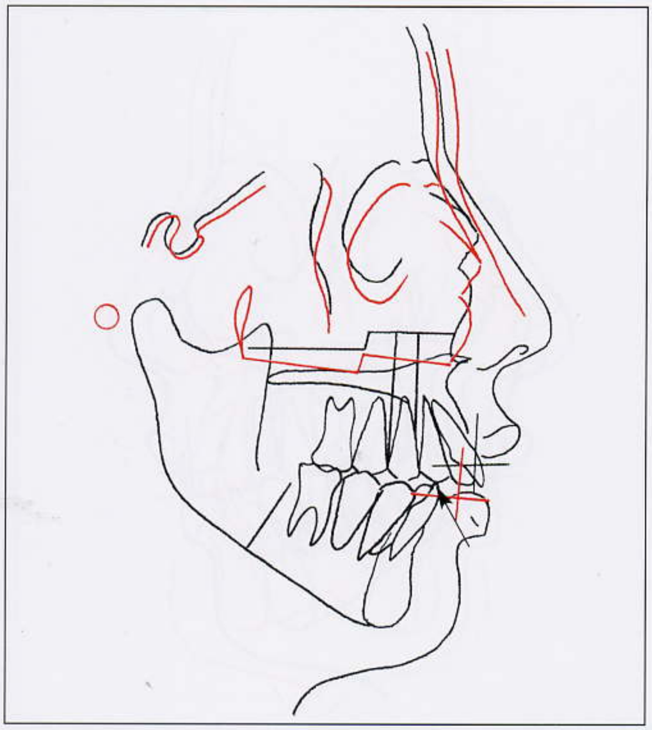


Fig 3-107 The mandible is autorotated until the mandibular incisor projects 2 mm above the horizontal line *(arrow)*.

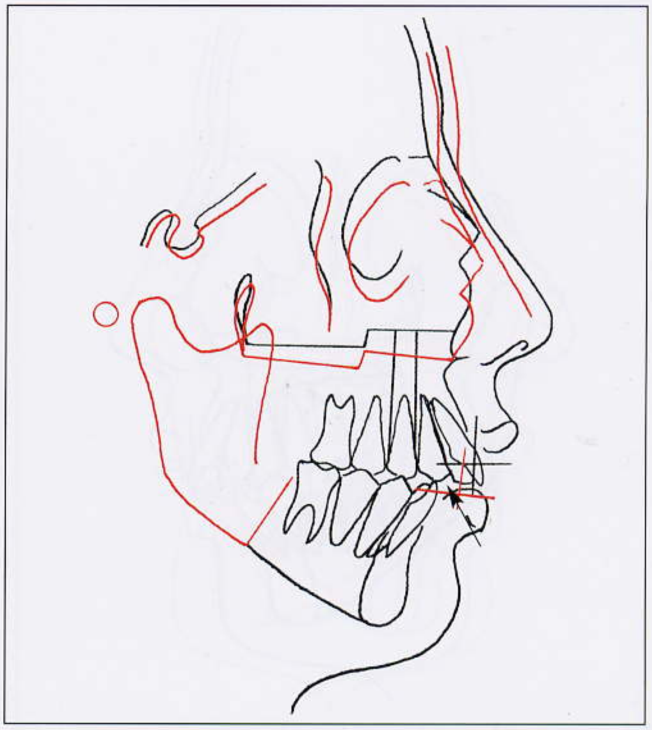


Fig 3-108 After autorotation of the mandible, the mandibular incisors are still a few millimeters behind the vertical line indicating the labial surface of the maxillary incisors *(arrow)*. The mandible will have to be advanced.

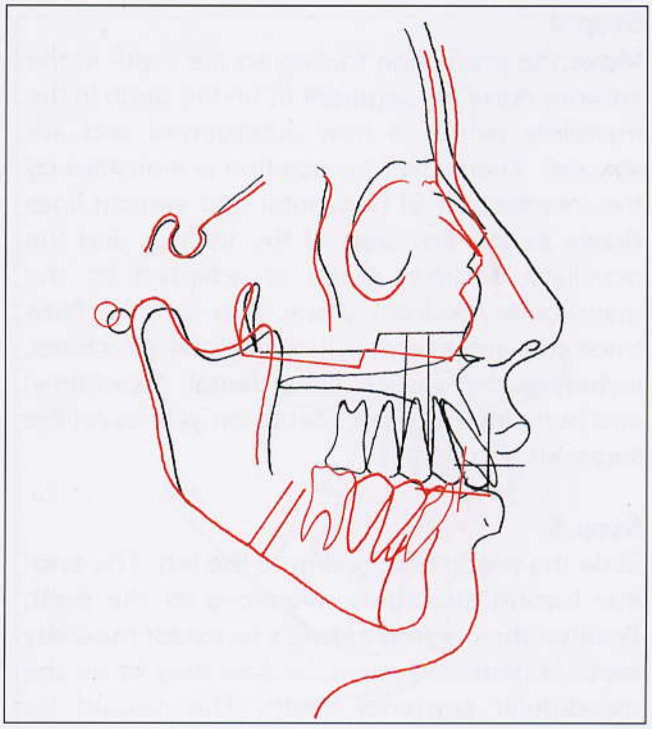


Fig 3-109 The mandible is advanced by moving the prediction tracing to the left.

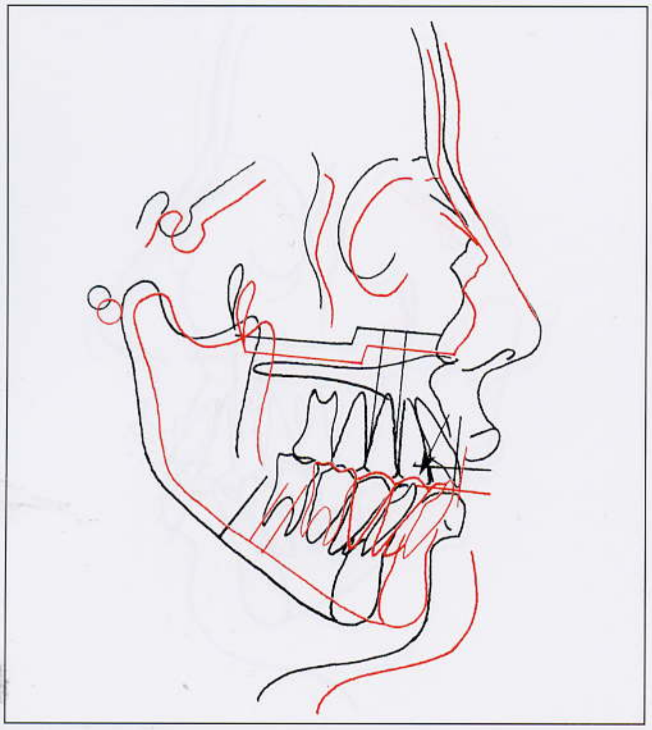


Fig 3-110 The teeth of the anterior maxillary segment on the original tracing now fit on the teeth of the mandible on the prediction tracing *(arrow)*.

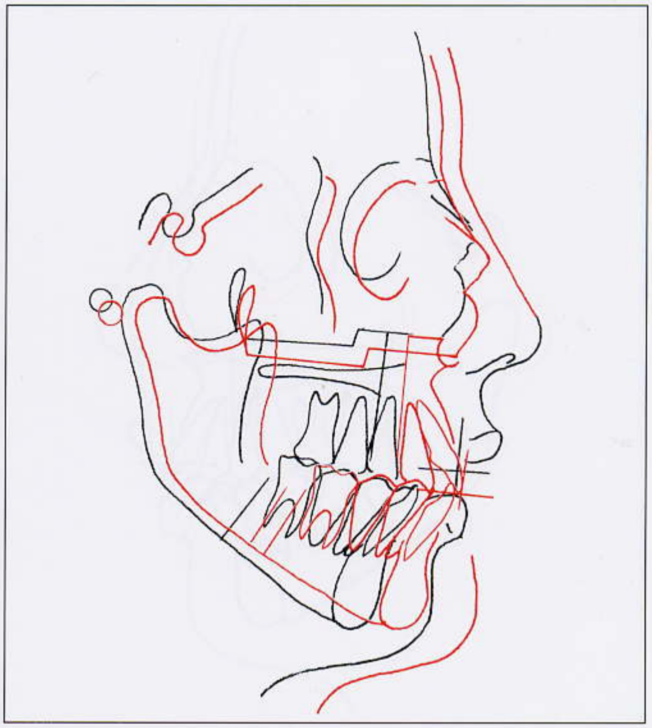


Fig 3-111 The maxillary incisor is placed between the mandibular incisor and the vertical line. The maxillary incisor's labial surface is now tangent to the vertical line.

Step 4

Move the prediction tracing so the teeth in the anterior maxillary segment fit on the teeth in the mandible (which is now autorotated and advanced). The incisor tip position is indicated by the intersection of horizontal and vertical lines drawn as the first step of the tracing, and the maxillary occlusal plane is adapted to the mandibular occlusal plane (Fig 3-110). Now trace the anterior maxillary skeletal structures, including the vertical (interdental osteotomy) and horizontal (Le Fort I osteotomy) lines on the segment (Fig 3-111).

Step 5

Slide the prediction tracing to the left. The original tracing structures will move to the right. Position the original tracing's posterior maxillary teeth (molars and premolars) so they fit on the mandibular posterior teeth. This should be done realistically, keeping in mind the roots of the teeth adjacent to the extraction socket of the first premolar and interdental ostectomy. The vertical interdental reference lines must, at most, touch. Further movement will be surgically unrealistic and increase the risk of damage to the adjacent teeth. Again, the mandibular occlusal plane dictates the vertical position of the posterior maxillary segment (Fig 3-112). Trace the skeletal structures, as well as the horizontal osteotomy line of the posterior maxillary segment (Fig 3-113).

Step 6

Slide the prediction tracing on the original tracing to superimpose the structures that were not affected by the surgery. A vertical and horizontal change is apparent in the relationship of the maxillary incisor and upper lip. The soft tissue change of the nasal tip and upper lip can now be predicted by drawing the soft tissue with dotted lines (Fig 3-114). As a guide, the vermilion (stomion) will shorten by 10% to 20%, the nasolabial angle change will vary (but tends to increase slightly), and the nasal tip will tip up slightly. Once the clinician is confident with the prediction, the maxillary soft tissue can be drawn in.

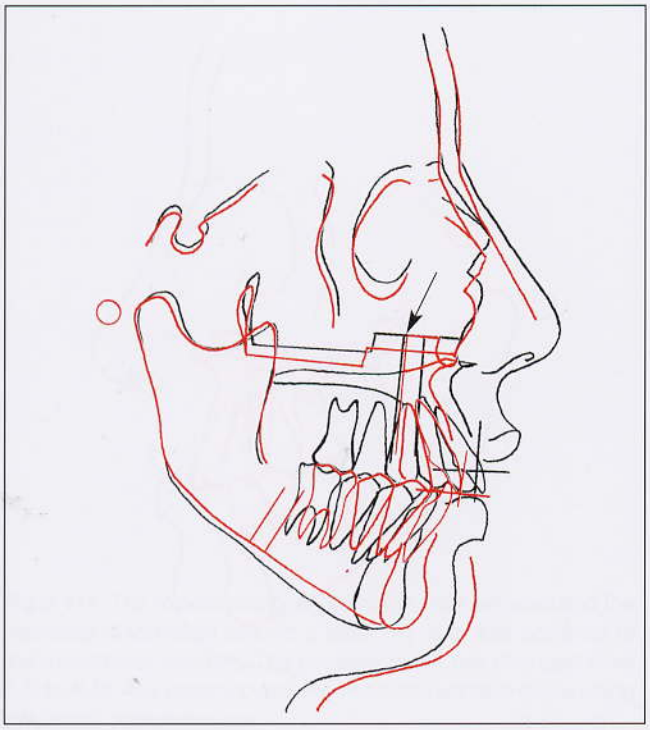


Fig 3-112 The posterior maxillary teeth on the original tracing are advanced by sliding the prediction tracing to the left and placed on the posterior mandibular teeth on the prediction tracing. The vertical lines (interdental limits of bone removal) must not overlap and at most be tangent *(arrow)*.

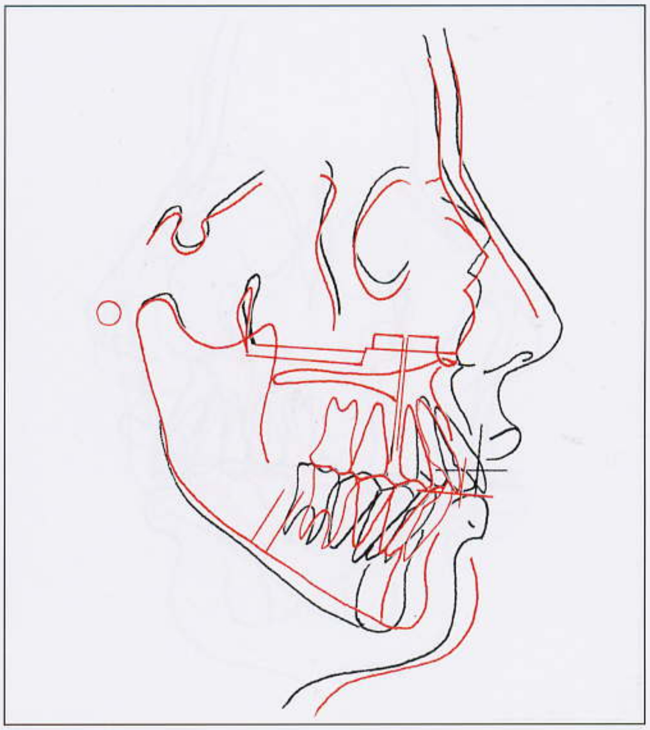


Fig 3-113 The interdental osteotomy lines are 1 mm apart, indicating that the interdental ostectomy can be performed safely without damage to the roots of the teeth adjacent to the osteotomy.

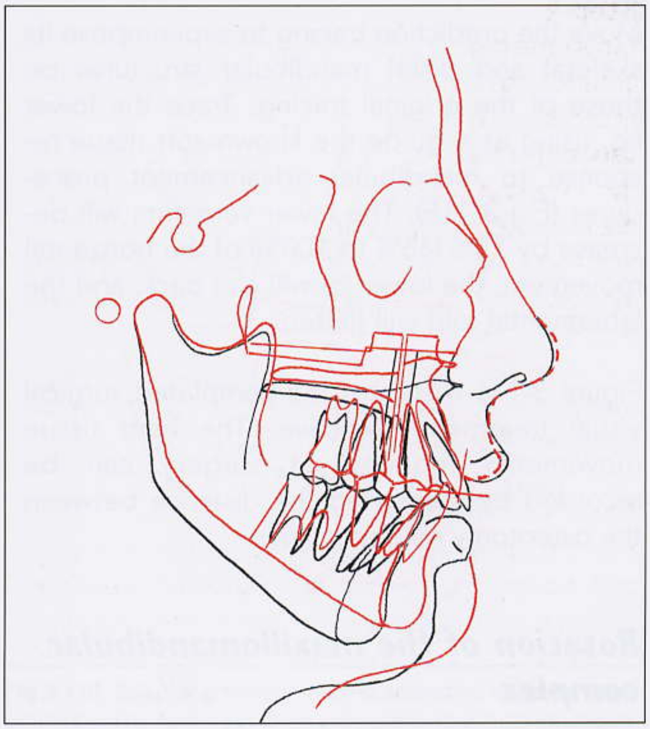


Fig 3-114 Prediction of the soft tissue of the nasal tip and upper lip.

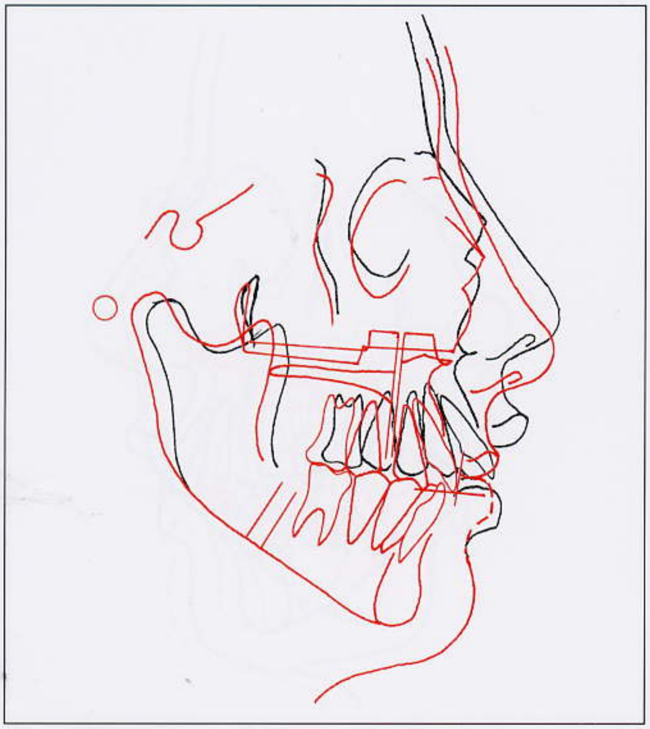


Fig 3-115 Lower lip prediction.

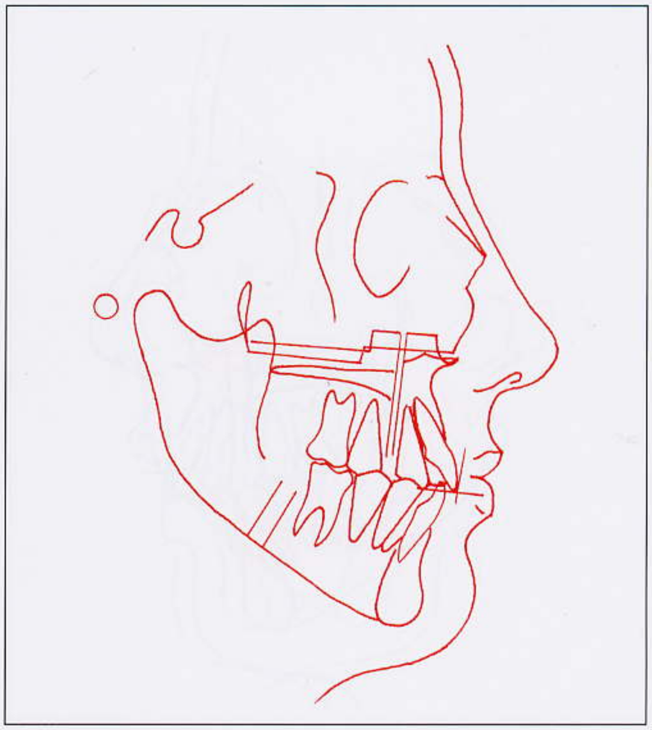


Fig 3-116 Completed surgical visual treatment objective.

Step 7
Move the prediction tracing to superimpose its skeletal and distal mandibular structures on those of the original tracing. Trace the lower lip, using as a guide the known soft tissue response to mandibular advancement procedures (Fig 3-115). The lower vermilion will decrease by 75% (66% to 100%) of the horizontal movement, the lower lip will curl back, and the labiomental fold will flatten.

Figure 3-116 illustrates the completed surgical visual treatment objective. The hard tissue movements required at surgery can be recorded by measuring the distance between the osteotomy reference lines.

Rotation of the maxillomandibular complex

In all the previous prediction tracings, the final occlusal plane was dictated by the mandibular occlusal plane (after autorotation in cases where vertical repositioning of the maxilla occurred). The mandible (and therefore the mandibular occlusal plane) will rotate around a point at or just posterior to the condyle. Any anteroposterior changes will take place along this "new" plane (Fig 3-117). This principle is not adhered to in treatment planning requiring rotation of the maxillomandibular complex and consequent alteration of the occlusal plane.

Case 1: Surgical prediction tracing involving clockwise rotation of the maxillomandibular complex

The presurgical cephalometric analysis of the patient in Case 1 is seen in Fig 3-118. The diagnosis is Class II malocclusion, maxillary anteroposterior deficiency, macrogenia, and mandibular alveolar anteroposterior deficiency.

Figure 3-119 illustrates a conventional surgical prediction involving maxillary advancement, mandibular advancement, and reduction genioplasty. However, it is not possible to achieve both good esthetic chin contour and an acceptable anteroposterior position by means of a re-

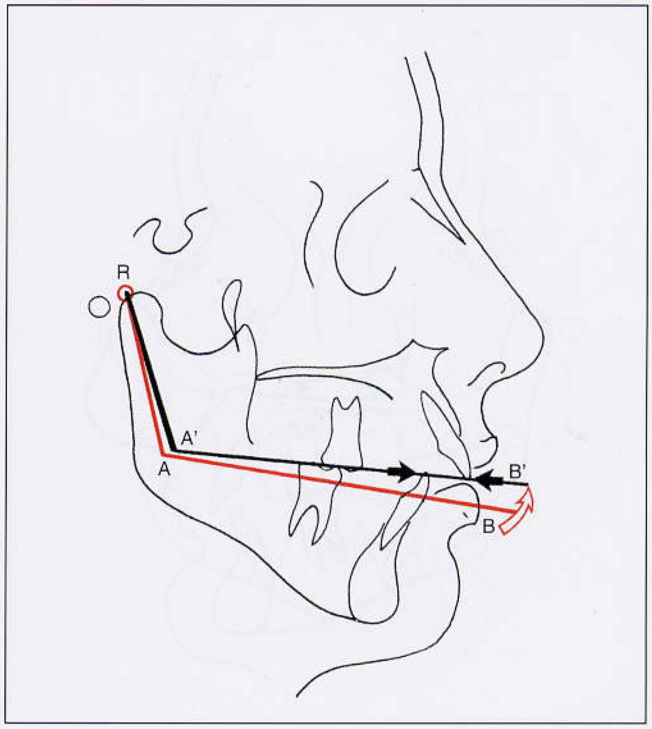


Fig 3-117 The maxilla has been superiorly repositioned and the mandible autorotated around a point (R) at or just posterior to the mandibular condyle. The occlusal plane has changed from A-B to A'-B'. Any anteroposterior corrections will take place along this "new" occlusal plane.

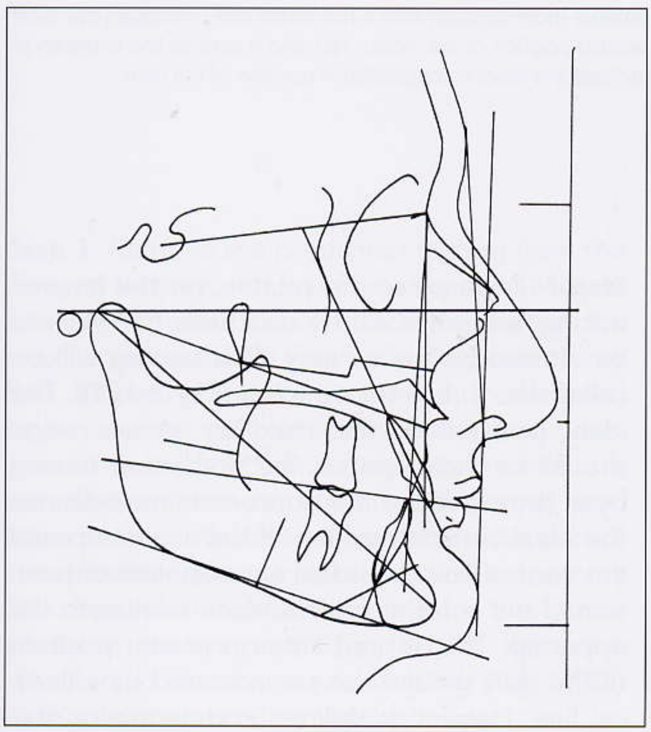


Fig 3-118 Presurgical cephalometric analysis of the patient in Case 1.

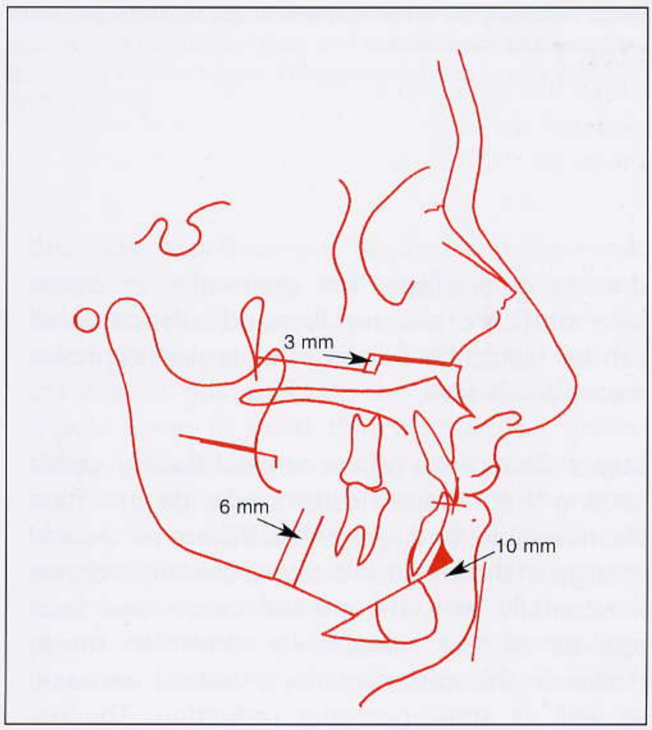


Fig 3-119 Surgical prediction tracing according to conventional principles. The surgery involves advancement of both the maxilla and mandible, as well as a large reduction genioplasty necessary to reduce the chin prominence. However, an unesthetic chin contour results from obliteration of the labiomental fold and poor definition of the lower border of the mandible.

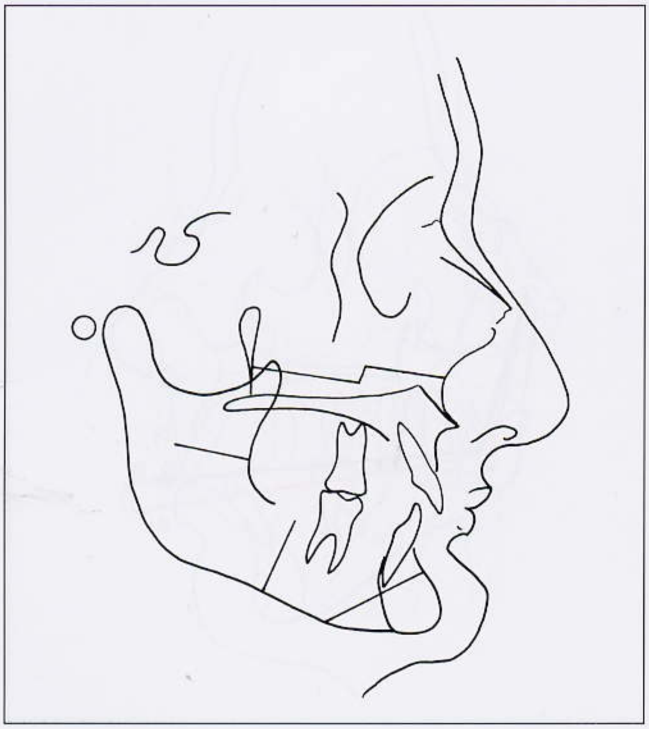


Fig 3-120 Original tracing of the patient in Case 1. For more accurate measuring, the intended osteotomy lines are drawn as close as possible to the actual anatomic site of the osteotomies. Both the horizontal and vertical osteotomy lines of the sagittal ramus osteotomy are drawn to monitor both horizontal and vertical mandibular movement.

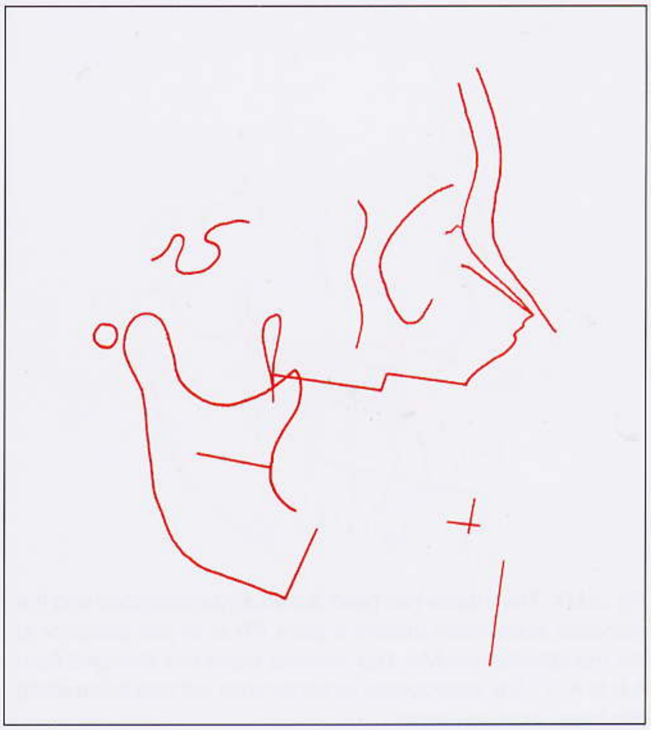


Fig 3-121 Prediction tracing. All the hard and soft tissue structures that will not be influenced by the surgery are traced. Guidelines for the ideal maxillary incisor position are indicated by a vertical line (indicating the ideal anteroposterior position of the anterior tooth surface) and a horizontal line (indicating the ideal vertical position of the incisor tip), and a vertical line is drawn to indicate the ideal anteroposterior position of the chin.

duction genioplasty. The alternative of clockwise rotation of the maxillomandibular complex can be tested by means of a surgical cephalometric prediction.

Step 1 Draw lines on the original tracing representing the intended osteotomies on the maxilla, mandible, and symphysis. Where no vertical change of the chin is indicated, the line is drawn horizontally with the mental nerve and root apexes of the mandibular teeth in mind. However, this case requires a vertical increase, as well as anteroposterior reduction. The osteotomy line, therefore, should be angulated downward. For accurate measurement, the osteotomy lines should be drawn as close as possible to the anatomic position where the osteotomies will be performed (Fig 3-120).

Step 2 Lay a piece of acetate over the original tracing, and trace all the structures that will not be altered by the surgery. This tracing will be called the *prediction tracing* (Fig 3-121). The ideal position of the maxillary incisor edge should be indicated on the prediction tracing by a "box," where the horizontal line indicates the ideal vertical position of the incisor tip and the vertical line, the ideal anteroposterior position of the anterior tooth surface relative to the upper lip. The desired anteroposterior position of the chin should also be indicated by a vertical line. Helpful guidelines in determining this line are the angle of facial convexity, the 0-degree meridian, and the clinician's judgment (Fig 3-122).

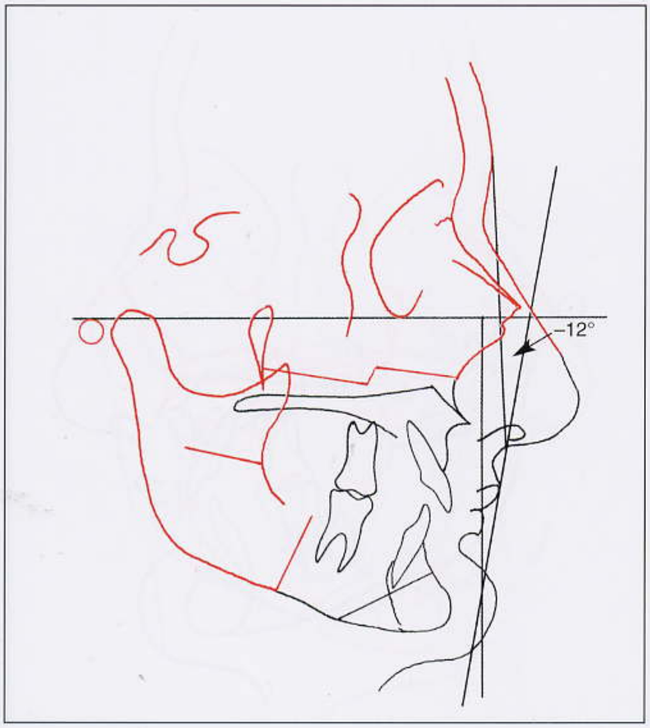


Fig 3-122 The facial contour, the 0-degree meridian, and the surgeon's clinical judgment act as guidelines to establish the ideal anteroposterior position of the chin.

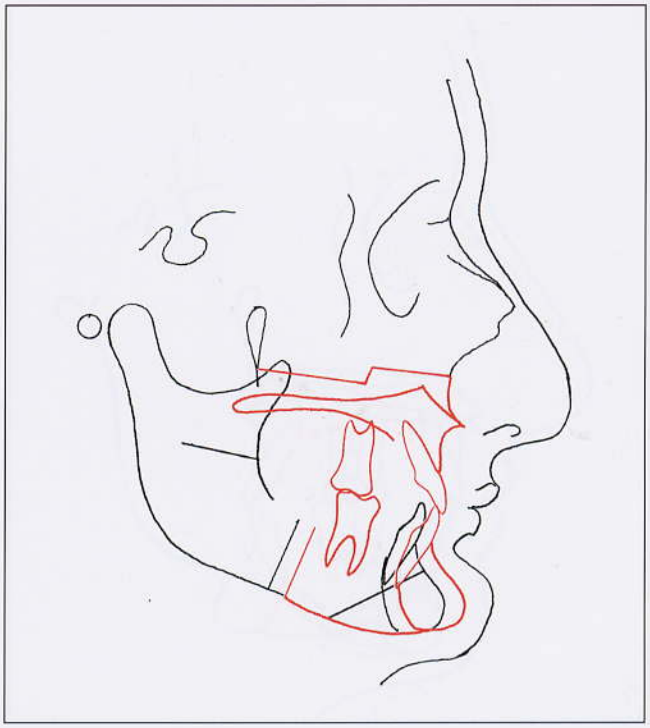


Fig 3-123 Maxillomandibular complex tracing developed by first tracing the bone and dentition of the maxilla below the Le Fort I osteotomy line. The tracing is then moved to the left (in this case) to achieve an ideal occlusion between the maxillary teeth of the maxillomandibular complex tracing and the teeth on the original tracing. The mandibular teeth and bone anterior to the vertical osteotomy line are traced. The genioplasty line is also indicated on this tracing.

Step 3 Remove the prediction tracing from the original tracing, and lay a new sheet of acetate over the original tracing. Trace the part of the maxilla below the Le Fort I maxillary osteotomy line. Move the acetate (to the left, in this case) to achieve the optimal occlusal relationship between the traced maxillary teeth and the mandibular teeth on the original tracing, and trace the mandibular teeth and the distal part of the mandible anterior to the vertical osteotomy line. Retrace the osteotomy line for the genioplasty at the symphysis (Fig 3-123). Keep the maxillomandibular complex tracing (Fig 3-124) in this position on the original tracing.

Step 4 Place the prediction tracing over the original tracing. The maxillomandibular complex tracing can now be moved between the original tracing and the prediction tracing. In this case, this tracing is rotated in a clockwise direction, advancing the maxilla and rotating the mandible posteriorly using the "box" for the maxillary incisor tip and the vertical line for the chin as guidelines. In this case the clinician should keep in mind that a reduction genioplasty is indicated to correct the macrogenia and increase the vertical height of the symphysis. When a satisfactory position has been achieved, trace the maxillomandibular complex on the prediction tracing. The part of the symphysis below the genioplasty osteotomy line, however, is not traced at this time (Fig 3-125).

Step 5 Remove the maxillomandibular complex tracing, and superimpose the prediction tracing on the original tracing. Draw the soft tissue prediction using the same principles used for conventional prediction of soft tissue response to

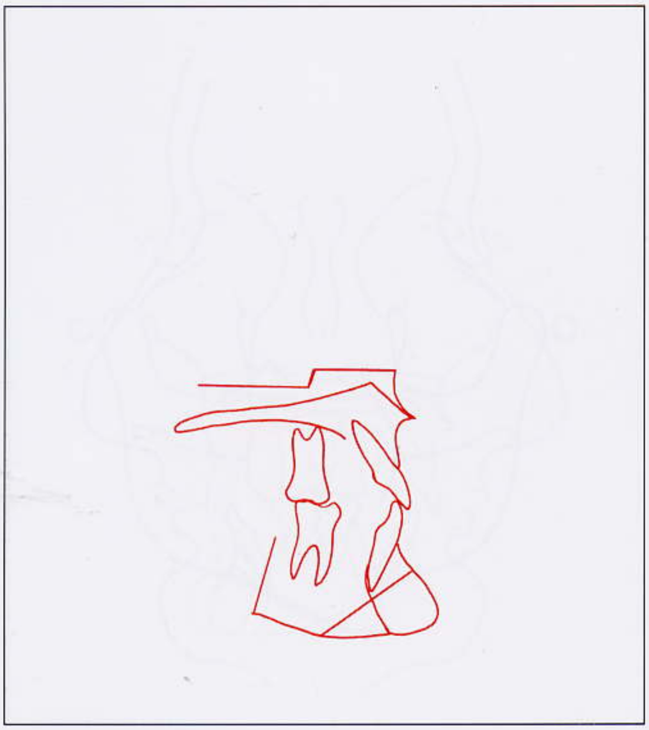


Fig 3-124 Maxillomandibular complex tracing.

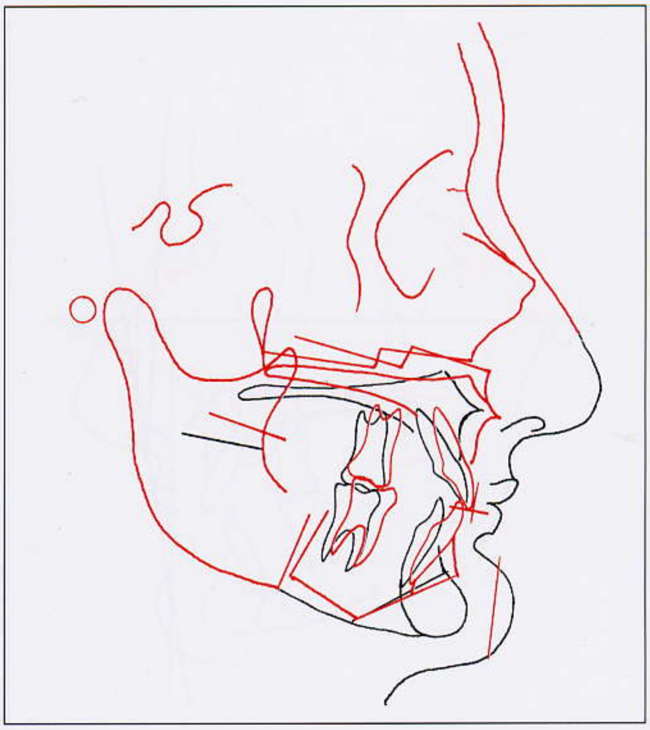


Fig 3-125 The maxillomandibular complex tracing is placed between the prediction tracing and the original tracing and rotated clockwise, guided by the "box" (indicating the maxillary incisor position) and the vertical line (indicating the chin position). The hard tissue of the maxilla and mandible is traced.

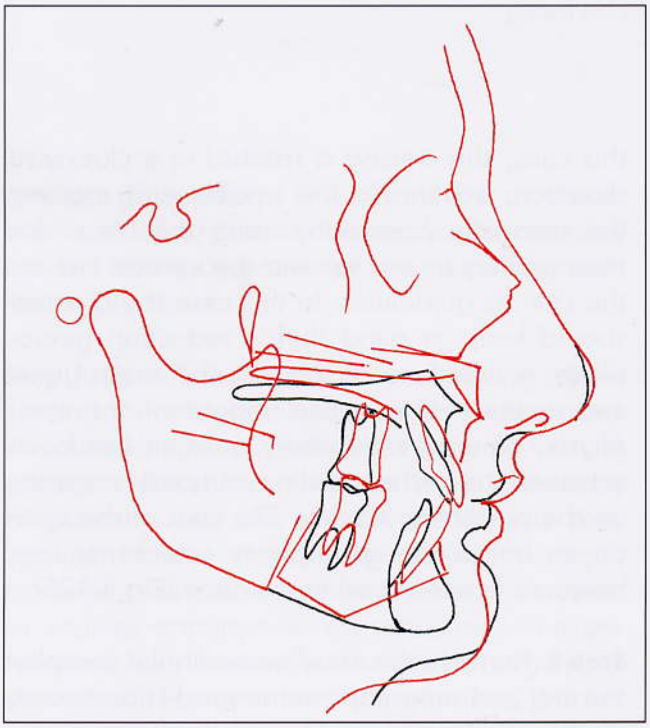


Fig 3-126 Prediction tracing superimposed on the original tracing. The expected soft tissue change, including the ideal soft tissue position of the chin, is drawn.

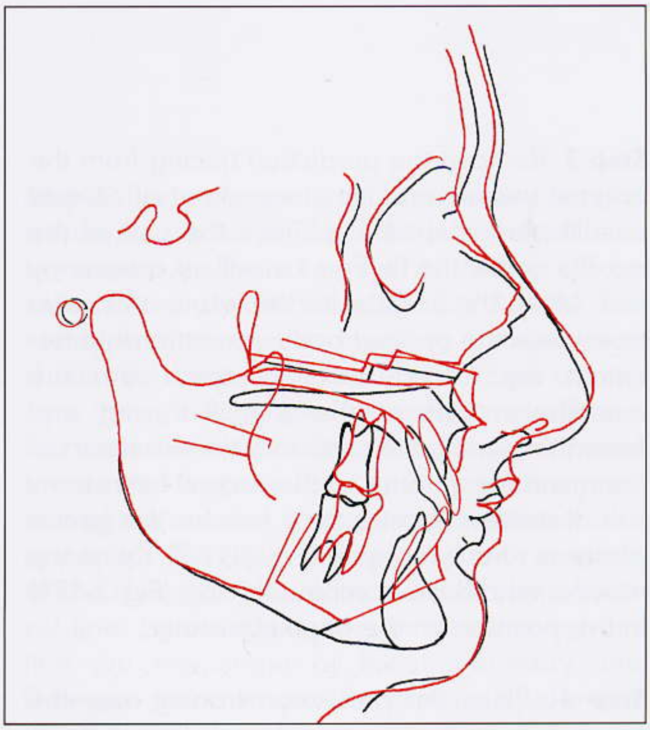


Fig 3-127 The prediction tracing is moved to the right to establish the chin reduction required for the predicted soft tissue result.

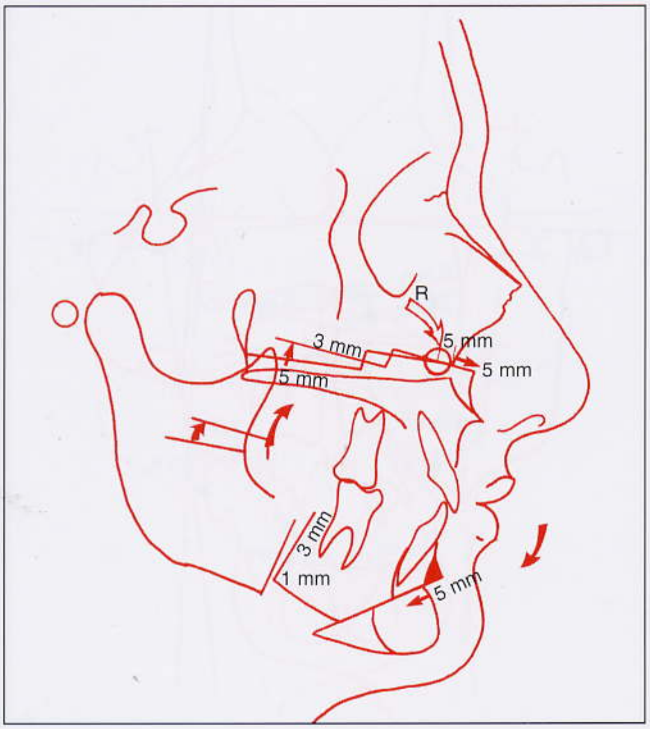


Fig 3-128 Completed surgical prediction tracing for Case 1. The rotation point (R) is located at the point where the Le Fort I osteotomy lines cross—in this case, 5 mm posterior to the piriform rim.

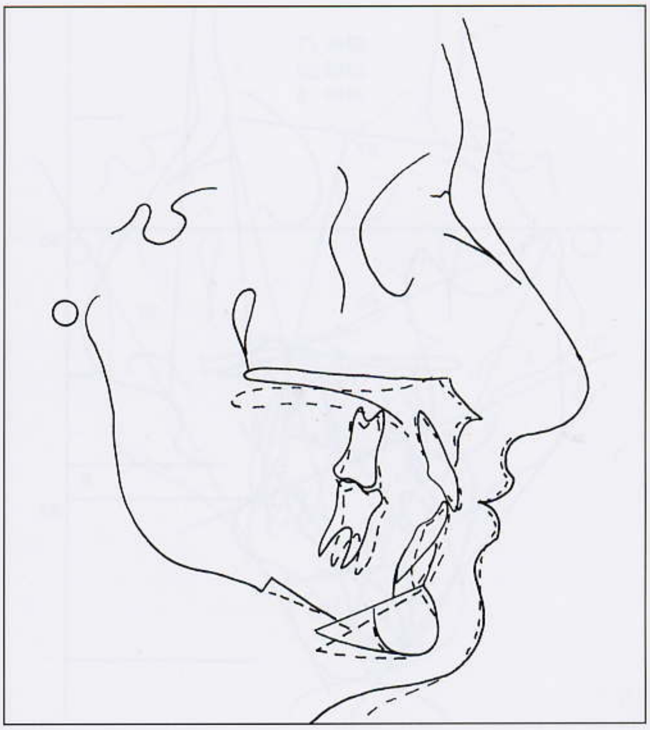


Fig 3-129 The composite tracing of the conventional prediction tracing *(dotted lines)* and the prediction tracing involving clockwise rotation of the maxillomandibular complex *(solid lines)* demonstrates the improved soft tissue contour achieved with the latter.

hard tissue change (Fig 3-126). Complete the prediction tracing by tracing the ideal soft tissue of the chin and the required reduction genioplasty (Fig 3-127). Note that in this instance, a much smaller reduction is indicated than in the conventional prediction (see Fig 3-119), resulting in a better soft tissue chin contour.

Step 6 Evaluate the predicted esthetic and functional results shown on the completed surgical prediction tracing (Fig 3-128). Changes may be indicated to improve the results. In the case demonstrated here, the magnitude of the chin reduction can be reduced by increasing the rotation of the maxillomandibular complex, keeping in mind the effect of the increased advancement of the maxilla. The surgical prediction tracing, however, should always stay within the limitations of sound surgical technique.

Step 7 Note the point (R) where the Le Fort I osteotomy lines of the original tracing and the prediction tracing cross (see Fig 3-128). This is the point around which the maxillomandibular complex will be rotated during surgery. The exact position of the rotation point should be noted and used during the model surgery, as well as during the actual surgical procedure. All jaw movements should be measured on the prediction tracing and model surgery and be recorded as in conventional treatment.

A comparison of the prediction tracing of conventional treatment planning and the prediction tracing reflecting clockwise rotation of the maxillomandibular complex shows that the latter yields superior esthetic results (Fig 3-129).

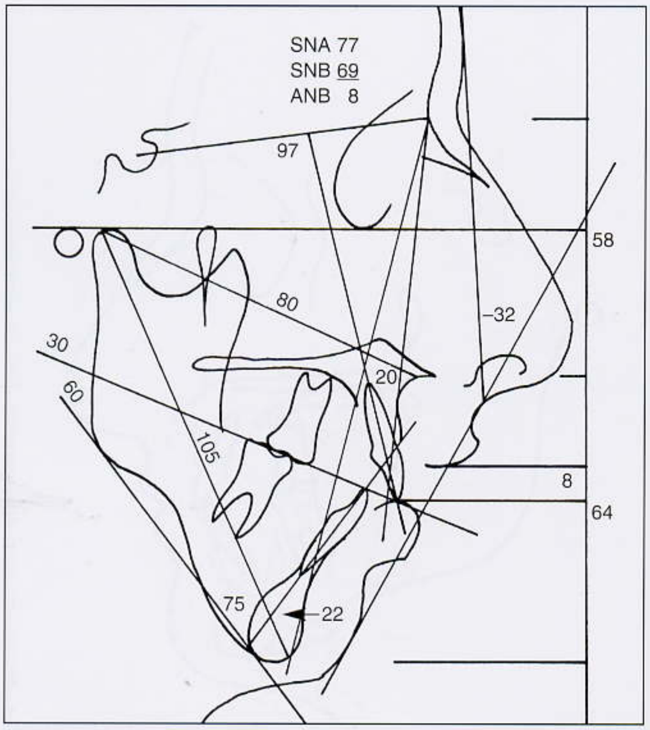


Fig 3-130 Presurgical cephalometric analysis of the patient in Case 2.

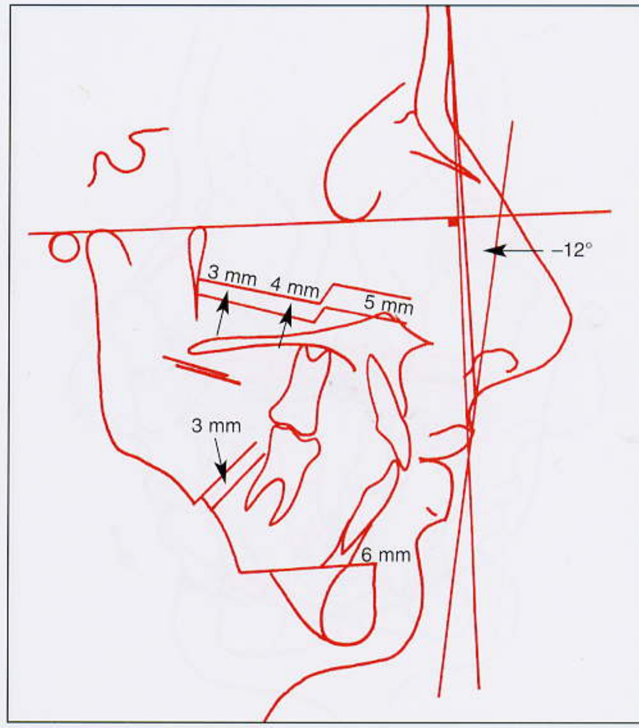


Fig 3-131 Surgical prediction tracing according to conventional principles. The surgery involves maxillary superior repositioning. The mandible will autorotate around a point just posterior to the condyle and is then advanced. The chin is advanced by a sliding genioplasty. The profile is still convex, and the chin is positioned too far posteriorly. Any further advancement of the chin through genioplasty, however, will lead to an unesthetic chin contour.

Case 2: Surgical prediction tracing involving counterclockwise rotation of the maxillomandibular complex

The presurgical cephalometric analysis of the patient in Case 2 is shown in Fig 3-130. The diagnosis is Class II malocclusion, mandibular anteroposterior deficiency, vertical maxillary excess, and microgenia.

Figure 3-131 illustrates the conventional surgical prediction involving maxillary superior repositioning, mandibular autorotation, and mandibular advancement combined with an advancement genioplasty. For an ideal chin position, the chin needs to be advanced more; however, further advancement by genioplasty will cause poor esthetic chin contour. The alternative of counterclockwise rotation of the maxillomandibular complex is tested by means of a surgical prediction tracing. This can lead to an improved esthetic result, as illustrated in Fig 3-132. Note the rotation point (R), in this case at the posterior nasal spine. The difference in surgical outcome results is demonstrated in a composite tracing in Fig 3-133.

Immediate preoperative model surgery

The primary goal of model surgery is to functionally and spatially simulate the patient's jaws and dental structures as accurately as possible to allow accurate simulation of the intended surgery. The preoperative position of these structures can be measured and recorded. The surgical movement of the jaw(s) or dentoalveolar segments, as indicated by cephalometric prediction tracings, is simulated on the casts,

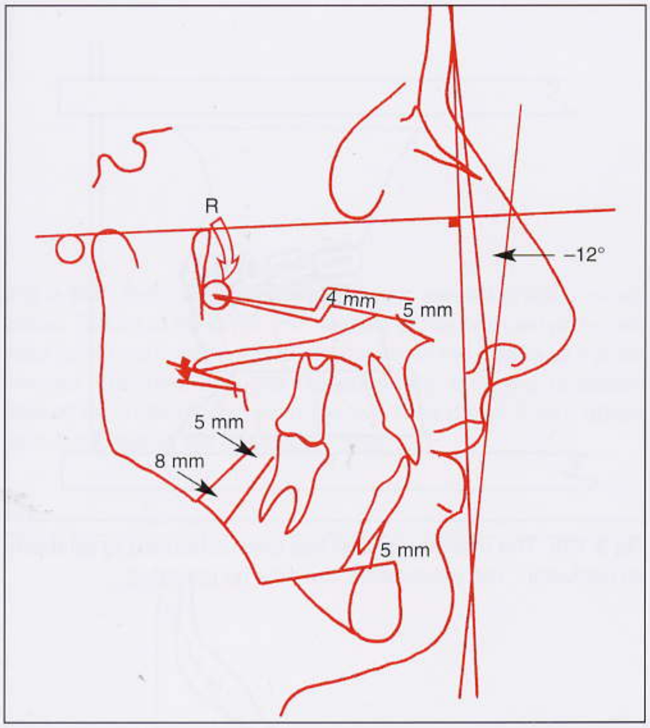


Fig 3-132 The surgical prediction tracing demonstrates counterclockwise rotation of the maxillomandibular complex around a point (R) at the posterior nasal spine. The rotation of the maxilla enables the surgeon to advance the mandible further than is possible with conventional planning. The anteroposterior position of the chin is acceptable and allows good soft tissue contour.

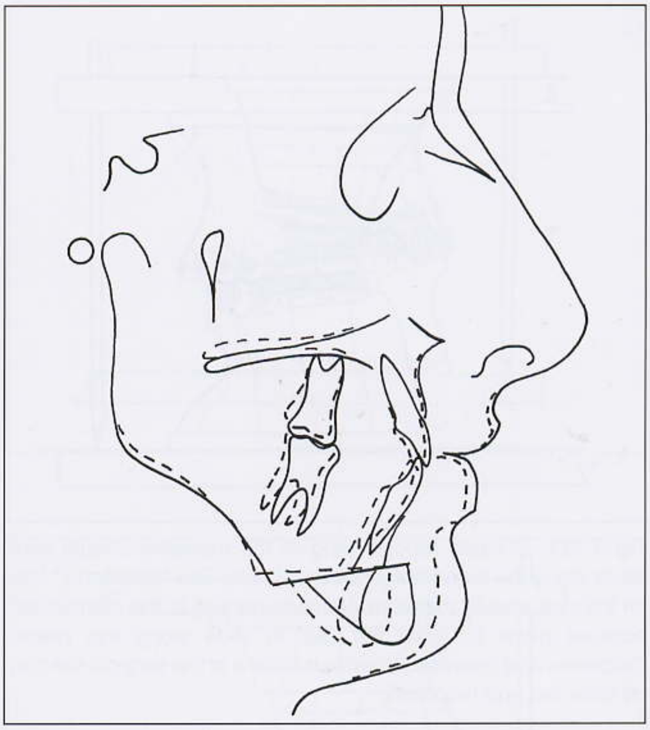


Fig 3-133 The difference in results is demonstrated by the composite tracing. The conventional prediction tracing *(dotted lines)* is compared with the prediction tracing using the counterclockwise rotation of the maxillomandibular complex *(solid lines)*.

and the specific spatial changes are then recorded. In short, model surgery is the dental cast version of cephalometric prediction of surgical results.

The first step in defining the patient's deformity in three planes of space is to place the dental casts on an anatomic articulator using a facebow transfer in centric occlusion. The plaster is trimmed to simulate the anatomy of the maxilla and mandible as closely as possible. Reference lines are then drawn on the mounted casts to record their positions in three planes of space. The second step is to determine the desired final position, aided by the cephalometric prediction tracing and clinical data. In the third step, premovement and postmovement measurements are compared. The clinician can now accurately determine what dimensional movements will be necessary to accomplish the intended surgical goals. The surgical options fall into three basic categories: *(1)* mandibular surgery only, *(2)* maxillary surgery only, and *(3)* two-jaw surgery.

Mandibular surgery only

When mandibular surgery alone is contemplated, the mandibular anterior or posterior movement or rotational movements are dictated by the maxillary dentition. The occlusion of the mandible is adapted to that of the maxilla.

For example, in mandibular advancement, model surgery would proceed as follows:

1. Draw a horizontal "osteotomy" line parallel to the mandibular occlusal plane (Fig 3-134).

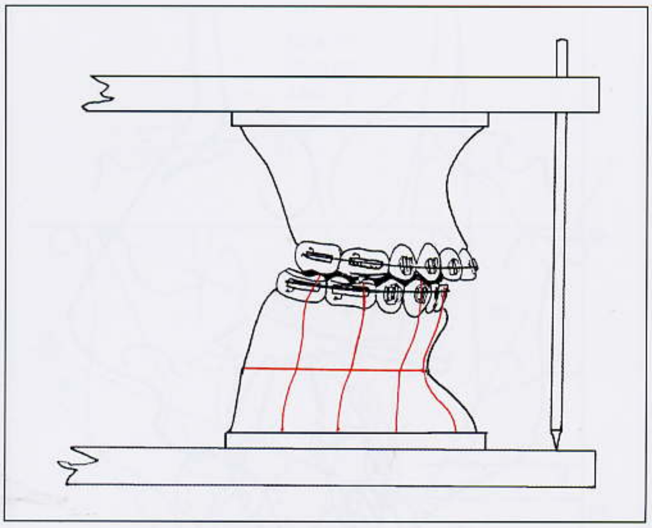


Fig 3-134 Surgical repositioning of the mandible should take place along the mandibular occlusal plane. The "osteotomy" line on the cast should therefore be made parallel to the mandibular occlusal plane to allow the cast to slide along this plane. Clockwise and counterclockwise rotations at the surgical site can be detected and recorded.

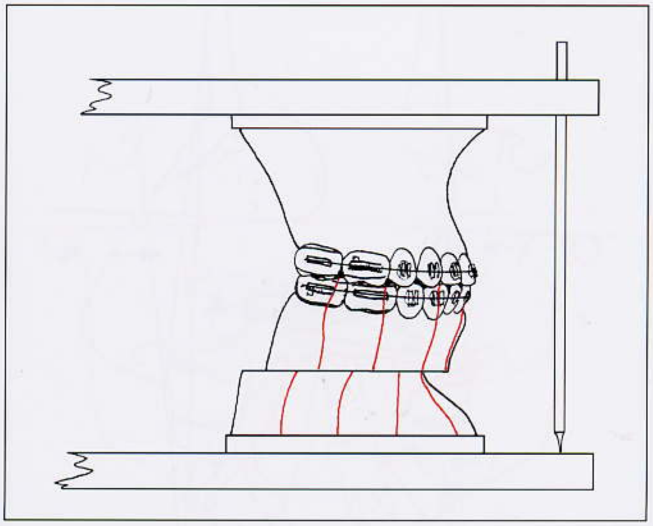


Fig 3-135 The mandibular cast has been advanced to establish an occlusion. The movements can now be recorded.

2. Draw vertical reference lines from the cusps of the molar, canine, and central incisors to the base of the cast (see Fig 3-134).
3. Measure the length of the vertical lines, and record the data.
4. Cut the mandibular cast on the horizontal osteotomy line.
5. Advance the cast into the most favorable dental occlusion (Fig 3-135).
6. Measure anteroposterior vertical and/or rotational movements and compare them with the premovement data.

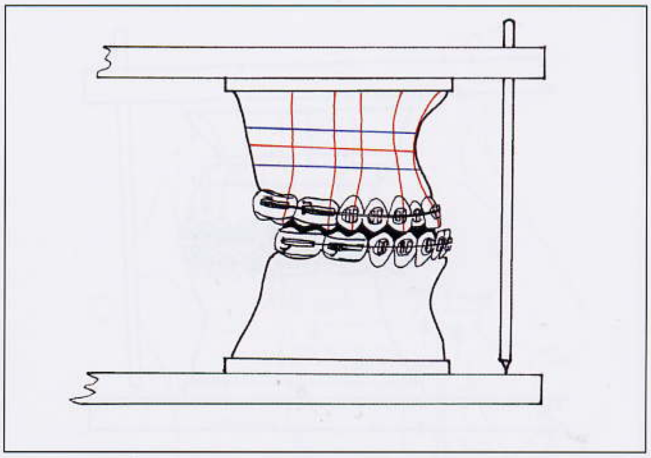
Maxillary surgery only

When maxillary surgery alone is contemplated, the mandibular dentition dictates the position of the maxilla. If any vertical changes of the maxilla are planned, the mandible will autorotate, which in turn will affect the anteroposterior position of the maxilla. The anteroposterior position is therefore dictated by the mandible, while the vertical position can be altered by vertical repositioning of the maxilla. A basic rule is that *the postoperative position of the operated jaw is determined by the unoperated jaw, except in the vertical plane when the maxilla is the jaw to be repositioned.*

Following are the procedures to be used in the case of maxillary repositioning (advancement in this case):

1. Draw a horizontal "osteotomy" line as close as possible to where the actual Le Fort I osteotomy will be performed (Fig 3-136).
2. Draw two horizontal lines, one line 5 mm above the osteotomy line and one line 5 mm below it (the two lines are 10 mm apart) (see Fig 3-136). The lateral walls of the maxilla are not parallel and taper downward. This situation often leads to telescoping, especially of the posterior maxilla, which limits bone contact, accurate surgical positioning, and adequate bone fixation. By measuring the distance between the horizontal lines close to the osteotomy line, a more accurate assessment of the necessary amount of bone removal can be made (Fig 3-137).
3. Draw vertical lines from the buccal cusps of the teeth to the base of the cast.
4. Measure the length of the vertical lines, and record the data.

Fig 3-136 The "osteotomy" line is drawn parallel to the occlusal plane. Failure to keep this line parallel to the occlusal plane will lead to vertical lengthening or shortening of the maxilla as it is advanced. For more accurate measurement, trimming of plaster should be limited to between the two lines drawn 5 mm above and 5 mm below the "osteotomy" line.



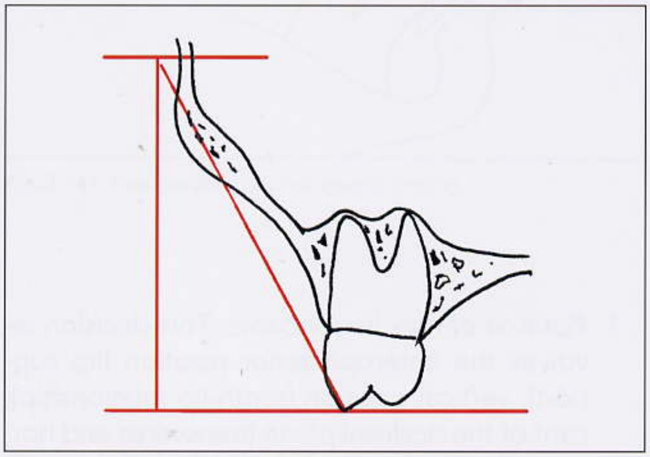


Fig 3-137 The discrepancy in measuring actual vertical height and measuring the tapering maxillary surface is demonstrated.

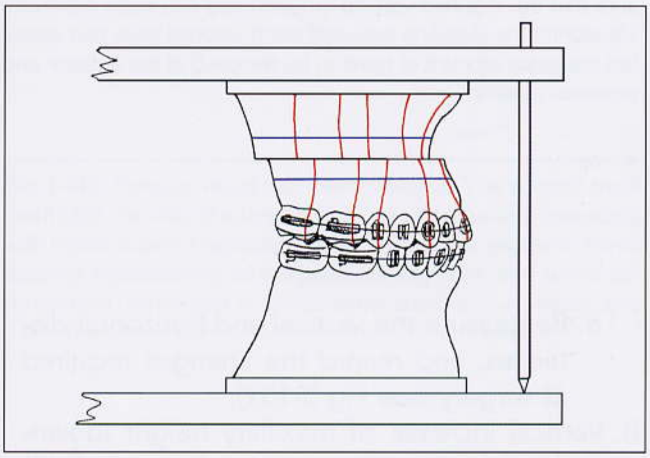


Fig 3-138 Maxillary cast in the planned position. Surgical changes can be recorded.

5. Cut the cast along the osteotomy line.
6. Perform anteroposterior maxillary repositioning:
   a. Advance the cast into the planned occlusion (Fig 3-138).
   b. If no vertical changes of the face are contemplated, the articulator pin should be kept fixed and the vertical height maintained.
   c. It may be necessary to trim the casts to fit into position.
   d. Remeasure the vertical and horizontal distances to record the required surgical movement.

Another example of maxillary surgery only is vertical maxillary repositioning. Following are the procedures to be used for model surgery in such cases:

A. Superior repositioning of the maxilla
   1. Loosen the articulating pin to allow free movement.
   2. Trim the cast to allow the necessary superior repositioning.
   3. Place the cast into the planned occlusion, and measure the vertical height from the incisor edge to the base of the cast to ensure that the required vertical reduction has been achieved (Fig 3-139).
   4. Tightening of the articulator pin
   5. Wax the cast into position.

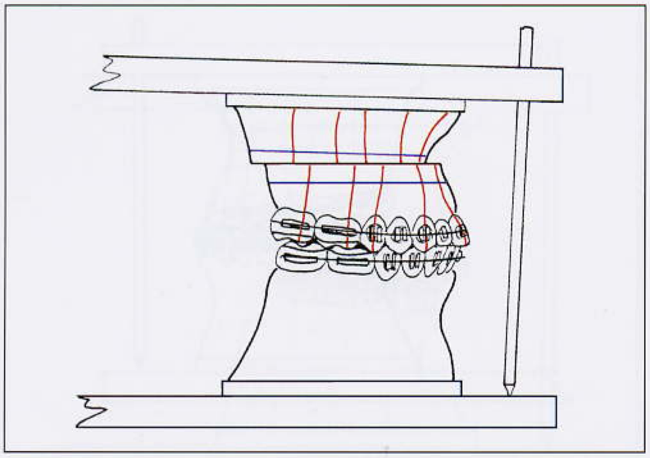


Fig 3-139 Trim the superior aspect of the cast. Measure the distance from the maxillary incisor tip to the base of the cast to ensure that the required vertical repositioning has been achieved. Measuring the distance between the horizontal lines can establish the exact amount of bone to be removed at the anterior and posterior maxilla.

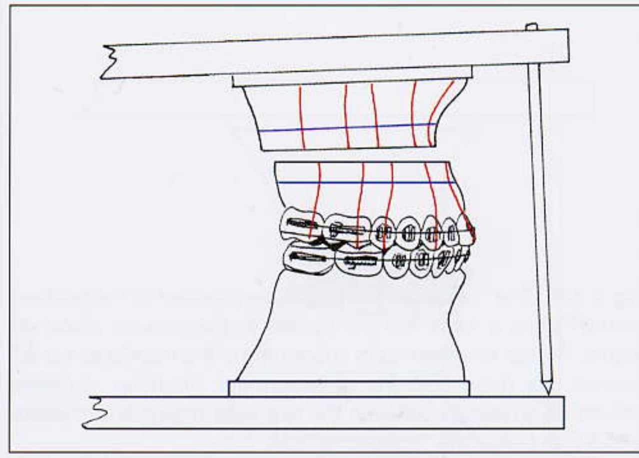


Fig 3-140 Open the articulator until the correct amount of vertical increase has been achieved. (Measure from the incisor tip to the base of the cast.)

6. Remeasure the vertical and horizontal distances, and record the changes required at surgery (see Fig 3-139).

B. Vertical increase of maxillary height (downgrafting)
1. Loosen the articulating pin to allow free movement.
2. Place the cast into the planned occlusion.
3. Open the articulator while monitoring the vertical increase from incisor tip to the base of the cast (Fig 3-140).
4. Once the desired vertical increase has been obtained, tighten the articulator pin.
5. Wax the cast into position.
6. Remeasure the vertical and horizontal distances, and record the surgical movements (see Fig 3-140).

Two-jaw surgery

Planning two-jaw surgery involves the most complex combination of procedures; therefore, a systematic approach is essential. After careful clinical, cephalometric, and occlusal analysis, the surgeon faces the following decisions:

1. *Position of maxillary incisors.* This decision involves the anteroposterior position (lip support), vertical position (tooth-lip relationship), cant of the occlusal plane (transverse and horizontal), and dental midline (facial midline).
2. *The occlusal plane and, therefore, the vertical position of the posterior maxilla.* This decision is determined by the position of the mandible after autorotation, unless either manipulation of the occlusal plane is contemplated or a transverse cant of the mandibular occlusal plane is present and should be corrected.
3. *Most ideal anteroposterior relationship of the mandible.* Once the mandible has been autorotated to the ideal vertical relationship to the new maxillary incisor position, it can be advanced or set back along the "new" occlusal plane to its most ideal anteroposterior relationship to the maxillary incisor.
4. *Coordination of anteroposterior changes of the left and right sides of the maxillary arch with the mandibular arch rotations.*
5. *Evaluation of transverse arch discrepancies (arch widths) and their correction (by posterior segmental model surgery) once the mandibular position has been established.*

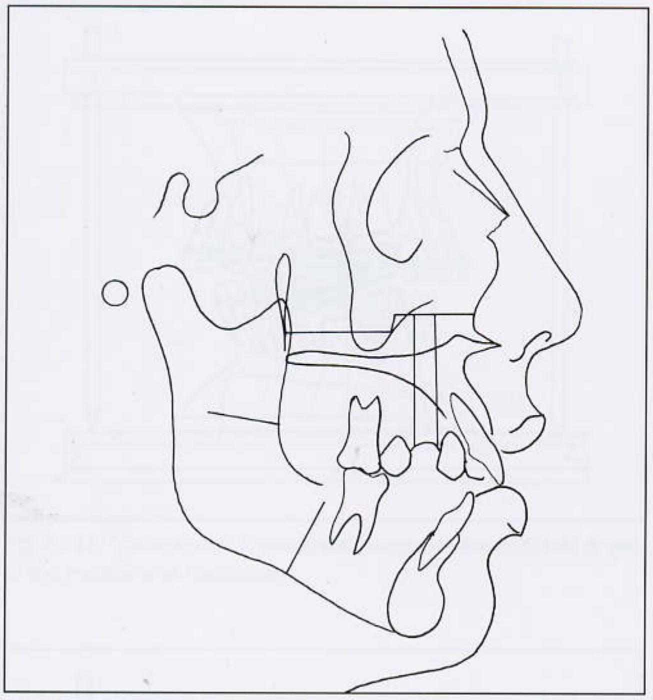


Fig 3-141 Preoperative cephalometric tracing.

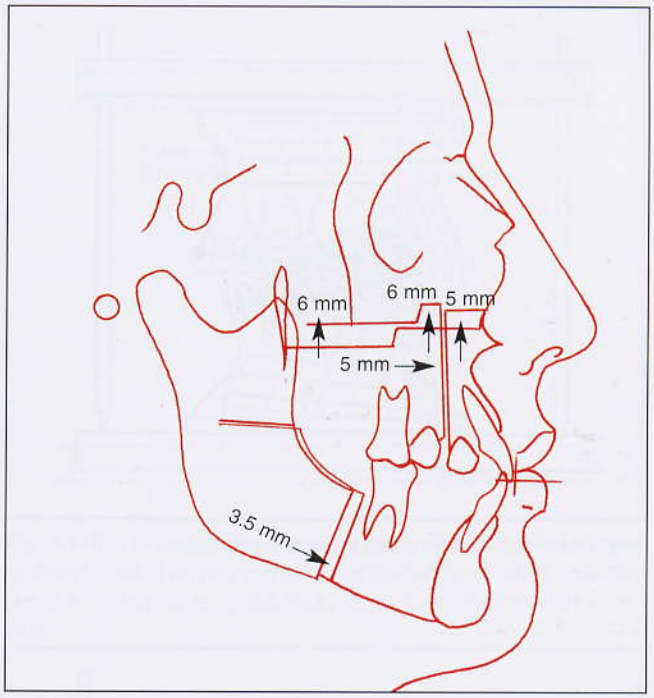


Fig 3-142 Surgical visual treatment objective. The surgical treatment plan consists of a three-piece Le Fort I maxillary osteotomy with 5-mm superior repositioning of the anterior segment, 6-mm superior repositioning of the posterior segment, and 5-mm advancement; expansion of the posterior maxillary segments; and 3.5-mm advancement of the mandible after autorotation.

Example of model surgery

The presurgical problem list of the patient depicted in the cephalometric tracing shown in Fig 3-141 consisted of the following:

- Class I molar and Class II canine relationships
- Anterior open bite
- Narrow maxillary arch
- Increased overjet
- Interdental space between maxillary canines and second premolars (the first premolars have been removed)
- Mandibular first premolars removed and the spaces closed orthodontically
- Vertical maxillary excess
- Mandibular anteroposterior deficiency

The surgical treatment plan follows (Fig 3-142):

- A three-piece Le Fort I maxillary osteotomy with differential superior repositioning of the anterior and posterior segments to allow the maxilla to autorotate
- Expansion of the posterior maxillary segments
- Closure of the spaces between canines and second premolars
- Advancement of the mandible

Step I

Articulate the casts on an anatomic articulator in centric occlusion using a facebow recording (Fig 3-143). Trim the casts to resemble as closely as possible the true anatomy of the maxilla and mandible. Make a duplicate cast of the mandibular dentition. Remove the articulated mandibular cast from the articulator, and articulate the duplicate cast in exactly the same way. Change the casts again, and keep the duplicate cast for use in the construction of an intermediate splint.

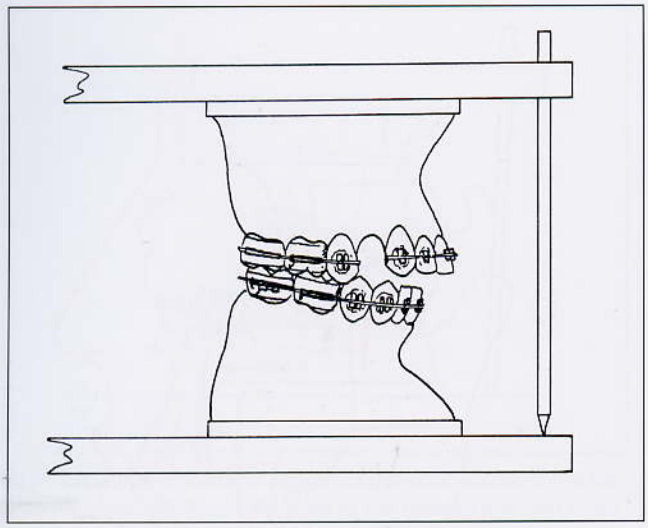


Fig 3-143 Casts articulated in centric occlusion.

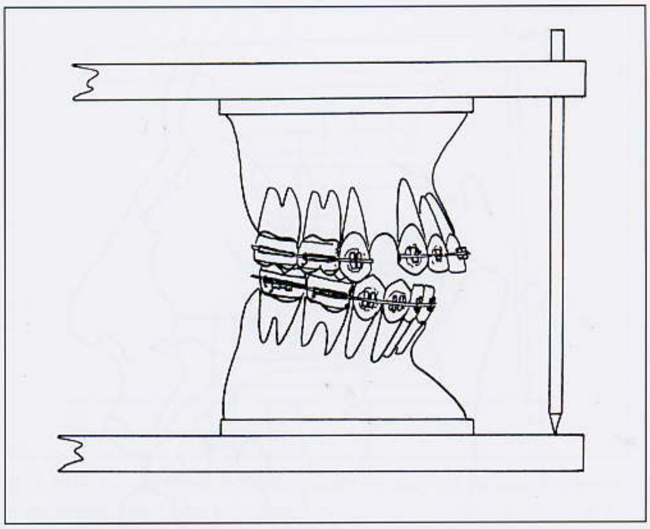


Fig 3-144 Draw the roots of the teeth.

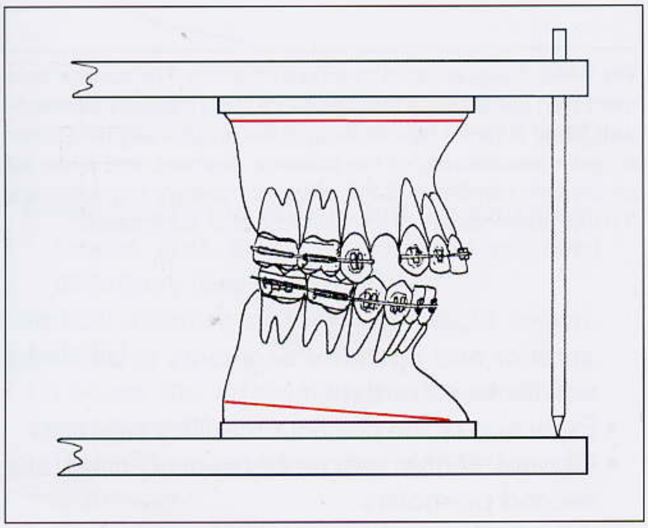


Fig 3-145 Horizontal lines for vertical measurements.

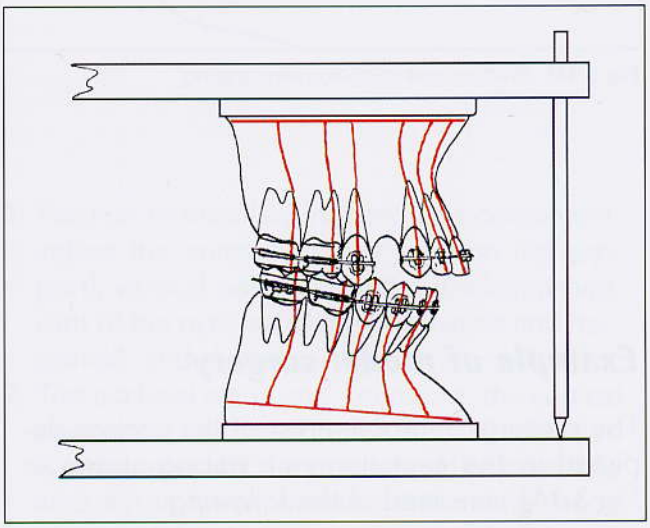


Fig 3-146 Vertical lines to record preoperative heights and measure planned vertical surgical changes.

Step 2

Draw reference lines:

1. Draw the tooth roots on the casts, using the panoramic radiograph as a guide. Pay special attention to the teeth adjacent to the interdental osteotomy (Fig 3-144).
2. Draw a line high on the maxillary cast and a line low on the mandibular cast parallel to the respective occlusal planes. These lines will serve as references for vertical measurement (Fig 3-145).
3. Perpendicular to each horizontal line, draw vertical lines to the buccal cusps of the teeth (Fig 3-146).
4. Draw "osteotomy" lines representing the actual planes along which surgical movements will take place. It is important, especially on the maxillary cast, to draw the osteotomy line at the same angle and plane at which the actual Le Fort I osteotomy will be performed. The mandibular osteotomy line (a sliding plane) should be parallel to the mandibular occlusal plane (Fig 3-147).

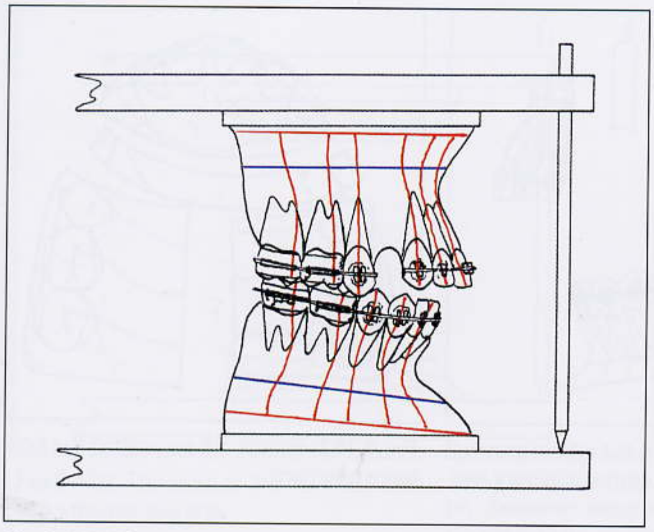


Fig 3-147 "Osteotomy" lines drawn parallel to the occlusal plane of the maxilla and mandible.

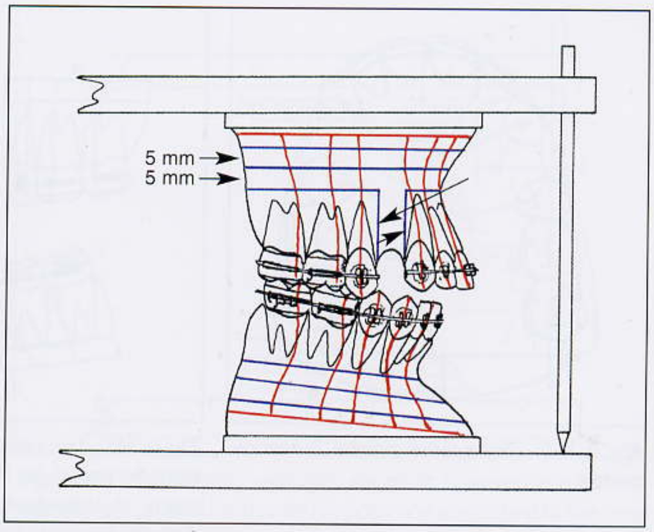


Fig 3-148 Horizontal lines equidistant to (5 mm from) the "osteotomy" lines. The two vertical lines *(arrows)* indicate a safe distance from the roots of the teeth to perform the interdental osteotomy.

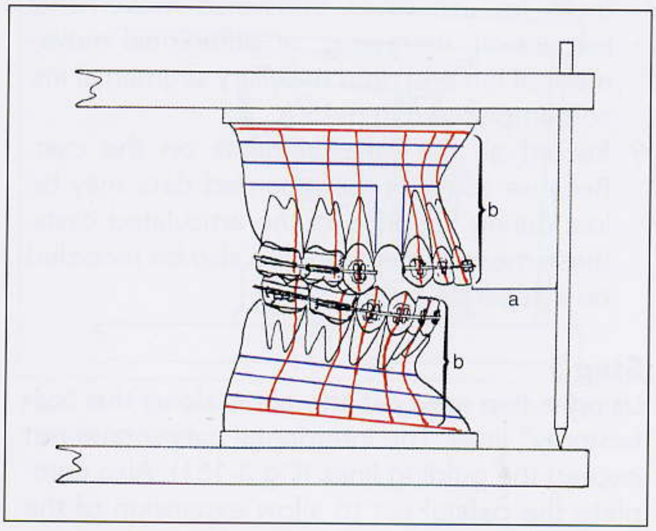


Fig 3-149 Measurement the anteroposterior position of maxillary incisor teeth (a) and the vertical distance from the horizontal line to the incisor tips and buccal cusps (b).

5. Draw two horizontal lines the same distance (eg, 5 mm) above and below the "osteotomy" lines. Measure the distance between them (eg, 10 mm) (Fig 3-148; see Fig 3-137).
6. Draw two vertical lines, one on each side of interdental "osteotomies." Measure the distance between these lines (see Fig 3-148). They should be drawn on a plane so that bone can safely be removed without risk of injury to the roots of the teeth next to the interdental osteotomies. The lines will act as the limits of safe bone removal during model surgery.
7. Measure the distance between the buccal surface of the maxillary incisor and the vertical pin of the articulator (Fig 3-149).
8. Draw transverse lines on the palatal surface of the maxillary cast from left to right, joining lingual cusps of molars, premolars, and canines. Measure these distances, and record

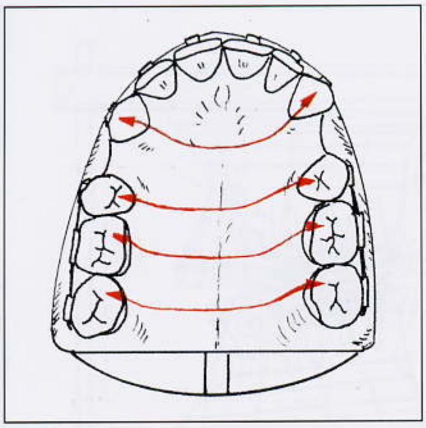


Fig 3-150 Transverse palatal measurements.

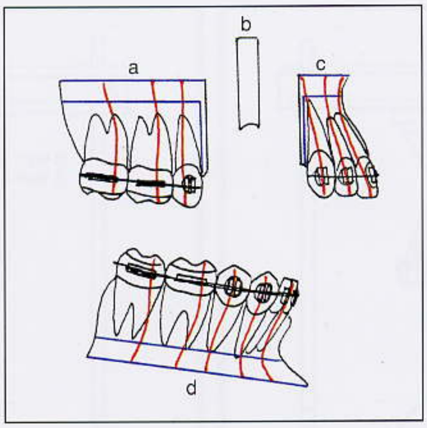


Fig 3-151 The cast is cut and interdental bone removed. *(a)* Posterior maxillary segment. *(b)* Interdental bone removed. *(c)* Anterior maxillary segment. *(d)* Mandibular segment.

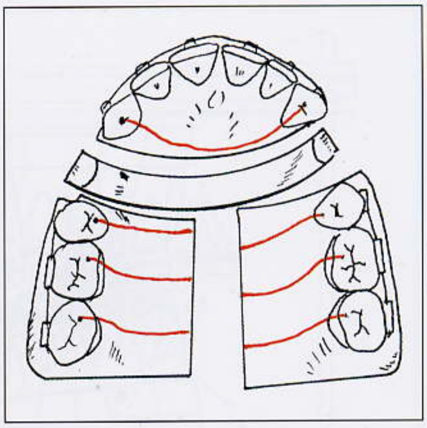


Fig 3-152 Palatal cut separating the posterior segments.

them for use when transverse movements (expansion, narrowing, or differential movement of left and right maxillary segments) are contemplated (Fig 3-150).

9. Record all the measurements on the cast. Because some of the recorded data may be lost during handling of the articulated casts, these measurements should also be recorded on a separate form.

Step 3

Using a thin saw, cut the casts along the "osteotomy" lines. The interdental cuts should not exceed the guiding lines (Fig 3-151). Also complete the palatal cut to allow expansion of the posterior segments (Fig 3-152). The articulator pin should still be tightened. If more than 5 mm of superior repositioning is contemplated, a few millimeters of plaster should be removed from the maxillary cast base (Fig 3-153).

Step 4

Position the anterior maxillary segment according to the cephalometric visual treatment objective (on which the postoperative anteroposterior and vertical positions of the maxillary central incisor have been planned) (see Fig 3-146). This is done by removing plaster from the plaster segment and using measurements from reference lines and the articulator pin. The segment is then waxed into position (Fig 3-154).

Step 5

Loosen the vertical pin of the articulator. Place the mandibular cast on the sliding plane and move it anteriorly while altering the vertical position by closing the articulator (autorotation). Ideal incisor and canine relationships are now established, and the mandibular segment is secured to the base with sticky wax (Fig 3-155).

Step 6

Trim the superior aspect of the posterior maxillary segment, and place the segment into position with the maxillary teeth to fit the mandibular occlusion. If any transverse discrepancies exist, consider a midline palatal osteotomy to facilitate either expansion or narrowing of the posterior maxilla. Trim the cast according to the actual anatomic structures (Fig 3-156). Unrealistic movements planned during model surgery cause problems during surgery.

Step 7

Measure the vertical and horizontal changes, and record the surgical movements (Fig 3-157). Transverse changes are measured from palatal cusp to palatal cusp (Fig 3-158). Replace the articulator pin and tighten it.

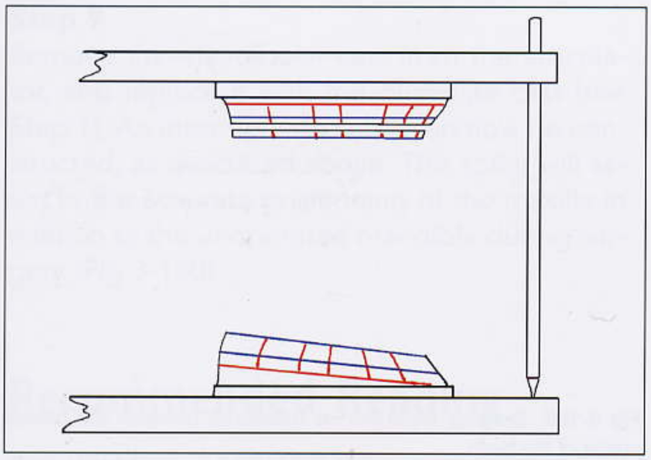


Fig 3-153 The base of the maxillary cast is trimmed, but not beyond the parallel line.

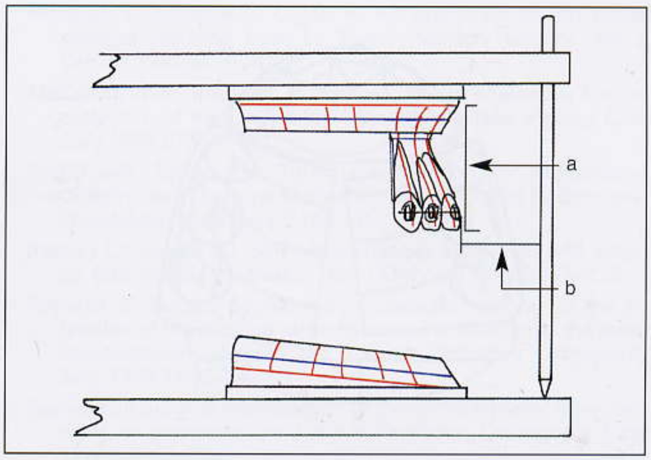


Fig 3-154 The anterior maxillary segment is waxed into the correct vertical (a) and horizontal (b) positions according to the treatment plan.

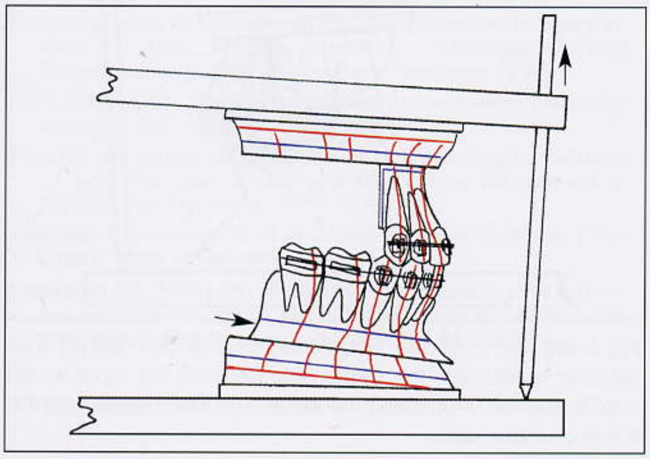


Fig 3-155 The articulating pin is loosened to allow mandibular autorotation. The mandibular cast is then advanced into the planned anteroposterior position.

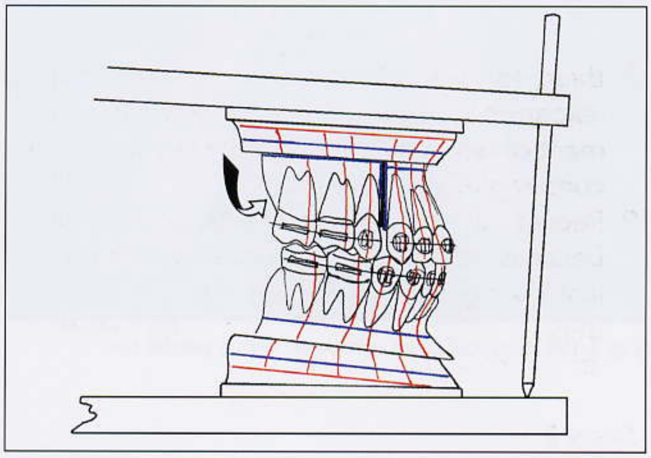


Fig 3-156 The posterior maxillary segments are trimmed to fit into the occlusion.

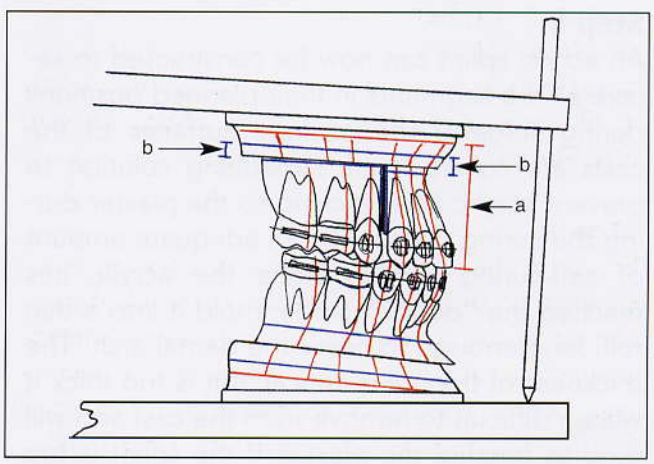


Fig 3-157 Vertical changes are measured by remeasuring the vertical lines from the cusps of the teeth to the horizontal lines (a). For accurate measurement of the amount of bone to be removed, the distance between the horizontal lines above and below the "osteotomy" line is remeasured (b).

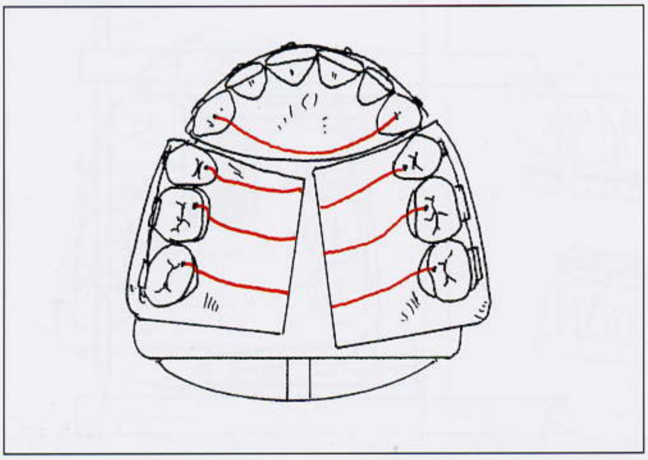


Fig 3-158 Surgical expansion is measured between the palatal cusps of the teeth.

Fig 3-159 Surgical splint reinforced with a palatal bar.

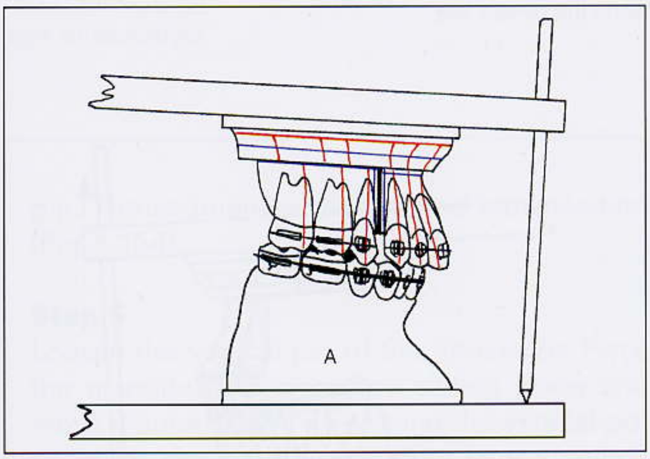


Fig 3-160 The duplicate "unoperated" mandibular cast (A) is articulated to establish the relationship between the repositioned maxilla and the unoperated mandible. The intermediate splint is made on these casts.

Step 8

An acrylic splint can now be constructed to secure all the segments in their planned positions during surgery. The occlusal surfaces of the casts are covered with separating solution to prevent acrylic from sticking to the plaster during the curing phase. Mix an adequate amount of self-curing acrylic. Once the acrylic has reached the "dough" stage, mold it into a thin roll, long enough to cover the dental arch. The thickness of the roll is critical. If it is too thick it will be difficult to remove from the cast and will tend to fracture the plaster. If the splint is too thin, however, it could easily fracture at a critical stage of surgery. When a large palatal expansion is contemplated, consider reinforcing the splint with a palatal bar (Fig 3-159).

Place the acrylic roll on the mandibular occlusal surface. Slowly close the articulator, gently forcing the teeth into the planned occlusion. Trim off any excess acrylic with a sharp knife. Place the articulator into a pressure pot, and allow the acrylic splint to cure under pressure. Once it has cured, remove the splint carefully, and trim and polish it. Make small interdental holes on the buccal side to facilitate intermaxillary wire placement. Some surgeons prefer to keep the splint on the maxilla for some time after surgery. The interdental holes facilitate fixation of the splint to the maxilla only.

Step 9

Remove the mandibular cast from the articulator, and replace it with the duplicate cast (see Step 1). An intermediate splint can now be constructed, as described above. This splint will assist in the accurate positioning of the maxilla in relation to the unoperated mandible during surgery (Fig 3-160).

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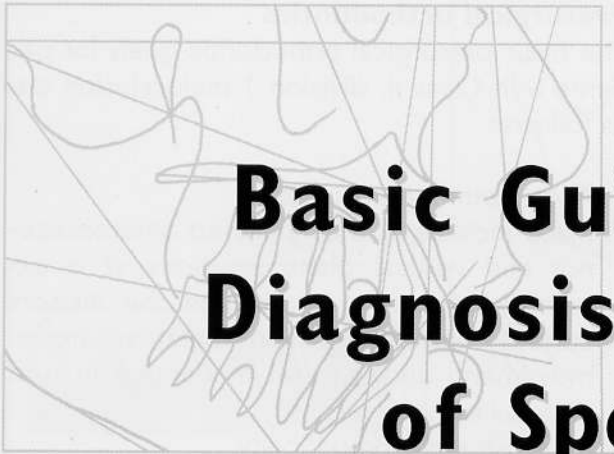


chapter 4

Basic Guidelines for the Diagnosis and Treatment of Specific Dentofacial Deformities

This chapter uses case studies to demonstrate individual dentofacial problems, combinations of problems, and the nuances involved in treating these patients to achieve optimal results. Patients with similar skeletal, soft tissue, and occlusal characteristics are grouped for convenience in description. Clinicians should remember, however, that each patient has a unique set of dentofacial problems requiring a specific treatment response, and a patient may have more than one deformity.

The following basic deformities and treatment principles for each deformity are discussed: *(1)* mandibular anteroposterior deficiency, *(2)* mandibular anteroposterior excess, *(3)* maxillary anteroposterior deficiency, *(4)* maxillary anteroposterior excess, *(5)* maxillary vertical deficiency, *(6)* maxillary vertical excess, *(7)* cases requiring rotation of the maxillomandibular complex, *(8)* open bite deformities, and *(9)* dentofacial asymmetry.

Mandibular Anteroposterior Deficiency

Patients with mandibular anteroposterior deficiency are without a doubt the largest single group of surgical orthodontic patients.

Class II, division I malocclusion

Clinical characteristics

Profile view

- A retruded, weak chin
- A deficient mandible giving the illusion of a large nose
- A short chin-to-throat length
- An obtuse lower lip–chin–throat angle

- An everted lower lip that wedges in behind the incisors
- Often, an upper lip that appears short, curled, and protrusive
- An acute labiomental fold
- An increased facial contour angle (convex profile)

Frontal view
- A curled lower lip
- A weak chin with the appearance of a double chin
- A deep labiomental fold

Dental characteristics
- A large overjet
- Usually, an increased overbite and an accentuated curve of Spee
- Usually, crowding in the mandibular incisor area
- A tendency for maxillary incisor spacing

Treatment
Growth modification is not feasible after adolescence. Without surgical correction of the jaw relationship, an orthodontic compromise will consist of the following:

1. Correction of excessive overjet
   a. Retraction of maxillary incisors (with or without extraction of first premolars)
   b. Proclination of mandibular incisors
2. Correction of excessive overbite
   a. Intrusion of maxillary incisors
   b. Intrusion of mandibular incisors
   c. Downward rotation of the mandible by opening the bite

At the beginning of treatment, the clinician must decide whether the treatment approach will be solely orthodontic or orthodontic and surgical. Because the orthodontic treatments in the two approaches differ substantially, it does not make sense to tell patients who are beginning orthodontic treatment, "Let's see how the treatment progresses; we may get away without surgery."

Presurgical orthodontics
The basic presurgical orthodontic goals for patients with Class II, division 1 malocclusion are as follows:

1. Align both dental arches.
2. Place incisors in their planned anteroposterior and vertical plane positions. It is extremely important to position the incisors correctly. Incisor position dictates surgical movement, and surgical movement in turn dictates esthetic results.
3. Establish arch compatibility.

Note particularly the orthodontic goal of properly positioning the maxillary and mandibular incisors presurgically in both anteroposterior and vertical planes of space. The position of the incisors dictates the surgical movement, and failure to eliminate dental compensation limits surgical correction. Because of crowding in the incisor area and a severe curve of Spee, it is often necessary to extract two first premolars in the mandibular arch. Extractions in the maxilla, however, frequently are not indicated. If there is some crowding in the maxillary arch, it is often possible to avoid extraction by gaining additional space through expansion of the maxillary arch—an adjustment often needed to accommodate the mandibular arch after surgical advancement. If extraction in the maxilla is deemed necessary, it may be advantageous to extract second premolars to enable minimal retraction of incisors. Retraction of these incisors otherwise would not only limit surgical movement but also have adverse esthetic effects (loss of lip support and increased nasolabial angle).

Patients with a Class II, division 1 malocclusion often have an excessive curve of Spee. It is important not to level the curve routinely before surgery. Patients with short faces often have prominent chins and, from an esthetic point of view, do not tolerate mandibular advancement. In these cases it is preferable not to level the curve of Spee presurgically. Surgical advancement of the mandible will result in a rotational movement, advancing the mandibular incisors with only slight advancement of the chin (see chapter 3). As a general rule, it is better to level

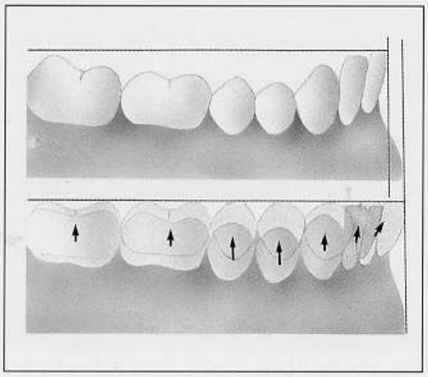


Fig 4-1 Orthodontic leveling of the curve of Spee will increase the anteroposterior arch length. If crowding is present in the incisor area, additional anteroposterior space will be required for arch alignment. Every 1 mm of curve leveling will result in a 0.6- to 1.0-mm increase in arch length.

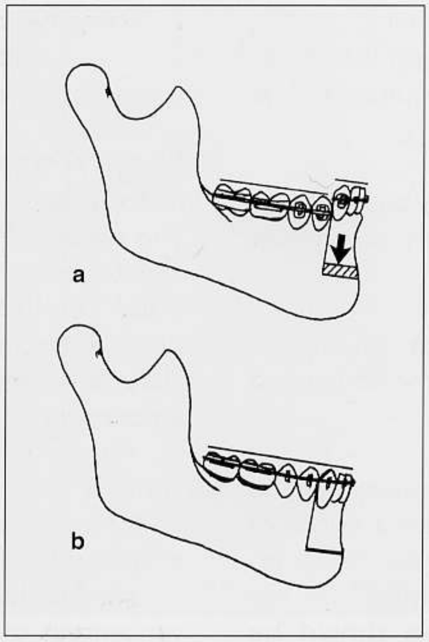


Fig 4-2 The curve of Spee can be leveled surgically by segmental orthodontic alignment of the dental arch *(a)*, followed by surgical inferior repositioning of the anterior dentoalveolar segment *(b)*.

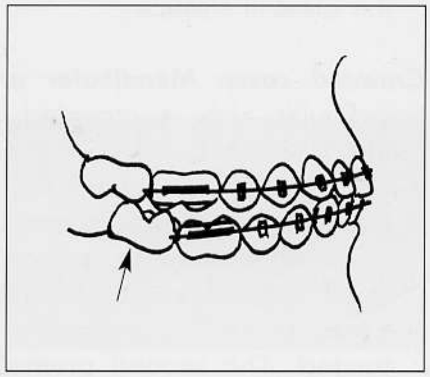


Fig 4-3 Leveling of the mandibular arch should include the second molars. An unbanded molar *(arrow)* often interferes with establishing the planned occlusion at surgery.

the curve by extrusion of premolars after surgery in short faces. The greater the facial height, the greater the likelihood that leveling should be done presurgically by intrusion of the incisors. Because anteroposterior space is needed for leveling and alignment, extractions are more likely to be necessary when a severe curve of Spee is combined with mandibular incisor crowding (Fig 4-1). Surgical leveling of the curve may be considered (Fig 4-2).

Arch compatibility plays an important role in immediate postsurgical stability and gives the surgeon an exact idea of where to position the mandible when a splint is not used during surgery. Three important aspects of arch compatibility follow:

1. Intercanine width is important. If the maxillary intercanine width is insufficient, it will not be possible to advance the mandible into the planned occlusion and anteroposterior position. Because a premature contact may shift the mandible laterally, a rotated canine may make it impossible to correct dental midlines. The use of an acrylic splint at surgery to eliminate this problem does not make sense, since the correct intercanine width must be achieved eventually. If it is achieved before surgery, the surgery will be more accurate, and tooth interdigitation will improve.
2. The mandibular second molars should be banded and leveled with the first molars. An overerupted, elevated, often rotated, unbanded second molar often causes occlusal interference at surgery (Fig 4-3).
3. Similar maxillary and mandibular arch forms should be established to prevent possible postsurgical crossbites. In mandibular deficiency cases, the maxillary arch is often slightly narrow and will need expansion to accommodate the mandibular arch after advancement.

Orthodontic mechanics

Crowded cases: Maxillary arch When the maxillary arch is crowded, the following approach is recommended:

1. Second premolars should be extracted.
2. Headgear use may be necessary to support the Class III elastics.

Crowded cases: Mandibular arch When the mandibular arch is crowded, the following methods should be used:

1. Extraction of premolars may be required. In cases with crowding, accentuated curve of Spee, and the need for mandibular incisor retraction, the first premolars should be extracted. The second premolars should be extracted in cases requiring less anteroposterior space for the planned mandibular incisor positioning.
2. Sectional arch retraction of the mandibular canines is recommended, because the anchorage characteristics are excellent.
3. Class III mechanics (eg, Class III elastics) may be needed, depending on the severity of the mandibular canine position problem, the mandibular incisor position, crowding, and the curve of Spee.

Noncrowded cases When minimal crowding or mild spacing between the teeth is present, a nonextraction approach is recommended:

1. During the leveling process in these cases, the use of Class III mechanics is mandatory.
2. As much retraction or uprighting of the mandibular incisor as possible is achieved with the aid of Class III mechanics (eg, J-hooks or Class III elastics and maxillary headgear support).
3. In these cases, maxillary and mandibular arches are coordinated to fit. When the overjet is not too great (4 to 5 mm), the patient is asked to move the mandible forward so the coordination of the maxillary and mandibular arches can be checked. The best way of checking coordination, however, is to take rough study casts and hand-simulate the surgical advancement of the mandible. Be sure to coordinate the overjet with the orthodontic prediction tracing.

Surgical treatment: Advancement of the mandible

The surgical technique of choice is the bilateral sagittal split ramus osteotomy advancing the distal (tooth-bearing) segment to maximum dental intercuspation. The position of the maxillary and mandibular incisors controls the amount the mandible can be advanced, as well as the facial height after surgery. Correct condyle positioning during surgery is extremely important (see the discussion of condylar sag in chapter 5).

The chin may still appear deficient after advancement of the mandible, and an advancement genioplasty may be indicated to improve final esthetics. The clinician makes this decision according to the presurgical visual treatment objective.

Light (2.5- to 3.5-oz) Class II elastics are placed after the completion of surgery. These elastics will override proprioception, guide the "new" occlusion, and bring the teeth into a solid occlusion.

Postsurgical orthodontics

The goals of postsurgical orthodontics are to bring the teeth into final occlusion and maintain them in that position. Treatment usually consists of final leveling of the curve of Spee, correction of minor crossbites, and final closure of small extraction spaces.

Case A.B.

A.B., a 16-year-old female patient, was referred to the orthodontist for the orthodontic treatment of a Class II malocclusion.

Main complaint

The patient mainly wanted her increased overjet corrected and also felt that her chin appeared too small.

Medical history

Her medical history was noncontributory.

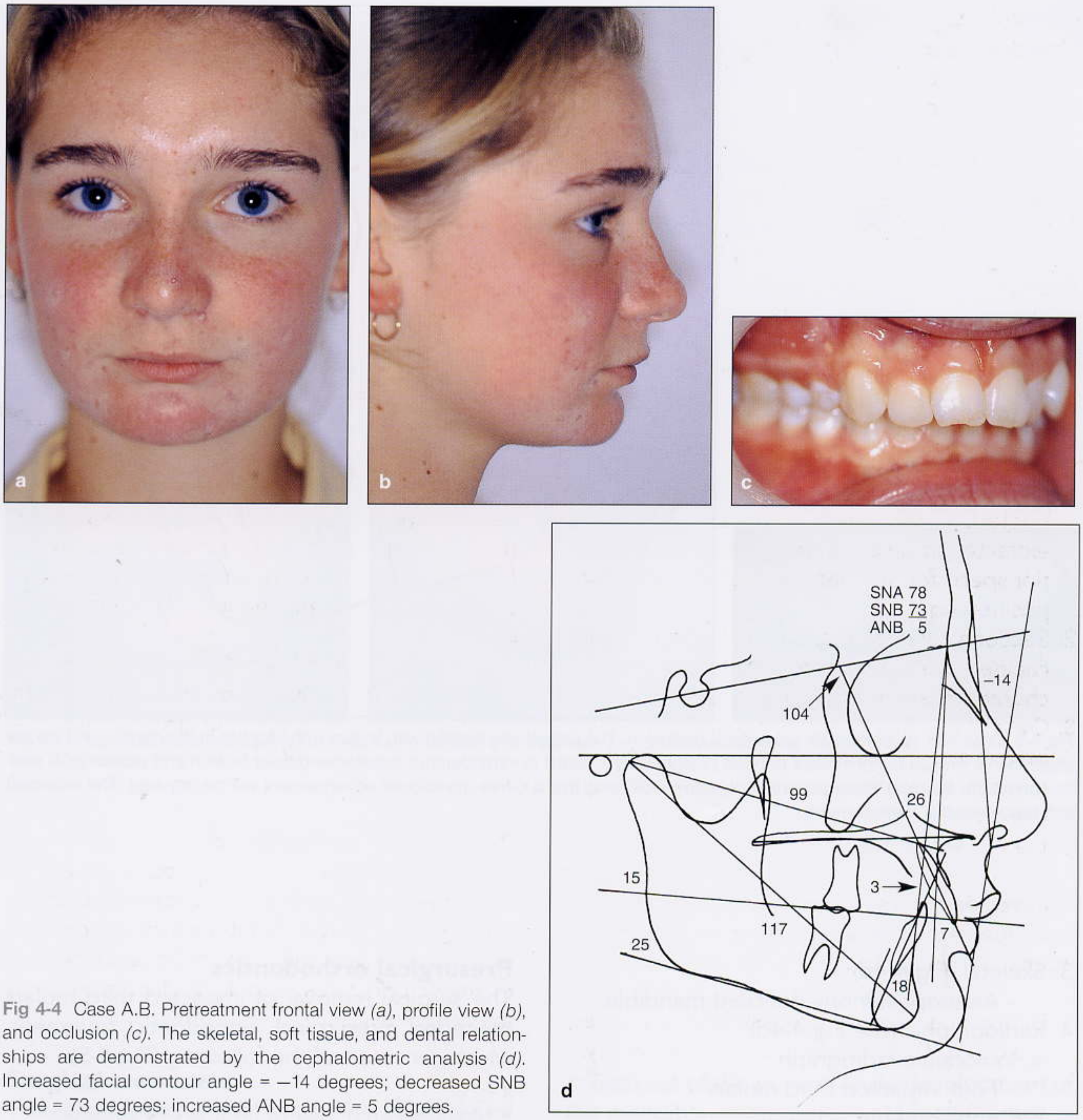


Fig 4-4 Case A.B. Pretreatment frontal view *(a)*, profile view *(b)*, and occlusion *(c)*. The skeletal, soft tissue, and dental relationships are demonstrated by the cephalometric analysis *(d)*. Increased facial contour angle = –14 degrees; decreased SNB angle = 73 degrees; increased ANB angle = 5 degrees.

Clinical examination

1. Soft tissue
   a. Frontal view (Fig 4-4a)
      - Short, deficient chin
      - Everted lower lip
      - Short lower facial third
   b. Profile view (Fig 4-4b)
      - Convex profile
      - Deep labiomental fold
      - Deficient mandible
2. Dental (Fig 4-4c)
   - Class II, division 1 malocclusion
   - Slightly accentuated curve of Spee
   - Slightly narrowed maxillary arch

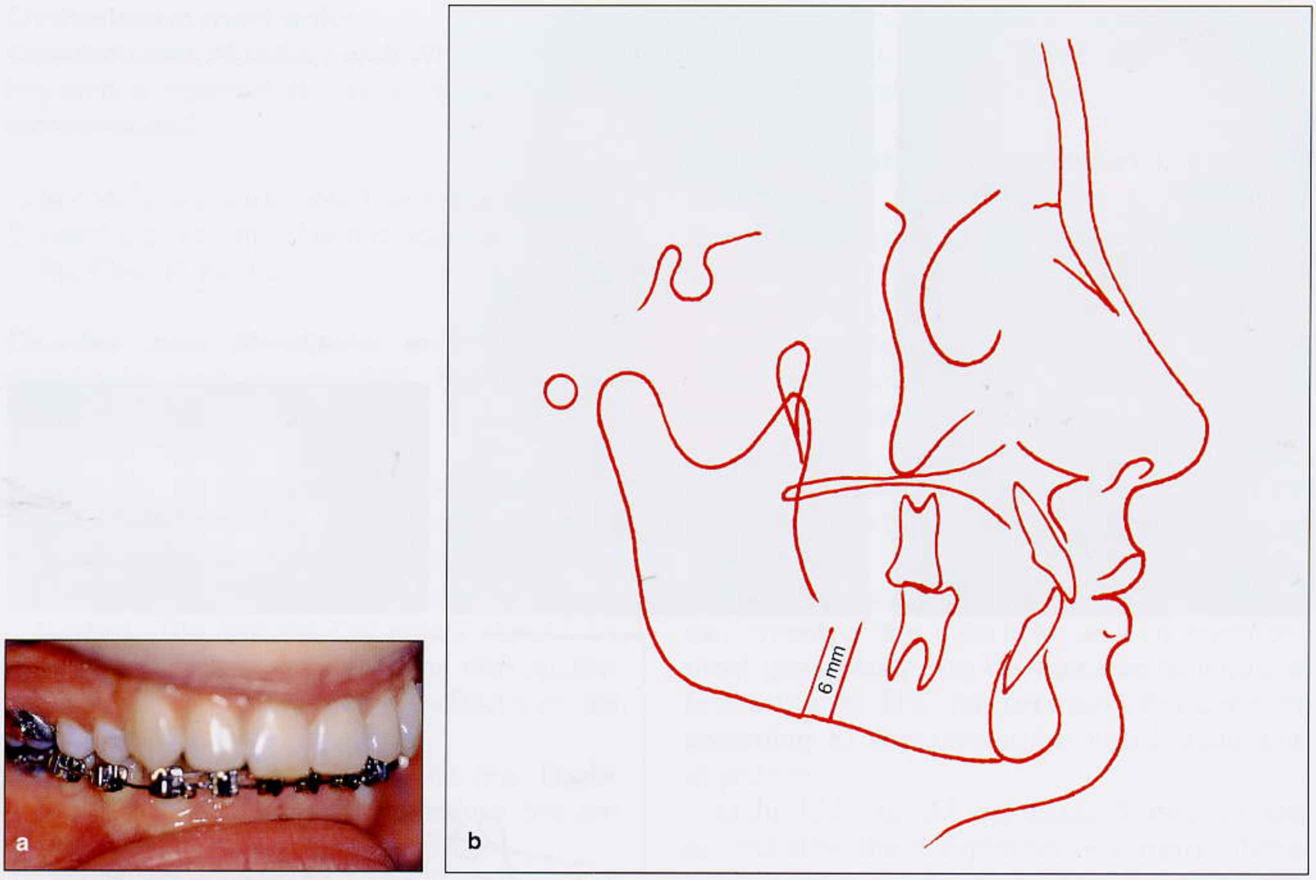


Fig 4-5 Case A.B. *(a)* Immediate presurgical occlusion. The patient was treated with lingual orthodontics in the maxilla, and buccal attachments (lingual buttons) were bonded presurgically to assist in intraoperative maxillomandibular fixation and postsurgical elastic control. *(b)* Surgical visual treatment objective indicating that a 6-mm mandibular advancement will be required. The expected soft tissue result is demonstrated.

3. Skeletal (Fig 4-4d)
   - Anteroposteriorly deficient mandible
4. Radiographic (see Fig 4-4d)
   a. Panoramic radiograph
      - Four impacted third molars
   b. Cephalometric
      - Class II, division 1 dental relationship
      - Slight maxillary dental protrusion
      - Mandibular anteroposterior deficiency

Problem list

1. Class II malocclusion
2. Mandibular anteroposterior deficiency
3. Deep bite
4. Slightly accentuated curve of Spee
5. Narrow maxillary arch
6. Slight protrusion of maxillary incisors

Presurgical orthodontics

The surgical removal of impacted third molars preceded presurgical orthodontic treatment, which consisted of the following (Fig 4-5):

- Maxillary arch: use of lingual orthodontics
  - Slight expansion of the maxillary arch to accommodate the mandibular arch after advancement
  - Slight retraction of maxillary incisors
- Mandibular arch: leveling of the curve of Spee
  - Establishment of a good arch form
  - Use of buccal orthodontics in the mandibular arch

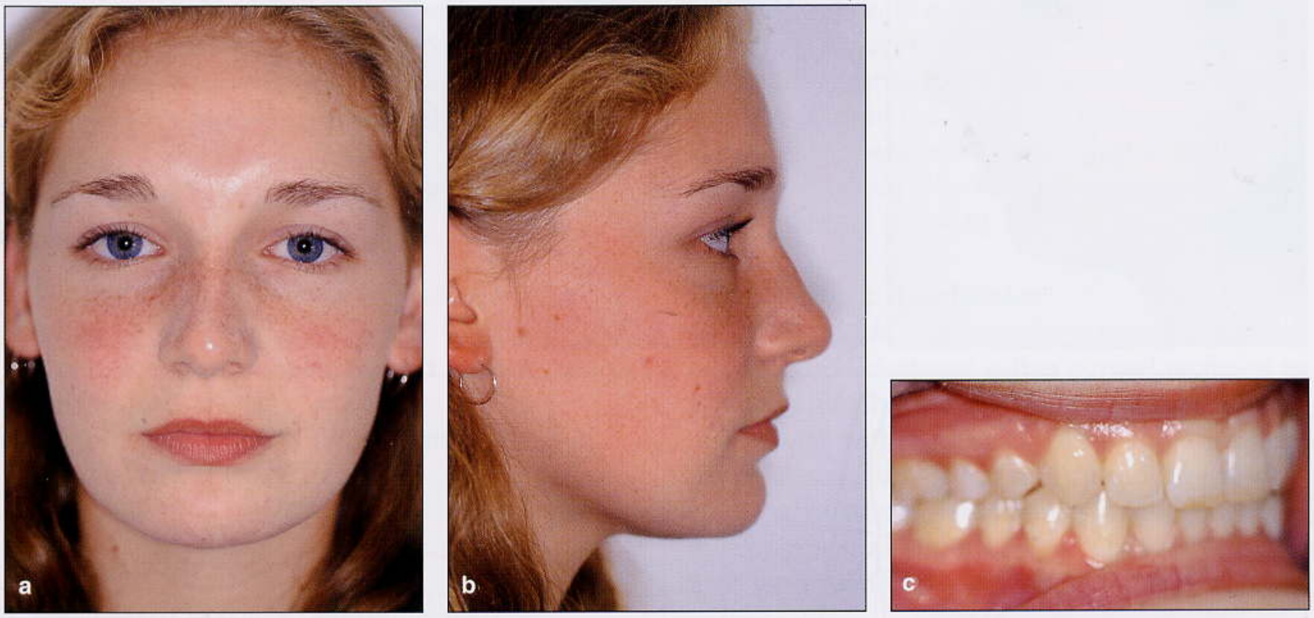


Fig 4-6 Case A.B. Posttreatment results are demonstrated in frontal view *(a)*, profile view *(b)*, and occlusion *(c)*.

Surgical treatment

The surgical treatment in this case consisted of a bilateral sagittal split ramus osteotomy to advance the mandible.

Postsurgical orthodontics

The surgery was performed after a 10-month period of orthodontic preparation. The postsurgical orthodontic treatment, which lasted 4 months, involved finalization of the occlusion. After band removal, the patient was placed in retention. Figure 4-6 illustrates the treatment result 8 months after orthodontic band removal.

Because of the general underdevelopment of the mandible, microgenia, or chin deficiency, is often found in combination with mandibular anteroposterior deficiency. In these cases, correction requires an augmentation sliding genioplasty in addition to mandibular advancement. Augmentation genioplasty, however, is not a substitute for mandibular surgery. Case O.J. illustrates the improved esthetic result after both mandibular advancement and augmentation genioplasty (Fig 4-7).

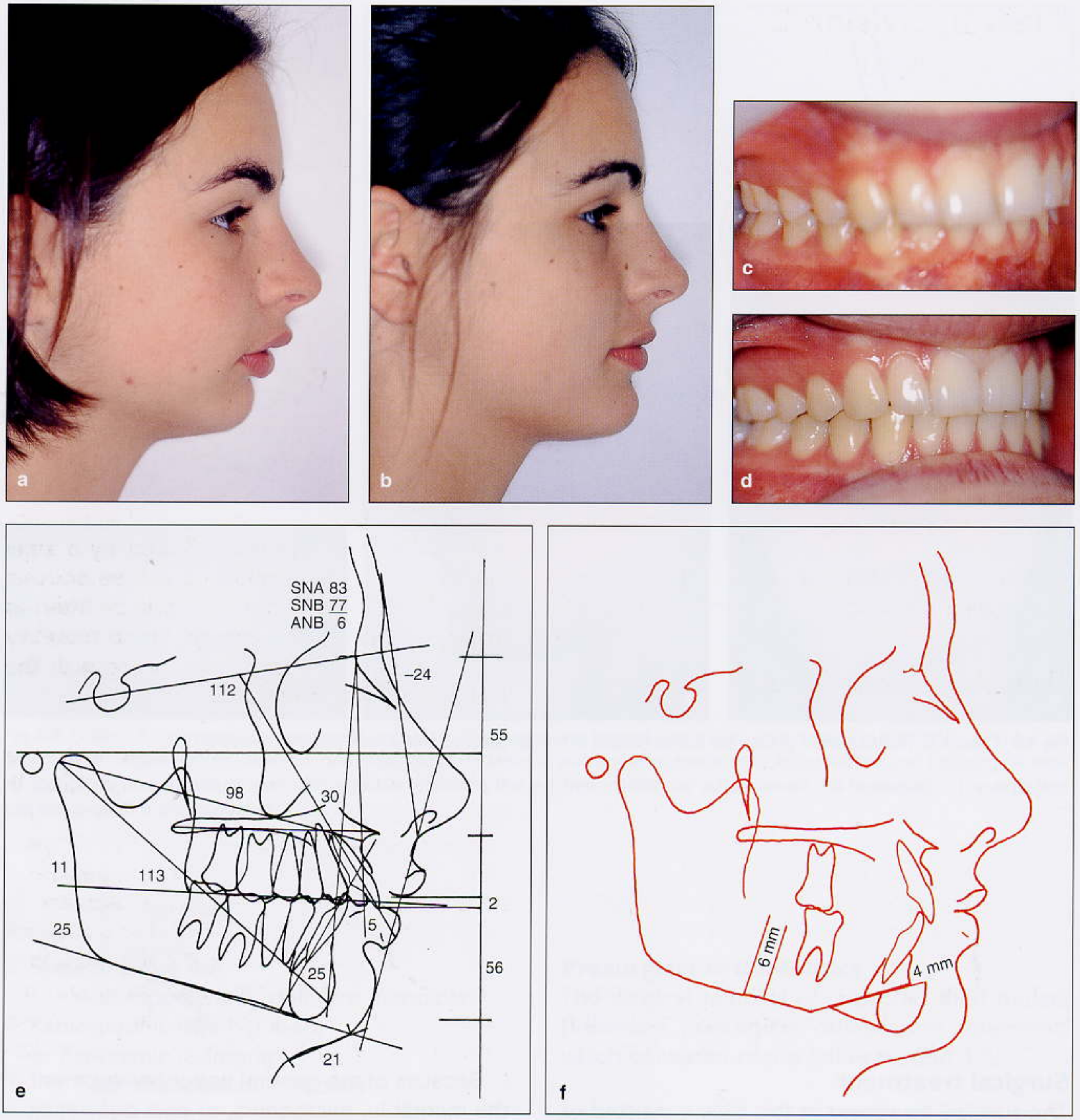


Fig 4-7 Case O.J. Preoperative profile view *(a)*, postoperative profile view *(b)*, preoperative occlusion *(c)*, and postoperative occlusion *(d)*. The cephalometric analysis *(e)* and surgical prediction tracing *(f)* demonstrate the esthetic enhancement from a 6-mm mandibular advancement combined with a 4-mm advancement of the chin.

Class II, division 2 malocclusion

Clinical characteristics

Profile view

- The "chin button" is pronounced.
- A deep labiomental fold is often present.
- The lower lip appears anteroposteriorly deficient and is curled.
- The lower facial height is short, and the mandible appears square.
- The mandibular plane angle tends to be low.

Frontal view

- The face appears short because of decreased vertical height.
- There is a curled lower lip and a deep labiomental fold.
- The elevator muscles of the mandible are usually well developed.

Dental characteristics

- Retroclined maxillary central incisors
- Labially flared maxillary lateral incisors
- A deep overbite, which is both skeletal and dental in origin
- Excessive curve of Spee
- Gingival tissue irritation behind the maxillary incisors and sometimes also on the labial aspect of the mandibular incisors due to deep bite
- A tendency toward clicking of the temporomandibular joints, probably related to the anterior locking effect of the deep bite

Treatment

Presurgical orthodontics

The basic presurgical orthodontic principles apply in Class II, division 2 malocclusion—namely, the need to properly position the maxillary and mandibular incisors (vertically, as well as in the anteroposterior plane), the need to level the curve of Spee, and the need to coordinate the dental arches. It is especially important to tip the maxillary incisors labially to create a good arch form, lip support, and a sufficient overjet. In severe deep bite cases it may be difficult to level the curve of Spee in the mandibular arch, and it may be necessary to open the bite with a glass ionomer bite plane cemented to the molars. Surgical leveling by segmental surgery may be considered, in which case segmental orthodontic alignment will be necessary (Fig 4-8).

In patients with a Class II deep bite occlusion, postsurgical leveling of the curve of Spee is indicated. Advancement of the mandible before total leveling of the curve will increase the facial height, and because of the rotation of the occlusal plane, the chin will not advance as much as the incisors (Fig 4-9).

Orthodontic mechanics

Maxillary arch The maxillary incisors can be leveled and advanced with a curved archwire or a simple flexible archwire followed by a steel round wire with a pronounced inverse occlusal curve. A stabilizing archwire should be fitted as soon as possible. The change in the maxillary incisor position should be reconciled with the arch length and lip support.

Mandibular arch In the mandibular arch, the teeth should be leveled with the aid of Class III elastics and soft flexible wires, but it is not necessary to completely correct the curve of Spee. This can be done after surgery, especially if there is a deep overbite and an increase in lower facial height is required. The stabilizing wire should have the curve of Spee bent into it. Presurgically, a deep curve is advantageous because the anterior part of the mandible is advanced downward and forward to create a Class I incisor relationship while the lower anterior facial height is increased (Fig 4-10).

Surgical treatment

A few surgical options for the correction of the occlusion and esthetic improvement may be considered:

1. Advancement of the mandible by means of a bilateral sagittal split ramus osteotomy.
2. Advancement of the mandible by means of a bilateral sagittal split ramus osteotomy combined with a reduction genioplasty to reduce

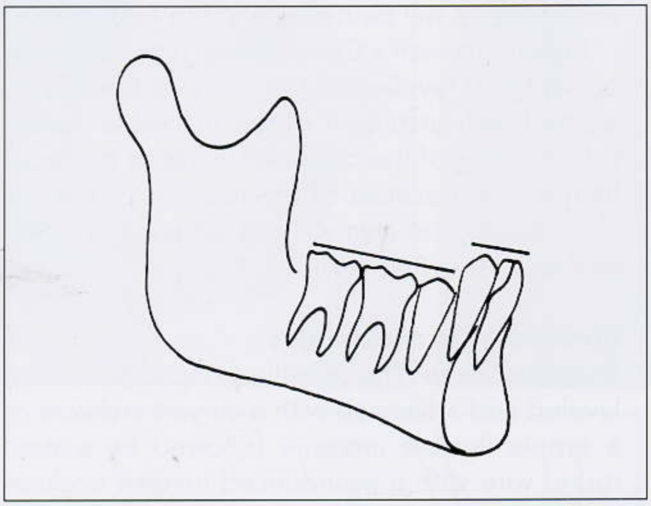


Fig 4-8 When a natural step exists in the mandibular arch, the dental arch may be leveled in segments, followed by surgical leveling. Surgical leveling has two advantages: no additional anteroposterior arch length is required and orthodontic treatment time is shortened.

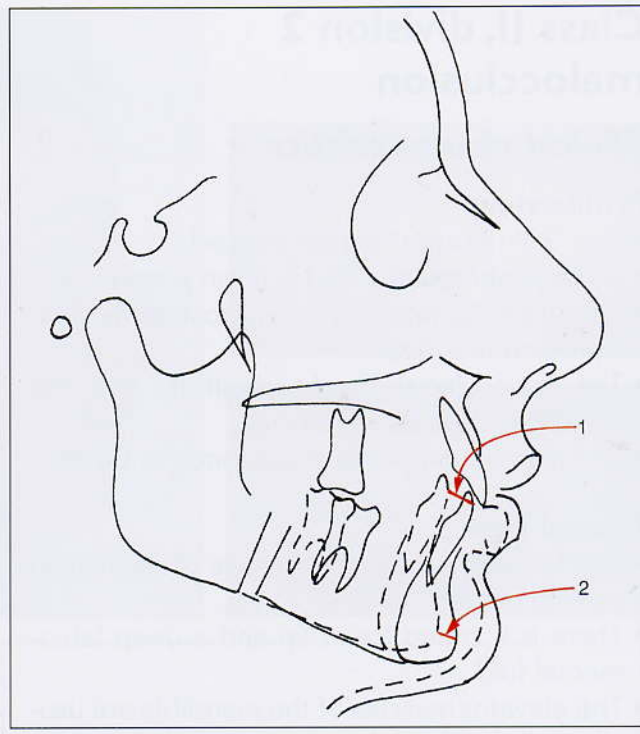


Fig 4-9 The incisor advancement (1) is greater than the advancement of pogonion (Pog) (2) because of the forward and downward rotation of the mandible.

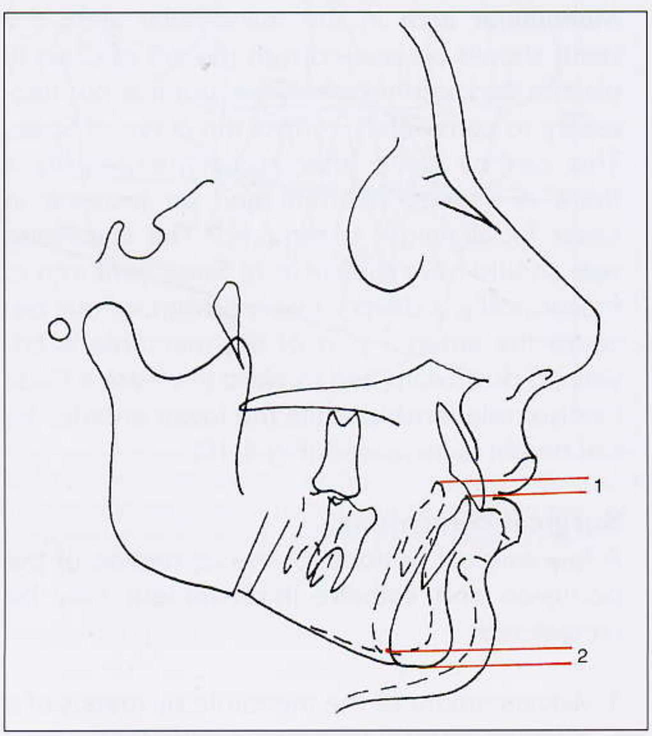


Fig 4-10 Downward rotation of the incisors during correction of the deep bite (1) will increase the anterior height of the mandible. Menton will be inferiorly repositioned (2).

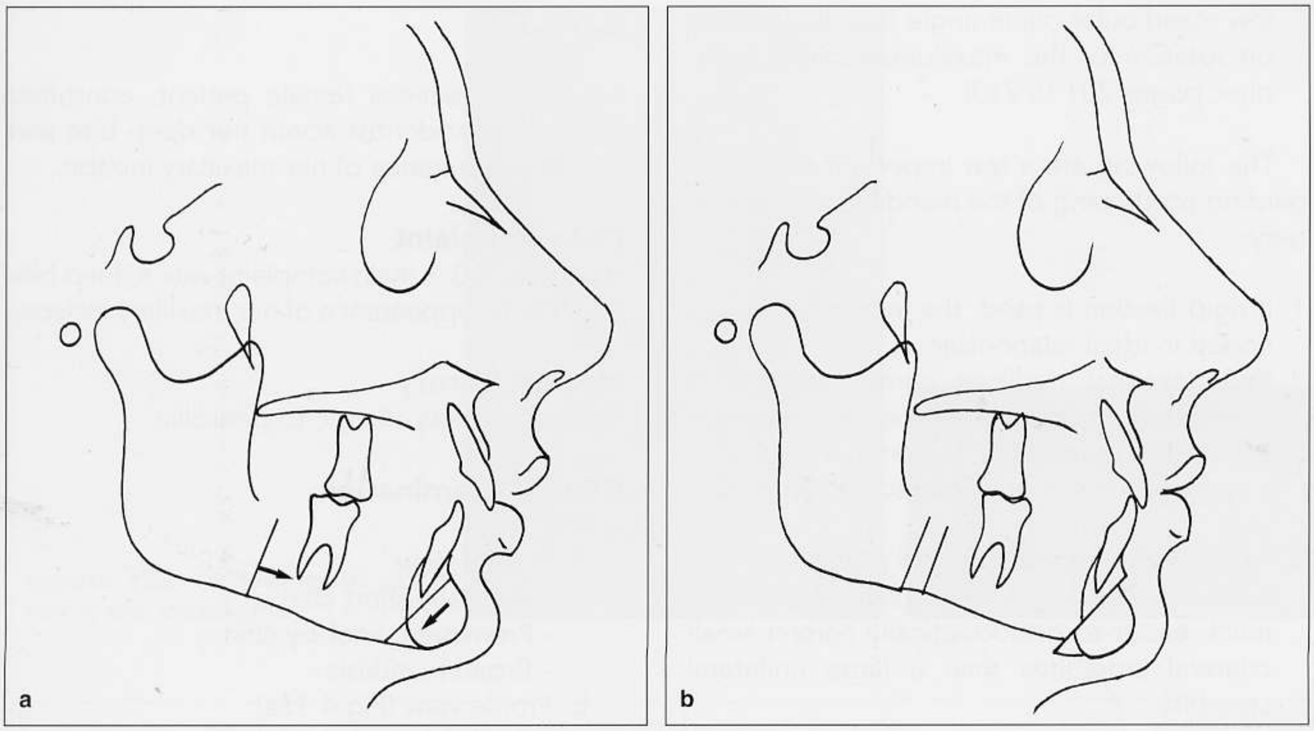


Fig 4-11 Bilateral sagittal split ramus osteotomy combined with a reduction genioplasty. By angling the osteotomy for reduction genioplasty *(a)*, the anterior height of the mandible is increased as the chin slides posteriorly and inferiorly *(b)*.

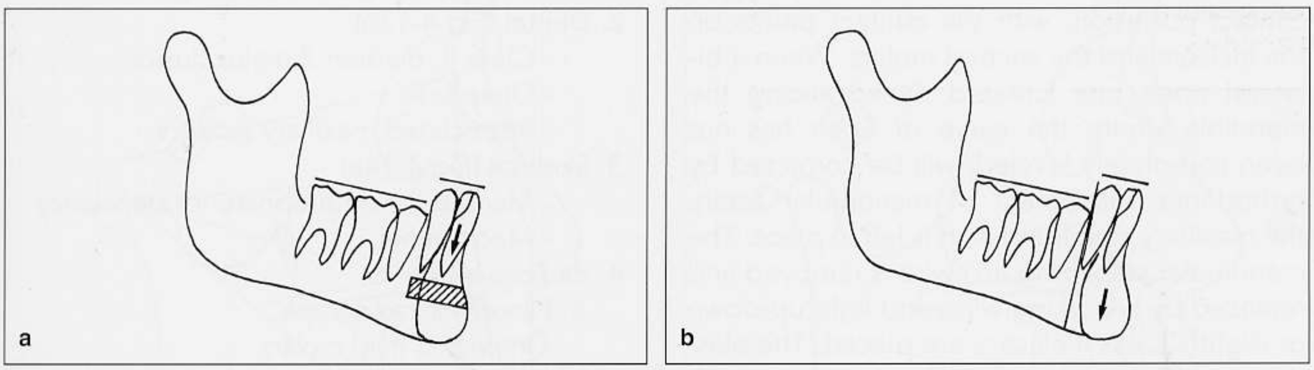


Fig 4-12 The curve of Spee may be surgically leveled after segmental orthodontic alignment by a subapical osteotomy *(a)* or an osteotomy including the lower border *(b)*, which will increase the vertical height of the face.

the chin prominence. By angling the osteotomy of the genioplasty, a vertical increase in the facial height can be achieved (posterior and inferior slide of the chin) (Fig 4-11).

3. A bilateral sagittal split osteotomy advancing the mandible combined with an anterior segmental osteotomy leveling the occlusal plane. The segmental osteotomy may be subapical or may include the body of the mandible, which will increase the vertical height of the face (Fig 4-12).
4. A total subapical osteotomy of the mandible advancing the dentoalveolar segment of the mandible. In this case, the chin position is maintained while the lower lip is advanced because of the dentoalveolar advancement.
5. Rotation of the maxillomandibular complex is a possible solution in cases with a severely

low mandibular plane angle (see the section on rotation of the maxillomandibular complex, pages 201 to 213).

The following are a few important points regarding positioning of the mandible during surgery:

1. If rigid fixation is used, the incisors are positioned in ideal relationship.
2. Keep skeletal midlines correct even if it means a slight dental discrepancy. The orthodontist can correct a mild dental midline discrepancy but not an incorrect skeletal midline.
3. There is often a tendency for posterior crossbites, so keep the crossbites symmetrical. It is much easier to orthodontically correct small bilateral crossbites than a large unilateral crossbite.

Postsurgical orthodontics

After surgery, patients often have a three-point contact occlusion, with the contact points on the incisors and the second molars. When a bilateral open bite (created by advancing the mandible where the curve of Spee has not been completely leveled) will be corrected by orthodontic movement of mandibular teeth, the maxillary stabilizing arch is left in place. The mandibular stabilizing archwire is removed and replaced by a working wire, and light up-down or slightly Class II elastics are placed. The elastics serve a dual purpose: *(1)* to bring the teeth into a solid occlusion and *(2)* to "override" the patient's proprioception, which will tend to place the mandible in maximum intercuspation.

Postoperative crossbites can be corrected by through-the-bite elastics. From this point forward, the patient's orthodontic treatment will be routine.

The retention phase of these patients is the same as for routine orthodontic cases. After 3 to 4 months, retainer use can be reduced to only nighttime. If the teeth are stable, retainer use may be discontinued after a few more months.

Case T.G.

T.G., a 16-year-old female patient, consulted with the orthodontist about her deep bite and the flat appearance of her maxillary incisors.

Main complaint

As noted, T.G.'s main complaint was a deep bite and the flat appearance of her maxillary incisors.

Medical history

The patient was allergic to penicillin.

Clinical examination

1. Soft tissue
   a. Frontal view
      - Vertically short chin
      - Prominent, knobby chin
      - Broad mandible
   b. Profile view (Fig 4-13a)
      - Deep labiomental fold
      - Prominent chin
      - Short lower-third facial height
2. Dental (Fig 4-13b)
      - Class II, division 2 malocclusion
      - Deep bite
      - Retroclined maxillary incisors
3. Skeletal (Fig 4-14a)
      - Mandibular anteroposterior deficiency
      - Macrogenia
4. Radiographic
   a. Panoramic radiograph
      - Impacted third molars
   b. Cephalometric (see Fig 4-14a)
      - Class II, division 2 malocclusion
      - Deep bite
      - Retroclined maxillary incisors
      - Mandibular anteroposterior deficiency
      - Macrogenia

Problem list

1. Class II occlusion
2. Mandibular anteroposterior deficiency
3. Deep bite
4. Retroclined maxillary incisors
5. Prominent chin

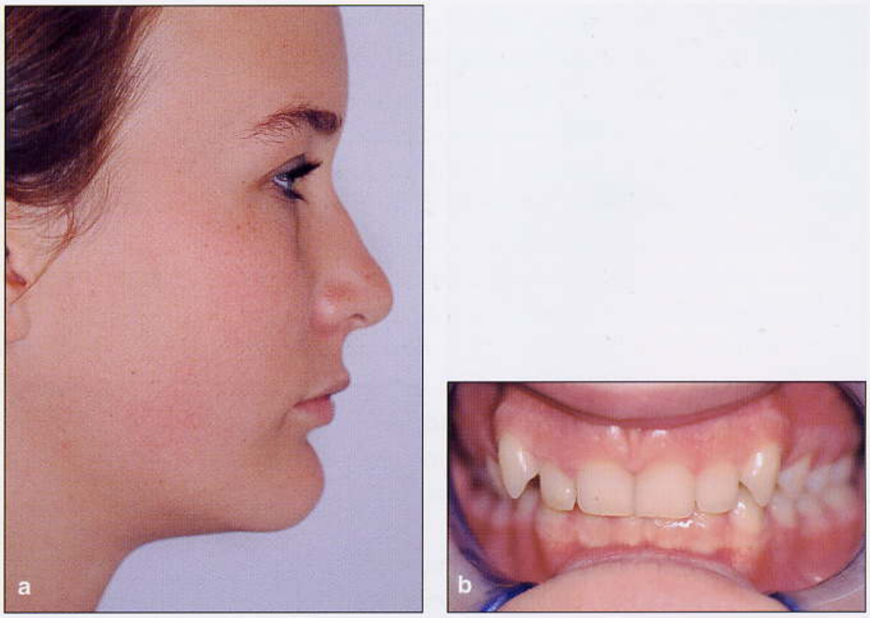


Fig 4-13 Case T.G. Pretreatment profile view *(a)* and occlusion *(b)*.

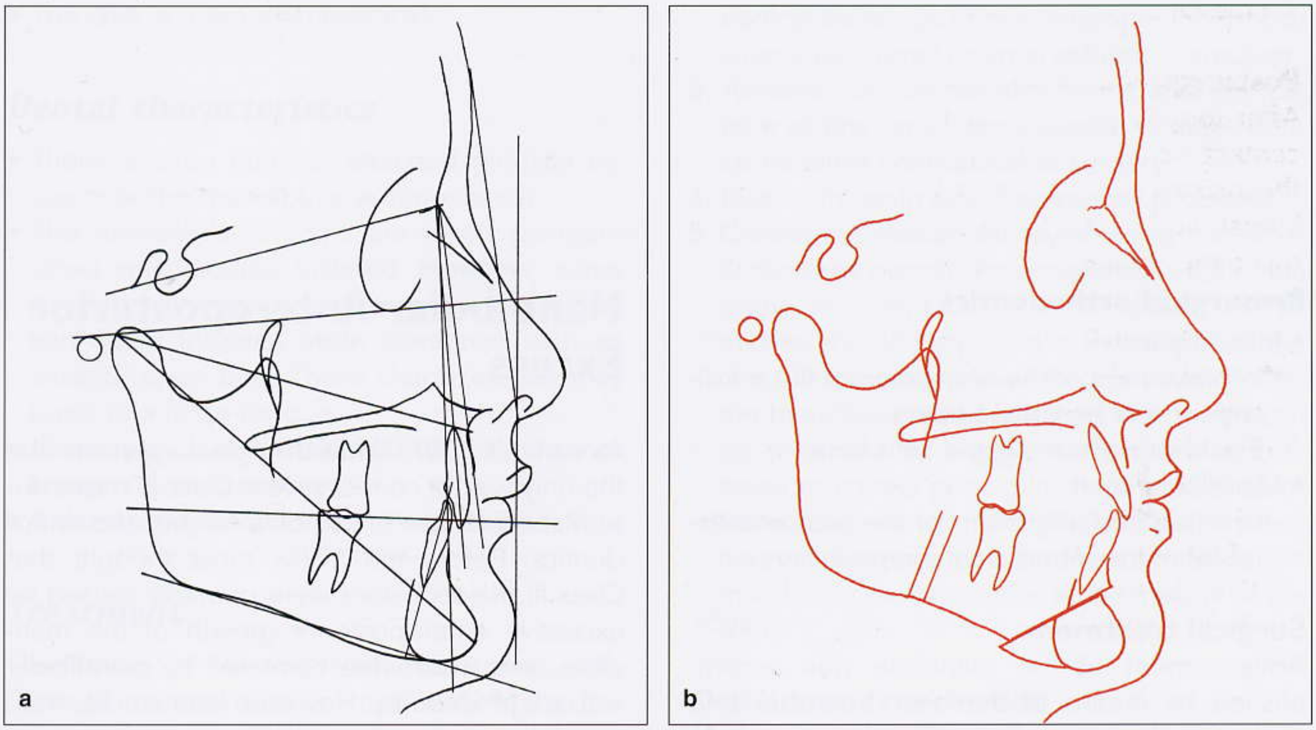


Fig 4-14 Case T.G. Pretreatment cephalometric analysis *(a)* and cephalometric prediction tracing *(b)*.

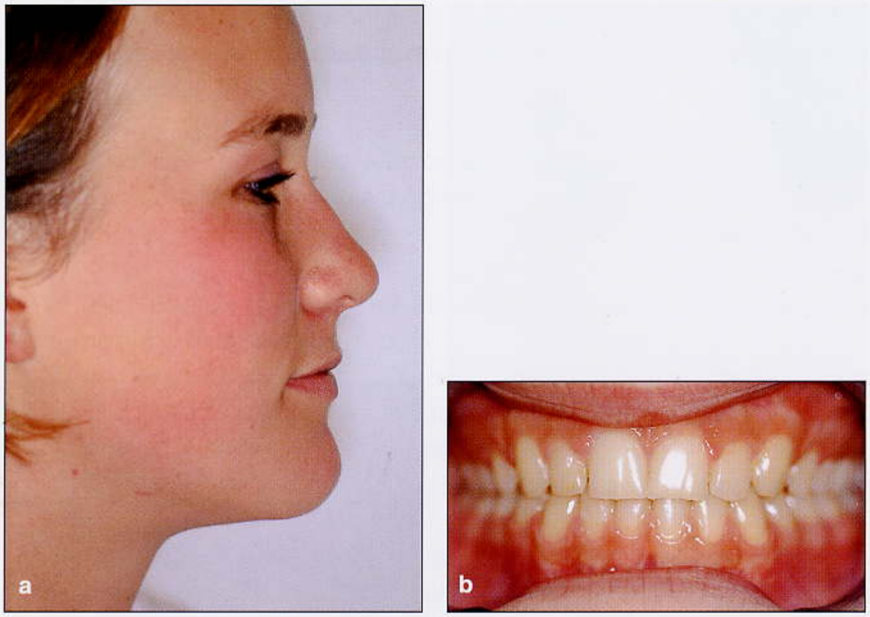


Fig 4-15 Case T.G. Posttreatment profile view *(a)* and occlusion *(b)*.

Presurgical orthodontics

- Maxillary arch
  - Improvement of the angulation of the maxillary incisors by labial tipping
  - Establishment of a good arch form
- Mandibular arch
  - Leveling and alignment of the arch and establishment of interarch compatibility

Surgical treatment

Advancement of the mandible was accomplished by means of a bilateral sagittal split ramus osteotomy, and the chin was anteroposteriorly reduced using a sliding genioplasty (Fig 4-14b).

Postsurgical orthodontics: Refinement of the occlusion and retention

The surgery was performed after an 18-month orthodontic preparatory phase and the orthodontic bands removed 3 months after surgery. The posttreatment results are illustrated in Fig 4-15.

Mandibular Anteroposterior Excess

As early as 1907, Edward Angle suggested that the only way to correct severe Class III malocclusion in adults was to combine surgery and orthodontics. Before the 1970s most thought that Class III malocclusions were primarily caused by excessive anteroposterior growth of the mandible, and most were corrected by mandibular setback procedures. However, later studies indicated that isolated mandibular anteroposterior excess occurs in only approximately 20% to 25% of Class III cases. Some maxillary skeletal anteroposterior deficiency is involved in 75% of cases with Class III malocclusions. Therefore, in Class III cases the clinician must determine whether one jaw is primarily at fault or a combination of maxillary deficiency and mandibular excess is causing the malocclusion.

Class III malocclusion

Clinical characteristics

Profile view

- There is a long chin-throat length with a well-defined inferior border of the mandible.
- A protrusive chin results in a prominent lower third of the face.
- The labiomental fold is reduced.
- The lip-chin-throat angle is acute.

Frontal view

- The lower third of the face appears "flat."
- The chin button is not prominent.
- A thin upper lip has reduced vermillion exposure.
- The labiomental fold is reduced.
- The mandible appears strong.
- The chin is often asymmetrical.

Dental characteristics

- There is often minimal attached gingival tissue over the mandibular anterior teeth.
- The mandibular incisors are often compensated and lingually inclined. However, some patients have generalized interdental spacing and flared incisors, often combined with an anterior open bite. These characteristics may point to a large tongue.
- There is a Class III malocclusion with anterior and posterior crossbites.
- A dental midline discrepancy is often present.

Treatment

The timing of treatment of adolescents with Class III malocclusion is important. Many patients with severe Class III dentofacial deformities want definitive treatment as soon as possible, and early treatment may be desirable from a social and psychologic point of view. However, if surgery is performed before completion of mandibular growth, the malocclusion is likely to recur as a result of growth.

Maxillary growth may be completed at age 15 or even age 14; therefore, when maxillary deficiency is the primary problem, delaying surgery until completion of growth is usually a feasible option. However, mandibular growth may continue until the early 20s. Some patients with severe mandibular excess are not willing to wait and elect to have surgery earlier, recognizing the fact that a second procedure may be necessary later. Case C.M., discussed later in the chapter, is an example of a case where surgery was offered to the patient before the completion of growth.

Presurgical orthodontics

Orthodontic preparation prior to surgery has five basic goals:

1. Eliminate (or reduce) anterior and posterior dental compensation with guidance from the orthodontic visual treatment objective.
2. Establish appropriate anteroposterior and vertical incisor positions. Improper incisor positions will curtail optimal esthetic correction.
3. Achieve compatible arch forms and intercanine widths, which are essential to make dental midlines compatible at surgery.
4. Deal with tooth size discrepancy problems.
5. Correct the mandibular asymmetries that often accompany mandibular prognathism. If the chin shape is acceptable, the mandibular dental midline should be placed in the middle of the chin. The asymmetry will be corrected during the mandibular setback procedure. It also can be corrected by a genioplasty, if one is indicated to correct poor chin shape or vertical or anteroposterior chin deformities. Thus, it is not always necessary to orthodontically place the mandibular dental midline in the midline of the chin.

Orthodontic mechanics

Mandibular arch The following techniques are recommended for orthodontic treatment of the mandibular arch:

1. Class III mechanics, including molar tie-backs, are not used when leveling, and the teeth are allowed to level forward. The orthodontic visual treatment objective should be refered to regularly to confirm the extent of incisor decompensation required.

2. On completion of leveling, Class II elastics may be used to advance the mandibular buccal segments and further procline the mandibular incisors. This movement should be monitored on sequential cephalometric films.
3. Arch length discrepancies should be reconciled with the desired mandibular incisor position.
4. When decompensating the mandibular incisors, the clinician should bear in mind that patients with mandibular anteroposterior excess often have a very thin, bony symphysis and a small area of attached gingiva in the incisor region.

Maxillary arch For orthodontic treatment of the maxillary arch, the following approach is recommended:

1. High-pull headgear should be applied to the maxillary incisor area nightly. This should be used with Class II mechanics to prevent extrusion of the maxillary incisors when advancing the mandibular dentition.
2. Headgear anchorage should aid retraction of the maxillary incisors or merely prevent their proclination during the leveling process.

Surgical treatment

Bilateral sagittal split osteotomy is the procedure of choice, although a transoral vertical ramus osteotomy may be indicated in cases requiring large setback procedures.

Correct positioning of the condyle is very important. The surgeon should carefully free the medial pterygoid muscle and the stylomandibular ligament from the medial side of the ramus. Otherwise, the proximal segment will be pushed back by the distal (tooth-bearing) segment, leading to a backward rotation of the ramus. With the return of muscle function, the patient will tend to position the mandible forward again.

If bicortical screws are used for rigid fixation, positional self-tapping screws are preferred to maintain bone segment positions. With setback procedures, especially where simultaneous correction of asymmetry is required, small intersegmental defects may develop. If these defects are closed by tightening the screws, the torquing effect will displace the condyles laterally (peripheral condylar sag; see the discussion of condylar sag in chapter 5).

The incidence of neurosensory morbidity with transoral vertical ramus osteotomy is less than that associated with a bilateral sagittal split ramus osteotomy, but the procedure carries an increased risk of poor condylar control.

On rare occasions, procedures such as body ostectomies or segmental subapical osteotomies are indicated to correct mandibular anteroposterior excess.

A genioplasty is often indicated to place the chin in its most esthetic anteroposterior, vertical, and midsagittal positions. The labiomental fold is often obtuse in Class III cases; reduction genioplasty would make this angle more obtuse, causing the chin to appear flat and resulting in an overall poor esthetic result. Chin shape is more important than the anteroposterior position of soft tissue pogonion.

Postsurgical orthodontics

Postsurgical orthodontics for Class III cases is very similar for all patients. In Class III open bite cases, the occlusion should be prepared presurgically so that the only postsurgical orthodontic tooth movements required are those with little or no potential to open the bite.

If a tendency to relapse is noticed, light (2.5- to 3.5-oz) Class III elastics should be placed immediately. A rectangular archwire should be in place in the maxilla to prevent molar extrusion.

The clinician should design the retention plan according to the original malocclusion and its possible relapse tendency.

Case D.G.

A 19-year-old male patient was referred to the orthodontist by his general practitioner for the correction of an open bite.

Main complaint

The patient said he was unable to bite properly, and the flat appearance of his midface bothered him.

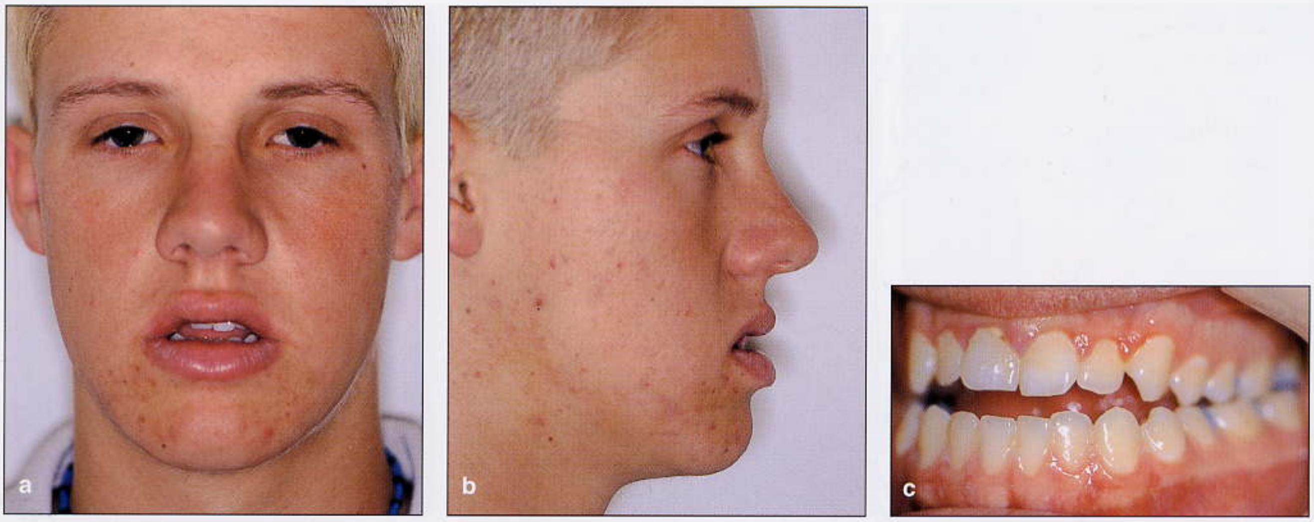


Fig 4-16 Case D.G. Pretreatment frontal view *(a)*, profile view *(b)*, and occlusion *(c)*.

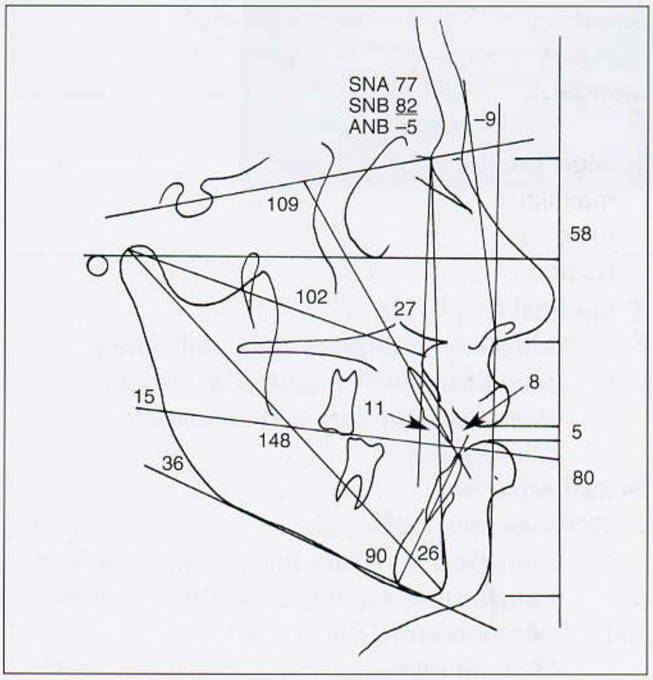


Fig 4-17 Case D.G. Pretreatment cephalometric analysis. Maxillary anteroposterior deficiency: SNA = 77 degrees; Class III skeletal relationship: ANB = −5 degrees; concave profile: facial contour angle = −9 degrees.

Medical history

The patient had asthma. He had contracted hepatitis A at age 15 and recovered satisfactorily.

Clinical examination

1. Soft tissue
   a. Frontal view (Fig 4-16a)
      - Deficient paranasal areas
      - Increased interlabial distance
      - Excessive lower lip vermilion exposure
   b. Profile view (Fig 4-16b)
      - Concave profile
      - Midface deficiency
      - Everted lower lip
      - Increased interlabial distance
      - Deficient chin
2. Dental (Fig 4-16c)
   - Class III malocclusion
   - Anterior open bite
   - Slightly compensated mandibular incisors

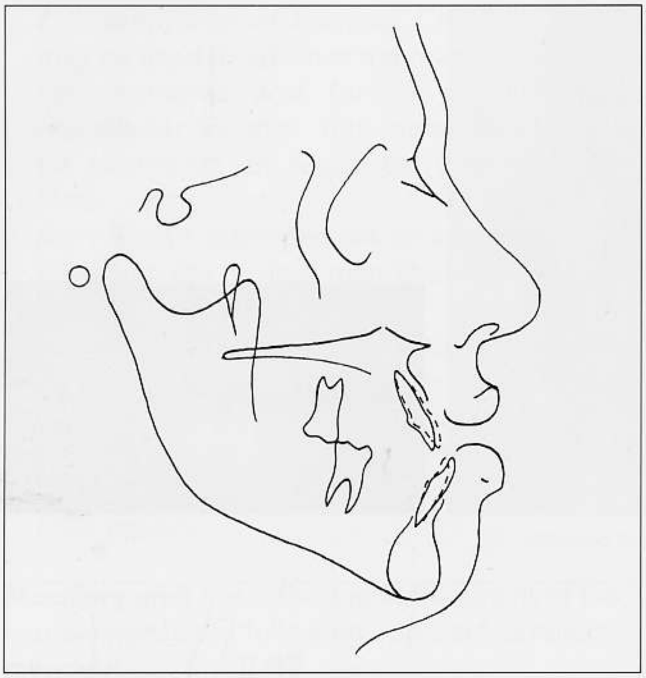


Fig 4-18 Case D.G. Orthodontic change: decompensation of the incisors.

3. Skeletal (Fig 4-17)
   - Maxillary anteroposterior deficiency
   - Mandibular anteroposterior excess
   - Posterior maxillary vertical excess
   - Microgenia
4. Radiographic
   a. Panoramic radiograph
      - Impacted maxillary third molars and partially erupted mandibular third molars
   b. Cephalometric (see Fig 4-17)
      - Class III malocclusion
      - Class III skeletal relationship
      - Maxillary anteroposterior deficiency
      - Anterior open bite
      - Slightly lingually inclined incisors
      - Lack of dental support for the upper lip
      - Everted lower lip
      - Mandibular anteroposterior excess
      - Flat chin

Problem list

1. Class III malocclusion
2. Maxillary anteroposterior excess
3. Posterior maxillary vertical excess
4. Incisor compensation

Presurgical orthodontics

- Maxillary arch (Figs 4-18 and 4-19)
  - Removal of the third molars
  - Leveling and alignment of the arch
  - Establishment of arch compatibility with the mandibular dental arch
  - No attempt to close the open bite by extrusion of incisors or by intrusion or expansion of posterior teeth
- Mandibular arch (see Figs 4-18 and 4-19)
  - Removal of the third molars
  - Leveling and alignment of the arch
  - Creation of a slight decompensation of incisors

Surgical treatment

A Le Fort I maxillary osteotomy was used to advance the maxilla by 3 mm. At the same time, the maxilla was superiorly repositioned 3 mm anteriorly (to establish the ideal tooth-lip relationship) and 6 mm posteriorly (to allow the mandible to autorotate) (Fig 4-20).

Because autorotation of the mandible worsened the Class III relationship, the mandible was set back 8 mm by means of a bilateral sagittal split ramus osteotomy.

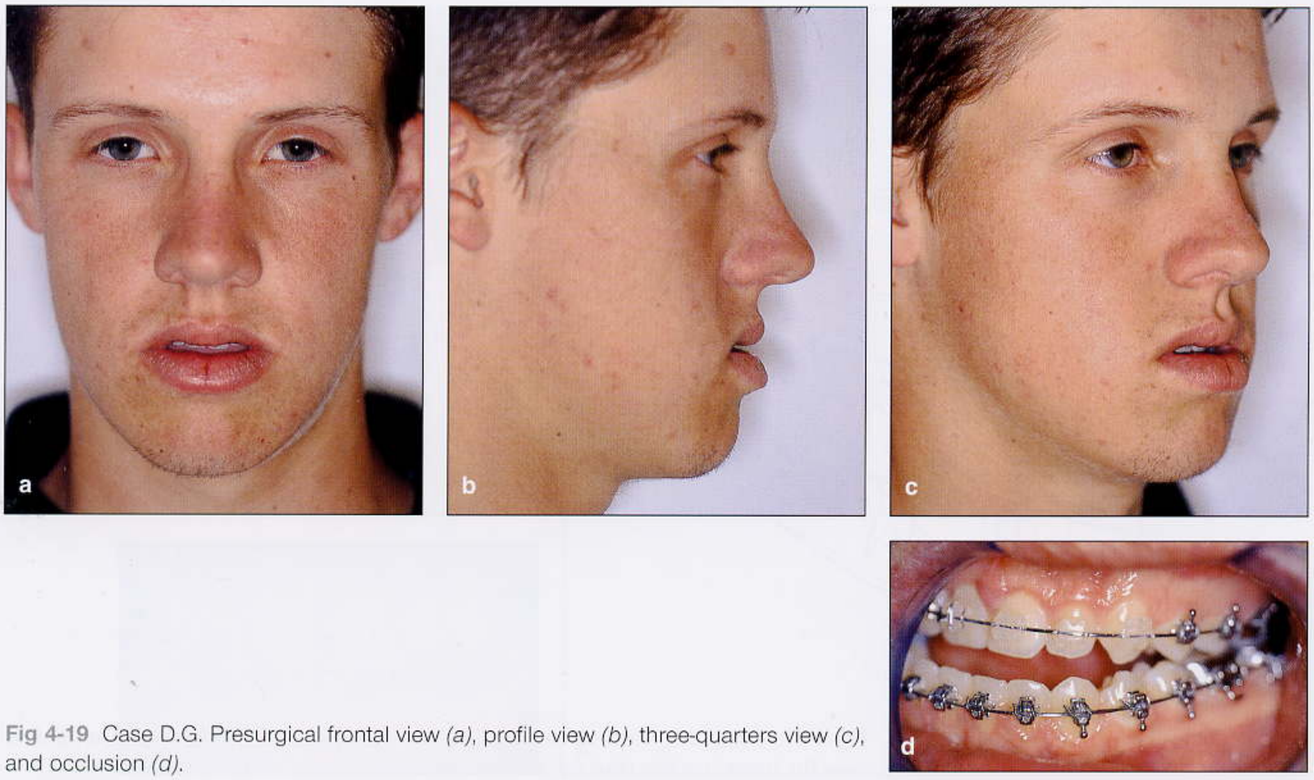


Fig 4-19 Case D.G. Presurgical frontal view *(a)*, profile view *(b)*, three-quarters view *(c)*, and occlusion *(d)*.

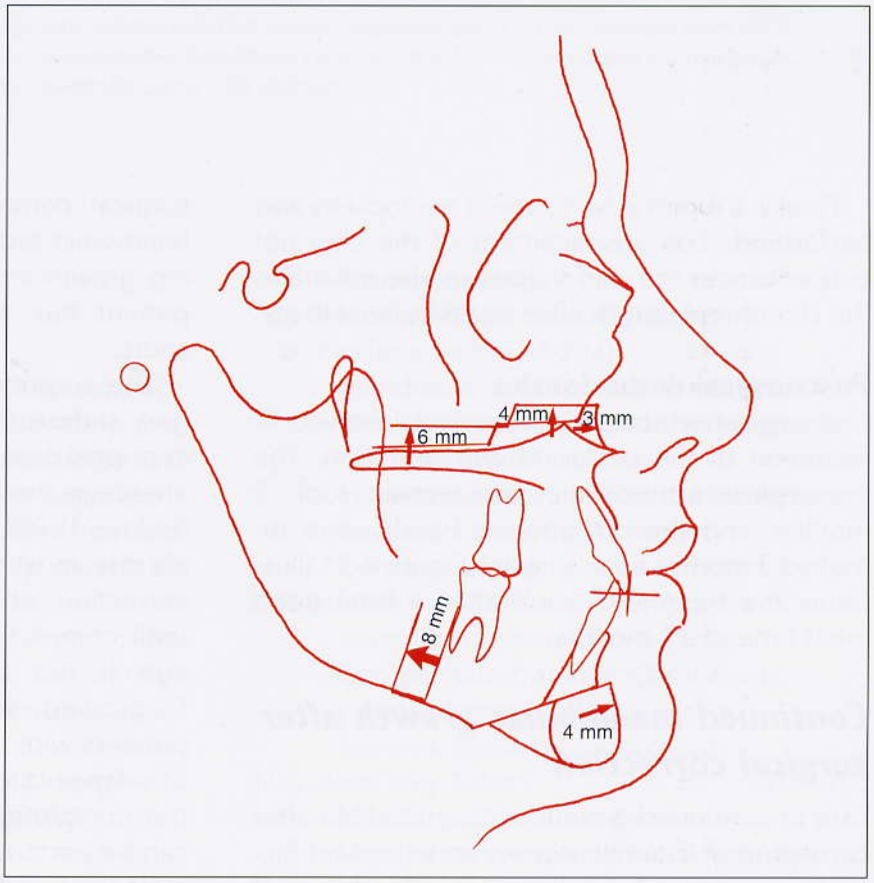


Fig 4-20 Case D.G. The surgical visual treatment objective includes maxillary superior repositioning with advancement, mandibular setback, and advancement genioplasty.

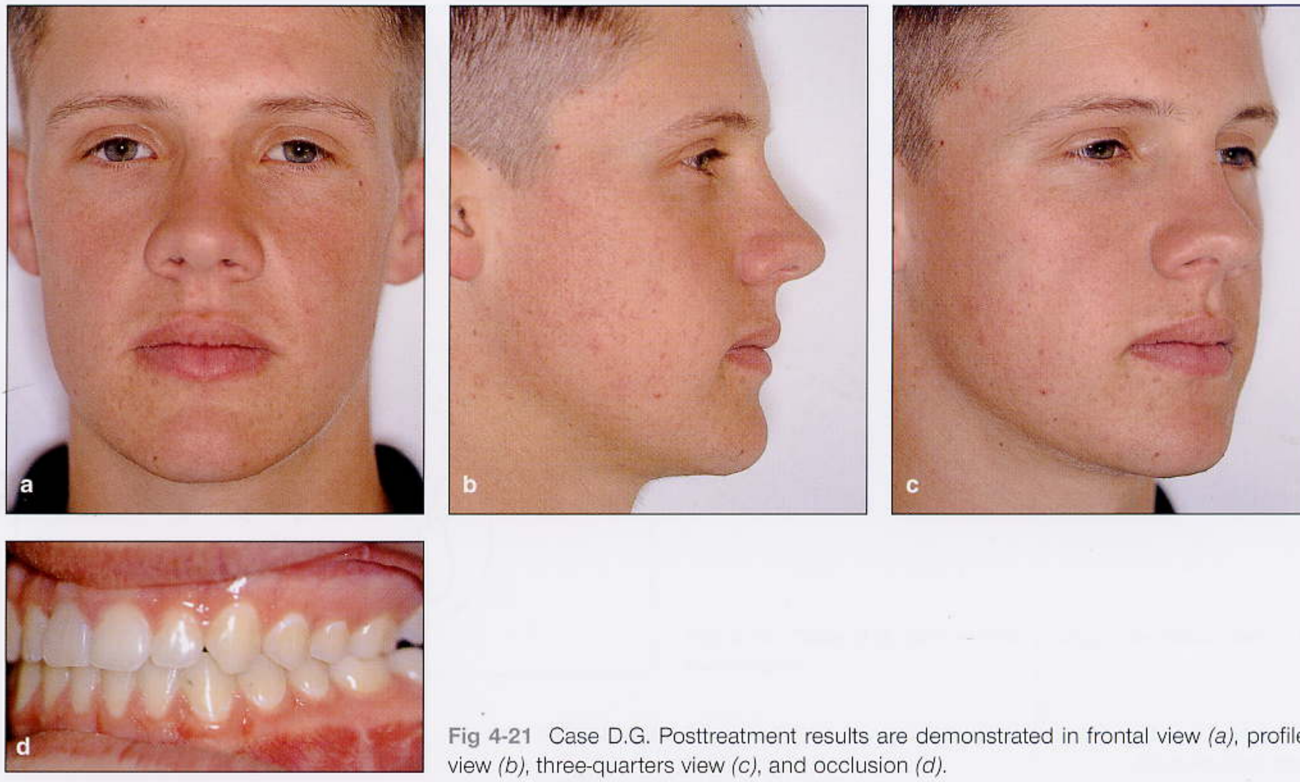


Fig 4-21 Case D.G. Posttreatment results are demonstrated in frontal view *(a)*, profile view *(b)*, three-quarters view *(c)*, and occlusion *(d)*.

Finally, a 4-mm advancement genioplasty was performed. The advancement of the chin not only enhances the chin shape but also maintains the chin-throat length after mandibular setback.

Postsurgical orthodontics

Postsurgical orthodontic treatment involved finalization of the occlusion and retention. The presurgical orthodontic preparation took 8 months, and the orthodontic bands were removed 3 months after surgery. Figure 4-21 illustrates the treatment result after a total treatment time of 11 months.

Continued mandibular growth after surgical correction

Late or continued growth of the mandible after correction of Class III cases is an important factor in postsurgical stability, so the clinician must ensure that facial growth is completed prior to surgical correction. Serial cephalograms and hand-wrist radiographs are helpful in monitoring growth and estimating whether a growing patient has experienced his or her growth spurt.

The surgeon may consider performing surgery before the completion of growth in exceptional cases, since "biological interest is not always in the patient's psychological interest" (Enlow, 1990). Ages 12 to 19 years are probably the most formative, and to postpone the correction of severe dentofacial deformities until completion of growth in individuals this age is not best for them psychologically. Surgical correction should be offered to these patients with the full understanding of the risk of relapse due to the continued growth. Upon the completion of growth, surgical correction can be performed. The following case illustrates a satisfactory outcome to the above problem.

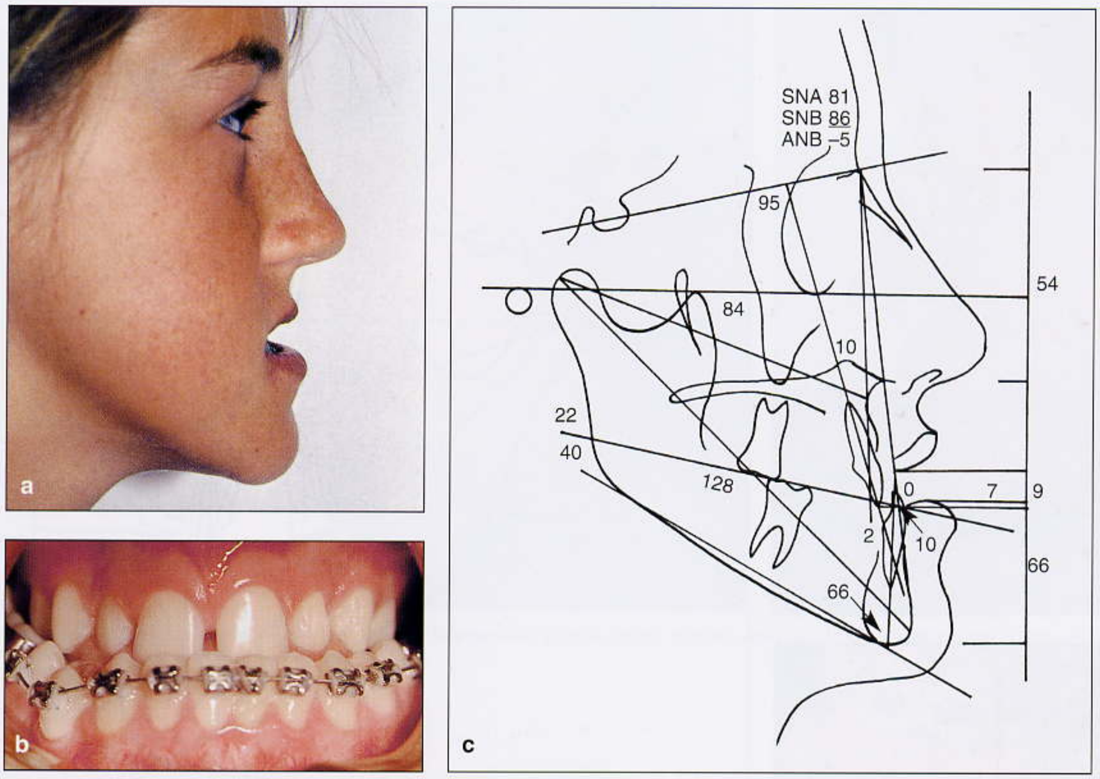


Fig 4-22 Case C.M. Pretreatment profile view *(a)*, occlusion *(b)*, and cephalometric analysis *(c)* 1 week after banding the mandibular arch (age, 12 ½ years). Class III skeletal relationship: ANB = –5 degrees, mandibular length to maxillary length = 84:128 mm; maxillary vertical excess: interlabial gap = 7 mm, maxillary tooth exposure under the upper lip = 9 mm; compensated mandibular incisors: mandibular incisor to N-B = 0 mm and 10 degrees, mandibluar incisor to mandibular plane = 66 degrees.

Case C.M.

Main complaint

According to the patient's parents, her facial appearance was a burden to her, affecting her schoolwork and social life. She was unhappy and was teased by her peers about her large mandible. She was also concerned about the fact that the unfavorable jaw relationship caused an increasingly severe speech problem.

Medical history

Her medical history was noncontributory.

Clinical examination

1. Soft tissue
   a. Frontal view
      - Increased interlabial distance
      - Unsupported upper lip that appears flat
      - Prominent chin
      - Increased lower facial height
   b. Profile view (Fig 4-22a)
      - Mandibular anteroposterior excess
      - Maxillary anteroposterior deficiency
      - "Gummy smile"
      - Increased maxillary incisor exposure
      - Increased lower facial height
      - Concave profile
2. Dental (Fig 4-22b)
   - Class III malocclusion
   - Compensated mandibular incisors
   - Posterior crossbites
   - Canines partially blocked out
3. Skeletal (Fig 4-22c)
   - Maxillary vertical excess
   - Maxillary anteroposterior deficiency
   - Mandibular anteroposterior excess

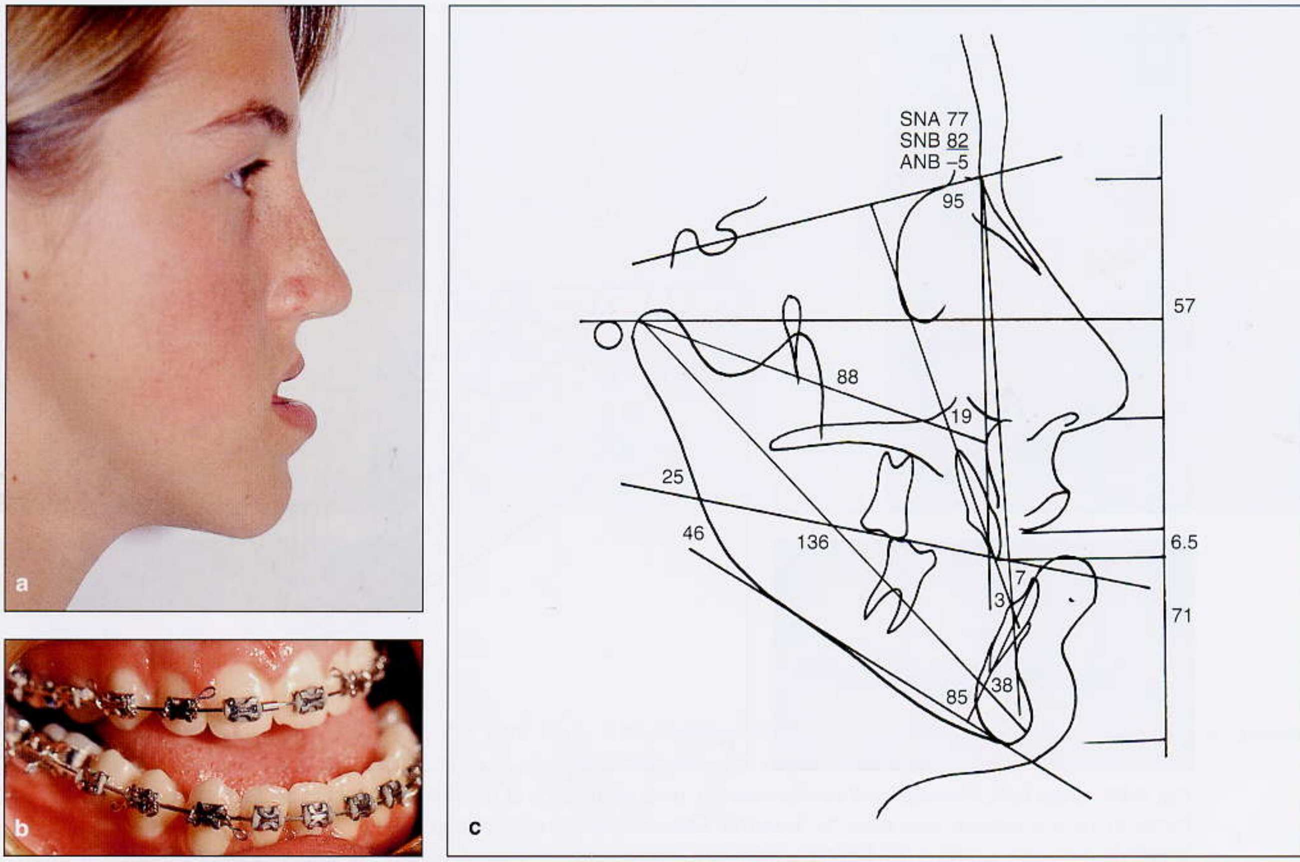


Fig 4-23 Case C.M. Immediate presurgical profile view *(a)*, occlusion *(b)*, and cephalometric tracing *(c)*. Note the profound anteroposterior and vertical growth.

4. Radiographic (see Fig 4-22c)
   a. Hand-wrist radiography
      - Patient still actively growing
   b. Cephalometric
      - Confirms the clinical observations

Problem list

1. Vertical maxillary excess
2. Maxillary anteroposterior deficiency
3. Mandibular anteroposterior excess
4. Class III malocclusion
5. Blocked-out maxillary canines
6. Compensated mandibular incisors
7. Patient still actively growing

Presurgical orthodontics

- Maxillary arch
  - Extraction of both maxillary first premolars
  - Arch alignment and closure of the spaces
  - Movement of the canines into the arch
- Mandibular arch
  - Decompensation of the incisors
  - Leveling of the curve of Spee
  - Establishment of interarch compatibility

The profound vertical and anteroposterior growth during orthodontic treatment is evident when the pretreatment (see Fig 4-22) and immediate presurgical records (Fig 4-23) are compared.

Surgical treatment

- A Le Fort I osteotomy that superiorly repositioned the maxilla (6 mm anteriorly and posteriorly), rotating the maxillomandibular complex slightly clockwise (Fig 4-24a) (see the section on rotation of the maxillomandibular complex, pages 201 to 213)
- Maxillary advancement (8 mm) (see Fig 4-24a)
- A bilateral sagittal split ramus osteotomy setting the mandible back (12 mm) (see Fig 4-24a)

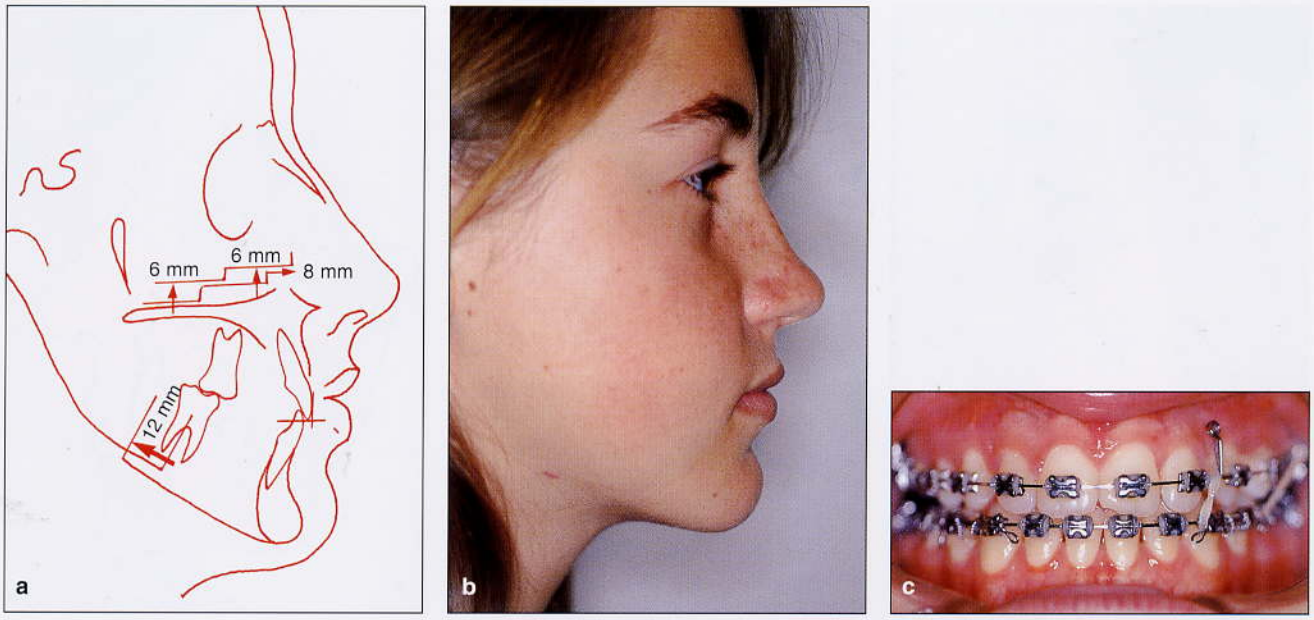


Fig 4-24 Case C.M. *(a)* Surgical prediction tracing. *(b)* Immediate postsurgical profile view. *(c)* Immediate postsurgical occlusion.

The surgical movements are large. This, along with the fact that the surgery is performed on a growing individual, makes the relapse potential significant in this case.

Postsurgical orthodontics

Postsurgical orthodontic treatment entails finalization of the occlusion and retention. In this case, the postsurgical skeletal change should be accurately monitored, and the dentition not compensated for any relapse or further growth. When surgery is performed early and further excessive mandibular growth is expected, the dentition should not be orthodontically compensated for this growth because *(1)* it will disguise the skeletal growth and *(2)* the teeth will need to be decompensated again before final surgical correction.

The postoperative results are demonstrated in Figs 4-24b and 4-24c. Postsurgical growth is evident in Fig 4-25 (10 months after surgery) and Fig 4-26 (4 years after surgery). Five years after the initial correction, the clinician decided to perform the final correction. After a short period of orthodontic treatment to decompensate the mandibular incisors slightly (Fig 4-27), the mandible was set back by means of a bilateral sagittal split osteotomy. The final result is illustrated in Fig 4-28 (1 year after the second surgery). This patient certainly benefited from early surgery, even though a second surgical procedure had to be performed 5 years after the initial correction. The fact that the bicortical screws had to be removed prior to performing the bilateral sagittal split osteotomy made the second surgery challenging. To facilitate this procedure, the use of resorbable fixation at the first surgery is indicated.

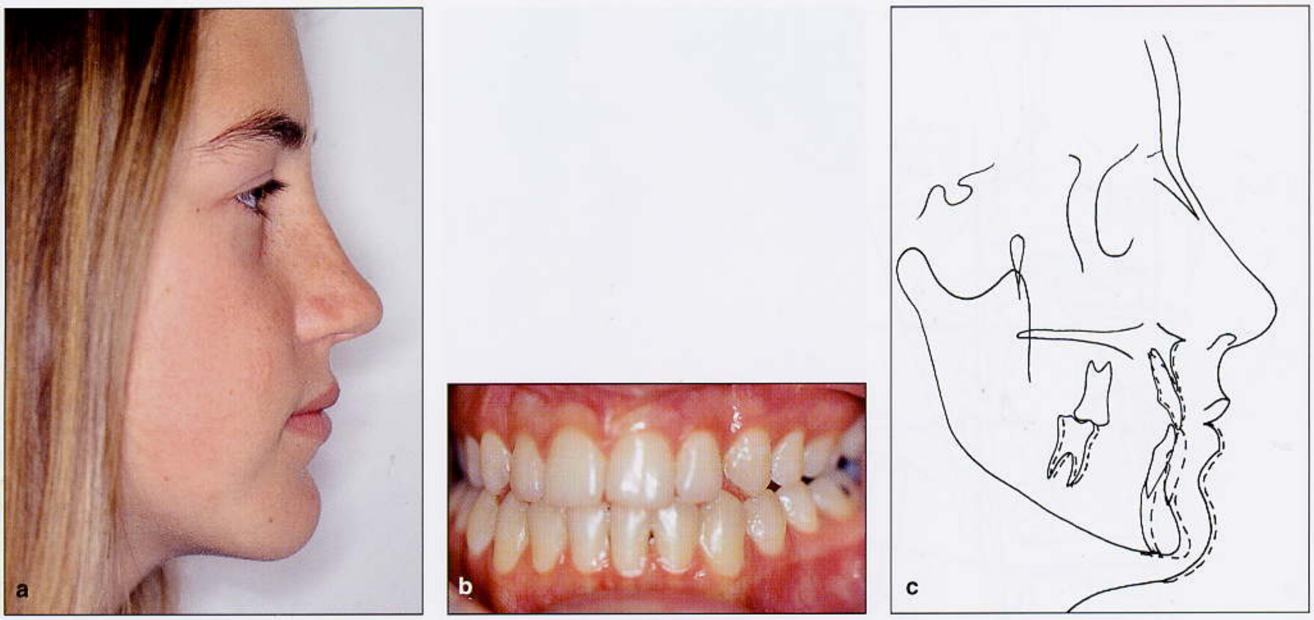


Fig 4-25 Case C.M. Relapse is evident 10 months after surgery. *(a)* Profile view. *(b)* Occlusion. *(c)* Cephalometric tracing indicating some signs of further mandibular growth.

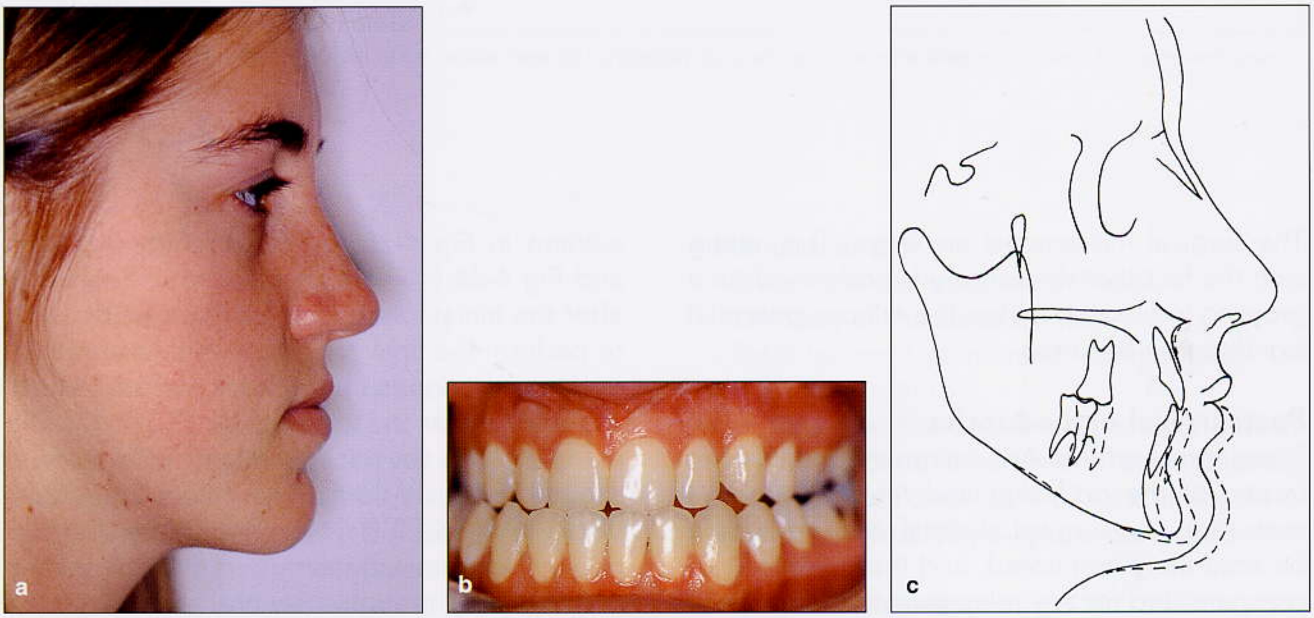


Fig 4-26 Case C.M. Four years after the initial correction, a Class III malocclusion is present. The maxilla remained stable. A profile view *(a)*, the occlusion *(b)*, and a cephalometric tracing *(c)* illustrate the further growth of the mandible.

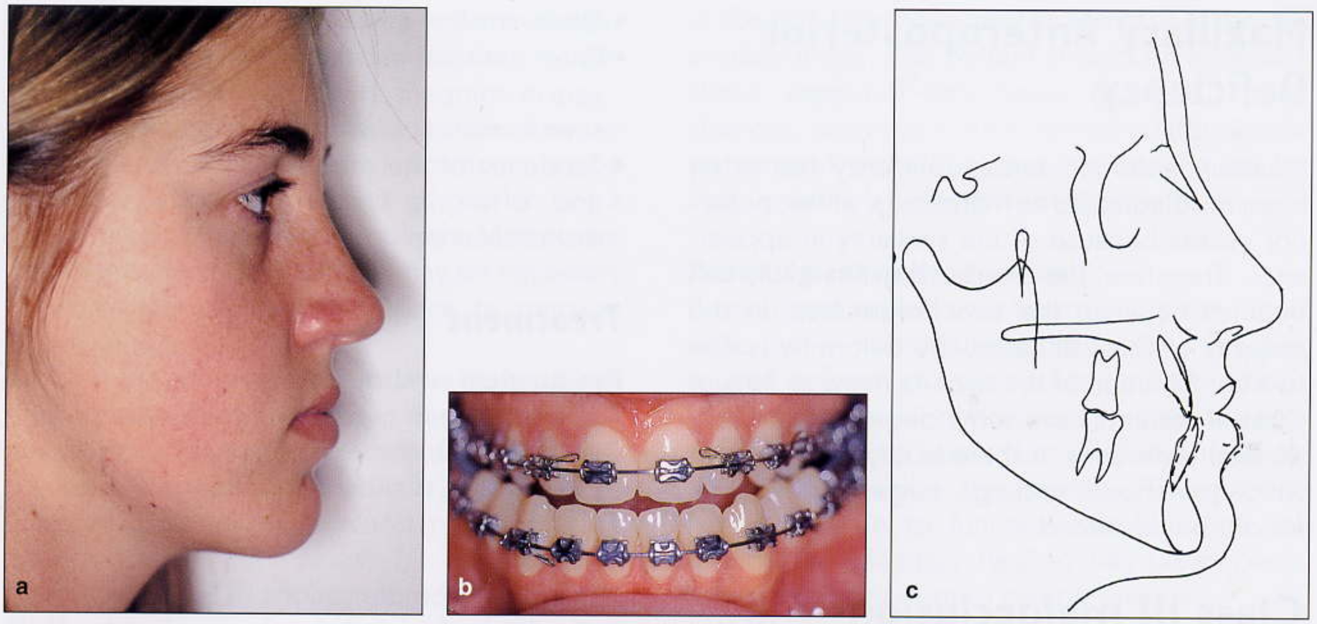


Fig 4-27 Case C.M. The decompensation of the mandibular incisors is completed before the second corrective procedure. *(a)* Profile view. *(b)* Occlusion. *(c)* Cephalometric tracing.

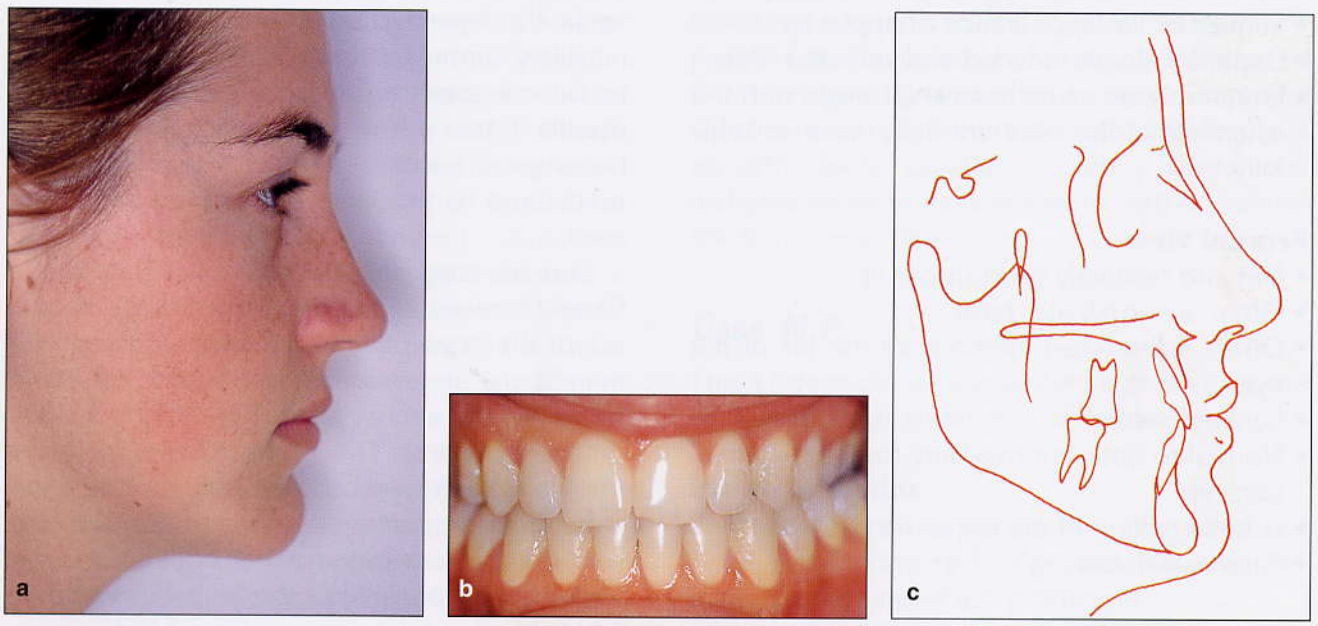


Fig 4-28 Case C.M. Posttreatment results are demonstrated in profile view *(a)*, occlusion *(b)*, and cephalometric tracing *(c)* 1 year after the second surgical procedure.

Maxillary Anteroposterior Deficiency

Maxillary anteroposterior deficiency has often been misdiagnosed as mandibular anteroposterior excess because of the similarity in appearance. Therefore, the clinician must carefully distinguish between the two deformities. In the majority of Class III cases, the deformity is due to a combination of the two. As many as 75% of Class III patients have some degree of maxillary skeletal deficiency. If there is any doubt about which jaw should undergo surgery, the maxilla should be advanced.

Class III malocclusion

Clinical characteristics

Profile view

- Sunken cheeks
- Chin and lower lip in balance with nose
- Sunken or flat appearance of upper lip
- Upper lip length reduced and vermillion thin
- Frequently, an acute nasolabial angle with the columella of the nose oriented more horizontally

Frontal view

- Flat and relatively short upper lip
- Often, a narrow alar base
- Often, sclera seen inferiorly of the iris of the eye
- Sunken cheeks
- Normal to deficient maxillary tooth-to-lip relationship
- Less vermillion of the upper lip showing
- Paranasal flattening

The relationship of each individual jaw to the cranium can be evaluated clinically by blocking out the mandible and then the maxilla with a hand or card.

Dental characteristics

- Class III malocclusion
- Often, crowding in the maxillary arch
- Often, small or absent maxillary lateral incisors
- Often, normal inclination of mandibular incisors in comparison with the lingual inclination seen in mandibular anteroposterior excess
- Tendency of the maxillary arch to be narrow and often in lingual crossbite with the mandibular arch

Treatment

Presurgical orthodontics

The treatment of maxillary anteroposterior deficiency has the same basic goals as does the treatment of mandibular anteroposterior excess:

1. Eliminate compensations.
2. Establish ideal incisor position (indicated by the orthodontic visual treatment objective).
3. Establish arch compatibility.
4. Level and align arches.

It is important to keep in mind that the transverse discrepancy that often accompanies the maxillary anteroposterior deficiency may have to be corrected by surgical expansion of the maxilla. If this is contemplated, the arch should be aligned accordingly and the roots of the teeth next to the interdental osteotomy deviated.

Two-jaw surgery may be indicated in severe Class III cases. Here the orthodontist should adopt the "two-patient" concept, in which the mandibular and maxillary arches are treated independently, almost as if they belong to two different patients. The objective is to align the maxillary and mandibular incisors in both vertical and anteroposterior planes of space so the surgeon can achieve optimal skeletal and esthetic correction without the limitations of dental interference.

Cases of maxillary deficiency often involve crowding in the maxilla, and retraction of incisors is indicated. This will necessitate extractions, which follow these principles:

1. If maximum retraction is necessary or significant crowding is present, removal of maxillary first premolars is indicated.

2. If little retraction is necessary and crowding is slight, removal of second premolars is indicated.
3. Advancement of mandibular incisors from an upright or lingually tipped position may be limited by lack of attached gingiva and/or a thin alveolar bone and symphysis. Mandibular second premolar extraction may be necessary to provide the required space to manage crowding.
4. The most common extraction pattern in Class III cases is extraction of maxillary first premolars and, when extraction in both arches is indicated, extraction of maxillary first premolars and mandibular second premolars (the opposite of Class II cases).

Orthodontic mechanics

Crowding is often present in the maxillary arch and requires tooth extraction. The canines are usually blocked out, which is often the patient's main complaint before treatment. The decision whether to extract the first or second premolars is influenced by the amount of crowding and required decompensation of the incisors. Presurgically, the maxillary incisors should be placed in good angulation in the central trough of bone. To achieve the best esthetic result, their anteroposterior positioning should be based on the visual treatment objective. Decompensation of the mandibular incisors is seldom indicated. The mandibular arch should be leveled and aligned so as to act as the "template" for the maxillary dental arch.

Surgical treatment

The maxilla is advanced by means of a Le Fort I osteotomy. This versatile procedure enables the surgeon to correct discrepancies in the vertical, transverse, and occlusal planes. Grafting is recommended both in cases with large advancements and cases with expansion of the palate. Various grafting materials are available, including bone harvested from local or distant sites, including the chin or iliac crest; allogenic freeze-dried bone; and artificial bone substitutes such as hydroxyapatite blocks.

Undesirable soft tissue changes may occur, including widening of the alar base, tipping up of the tip of the nose, and an increase in the nasolabial angle. The patient should be informed about expected soft tissue changes. These changes, however, can be controlled (for details on surgical technique, see the section on Le Fort I maxillary osteotomy in chapter 5).

Postsurgical orthodontics

Postsurgical orthodontic treatment is very similar to that of mandibular setback cases. A splint is used only when a multipiece Le Fort I maxillary osteotomy is performed. In two-jaw surgery, an intermediate splint is always used to accurately position the maxilla. The patient would be able to function with the occlusal splint until adequate healing has taken place and active orthodontics can be resumed.

Ligature wires between teeth adjacent to interdental osteotomies should be placed by the surgeon and be removed only by the orthodontist during the placement of a continuous archwire.

When surgical expansion has been performed, the transverse dimension should be maintained by an occlusal splint reinforced by a palatal bar. The palatal bar prevents bending of the splint during and after surgery. Once the splint is removed, the orthodontist should place an orthodontic palatal bar and a continuous archwire as soon as possible to further control the transverse dimension.

Case M.P.

This 17-year-old female patient was seen by the orthodontist for alignment of her teeth.

Main complaint

The patient wanted her teeth aligned and her "bad bite" corrected. She also felt that her mandible appeared too prominent.

Medical history

Her medical history was noncontributory.

Clinical examination

1. Soft tissue
   a. Frontal view (Fig 4-29a)
      - Flat paranasal areas
      - Lack of upper lip support

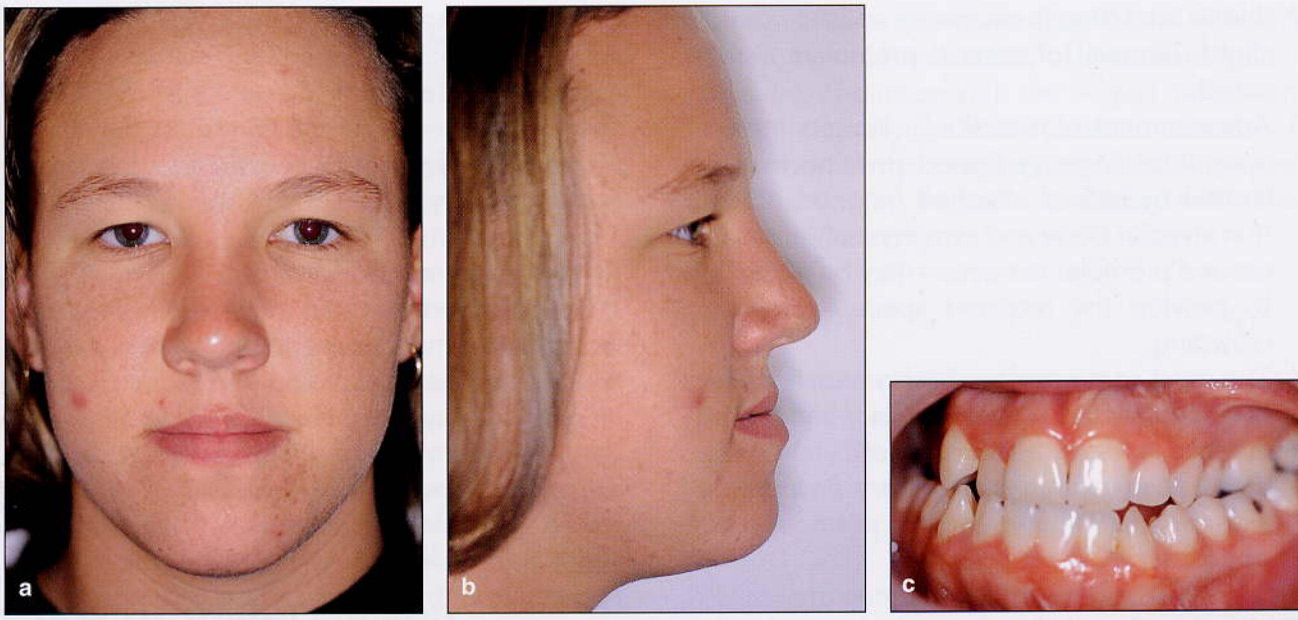


Fig 4-29 Case M.P. Pretreatment frontal view *(a)*, profile view *(b)*, and occlusion *(c)*.

- Relatively small amount of upper lip vermilion exposure

b. Profile view (Fig 4-29b)
- Concave profile
- Lack of upper lip support
- Lower lip ahead of the upper lip
- Obtuse labiomental fold
- Acute nasolabial angle

2. Dental (Fig 4-29c)
- Class III malocclusion
- Anterior and posterior crossbites (absolute)
- Compensated mandibular incisors
- Narrow maxillary dental arch
- Maxillary dental midline 1.5 mm toward the left
- Maxillary left first premolar absent
- Crowding in the maxillary and mandibular arches

3. Skeletal (Fig 4-30)
- Maxillary anteroposterior deficiency
- Maxillary transverse deficiency
- Vertical excess of the anterior mandible
- Tendency toward anteroposterior deficiency of the chin

4. Radiographic

a. Panoramic radiograph
- Maxillary left first premolar absent
- Four impacted third molars

b. Cephalometric (see Fig 4-30)
- Confirms clinical observations

Problem list

1. Class III malocclusion
2. Maxillary anteroposterior deficiency
3. Maxillary transverse deficiency
4. Maxillary dental midline toward the left
5. Lingually inclined mandibular incisors
6. Anterior mandibular vertical excess

Presurgical orthodontics

- Maxillary arch (Fig 4-31)
  - Extraction of the maxillary right first premolar and removal of impacted third molars
  - Correction of the dental midline
  - Establishment of a good arch form in two segments, from the maxillary right central incisor to second molar and from the maxillary left central incisor to second molar

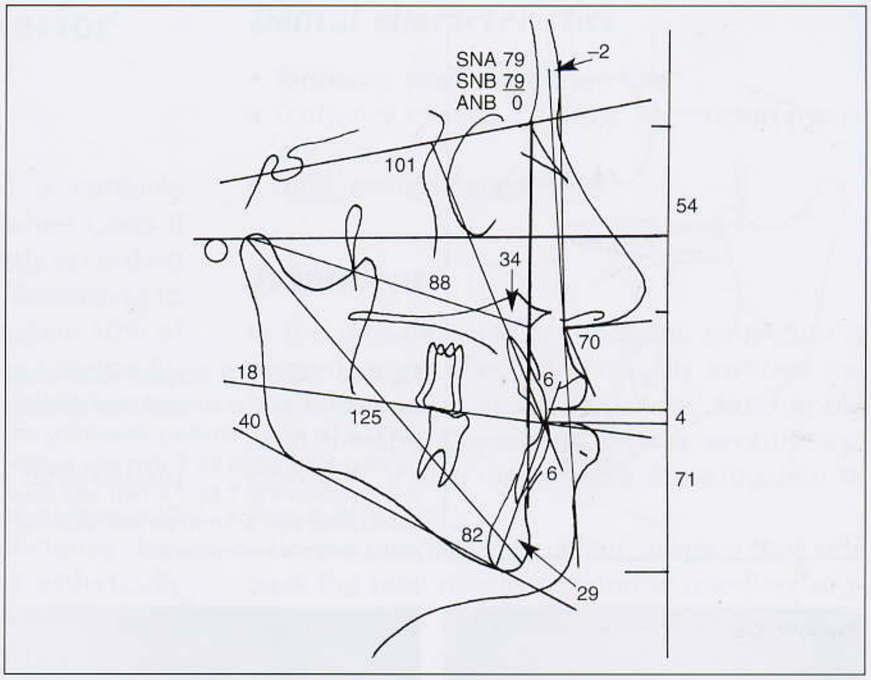


Fig 4-30 Case M.P. Cephalometric analysis. Class III dental relationship; Class III skeletal relationship; maxillary anteroposterior deficiency: SNA = 79 degrees, ratio of maxillary length to mandibular length = 88:125 mm; increased lower-third facial height: ratio of middle third to lower third = 54:71 mm; increased anterior mandibular height: height = 46 mm, ratio of upper lip to lower lip = 21:46; obtuse labiomental fold; lingually inclined mandibular incisors: mandibular incisor to mandibular plane, 82 degrees; acute nasolabial angle, 70 degrees; concave profile: facial contour angle = –2 degrees.

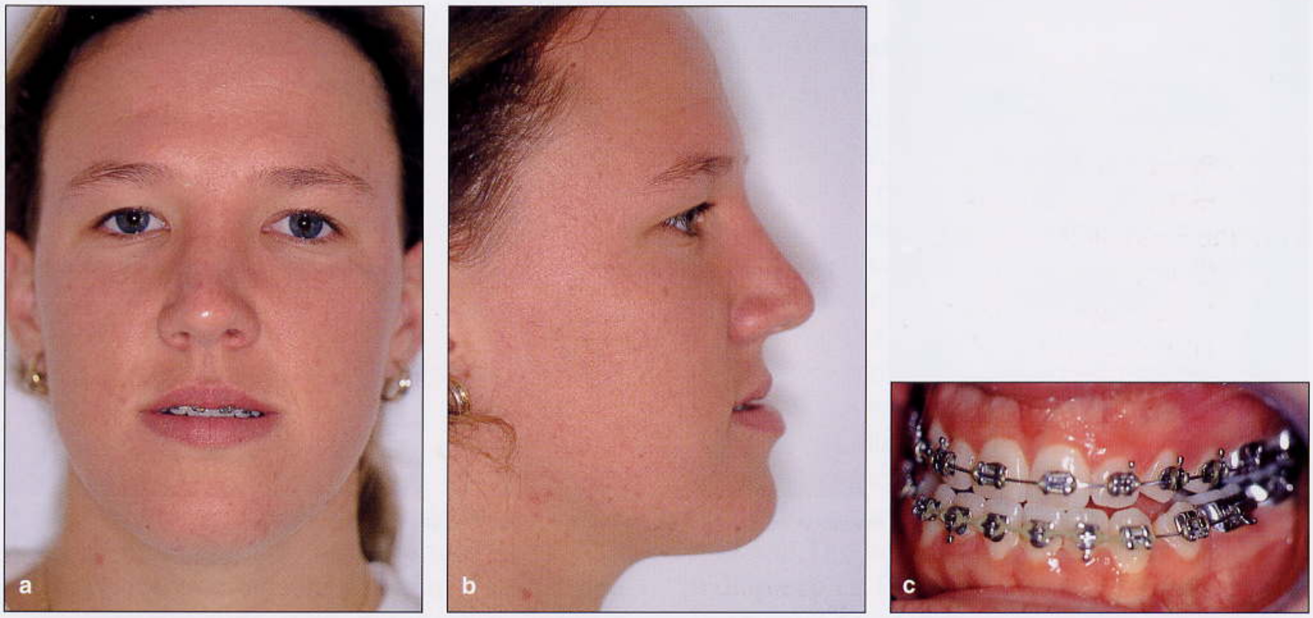


Fig 4-31 Case M.P. Presurgical frontal view *(a)*, profile view *(b)*, and occlusion *(c)*. Note the orthodontic correction of the dental midlines and the decompensation of the mandibular incisors.

- Expansion of the arch within the bony base
- Deviation of the roots of the central incisors

• Mandibular arch (see Fig 4-31)
- Extraction of both mandibular second premolars and removal of impacted third molars
- Establishment of a good arch form
- Decompensation of the incisors

Surgical treatment

- The maxilla was advanced and expanded by means of a two-piece Le Fort I maxillary osteotomy. The interdental osteotomy was performed between the maxillary central incisors. The maxilla was superiorly repositioned to improve the tooth-lip relationship (Fig 4-32).

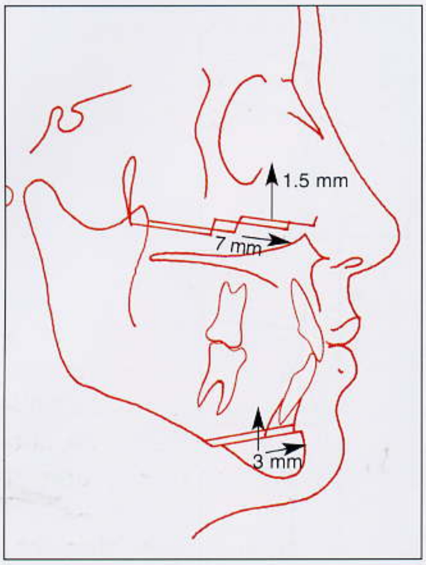


Fig 4-32 Case M.P. Surgical visual treatment objective. The surgical plan consists of *(1)* a Le Fort I maxillary osteotomy advancing the maxilla by 7 mm and superiorly repositioning it by 1.5 mm and *(2)* a genioplasty with a 3-mm vertical reduction and a 3-mm advancement.

Fig 4-33 Case M.P. Posttreatment results are demonstrated in frontal view *(a)*, profile view *(b)*, and occlusion *(c)*.

- Finally, genioplasty was performed to reduce the vertical height of the chin and advance the chin slightly (see Fig 4-32).

Postsurgical orthodontics

- Corrected the angulation of the maxillary incisors.
- Controlled the surgical expansion by placing a palatal bar as soon as possible after surgery.
- Refined the occlusion.
- Initiated orthodontic retention after debanding.

The surgery was performed after a 17-month presurgical period of orthodontics, and the orthodontic bands were removed 4 months after surgery. The treatment results 6 months after band removal are illustrated in Fig 4-33.

Maxillary Anteroposterior Excess

Maxillary anteroposterior excess is certainly not as common as was implied when Class II malocclusions were classified strictly according to the Angle dental classification. According to McNamara (1981), only approximately 10% of a group of 277 patients with Class I malocclusions had true maxillary anteroposterior excess.

The clinician should carefully differentiate between maxillary anteroposterior excess and mandibular anteroposterior deficiency because of the previously discussed esthetically unfavorable results achieved after the surgical or orthodontic retraction of maxillary incisors in a patient with mandibular anteroposterior deficiency. Of course, maxillary anteroposterior excess can occur in combination with mandibular deficiency (see Case O.M. later in this section).

Overview

Clinical characteristics

Profile view
- General protrusion of the middle third of the face
- Nose that often appears large and has a dorsal hump
- Prominent infraorbital rims and cheekbones
- Upper lip often short and everted
- Deep labiomental sulcus due to the fact that the lower lip curls under the maxillary incisors
- Lip incompetence
- Acute nasolabial angle

Frontal view
- Noticeable prominence of the middle third of the face
- Often, a long lower facial height
- Short, curled upper lip
- Curled lower lip under maxillary incisors

Dental characteristics

- Tendency toward an open bite
- Tendency toward a narrow, constricted maxillary arch
- High, arched palatal vault

Treatment

In the growing child, orthodontic correction is certainly most effective. It usually involves the use of headgear and multibanded fixed appliance therapy. Depending on the severity and crowding, it also may involve the extraction of four premolars.

In the nongrowing patient, surgery that sets back the total maxilla or anterior maxillary segment hastens treatment and avoids headgear therapy. Total maxillary setback is performed at the Le Fort I level and is technically difficult.

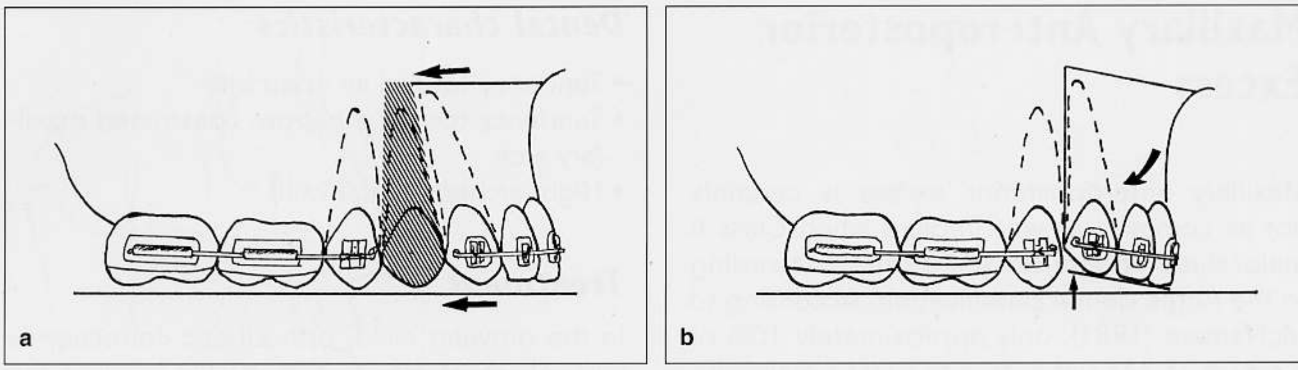
Surgical treatment

Three surgical techniques for repositioning the anterior maxilla have been described by Wassmund (1935), Cupar (1954), and Wunderer (1963). When posterior movement of the anterior maxillary segment is the main objective, the technique described by Wunderer is the most practical approach.

An anterior segmental osteotomy of the maxilla is often performed as part of a multisegment Le Fort I procedure because patients who need anterior maxillary correction often need additional corrections to the maxilla (eg, superior repositioning and/or expansion of the posterior maxilla). The author finds it easier to perform a multipiece Le Fort I procedure than an anterior segmental osteotomy.

In the presurgical phase, the roots of the teeth on either side of the osteotomy cut must be deviated sufficiently. Inadequate deviation of the roots of these teeth will:

1. Limit the surgical setback
2. Increase the risk of damage to the tooth roots at surgery
3. Force the surgeon to rotate the segment, thereby either elevating the canines out of occlusion or tipping the incisors inferiorly (Fig 4-34)



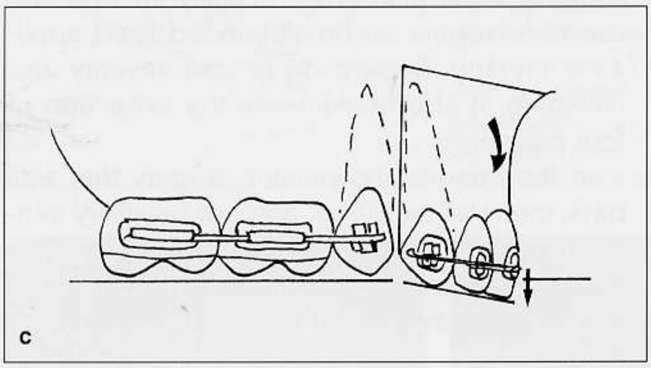


Fig 4-34 Inadequate orthodontic root deviation *(a)* will force the surgeon to either lift the canine superiorly out of the occlusion *(b)* or tip the incisors inferiorly *(c)*, increasing the anterior height of the maxilla.

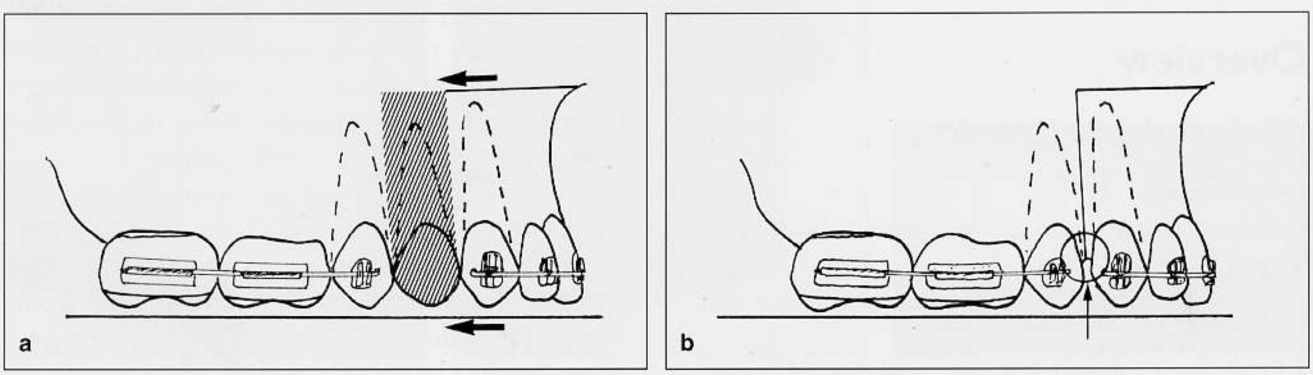


Fig 4-35 *(a)* Adequate orthodontic deviation of the roots of the teeth adjacent to the interdental osteotomy will allow the surgeon to close an interdental space. *(b)* To ensure the integrity of the periodontium, the space should never be completely closed, and a small amount of alveolar bone should always be left intact at the alveolar crest.

Adequate deviation of the roots allows setback of the anterior maxillary segment. A small area of interproximal bone should be maintained and the crowns of the teeth not forced together (Fig 4-35).

Maxillary setback procedures are seldom indicated. The clinician contemplating such a procedure should consider the esthetic effects carefully before making a final decision.

Fig 4-36 Case O.M. Pretreatment frontal view *(a)*, profile view *(b)*, three-quarters view *(c)*, and occlusion *(d)*.

Clinical cases

Case O.M.

The general practitioner referred this 32-year-old female patient to the orthodontist for the correction of her protruding teeth.

Main complaint
The patient was self-conscious about her prominent front teeth and inability to close her lips without strain.

Medical history
Her medical history was noncontributory.

Clinical examination

1. Soft tissue (Figs 4-36a to 4-36c)
   a. Frontal view
      - Increased interlabial gap
      - Increased maxillary incisor exposure
      - Everted lower lip
      - Chin that appears narrow
   b. Profile view
      - Convex profile
      - Increased interlabial gap
      - Protruding upper and lower lips
      - Deficient chin
2. Dental (Fig 4-36d)
   - Maxillary and mandibular dental protrusion
   - Class II malocclusion
   - Increased incisor overjet
   - Small area of attached gingiva in the mandibular incisor region
   - Gingival recession at the maxillary second premolars
3. Skeletal (Fig 4-37)
   - Vertical maxillary excess
   - Maxillary anteroposterior excess
   - Mandibular anteroposterior deficiency
   - Microgenia
   - Narrow chin

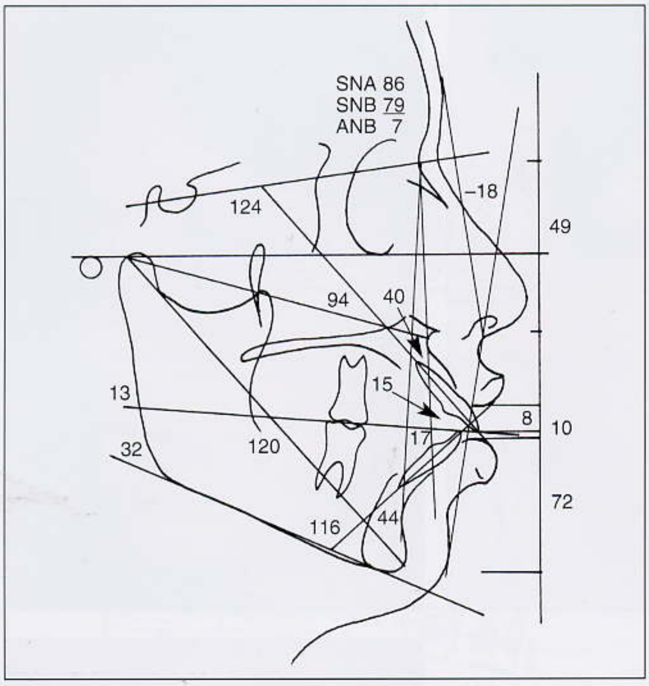


Fig 4-37 Case O.M. Pretreatment cephalometric analysis. Convex profile: facial contour angle = −18 degrees; increased interlabial gap: 10 mm; increased lower-third facial height: ratio of middle facial height to lower facial height = 49:72 mm; maxillary anteroposterior excess: SNA = 86 degrees; maxillary dental protrusion: maxillary incisor to S-N = 124 degrees, maxillary incisor to N-A = 15 mm and 40 degrees; mandibular dental protrusion: mandibular incisor to mandibular plane = 116 degrees, mandibular incisor to N-B = 17 mm and 44 degrees.

Fig 4-38 Case O.M. Frontal view *(a)*, profile view *(b)*, and right side of the occlusion *(c)* after completion of orthodontic preparation.

4. Radiographic
   a. Panoramic radiograph
      - Root treated at the maxillary left first molar
   b. Cephalometric (see Fig 4-37)
      - Confirms the clinical observations

Problem list

1. Bidental protrusion
2. Maxillary anteroposterior excess
3. Vertical maxillary excess
4. Mandibular anteroposterior deficiency
5. Microgenia
6. Class II malocclusion

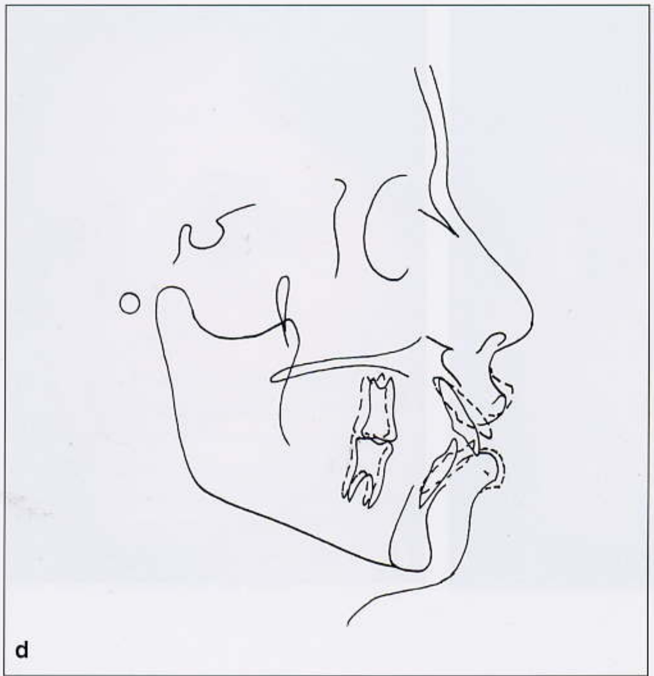


Fig 4-38 *Continued* Case O.M. The dental change after presurgical orthodontics is illustrated in *(d)*.

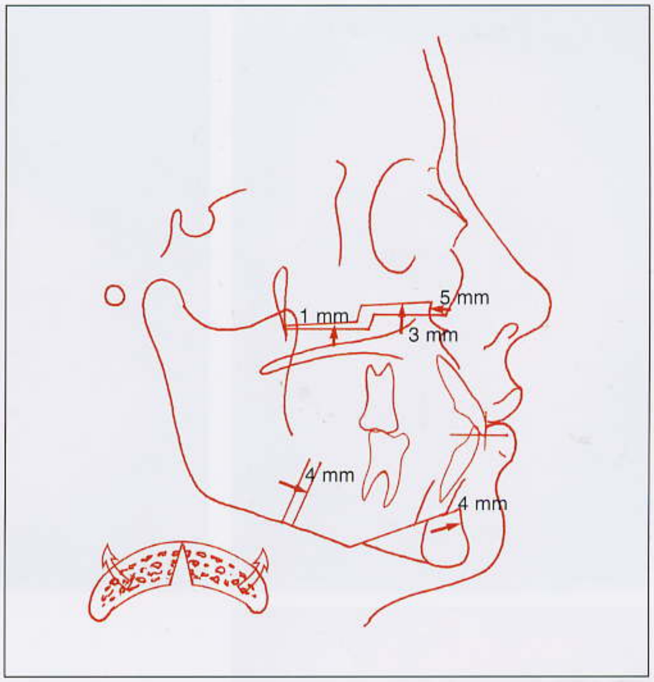


Fig 4-39 Case O.M. The surgical correction consisted of a Le Fort I osteotomy to superiorly reposition and set back the maxilla, bilateral sagittal split osteotomy to advance the mandible, and genioplasty to advance and widen the chin *(inset)*.

Presurgical orthodontics

- Maxillary arch (Figs 4-38a to 4-38d)
  - Extraction of both maxillary second premolars
  - Retraction of the incisors
  - Establishment of a good arch form
- Mandibular arch (Figs 4-38a to 4-38d)
  - Extraction of both mandibular first premolars
  - Retraction of the incisors
  - Leveling of the curve of Spee
  - Establishment of interarch compatibility

Surgical treatment

- Le Fort I maxillary osteotomy to superiorly reposition the maxilla with a setback (Fig 4-39)
- Bilateral sagittal split osteotomy to advance the mandible (see Fig 4-39)
- Genioplasty to simultaneously advance and widen the chin (see Fig 4-39)

Postsurgical orthodontics

Postsurgical orthodontic treatment completed the interdigitation of the teeth and also involved retention. The surgery was performed 24 months after the commencement of orthodontic treatment, and the orthodontic bands were removed 8 months after surgery. The treatment results are illustrated in Fig 4-40.

Case M.G.

Case M.G. illustrates the anteroposterior and vertical reduction of the maxilla by means of a segmental Le Fort I procedure (Figs 4-41 to 4-43).

Fig 4-40 Case O.M. Posttreatment results are demonstrated in frontal view *(a)*, profile view *(b)*, three-quarters view *(c)*, and occlusion *(d)*.

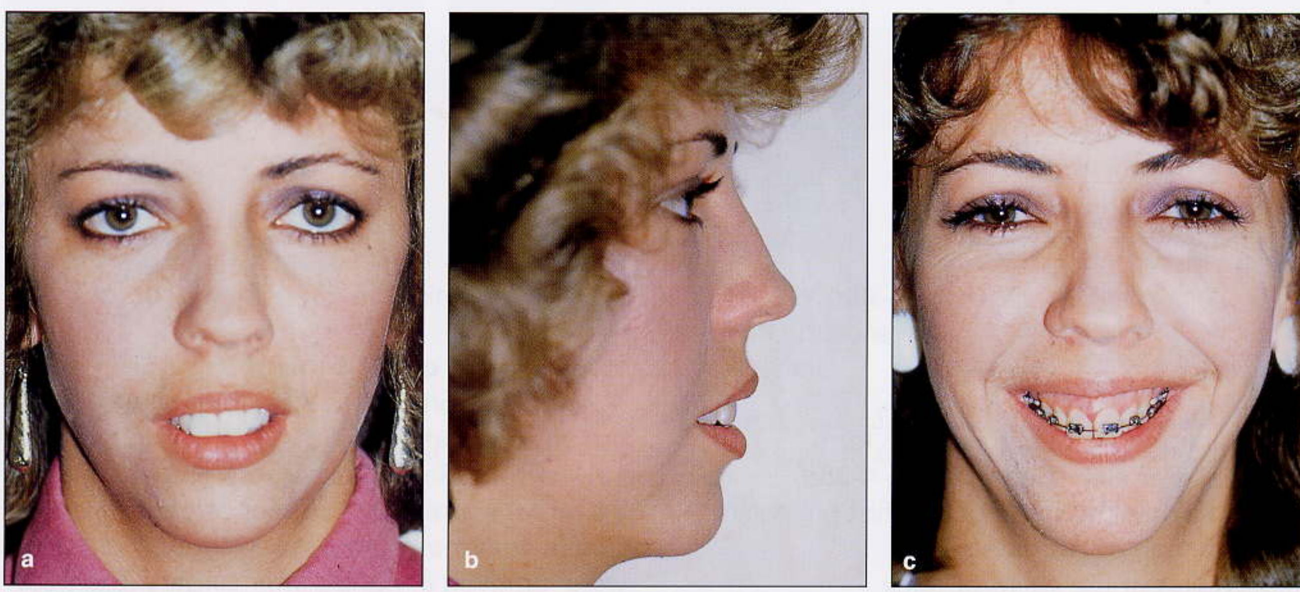


Fig 4-41 Case M.G. Pretreatment frontal view *(a)*, profile view *(b)*, smile *(c)*, and occlusion *(d)*.

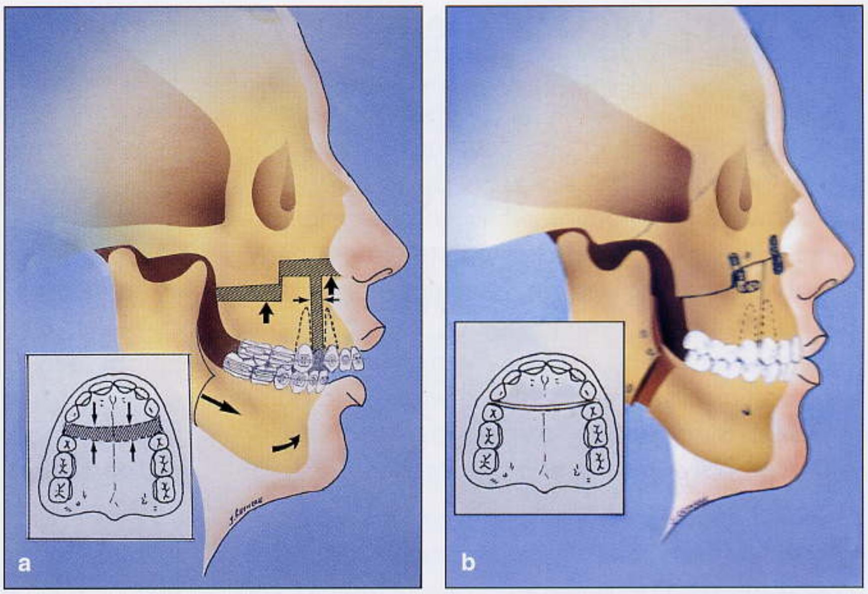


Fig 4-42 Case M.G. The maxillary first premolars were removed and the maxillary arch aligned in three segments. Excessive space was maintained *(a)* and surgically closed by posterior repositioning of the anterior maxillary segments *(b)*. The maxilla was superiorly repositioned and the mandible advanced.

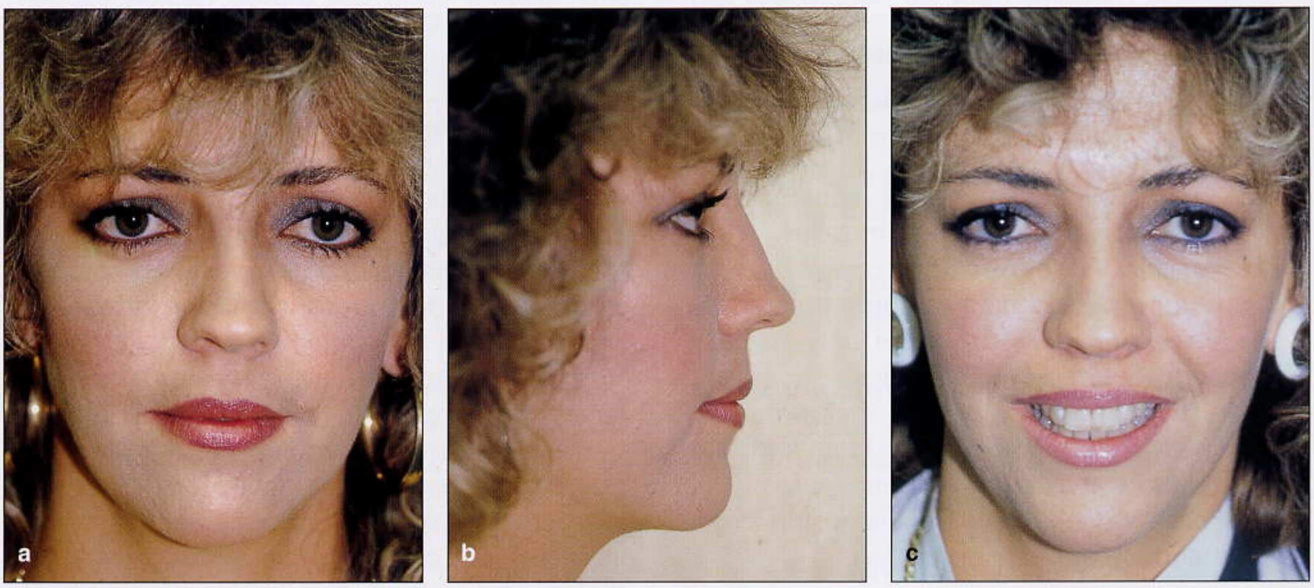


Fig 4-43 Case M.G. Posttreatment frontal view *(a)*, profile view *(b)*, smile *(c)*, and occlusion *(d)*. Note the correction of the maxillary midline.

Maxillary Vertical Deficiency

Maxillary vertical deficiency is very often associated with maxillary anteroposterior deficiency in which the maxilla did not develop in a forward and downward direction. It is common in patients with cleft lip and cleft palate, where early surgery often curtails normal development of the maxilla. Because overclosure of the mandible makes patients with maxillary vertical deficiency appear clinically similar to those with mandibular anteroposterior excess, the clinician should differentiate between the two deformities.

Overview

Clinical characteristics

Profile view

- The lower and middle thirds of the face are proportionally reduced in height when the patient's teeth are in occlusion.
- The nasolabial angle is acute.
- Overclosure causes the chin to appear excessive.
- The profile improves when the mandible is in the rest position.
- The maxillary incisors are not visible under the upper lip.

Frontal view

- The face appears short and square, with strong, exaggerated masseter muscles.
- The maxillary incisors are often not visible with the mouth open, creating an edentulous appearance, and the incisors are only partially exposed when the patient smiles.
- When the mandible is closed, the corners of the mouth are turned down, and skin folds are apparent lateral to the oral commissure.
- Nasal base may be broad and the nostrils large.
- The mandible appears excessive.

Dental characteristics

- The heavy musculature and overclosed occlusion frequently predispose the patient to bruxism and resulting attrition.
- Interocclusal freeway space is often increased.
- There is a Class III dental relationship.

Treatment

The surgical treatment objective in cases of maxillary vertical deficiency is to reposition the maxilla forward and downward. The mandible will rotate clockwise, and the vertical height of the face will increase. Patients with maxillary vertical deficiency invariably have an increased interocclusal freeway space, which should be carefully evaluated. The increase in vertical height achieved by downgrafting the maxilla should be less than the "available" interocclusal freeway space.

The extent of the vertical deficiency can be measured only with the patient's lips in repose and almost touching. Pretreatment cephalometric radiographs should be taken with the mandible in the rest position and the lips barely touching. This can be facilitated by the use of a wax splint. The cephalometric visual treatment objective should be created on a radiograph taken with the mandible rotated open and the lips barely apart. This radiograph will give the surgeon a good indication of *(1)* the required amount of maxillary downgrafting to achieve an ideal lip-tooth relationship and *(2)* the mandibular anteroposterior position following clockwise rotation.

Presurgical orthodontics

The objective in presurgical orthodontic treatment in maxillary vertical deficiency cases is to *(1)* level and align the teeth and *(2)* coordinate the arches. Significant anteroposterior compensations are seldom present, and the incisors can often be left in their original anteroposterior positions. If severe crowding is present, the maxillary and mandibular first premolars are extracted; with mild crowding, the maxillary and mandibular second premolars are extracted. Where larger maxillary advancement is needed in cases with crowding, the first maxillary premolars and second mandibular premolars are extracted to create a large crossbite.

If a transverse deficiency of the maxilla is present, it is best to correct it surgically. The maxillary arch can often be coordinated in two halves to "fit" the mandibular arch and the archwire cut in the center. A stabilizing palatal arch should be placed as soon as possible after surgery, and it should be anticipated presurgically.

Surgical treatment

The maxilla can be repositioned inferiorly by a Le Fort I downgrafting procedure. This procedure was unstable in the past, and as high as a 70% loss of vertical height has been reported. However, rigid fixation has substantially improved the stability of the procedure.

Definitive presurgical planning of the exact amount of maxillary inferior repositioning is critical. The clinician should be guided by both the amount of interocclusal rest space and the maxillary incisor–upper lip relationship.

After the maxilla is mobilized on the Le Fort I level, intermaxillary fixation is placed. The condyles are seated in the glenoid fossae, and with gentle backward and upward pressure at the mandibular angles, the maxilla is rotated closed until the desired, preplanned interosseous distance is achieved. Four bone plates—two at the zygomatic buttresses and two at the piriform rims—are placed.

An interpositioning graft is then placed (or it may be placed before the bone plates). This graft is shaped to fit snugly into the bony defect to prevent displacement into the maxillary sinus. If the transverse dimension of the maxilla is increased by surgical expansion, an acrylic occlusal splint is placed and the palatal bone defect grafted. An interdental wire is inserted between the teeth adjacent to the interdental osteotomy.

Patients with a combination of vertical and anteroposterior deficiency may be candidates for the Le Fort I downsliding osteotomy design. The surgical plan for these patients should include maxillary advancement in addition to correction of the vertical discrepancy. In these cases, the osteotomy is angled to provide an inclined plane that will increase the vertical dimension as the maxilla slides forward. The horizontal length from the piriform rim to the lateral aspect of the zygoma is measured on a lateral cephalogram. This measurement is used to calculate the downward angulation of the osteotomy and the position of the vertical steps.

Postsurgical orthodontics

At the first postsurgical visit, the orthodontist checks the occlusion and instructs the patient to wear appropriate elastics. If surgical expansion of the maxillary arch was performed, the orthodontist should do the following:

1. Remove the sectional archwire and replace it with a continuous archwire.
2. Place a palatal arch that is carefully adapted to the lingual surface of all teeth distal to the canines.

At first, the orthodontist sees the patient once every 1 to 2 weeks for routine adjustment of archwires and elastics. With good progress, the patient goes to a 4-week adjustment schedule, and postsurgical orthodontic treatment is concluded as previously discussed.

Clinical case

Case B.E.

This 15-year-old female patient was referred by her practitioner for the correction of a Class III malocclusion.

Main complaint

The patient's main complaint was that she was unable to bite anything with her front teeth and that her face appeared too flat.

Medical history

The patient's medical history was noncontributory.

Clinical examination

1. Soft tissue
   a. Frontal view (Figs 4-44a and 4-44b)
      - Paranasal flattening
      - Lack of upper lip support
      - Maxillary incisors barely visible when the patient's lips are apart
      - Mandible that appears large
   b. Profile view (Fig 4-44c)
      - Concave profile
      - Upper lip that appears flat
      - Mandible that appears to be strong and overclosed

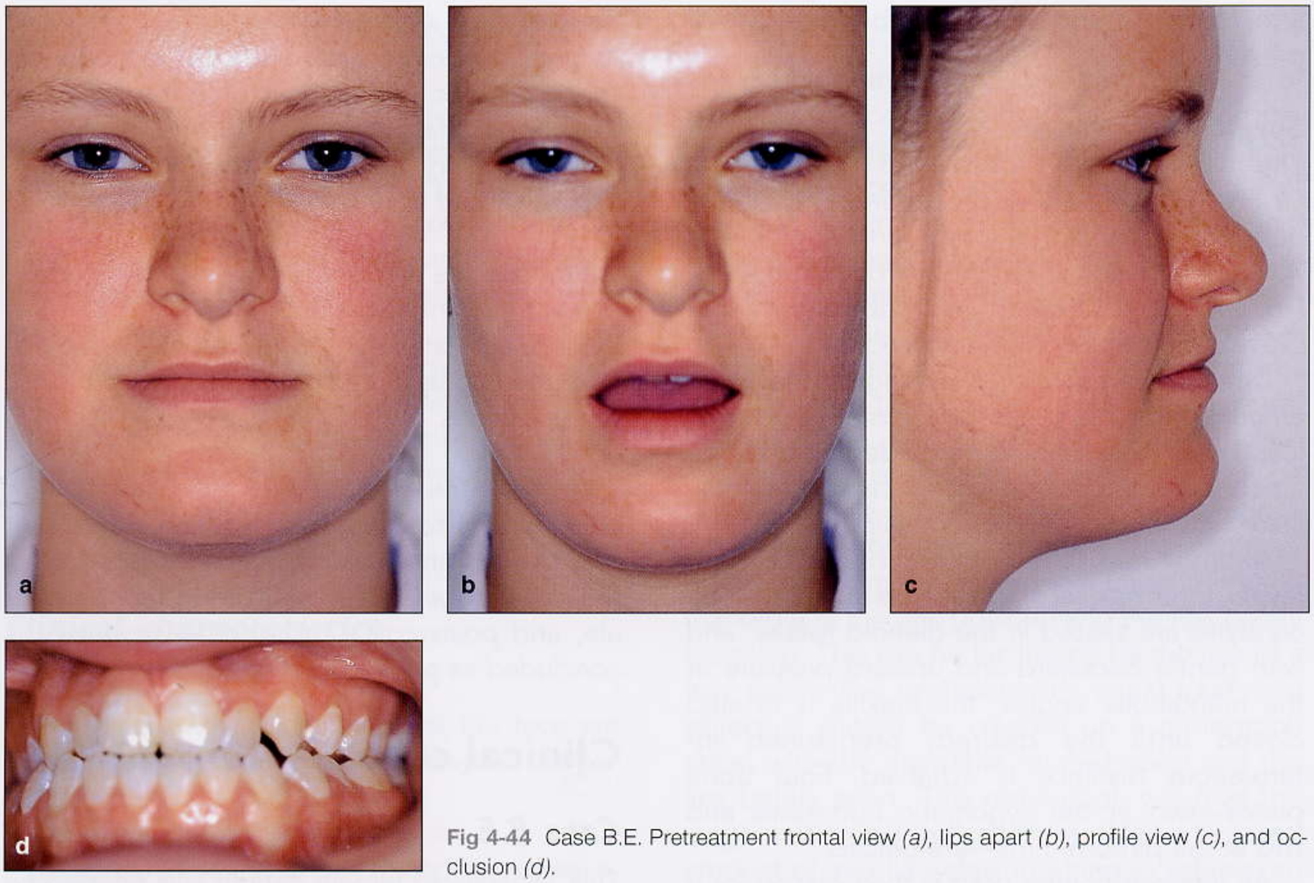


Fig 4-44 Case B.E. Pretreatment frontal view *(a)*, lips apart *(b)*, profile view *(c)*, and occlusion *(d)*.

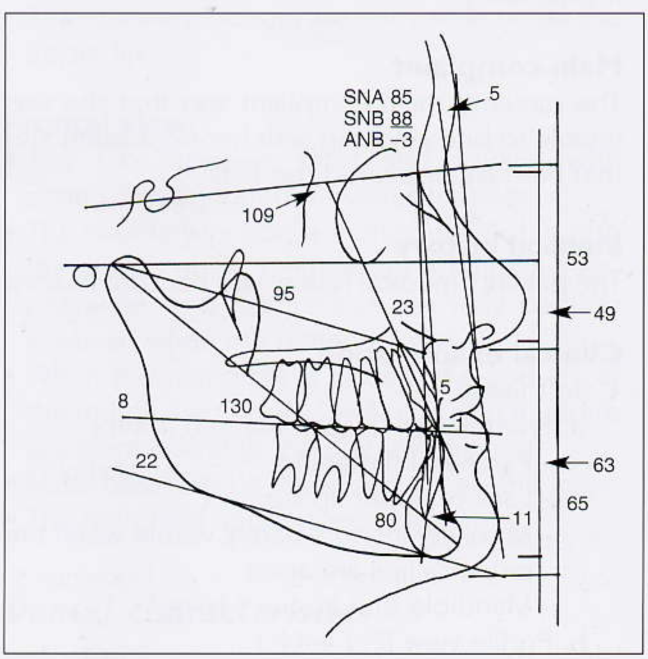


Fig 4-45 Case B.E. Pretreatment cephalometric analysis. Class III malocclusion; maxillary anteroposterior deficiency; Class III skeletal relationship: ANB = −3 degrees; mandibular incisor compensation: mandibular incisor to mandibular plane = 80 degrees, mandibular incisor to N-B = 11 degrees; concave profile: facial contour angle = 5 degrees.

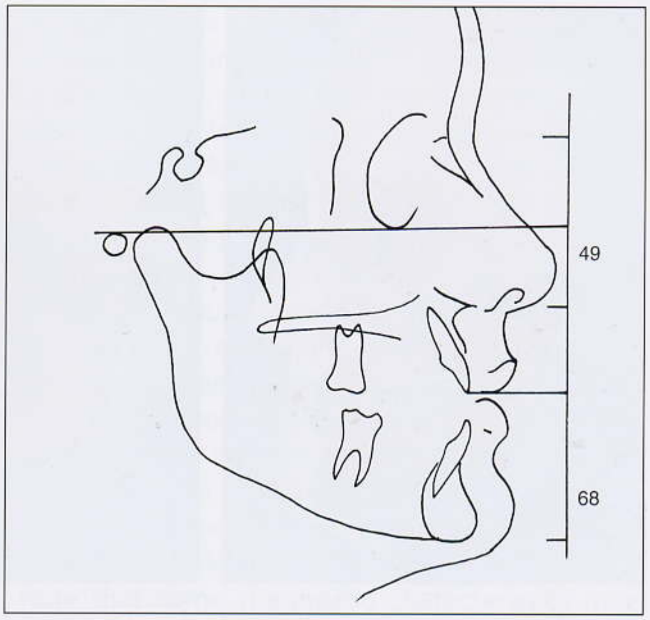


Fig 4-46 Case B.E. Tracing of a pretreatment cephalometric radiograph taken with the patient's mandible rotated clockwise until the lips just part. Note the maxillary incisor–lip relationship. The final vertical position of the maxilla is planned from this tracing.

Fig 4-47 Case B.E. Immediate presurgical occlusion.

2. Dental (Fig 4-44d)
   - Edge-to-edge incisor relationship with an open bite tendency
   - Class III malocclusion
   - Narrow maxillary arch
   - Tendency to posterior crossbites
   - Compensated mandibular incisors
3. Skeletal (Figs 4-45 and 4-46)
   - Anteroposterior maxillary deficiency
   - Vertical maxillary deficiency
4. Radiographic (see Figs 4-45 and 4-46)
   a. Cephalometric
   - Confirms the clinical diagnosis of a Class III malocclusion with vertical and anteroposterior maxillary deficiency

Problem list

1. Vertical maxillary deficiency
2. Anteroposterior maxillary deficiency
3. Class III malocclusion
4. Anterior open bite
5. Narrow maxillary arch

Presurgical orthodontics

- Maxillary arch (Fig 4-47)
  - Alignment of the arch
  - Expansion of the posterior teeth within the bony limits
- Mandibular arch (see Fig 4-47)
  - Decompensation of the incisors
  - Establishment of interarch compatibility

Surgical treatment

Surgical treatment involved a Le Fort downsliding osteotomy. The osteotomy is performed at a predetermined angle so that the maxilla will slide downward as it is advanced, thus increasing the vertical height while bone contact is maintained (Fig 4-48).

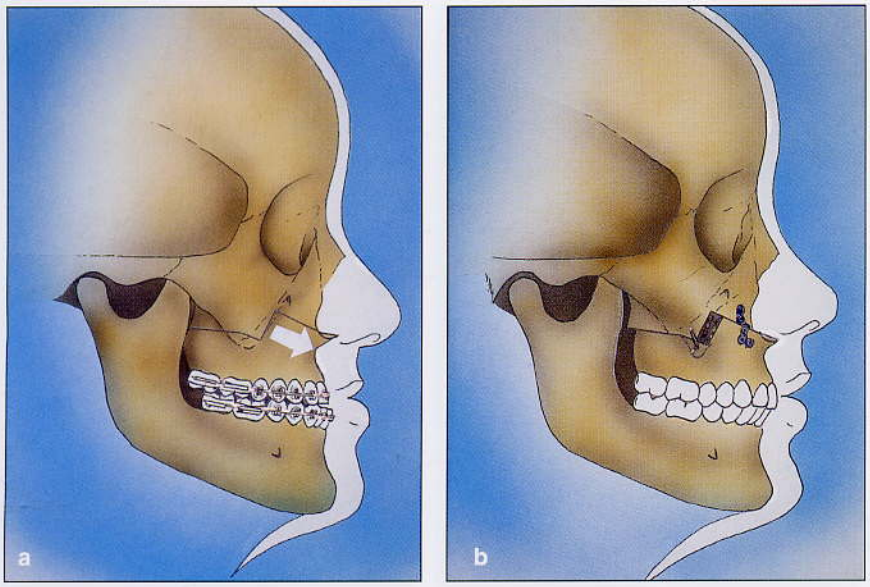


Fig 4-48 Case B.E. *(a)* Surgical plan illustrating the angled Le Fort I osteotomy. *(b)* As the maxilla is advanced, it will slide downward, increasing the vertical height.

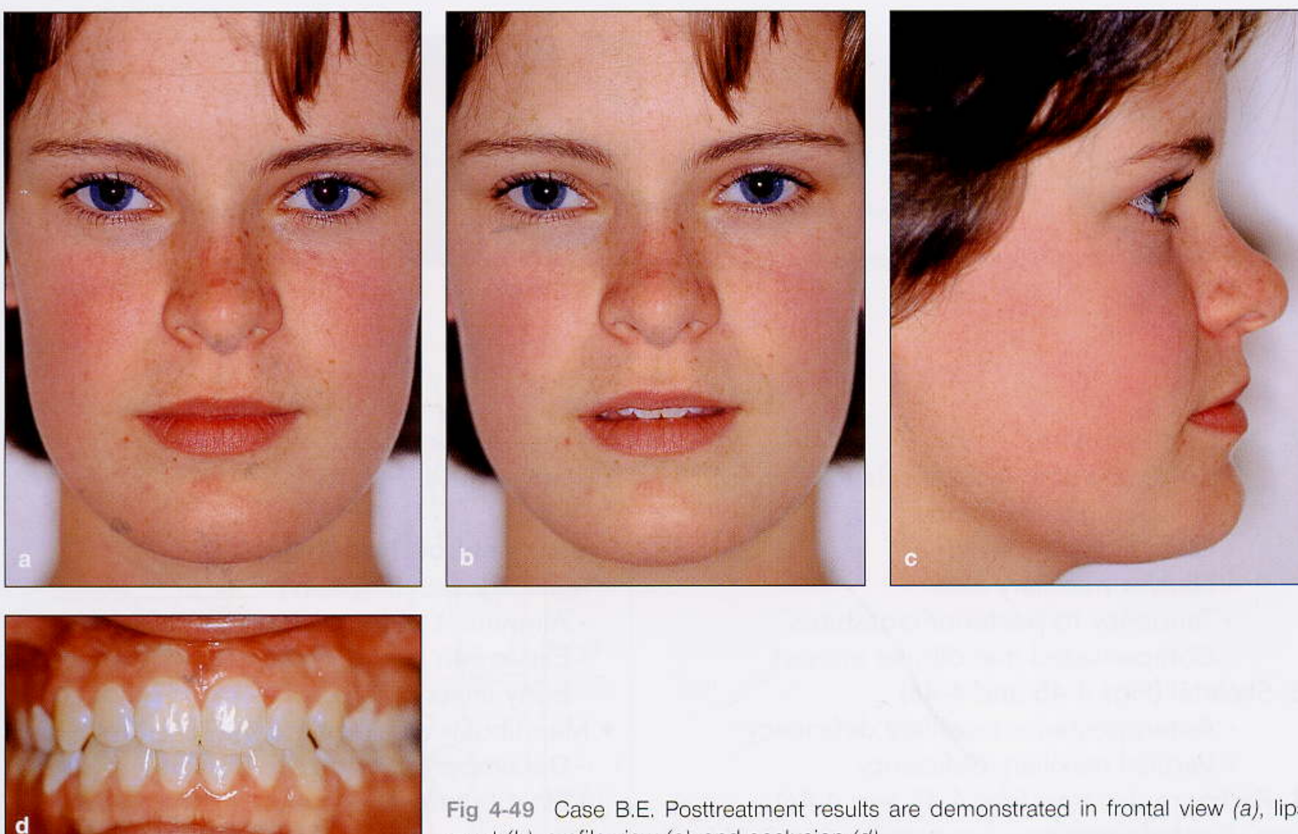


Fig 4-49 Case B.E. Posttreatment results are demonstrated in frontal view *(a)*, lips apart *(b)*, profile view *(c)*, and occlusion *(d)*.

Postsurgical orthodontics

The postsurgical orthodontic treatment finalized the occlusion and advanced to the retention stage. The orthodontic preparation before surgery took 6 months, and the bands were removed 4 months after surgery. Figure 4-49 illustrates the posttreatment results 7 months after surgery.

Maxillary Vertical Excess

Approximately 30% of patients seeking treatment have a vertical increase in the lower third of the face. In our experience, the main complaints of patients with vertical maxillary excess are a gummy smile and/or functional problems due to the anterior open bite, the hallmarks of the long face deformity.

Overview

Clinical characteristics

Profile view

- Increased total facial height due to an increased lower facial height
- Mandible rotated downward and backward
- Increased interlabial distance (greater than 4 mm)
- Increased maxillary incisor exposure (except in some open bite cases)
- Sunken cheeks
- Often, a well-developed, almost excessive, curled lower lip

Frontal view

- Narrow alar base width
- Excessive maxillary incisor exposure (except in some open bite cases)
- Increased interlabial distance
- Often, increased vermillion exposure of the lower lip
- Increased lower-third facial height
- Gummy smile
- Depressed paranasal areas with a tendency to flat cheeks

Dental characteristics

- Often, an anterior bite
- High, arched palate with a large distance between the root apexes and the nasal floor
- V-shaped maxilla and teeth often in palatal crossbite
- Mandibular incisors that tend to become more upright and therefore more crowded

Because of the excessive vertical growth of the maxilla, the mandible tends to rotate downward and backward. These patients, therefore, often also have problems in the anteroposterior plane. Patients with long faces can be described as being skeletal Class I rotated to Class II or as Class III rotated to Class I. It can be concluded that excessive vertical growth of the maxilla will make mandibular anteroposterior deficiencies appear worse and mandibular anteroposterior excesses appear better. Frequently there is an accentuated curve of Spee due to overeruption of mandibular incisors, especially in cases without open bites.

There is a tendency for anterior open bites in two thirds of these patients. The clinician should note that some diagnostic characteristics may be camouflaged in patients with vertical maxillary excess and deep bites (Fig 4-50). First, because of the deep bite, the lower facial height may not be increased. Second, the maxillary incisors may be excessively exposed under the upper lip; however, this exposure is covered by the lower lip.

The combination of three main characteristics may be considered diagnostic for vertical maxillary excess:

1. Increased mandibular plane angle
2. Increased total anterior facial height
3. Decreased percentage contribution of upper facial height to total facial height

Treatment

The two most important rules in the treatment of vertical maxillary excess follow:

1. Never treat the smile.
2. Always plan the treatment with the lips in repose.

There is no alternative to surgery for adult patients with vertical maxillary excess. Attempts to close the open bite by orthodontic extrusion of anterior teeth or intrusion of posterior teeth are not a solution, for two reasons: *(1)* relapse into open bite almost always occurs, and *(2)* extrusion of the maxillary incisors will worsen the esthetics.

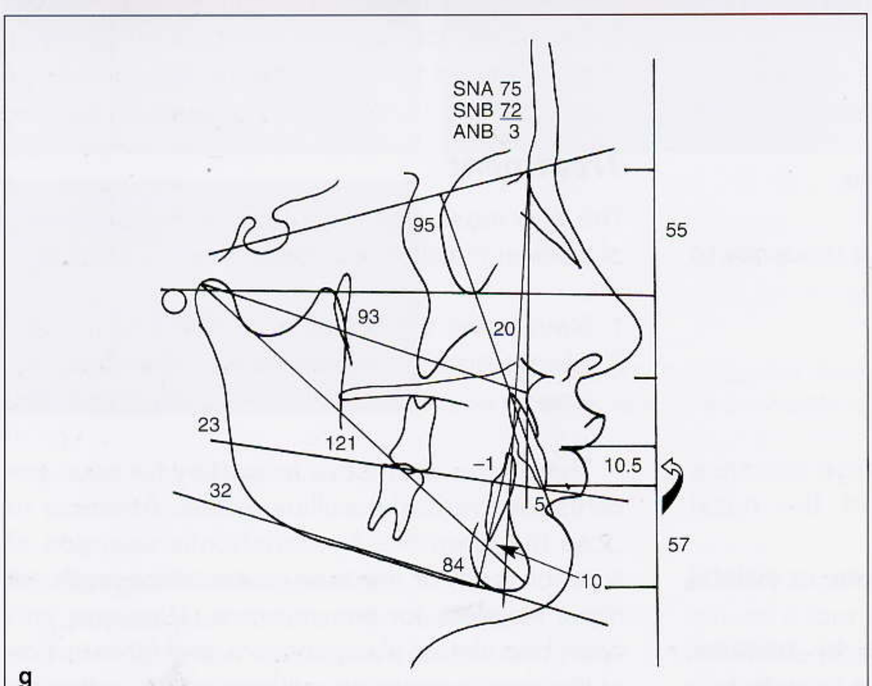


Fig 4-50 Frontal view *(a)* and profile view *(b)* of a patient with a severe Class II deep bite *(c)*. The vertical height of the maxilla cannot be assessed because of the overclosed bite. The vertical excess (excessive tooth exposure under the upper lip) is evident *(d and e)* when the mandible is rotated into the correct interincisal overbite. Note the gummy smile *(f)*. Vertical excess (disguised by the deep bite) is demonstrated on the cephalometric tracing *(g)*.

Presurgical orthodontics

As in all surgical orthodontic cases, the approach is to align the teeth presurgically to facilitate the planned surgery so that the teeth will fit into occlusion after surgery:

1. It is preferable to level the mandibular arch before surgery (in contrast to the approach in patients with short faces).
2. Patients with vertical maxillary excess and severe open bites often have an excessive reverse curve in the maxillary arch. In these cases it is advantageous to level the arch in segments and deviate the roots of teeth to allow interdental osteotomies. Therefore, level within the segments. Do not attempt to close the open bite; rather, open the bite further.
3. A similar principle applies in the decision to expand a narrow maxilla orthodontically. The teeth should not be expanded beyond their bony base. Any relapse of an expanded maxillary arch will tend to open the bite anteriorly. Surgical expansion is recommended, especially in more severely narrowed maxillae and in older patients.

Orthodontic mechanics

- Mandibular arch
  - Routine orthodontic techniques are used to level, align, close all spaces, and achieve a good arch form.
  - Extractions and Class II or Class III mechanics may be necessary, depending on the case.
- Maxillary arch
  - Teeth adjacent to the proposed interdental osteotomies (eg, between maxillary canines and premolars or between maxillary lateral incisors and canines) are bonded with brackets that will "diverge" the roots away from the surgical site to prevent accidental surgical insult to the roots. For example, a maxillary left canine bracket is placed on the right canine and vice versa. This still applies if premolars are removed to provide crowding relief. After surgery is completed, these brackets are removed and the correct brackets bonded to obtain normal root inclination.
  - Leveling is accomplished using sectional nickel-titanium alloy (Nitinol) wires or similar wires. Stabilization is then undertaken with sectional finishing archwires bent to conform to the arch form for each segment.
  - Extraction spaces can be closed by surgically approximating the segments.
  - If no vertical segmental discrepancies exist, the maxillary arch is leveled with a continuous archwire, taking care that the maxillary incisors do not level forward; nightly headgear use may be required. The maxillary and mandibular arches are coordinated with the aid of study casts.
  - Intrusive posterior mechanics, such as palatal bars or high-pull headgear, should be avoided.
  - Mandibular molars should be brought upright to encourage bite opening. This will accentuate the vertical problem and introduce less chance of relapse.

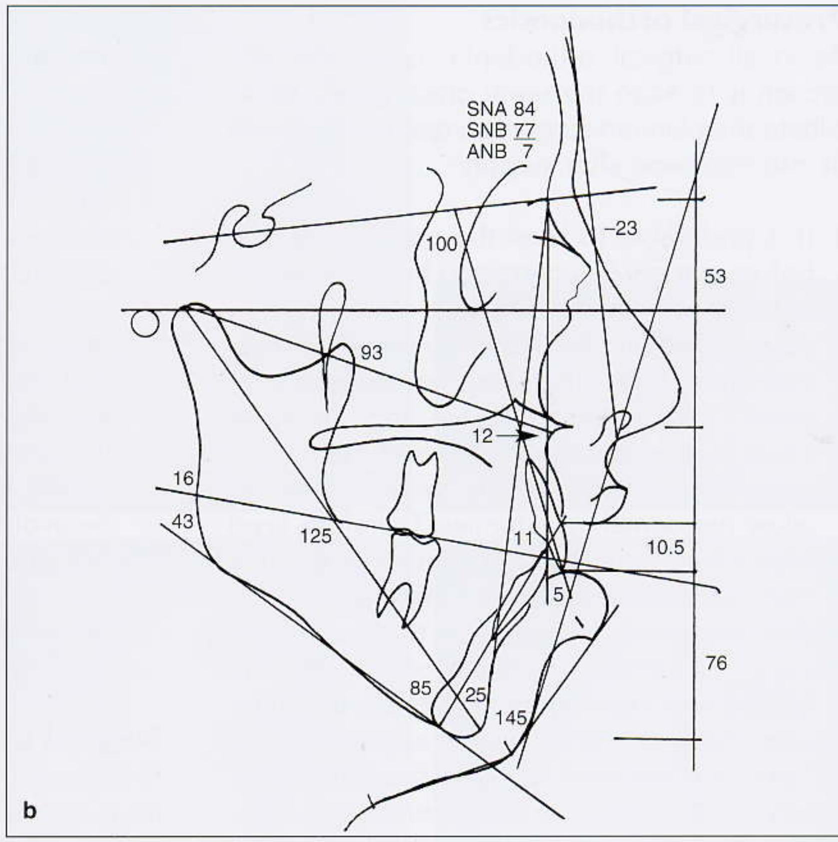
Surgical treatment

To correct the vertical discrepancy, the maxilla must be superiorly repositioned by a Le Fort I osteotomy. Two critical elements must be considered in the final treatment planning:

1. How far must the maxilla be superiorly repositioned?
2. After straight vertical repositioning of the maxilla, where will the mandible be?

Extent of superior repositioning The amount of superior repositioning is critical, because moving the maxilla too far superiorly is more detrimental to facial esthetics than leaving the vertical excess uncorrected. Consider the following points when planning superior repositioning of the maxilla:

1. Patients with short upper lips show more teeth than patients with long upper lips.
2. Younger patients tolerate (esthetically and psychologically) more upward movement of the maxilla than do older patients. Remember that the upper lip will lengthen with age.
3. Exposure of 30% to 40% of the clinical crowns of the maxillary incisors beneath the upper lip is esthetically pleasing.
4. During superior repositioning of the maxilla, the upper lip will shorten.



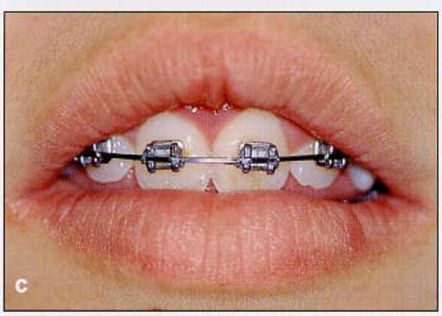


Fig 4-51 Assessment from a profile view *(a)* and a lateral cephalometric tracing *(b)* reveals an interlabial distance of 10 mm, requiring superior repositioning of the maxilla. If only this view is considered, superior repositioning of at least 6 mm is indicated. *(c)* Because of an accentuated Cupid's bow of the upper lip, the central incisors' entire crowns are exposed under the upper lip, while the lateral incisors are exposed much less. If planning of superior repositioning of the maxilla considers only the central incisor exposure, excessive superior repositioning will result in only the tips of the central incisors being visible under the upper lip.

5. Plan, in general, for a 4-mm tooth exposure after surgery.
6. It is not mandatory to elevate the maxilla until the lips make contact. A few millimeters of lip incompetence is acceptable and, in many cases, attractive.
7. Large movements, if not controlled, may lead to widening of the alar base of the nose and tipping up of the nasal tip. Because both effects are controllable, take them into consideration in treatment planning and surgical technique.
8. Moving the maxilla too far superiorly gives poor esthetic results, but moving it posteriorly at the same time yields even worse results.
9. Consider the upper lip shape. Patients with an extreme Cupid's bow may only have excessive exposure of the two central incisors. If surgery is planned using the lateral cephalometric radiograph without considering the lip shape, treatment may result in only the tips of the two central incisors being visible under the upper lip (Fig 4-51).

Anteroposterior position of the mandible The mandible will autorotate counterclockwise around a point at the condyle. As a consequence, the mandibular incisors will rotate forward (more so in high-angle cases than in low-angle cases). When the extent of maxillary superior repositioning has been decided, the anteroposterior position of the mandibular incisor should be considered. It may be necessary to advance the maxilla slightly to achieve a Class I malocclusion. If the mandible is anteroposteriorly deficient, a maxillary setback may be considered to achieve a Class I malocclusion; however, advancing the mandible is preferable. It is much better to accept the need for two-jaw surgery to achieve a good occlusion than to significantly compromise the esthetics and limit the surgery to one jaw. In Class III cases, the Class III dental relationship will worsen as the mandible is autorotated, necessitating either maxillary advancement or mandibular setback.

Important surgical considerations The amount of superior repositioning of the maxilla is critical. Take great care during surgery to accurately position the maxilla in the planned position. An intermediate splint is helpful.

Condyle positioning, again, is critical. The condyle can be displaced by minor bony interferences in the posterior maxilla. With maxillomandibular fixation, this condylar displacement will not be revealed until 6 weeks after surgery, after removal of maxillomandibular fixation. With rigid internal fixation, the malpositioning can be detected after intraoperative removal of maxillomandibular fixation and can be corrected by the removal of bone plates and the elimination of posterior interferences (see the section on intraoperative diagnosis of condylar sag during Le Fort I maxillary osteotomy in chapter 5).

It is often necessary to surgically expand the posterior maxilla through parasagittal osteotomies in the palate. A bone graft or hydroxyapatite blocks should be grafted into the defect and the segments stabilized by a splint with a palatal bar. Grafting should be used for any expansions greater than 3 mm.

The piriform rim should be contoured to accommodate the soft tissue of the nose.

The bony and cartilaginous septum should be shortened appropriately to prevent warping of the nasal septum during superior repositioning of the maxilla. To centralize the septum, a septum suture may be used to attach the septal cartilage to the base of the nasal spine as it passes through a hole in the nasal spine.

Wound closure should be meticulous. A cinch suture can control the alar base width, and V-Y closure can create lip lengthening or control the length of the upper lip. Resuture the perioral muscles, and then carefully suture the mucosa, taking thin bites. Be sure to maintain the soft tissue midline when suturing.

Postsurgical orthodontics

If a splint is used during surgery, the orthodontist should see the patient immediately after its removal. Stabilizing archwires are removed and replaced with working archwires, and light (2.5- to 3.5-oz) vertical or slightly Class II elastics are placed.

After surgical expansion, the most important, and possibly the most challenging, part of postsurgical orthodontics is to maintain the transverse dimension of the palate. The expanded dentoalveolar segments must be held in their expanded position during orthodontic finishing. This can be accomplished using either a heavy auxiliary wire in the headgear tubes, along with working wires, or a transpalatal arch (the latter may be more practical). The dentoalveolar segments do not stabilize until 4 to 6 months after surgery. In general, the postsurgical orthodontic treatment of patients with long faces is often quick because the arches were leveled either before or during surgery.

Clinical case

Case J.S.

The mother of this 16-year-old patient was treated by the author 10 years previously for the correction of vertical maxillary excess and mandibular deficiency. The patient was now referred for surgical correction of the same problem.

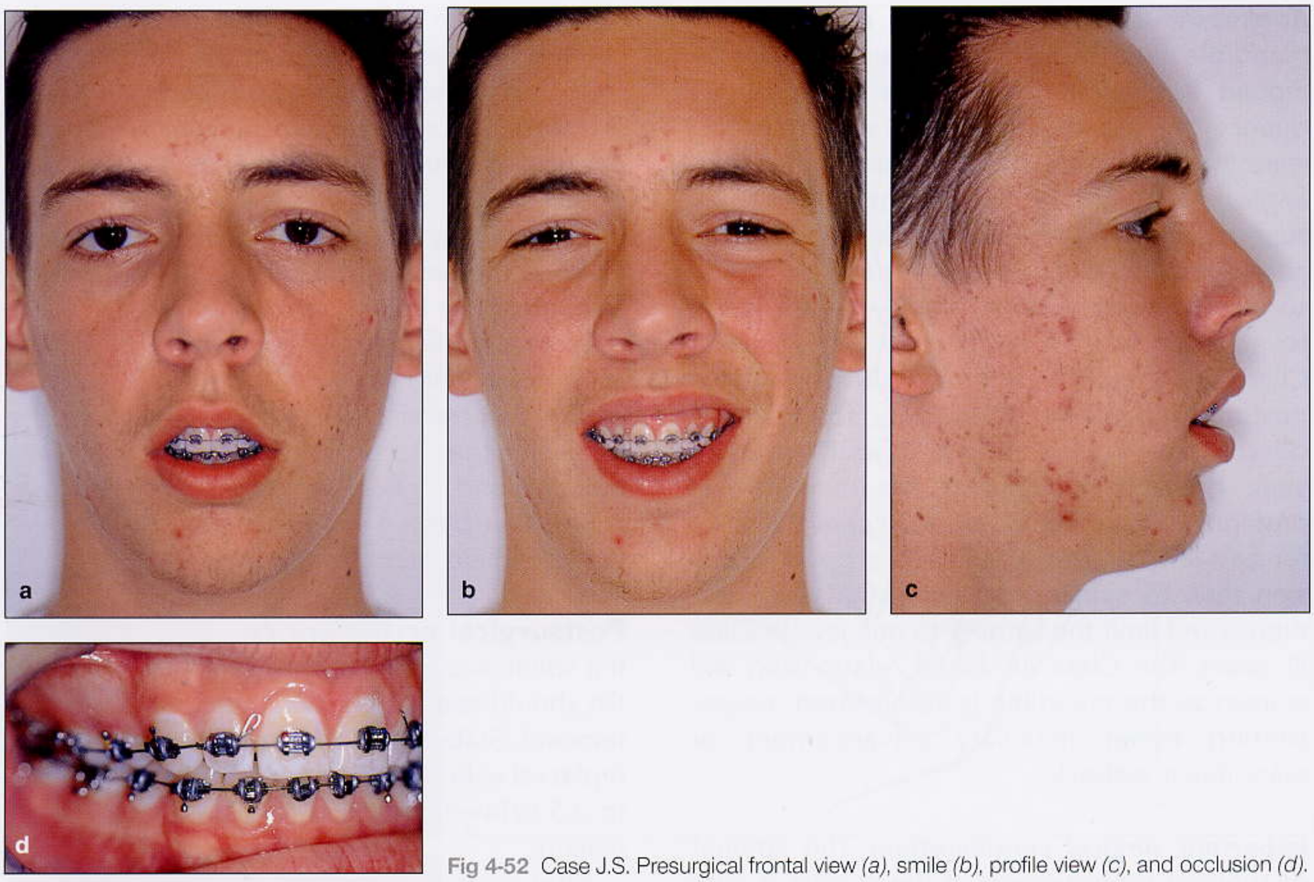


Fig 4-52 Case J.S. Presurgical frontal view *(a)*, smile *(b)*, profile view *(c)*, and occlusion *(d)*.

Main complaint

The patient was unhappy about his gummy smile and inability to create a lip seal without strain.

Medical history

The patient's medical history was noncontributory.

Clinical examination

1. Soft tissue
   a. Frontal view (Figs 4-52a and 4-52b)
      - Gummy smile
      - Increased interlabial gap
      - Excessive maxillary incisor exposure under the upper lip
      - Increased lower-third facial height
      - Increased lower lip vermillion exposure

   b. Profile view (Fig 4-52c)
      - Convex profile
      - Deficient chin
      - Prominent lower lip
      - Increased lower-third facial height
      - Increased tooth exposure
      - Increased interlabial gap
2. Dental (Fig 4-52d)
   - Class II malocclusion
   - Missing first premolars
3. Skeletal
   - Vertical maxillary excess
   - Mandible rotated clockwise and relatively deficient
   - Microgenia

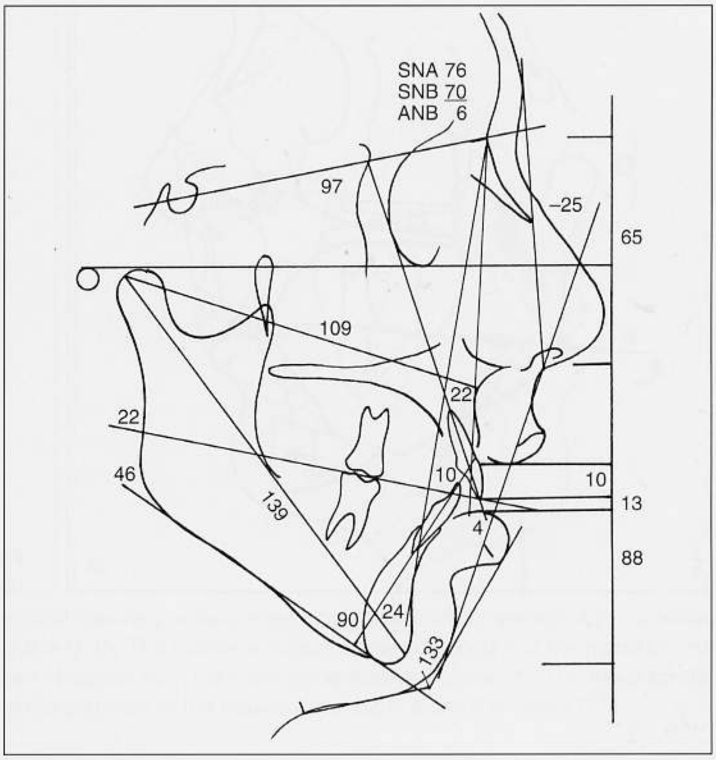


Fig 4-53 Case J.S. Presurgical cephalometric analysis. Vertical maxillary excess: interlabial gap = 13 mm, maxillary incisor tooth exposure = 10 mm, ratio of middle-third to lower-third height = 65:88 mm; convex profile: facial contour angle = −25 degrees; normal maxillary and mandibular length relationship: 109:139 mm.

4. Radiographic
   a. Panoramic radiograph
      - Missing first premolars
   b. Cephalometric radiograph (Fig 4-53)
      - Confirms clinical observations

Problem list

1. Vertical maxillary excess
2. Microgenia
3. Class II malocclusion

Presurgical orthodontics

The presurgical orthodontic treatment was completed by the time of the final referral.

Surgical treatment

- Le Fort I maxillary osteotomy to reposition the maxilla superiorly (Fig 4-54)
- Mandible autorotated counterclockwise into a Class I dental relationship (see Fig 4-54)
- Advancement genioplasty (see Fig 4-54)

Postsurgical orthodontics

Postsurgical orthodontic treatment involved completing the interdigitation of the teeth and retention. The pleasing postsurgical result is demonstrated in Fig 4-55.

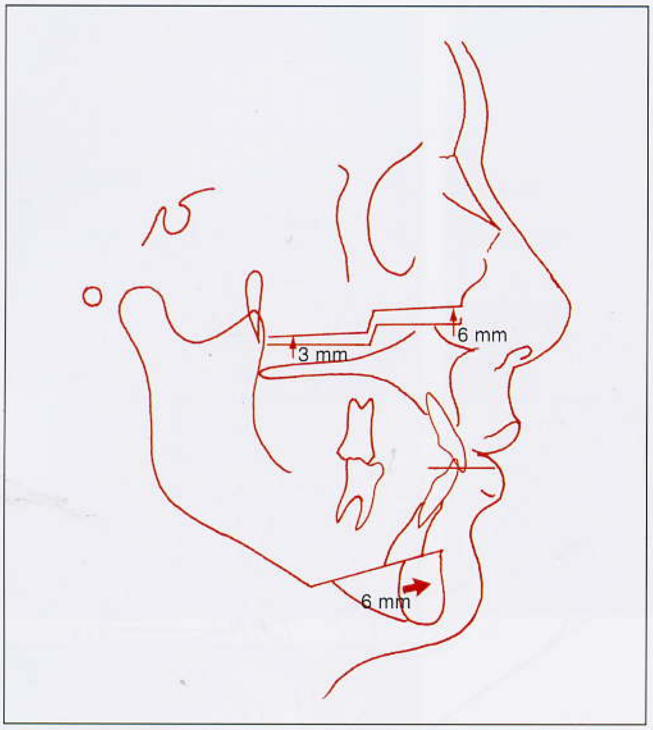


Fig 4-54 Case J.S. Surgical cephalometric visual treatment objective.

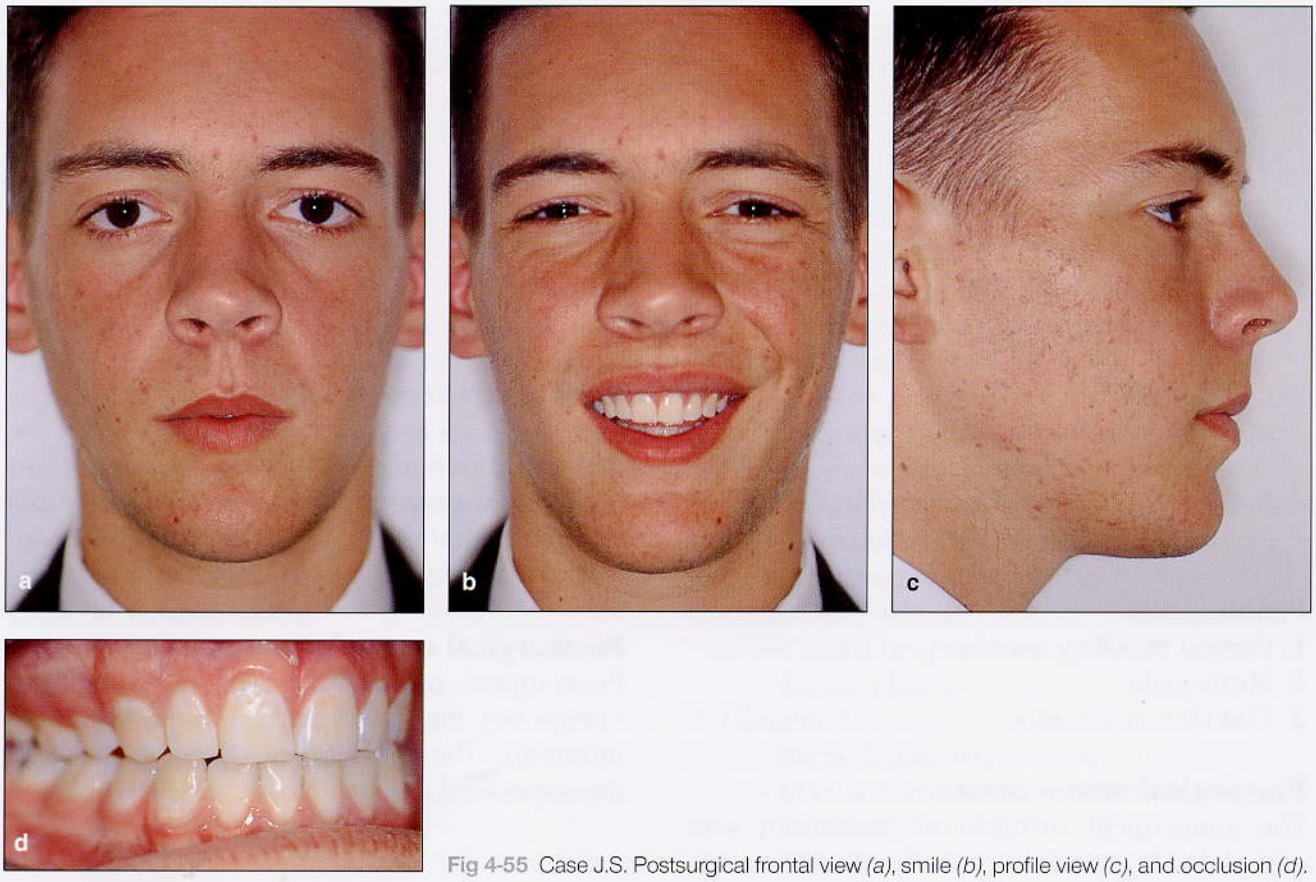


Fig 4-55 Case J.S. Postsurgical frontal view *(a)*, smile *(b)*, profile view *(c)*, and occlusion *(d)*.

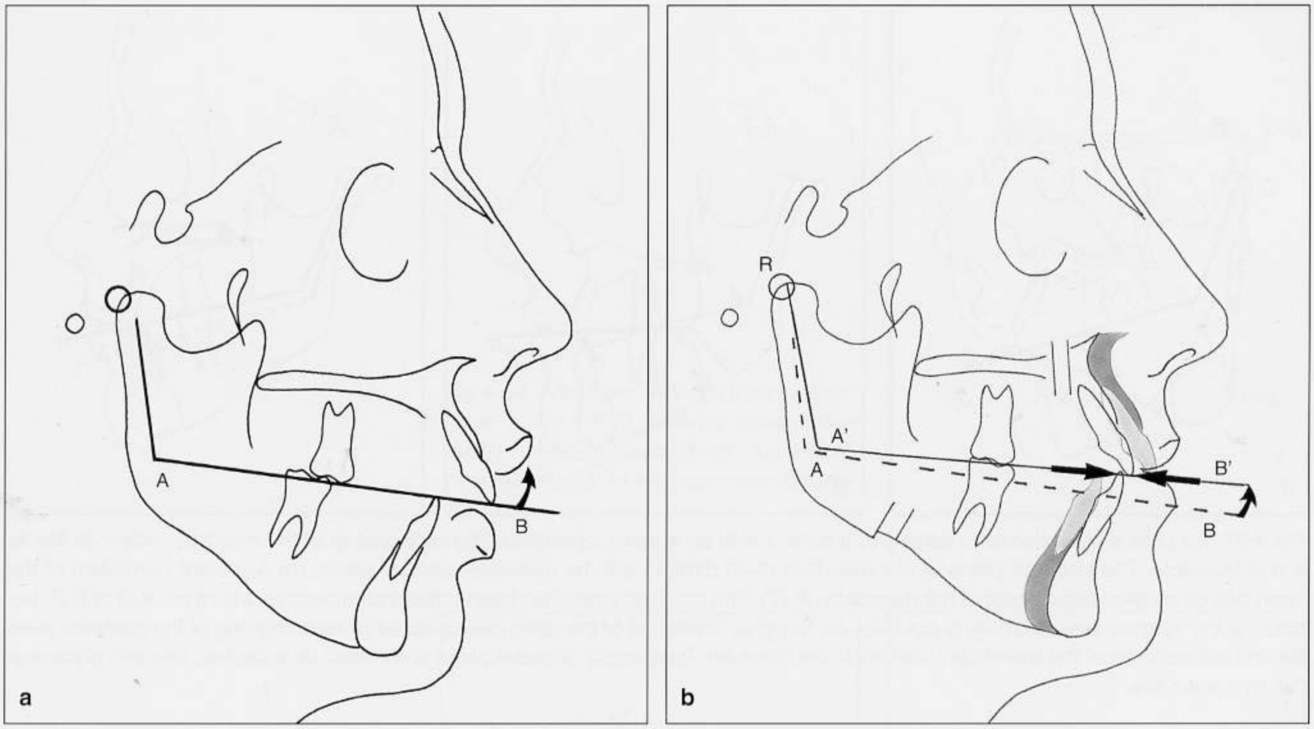


Fig 4-56 *(a)* Lateral cephalometric tracing of a patient with vertical maxillary excess, maxillary anteroposterior excess, and mandibular anteroposterior deficiency. The presurgical occlusal plane is A-B. *(b)* The maxilla is superiorly repositioned and the mandible autorotated around R. The "new" occlusal plane (A'-B') has been changed from the presurgical occlusal plane (A-B) by the autorotation of the mandible. The mandible is advanced, and the anterior segment of the maxilla is set back along this plane.

Rotation of the Maxillomandibular Complex

Most dentofacial deformities can be treated successfully using conventional treatment planning. With conventional treatment planning, alteration of the occlusal plane is often an inevitable consequence of any surgical adjustment to the vertical position of the maxilla and the resultant autorotation of the mandible (Fig 4-56a). This rotation of the mandibular occlusal plane occurs around a point at or just behind the head of the condyle. To achieve occlusal contact in these cases, the maxilla must be aligned along a "new" occlusal plane, which is determined by the extent of the autorotation of the mandible. Hence, it is the position assumed by the mandible that dictates the final anteroposterior cant of the occlusal plane. Any anteroposterior repositioning of the maxilla or mandible must take place along this "new" occlusal plane (Fig 4-56b).

Any counterclockwise rotation of the distal segment around a point beyond the condyle (at the surgical site) of the mandible may jeopardize posttreatment stability (Figs 4-57a and 4-57b). A more stable result can be achieved by superior repositioning of the posterior maxilla and autorotation of the mandible (rotation at the condyle) (Fig 4-57c).

Difficulty achieving acceptable esthetic results in the treatment of cases with Class II low mandibular planes and deep bites led to the development of a surgical treatment design in which the occlusal plane is deliberately altered. This treatment design has been used to successfully treat other dentofacial deformities as well. The clinician cannot arbitrarily decide to manipulate the occlusal plane angulation; this decision is made only when the desired results cannot be obtained by conventional treatment planning.

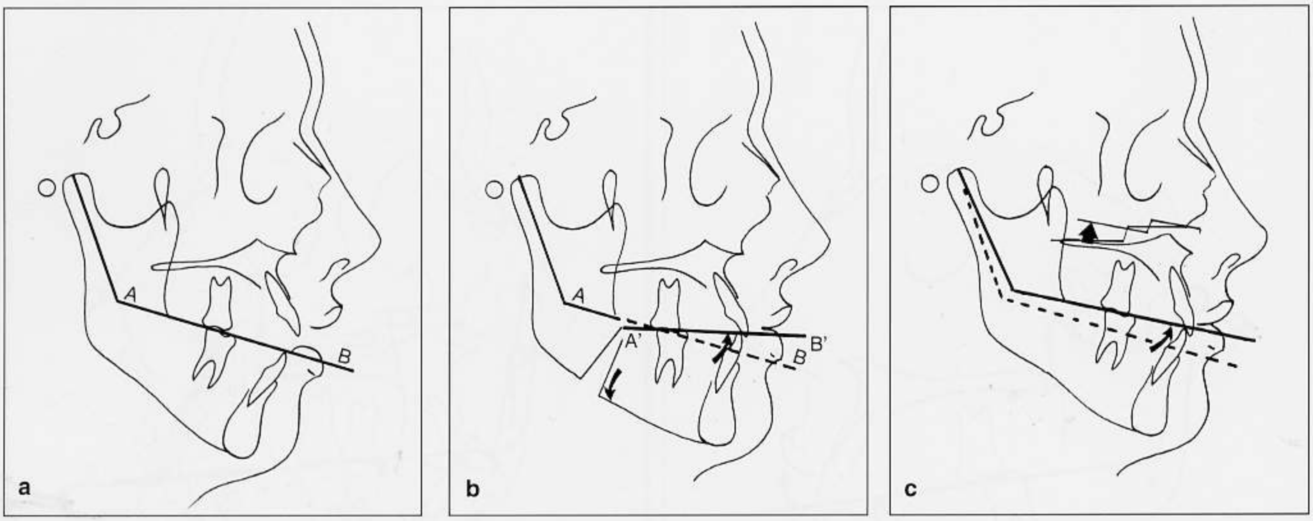


Fig 4-57 *(a)* Lateral cephalometric tracing of a patient with an anterior open bite. The relationship of the maxillary incisor to the lip line is favorable. The occlusal plane of the mandible (A-B) differs from the maxillary occlusal plane. *(b)* Apparent correction of the open bite by surgical adjustment of the mandible (A'-B'). The occlusal plane has been rotated counterclockwise from A-B to A'-B' (rotation at the surgical site). Stability is doubtful. *(c)* Surgical correction of the open bite by superior repositioning of the posterior maxilla and autorotation of the mandible (rotation at the condyle). Presurgical occlusal plane is denoted by a dashed line and postsurgical, by a solid line.

This change in occlusal plane angulation—which is also called manipulation, alteration, or rotation of the occlusal plane—might be better defined as a rotation of the maxillomandibular complex to enhance esthetic and functional treatment results. The rotation should take place around a preselected point in a clockwise or counterclockwise direction and thus will alter the occlusal plane. It is by no means an attempt to correct the occlusal plane angle to a normal angulation.

Manipulation of the occlusal plane: Geometry and planning

Surgical repositioning of the jaws involves complicated three-dimensional movements of geometrically complex structures. The diagnostic information gained from the preoperative clinical examination, study casts, and radiographic evaluation must be carefully integrated to establish the appropriate surgical treatment plan.

Alteration of the occlusal plane should be considered only if conventional treatment planning does not yield satisfactory results. It is extremely difficult to simply "place" or "select" a new occlusal plane without selecting a point around which to rotate the maxillomandibular complex or alter the occlusal plane. It is easier and more accurate, both in planning and in surgery, to rotate the maxillomandibular complex around a preselected point.

The geometry of maxillomandibular complex rotation is best illustrated by constructing a triangle involving the posterior nasal spine (PNS), anterior nasal spine (ANS), and pogonion (Pog) (Fig 4-58). Any point on the triangle posterior or inferior to ANS may be chosen as the rotation point. The location of the point and the direction of rotation are dictated by the esthetic requirements of each patient. Opposite esthetic results can be achieved by either clockwise or counterclockwise rotation of the maxillomandibular complex. In addition, the effects can be enhanced by moving the point more anteriorly or posteriorly between ANS and PNS or inferiorly or superiorly between ANS and Pog. The desired position of the maxillary incisor,

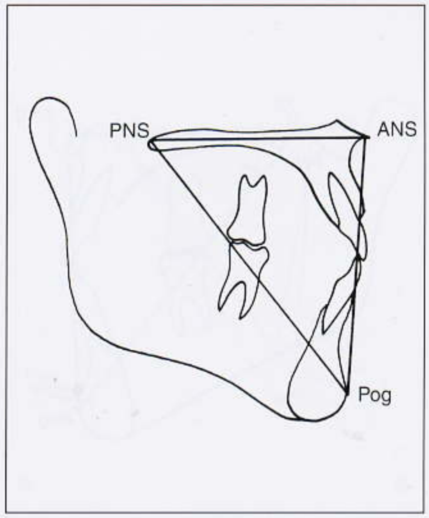


Fig 4-58 A triangle involving the posterior nasal spine (PNS), anterior nasal spine (ANS), and pogonion (Pog) is used to plan the rotation of the maxillomandibular complex.

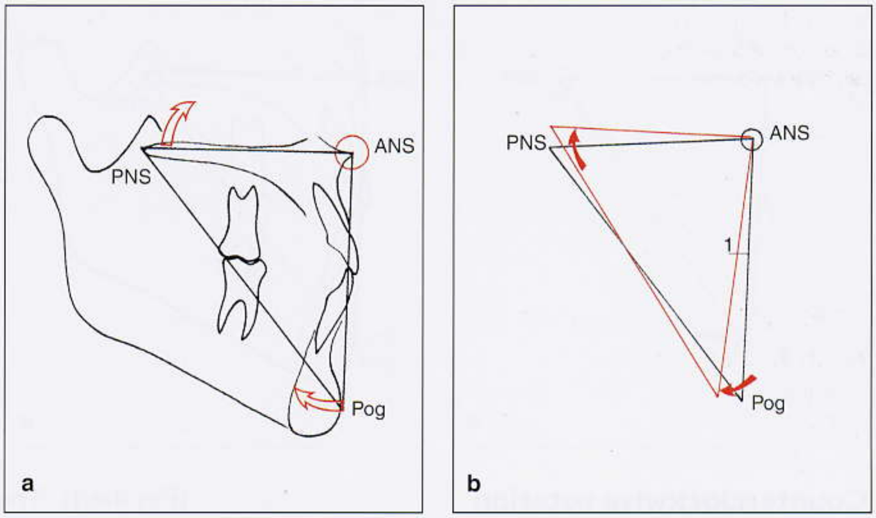


Fig 4-59 *(a)* Clockwise rotation of the triangle (maxillomandibular complex) around the ANS. *(b)* The vertical height of the anterior maxilla is maintained while the posterior maxilla is superiorly repositioned. The maxillary incisor (1) and pogonion rotate posteriorly.

paranasal anatomy, and chin prominence will help establish the point of rotation.

The selection of the precise point of maxillary rotation is guided primarily by the esthetic requirements of the patient. When patients require more upper lip and paranasal support (and less chin retraction), the maxillary incisor tip is used as the center of rotation. When no maxillary advancement is desired and definitive posterior displacement of the chin is planned, the rotation point is placed superiorly at ANS. The facial changes to be expected after rotation at different points and direction of rotations are described in the following sections.

Rotation point at the anterior nasal spine

Clockwise rotation

Surgical superior repositioning of PNS as a result of clockwise rotation around a point at ANS will result in the following changes (Fig 4-59):

1. Increased occlusal plane angle
2. Retraction of the maxillary incisor tip
3. Decreased maxillary incisor angulation
4. Decreased chin projection
5. Increased mandibular plane angle
6. Increased mandibular incisor angle

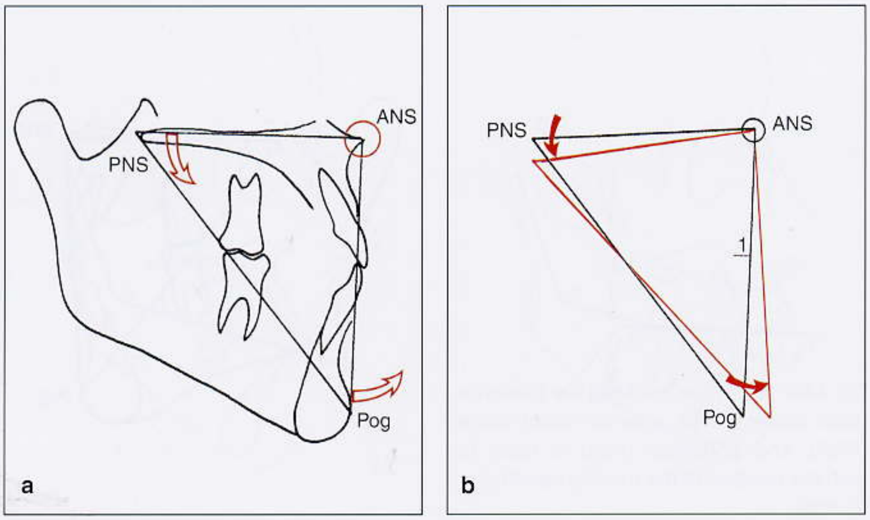


Fig 4-60 *(a)* A triangle (the maxillomandibular complex) is rotated counterclockwise around a point at the ANS. *(b)* The posterior maxilla is inferiorly repositioned. The pogonion and maxillary incisor (1) rotate forward and slightly superiorly.

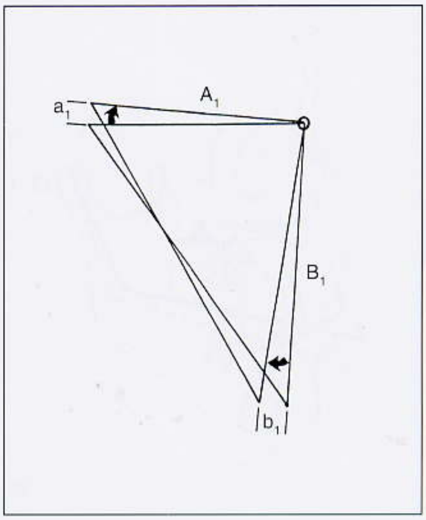


Fig 4-61 Center of clockwise rotation (in this case) is located at the ANS. a_1 = superior repositioning of the posterior maxilla; b_1 = posterior rotation (displacement of the pogonion); A_1 = maxillary length; B_1 = lower-third facial height.

Counterclockwise rotation

Downgrafting of the posterior maxilla (PNS) as a result of counterclockwise rotation around a point at ANS will result in the following changes (Fig 4-60):

1. Decreased occlusal plane angle
2. Decreased mandibular plane angle
3. Decreased mandibular incisor angle
4. Increased chin projection
5. Increased maxillary incisor angulation
6. Slight advancement of the maxillary incisor

The anterior or posterior movement of Pog (b_1) is greater than the superior or inferior repositioning of the posterior maxilla (a_1), because the height of the lower third of the face (ANS to Pog [B_1]) is greater than the anteroposterior maxillary length (ANS to PNS [A_1]) (Fig 4-61). The ratio of the movements may be expressed as:

$$\frac{a_1}{b_1} = \frac{A_1}{B_1}$$

Rotation point posterior to the anterior nasal spine

Clockwise rotation

The following effects of clockwise rotation will be enhanced by placing the rotation point further posterior (Fig 4-62):

1. Increased occlusal plane angle
2. Increased mandibular plane angle
3. Increased mandibular incisor angle
4. Increased lower facial height
5. Increased mandibular incisor angle

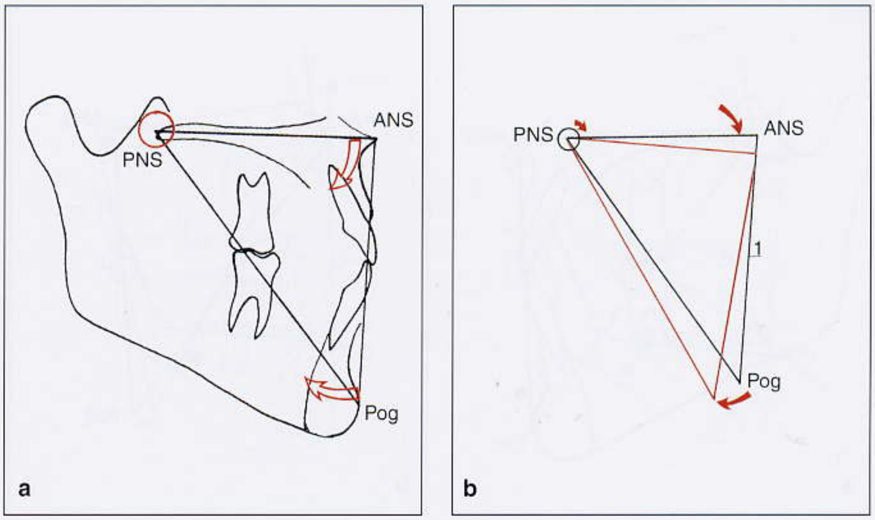


Fig 4-62 *(a)* A triangle (the maxillomandibular complex) is rotated clockwise around a point at the PNS. *(b)* The anterior maxilla is moved inferiorly, the maxillary incisor (1) moves posteriorly with a slight vertical increase, and the Pog rotates posteriorly and inferiorly.

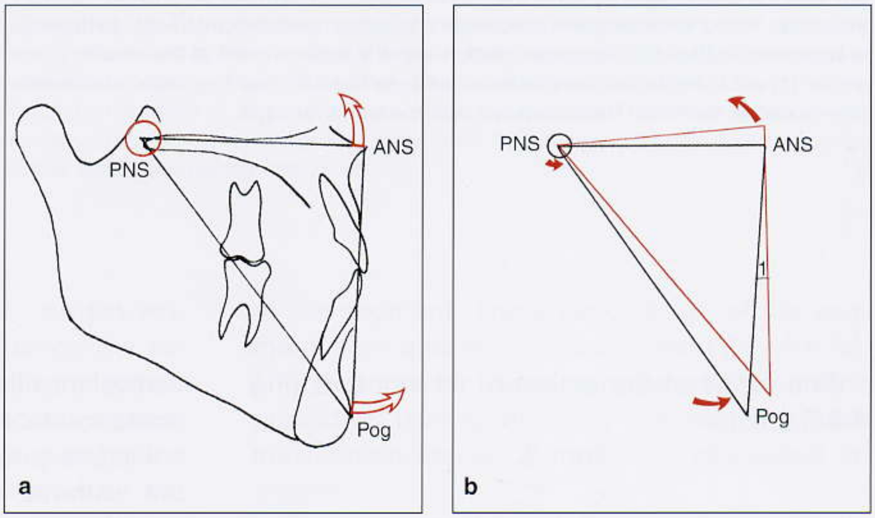


Fig 4-63 *(a)* A triangle (the maxillomandibular complex) is rotated counterclockwise around a point at the PNS. *(b)* The anterior maxilla is repositioned superiorly, while Pog and the maxillary incisors (1) are advanced.

6. Decreased maxillary incisor angulation
7. Decreased chin projection

Counterclockwise rotation

In counterclockwise rotation, the following effects of the rotation will increase the more posterior the point of rotation is placed (Fig 4-63):

1. Decreased occlusal plane angle
2. Decreased mandibular plane angle
3. Decreased exposure of the maxillary incisors
4. Decreased anterior lower facial height
5. Decreased mandibular incisor angle
6. Increased chin projection
7. Increased maxillary incisor angulation

Rotation point inferior to the anterior nasal spine

Clockwise rotation

Surgical superior repositioning of the posterior maxilla as a result of rotation around a point inferior to ANS (eg, the maxillary incisor tip) will result in the following (Fig 4-64):

1. Increase in occlusal plane angle
2. Advancement of the maxilla at the ANS (b_2)
3. Decrease in the maxillary incisor angle (less decrease than is seen when the rotation point is at ANS)
4. Posterior repositioning of Pog (c_2) (less than when the rotation point is at ANS)

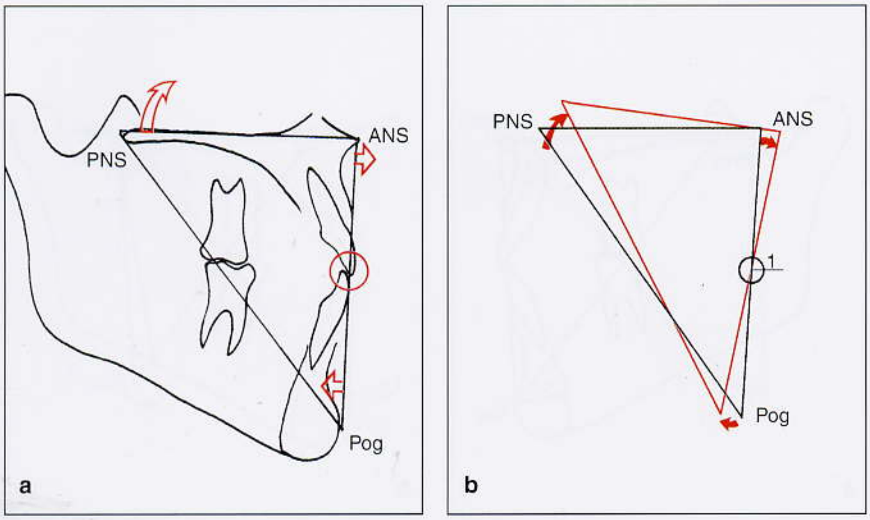


Fig 4-64 *(a)* Clockwise rotation of the maxillomandibular complex around the maxillary incisor tip. A counterclockwise rotation with a selected rotation point inferior to the ANS is seldom indicated. *(b)* Clockwise rotation with the rotation point at the maxillary incisor tip (1) will have the following effects: advance the ANS, set Pog back, and superiorly reposition the PNS. The incisor will become slightly upright.

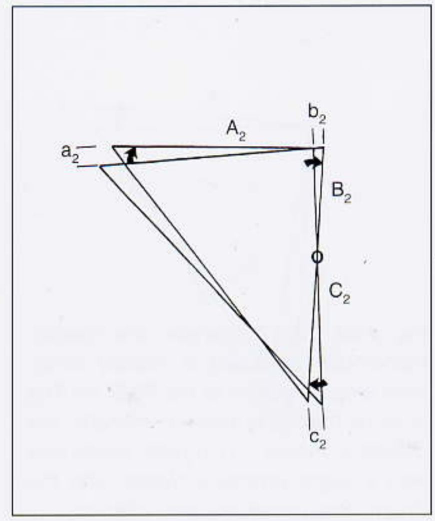


Fig 4-65 The ratio of the anterior movement of the ANS (b_2) to the posterior movement of Pog (c_2) is equal to the ratio between the distance from the ANS to the maxillary incisor tip (B_2) and the distance from incisor tip to Pog (C_2). A_2 represents the maxillary length, a_2 the amount of superior repositioning of the posterior maxilla.

The ratios of the extent of movements (Fig 4-65) are:

$$\frac{b_2}{c_2} = \frac{B_2}{C_2}$$

where B_2 = the distance from the ANS to the maxillary incisor tip and C_2 = the distance from the maxillary incisor tip to Pog.

Counterclockwise rotation

Counterclockwise rotation would result in posterior repositioning of the maxilla, which is very rarely indicated, technically difficult, and not recommended.

Indications for the rotation of the maxillomandibular complex

Figure 4-66a, the cephalometric tracing of a patient with a Class III malocclusion, illustrates the applicability of rotation of the maxillomandibular complex. The problem is characterized by vertical maxillary excess and mandibular anteroposterior excess.

First, a prediction tracing is created to test the esthetic effect of the conventional approach, which involves superior repositioning of the maxilla to permit autorotation and subsequent setback of the mandible. The cant of the occlusal plane, therefore, would be dictated by the inclination of the mandibular dental arch after autorotation. The prediction tracing is examined to assess whether the desired esthetic result can be achieved. The lower third of the face is still too prominent (a facial contour angle of –5 degrees) (Fig 4-66b). Superior repositioning of the posterior maxilla, however, allows for a clockwise rotation of the entire lower third of the face (maxillomandibular complex) around a center at the anterior nasal spine (Fig 4-66c). This modification of the operative plane could enable the surgeon to achieve a more ideal esthetic result and is tested on a second prediction tracing (compare Fig 4-66b with Fig 4-66c). A facial contour angle of –11 degrees has now been achieved.

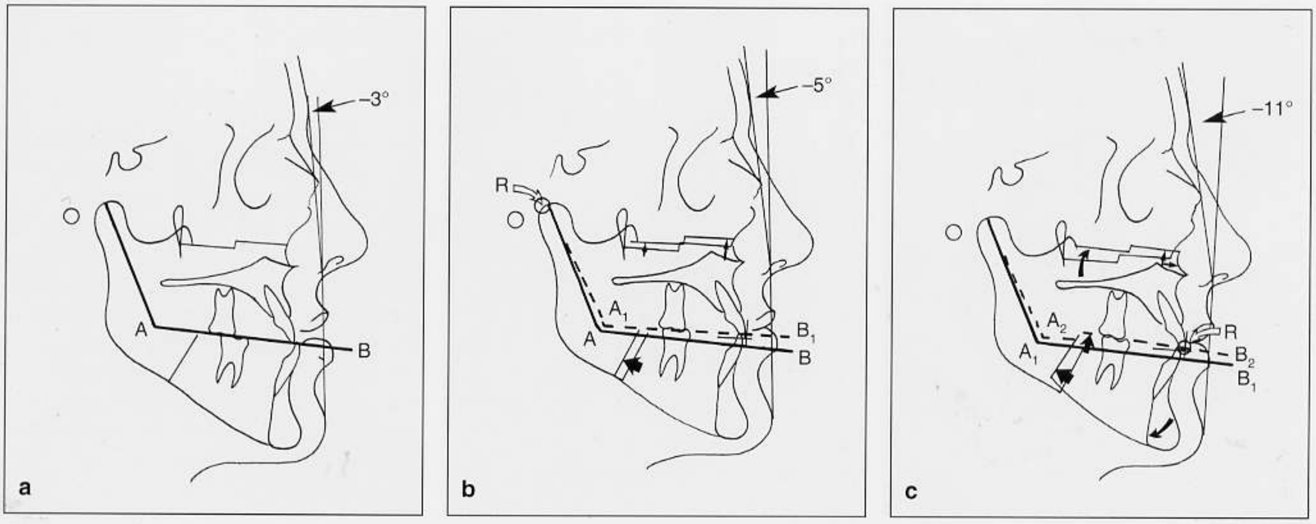


Fig 4-66 *(a)* Lateral cephalometric tracing of a patient with a vertical maxillary excess and mandibular anteroposterior excess. The occlusal plane (A-B) facial contour angle is −3 degrees. *(b)* Trial prediction tracing of the patient. The maxilla has been superiorly repositioned, and A_1-B_1, the new occlusal plane, is determined by the mandible after autorotation around condyle (R). The mandible is now set back according to this plane. Note the facial contour angle of −5 degrees. The chin is still too prominent. *(c)* Surgical prediction tracing of the patient. After autorotation of the mandible (A_1-B_1), the occlusal plane is manipulated by further superior repositioning of the posterior maxilla (A_2-B_2). The center of rotation (R) is now located at the ANS. A more esthetic facial contour angle is established (−11 degrees) as a result of the further distalization of the chin point.

In addition to the esthetic objectives, anatomic considerations also influence the selection of the center of rotation and the extent of change of the occlusal cant. Excessive superior repositioning of the posterior nasal spine (more than 5 to 6 mm) may compromise the nasal airway. Where indicated, therefore, it may be necessary to perform a horseshoe-shaped Le Fort I osteotomy to separate the dentoalveolar portions of the maxilla from the palate, which thus remains attached to the nasal septum. The vertical dimension of the nasal airway is thereby maintained, while the dentoalveolar segments are free to be repositioned.

An excessive change in the occlusal plane angle could affect the balance between the condylar guidance of the eminentia articularis and the cuspal angulations responsible for protrusive disclusion. However, the interrelationship and possible effects of changes require further research.

Clockwise rotation of the distal segment of the mandible may lead to interference of the step of the horizontal osteotomy on the medial side of the ramus. This step may need to be contoured (Fig 4-67a) to allow free movement of the segment. The anterior edge of the segment often also requires contouring (Fig 4-67b). The method for developing a cephalometric prediction tracing involving the rotation of the maxillomandibular complex is discussed in chapter 3.

Clockwise rotation of the maxillomandibular complex around a point posterior to the nasal spine allows vertical lengthening of the anterior facial height. In Case E.H., shown in Figs 4-68 and 4-69, the maxillomandibular complex is rotated clockwise around a point at the zygomatic buttress. Figure 4-68b shows the expected soft tissue result after conventional treatment planning—a flat labiomental curve. The expected soft tissue result after rotation of the maxillomandibular complex is demonstrated in Fig 4-68c.

Rotation of the maxillomandibular complex around a point at the tip of the maxillary incisors is illustrated by Case B.T. in Figs 4-70 to 4-73. The treatment is complicated by the fact that the first maxillary premolars were extracted when the patient was young.

Case G.M. demonstrates clockwise rotation of the maxillomandibular complex around the anterior nasal spine (Figs 4-74 to 4-78).

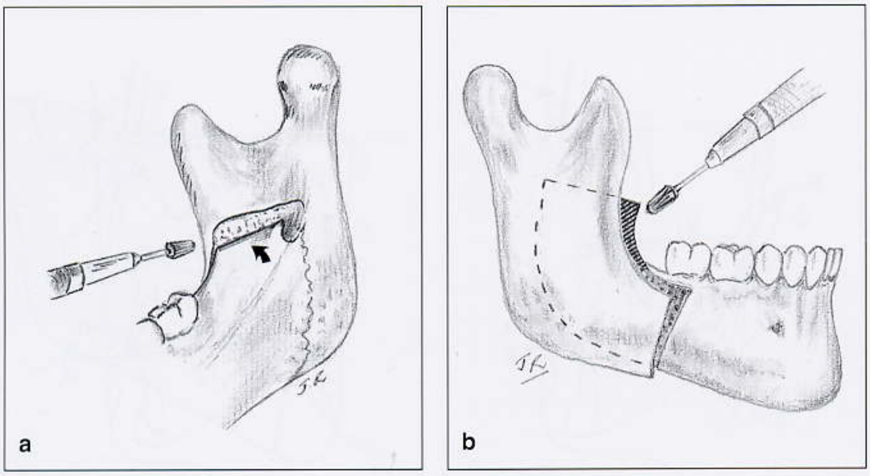


Fig 4-67 *(a)* Before the posterior aspect of the distal segment is rotated posteriorly, the bone on the proximal segment above the horizontal part of the ramus osteotomy must be removed to allow the segments to fit passively together. If this bony interference is not removed and the segments are forced together by rigid fixation, the condyle will be displaced laterally. *(b)* After clockwise rotation, the vertical part of the distal segment may be pronounced and therefore should be contoured.

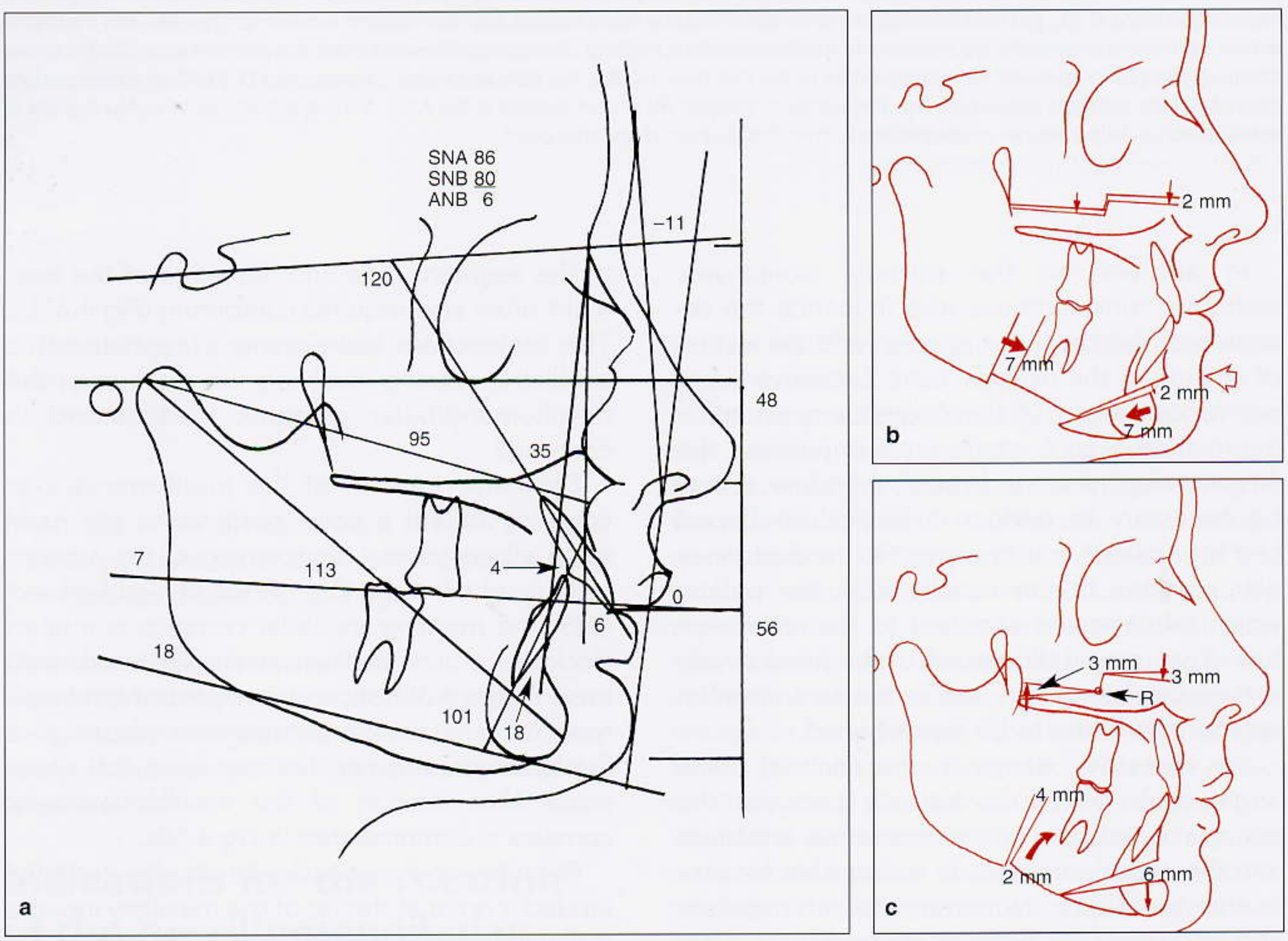


Fig 4-68 Case E.H. *(a)* Pretreatment cephalometric analysis. *(b)* Surgical plan. *(c)* The maxillomandibular complex is rotated clockwise around the zygomatic buttress (R). Note the difference between the conventional profiles in *(b)* and *(c)*.

Fig 4-69 Case E.H. Pretreatment frontal view *(a)*; profile view *(b)*; three-quarters view *(c)*; occlusion, right *(d)*; occlusion, center *(e)*; and occlusion, left *(f)*. Treatment results: frontal view *(g)*; profile view *(h)*; three-quarters view *(i)*; occlusion, right *(j)*; occlusion, center *(k)*; and occlusion, left *(l)*.

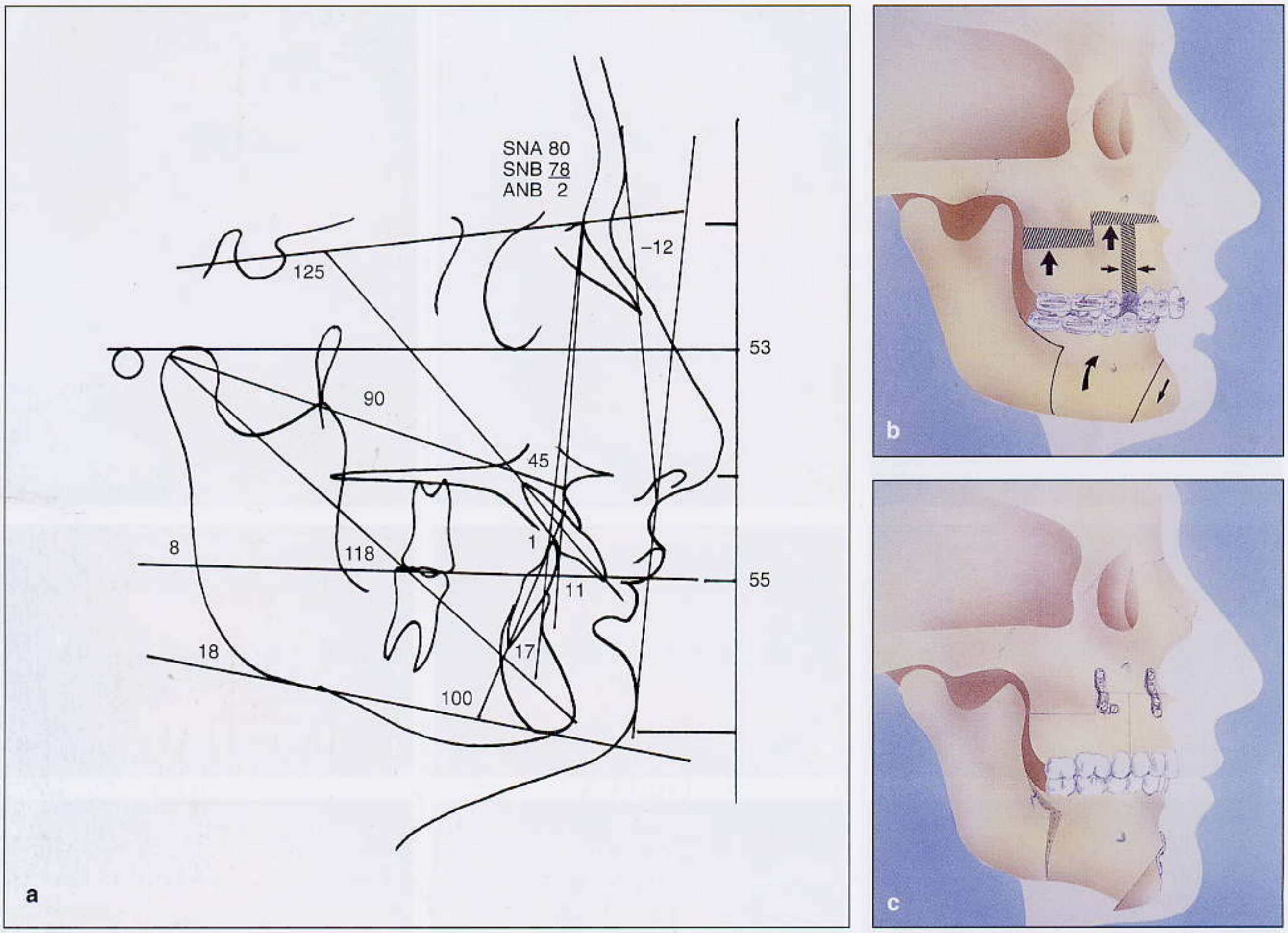


Fig 4-70 Case B.T. Pretreatment cephalometric analysis *(a)* and surgical plan *(b and c)*. Note that the extraction spaces are closed surgically.

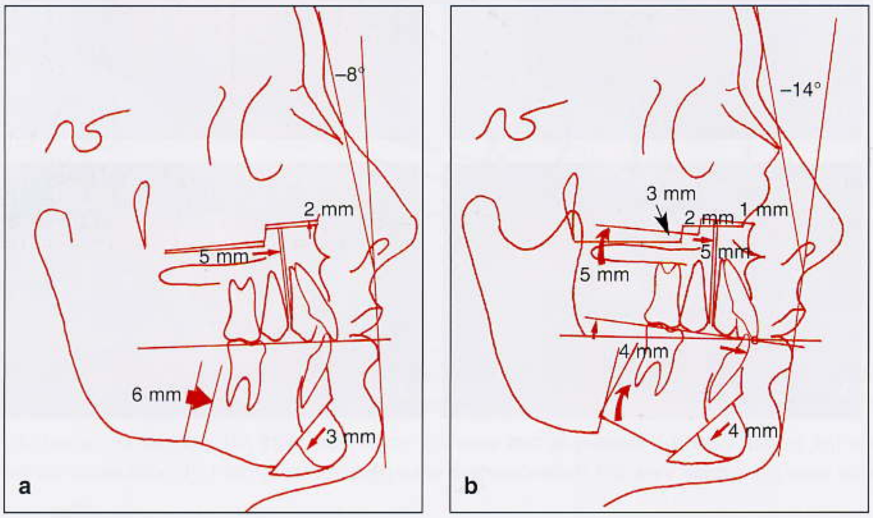


Fig 4-71 Case B.T. *(a)* Surgical prediction tracing done according to conventional treatment planning. Note that the chin appears prominent (facial contour angle is -8 degrees), and further reduction of the chin will obliterate the labiomental curve. *(b)* The maxillomandibular complex is rotated clockwise around the incisor tip, facilitating a more convex profile.

Fig 4-72 Case B.T. *(a)* Pretreatment occlusion. *(b)* Presurgical occlusion. *(c)* Posttreatment occlusion.

Fig 4-73 Case B.T. *(a)* Pretreatment frontal view. *(b)* Pretreatment profile view. *(c)* Posttreatment frontal view. *(d)* Posttreatment profile view.

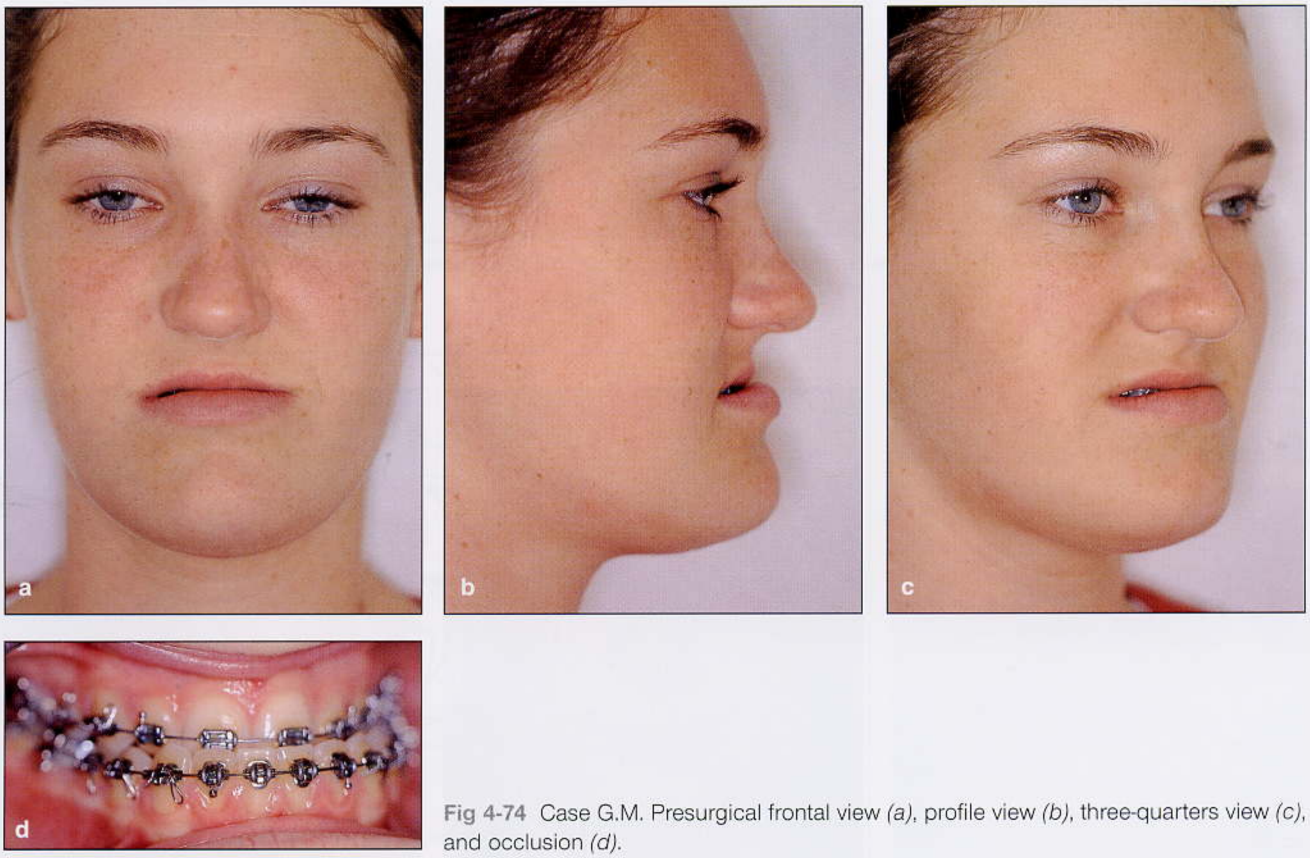


Fig 4-74 Case G.M. Presurgical frontal view *(a)*, profile view *(b)*, three-quarters view *(c)*, and occlusion *(d)*.

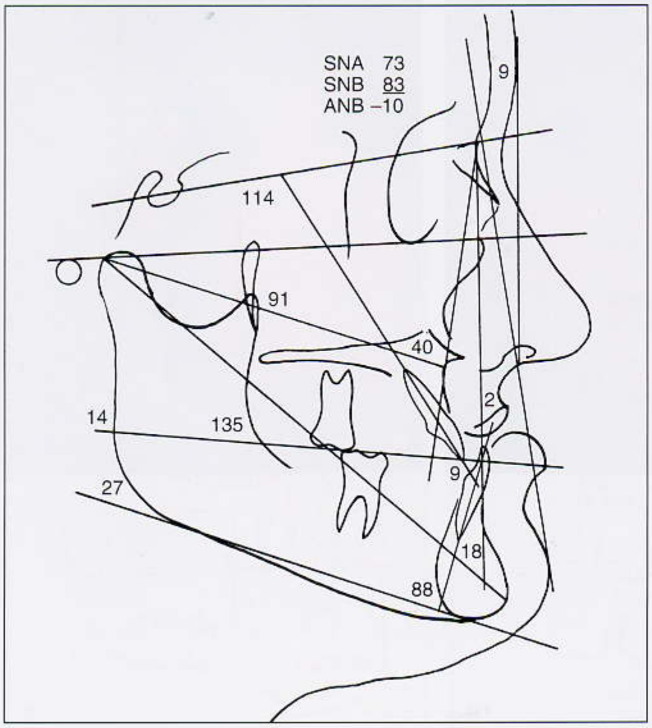


Fig 4-75 Case G.M. Presurgical cephalometric tracing analysis. Maxillary anteroposterior deficiency: SNA = 73 degrees; mandibular anteroposterior excess: SNB = 83 degrees; Class III skeletal relationship: ANB = −10 degrees; concave profile: facial contour angle = 9 degrees.

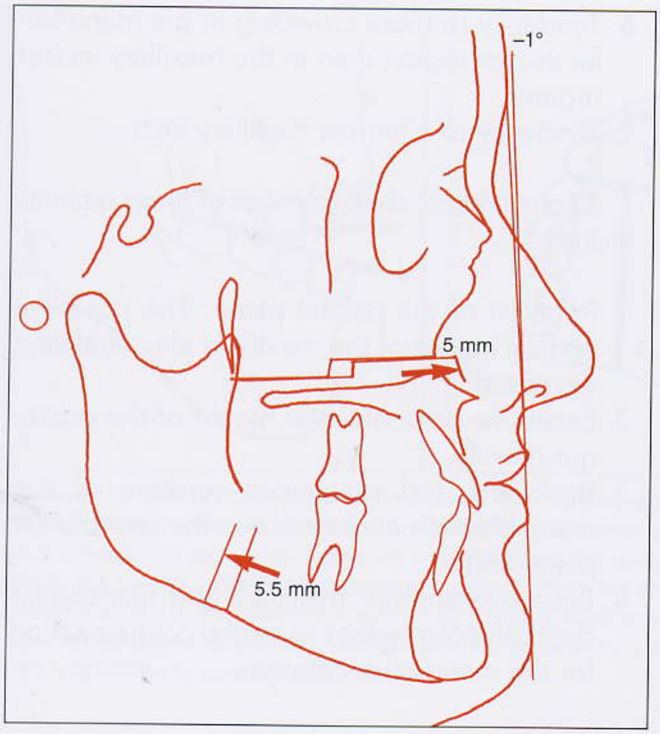


Fig 4-76 Case G.M. Presurgical visual treatment objective. Conventional treatment planning does not render an esthetically pleasing profile. The facial contour still appears concave (facial contour angle = −1 degree).

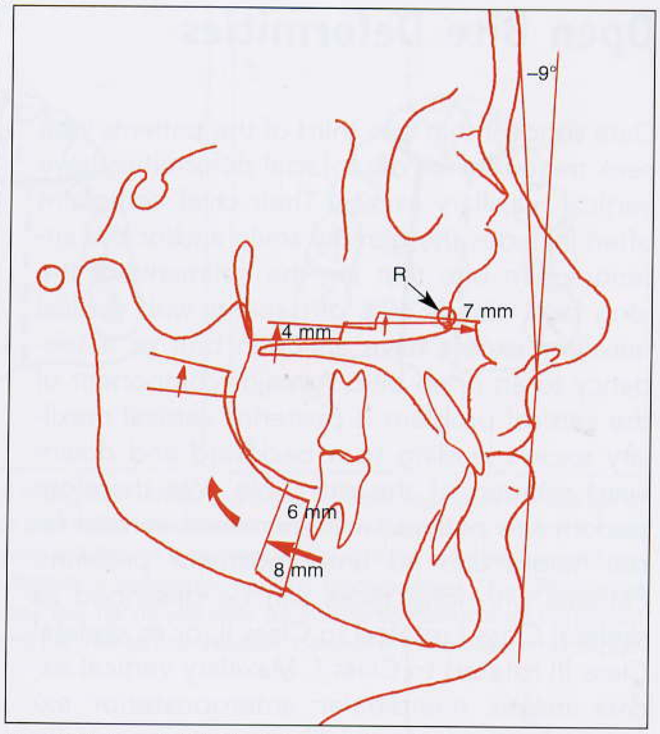


Fig 4-77 Case G.M. Clockwise rotation of the maxillomandibular complex at point R allows for a larger amount of mandibular setback and a more pleasing facial contour angle of −9 degrees.

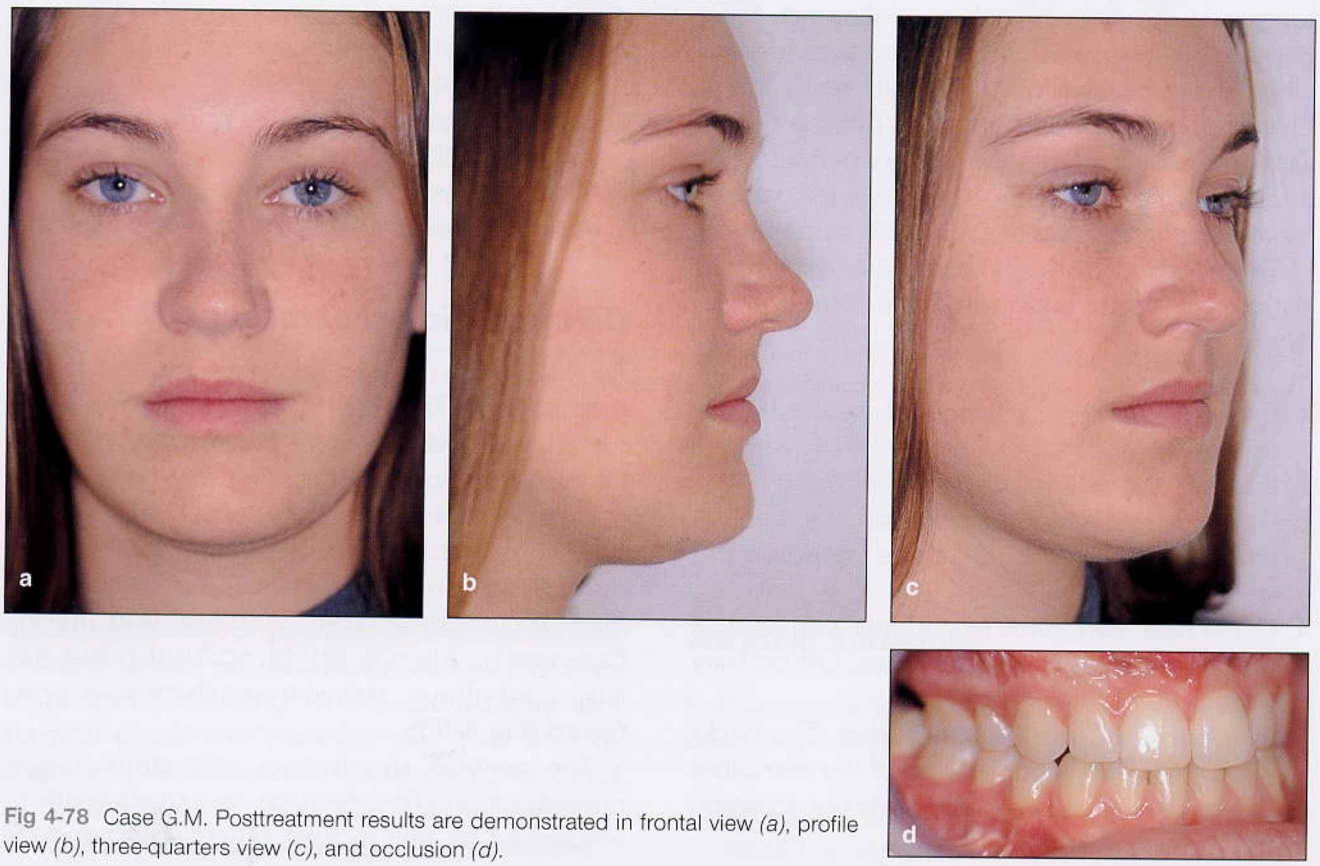


Fig 4-78 Case G.M. Posttreatment results are demonstrated in frontal view *(a)*, profile view *(b)*, three-quarters view *(c)*, and occlusion *(d)*.

Open Bite Deformities

Data suggest that one third of the patients who seek treatment for dentofacial deformities have vertical maxillary excess. Their chief complaint often includes the gummy smile and/or the anterior open bite that are the hallmarks of the long face. Nearly 60% of patients with vertical maxillary excess have an open bite or a tendency to an open bite. A major component of the vertical problem is posterior vertical maxillary excess leading to a backward and downward rotation of the mandible. We therefore seldom see patients with increased vertical facial height and no anteroposterior problem. Patients with long faces can be described as skeletal Class I rotated to Class II, or as skeletal Class III rotated to Class I. Maxillary vertical excess makes mandibular anteroposterior excesses better and mandibular anteroposterior deficiencies worse.

Patients with long faces who have anterior open bites are very likely to be labeled as having a tongue thrust because they place the tip of the tongue in the opening when swallowing. Most people, however, position their tongues forward when trying to swallow with their teeth apart. This positioning of the tongue is often a necessary physiologic adaptation to the open bite, not its cause. The size of the tongue is probably a more important factor in causing an open bite.

The following are clinical characteristics of patients with long faces who have anterior open bites:

1. Excessive anterior facial height, particularly in the lower third.
2. Increased interlabial gap (> 4 mm).
3. Gummy smile. Assessment of the vertical maxillary excess should not be based on the smile.
4. Open bite. Two thirds of patients with vertical maxillary excess have open bites. Others may have normal or deep bites.
5. Tendency to Class II malocclusion. The backward and downward rotation of the mandible affects the relative anteroposterior position of the mandible.
6. Tendency to more crowding in the mandibular incisor region than in the maxillary incisor region.
7. Tendency to a narrow maxillary arch.

Cephalometric characteristics of these patients include:

1. Rotation of the palatal plane. The posterior vertical height of the maxilla is almost always increased.
2. Excessive dentoalveolar height of the posterior maxilla.
3. Backward and downward rotation of the mandible with an increase in the mandibular plane angle.
4. Excessive anterior maxillary and mandibular dentoalveolar height as partial compensation for the mandibular rotation.

Class I open bite

Clinical characteristics

1. Vertical maxillary excess—more posterior than anterior
2. Mandible rotated clockwise (backward)
3. Increased interlabial gap
4. Often, increased exposure of maxillary incisors under the upper lip
5. Often, transverse maxillary deficiency
6. Possibly a skeletal Class III rotated to a Class I

Orthodontic preparation

Two decisions have to be made in orthodontic preparation. The first is to decide between continuous archwire (one-piece) and segmental arch (multipiece) mechanics. When a dual occlusal plane exists, segmental arch orthodontics is indicated to avoid possible orthodontic extrusion of anterior teeth, which may lead to unpredictable stability (Fig 4-79). Conversely, when a single occlusal plane exists, continuous archwire mechanics is preferred (Fig 4-80).

The second decision is extraction versus nonextraction. The decision to extract teeth is influenced by two factors: *(1)* crowding and *(2)*

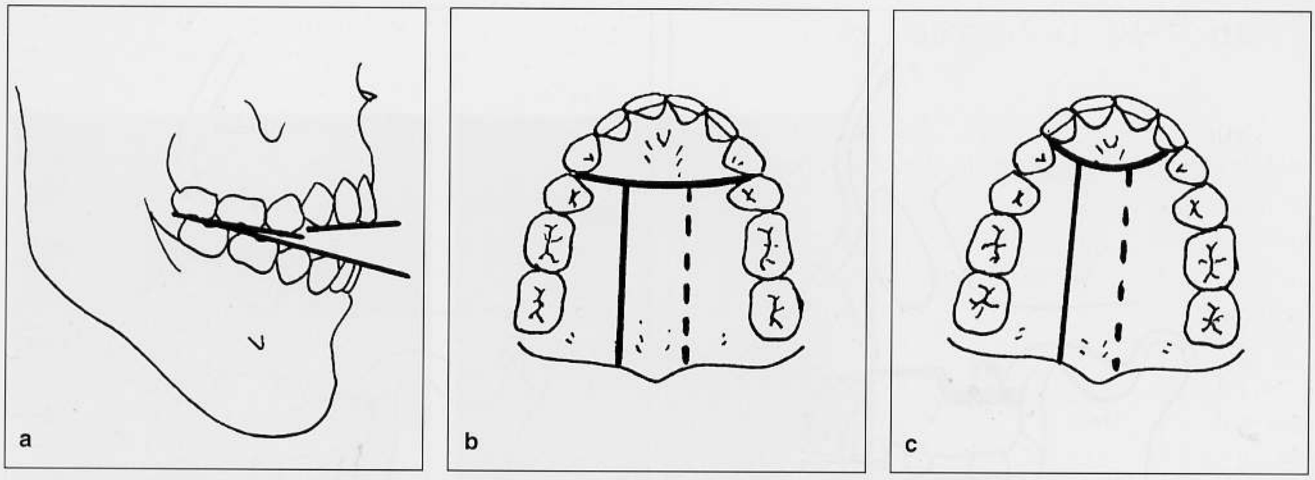


Fig 4-79 *(a)* Dual occlusal plane of the maxilla. The maxillary arch is aligned in three segments, and the segments are aligned to conform to the mandibular arch form. *(b)* Interdental osteotomies are performed between the canines and premolars to allow for surgical correction of vertical discrepancies. A palatal osteotomy (unilateral or bilateral) is performed lateral to the nasal septum and medial to the greater palatine neurovascular bundle to allow the correction of transverse maxillary discrepancies. The orthodontist should ensure that the intercanine width is sufficient to accommodate the mandibular arch. *(c)* Interdental osteotomies performed between the lateral incisors and canines allow the surgeon to control the intercanine distance. Correction of transverse discrepancies is facilitated by palatal osteotomies.

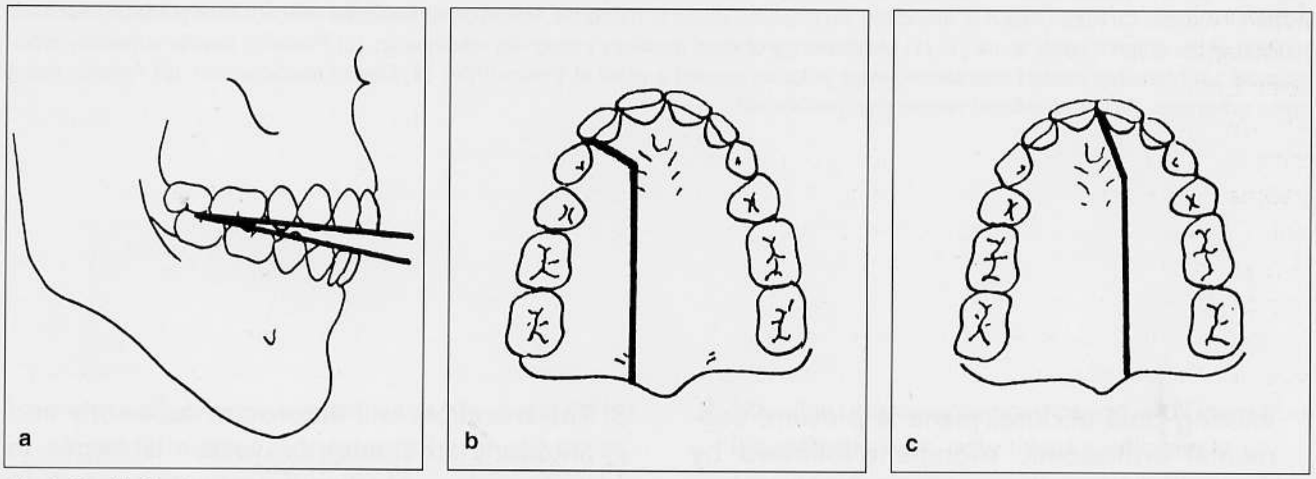


Fig 4-80 *(a)* Single occlusal plane of the maxilla. A continuous arch will be used to level the maxillary occlusion on a single plane. Maxillary transverse arch discrepancy is corrected by segmental surgery, and, depending on the orthodontic arch alignment, the position of the interdental osteotomy may vary: *(b)* a unilateral segmental osteotomy with interdental osteotomy between lateral incisor and canine teeth or *(c)* a maxillary midline osteotomy with an interdental osteotomy between the maxillary central incisors.

the anteroposterior position of the mandibular incisors. When no mandibular surgery is contemplated (according to the orthodontic and surgical prediction tracings), the final anteroposterior position of the maxilla will be dictated by the anteroposterior position of the mandibular incisors after autorotation of the mandible.

Surgical solutions

Following are surgical solutions to Class I open bites (Fig 4-81):

1. Superiorly reposition the maxilla (using segmental or one-piece mechanics). When a pre-

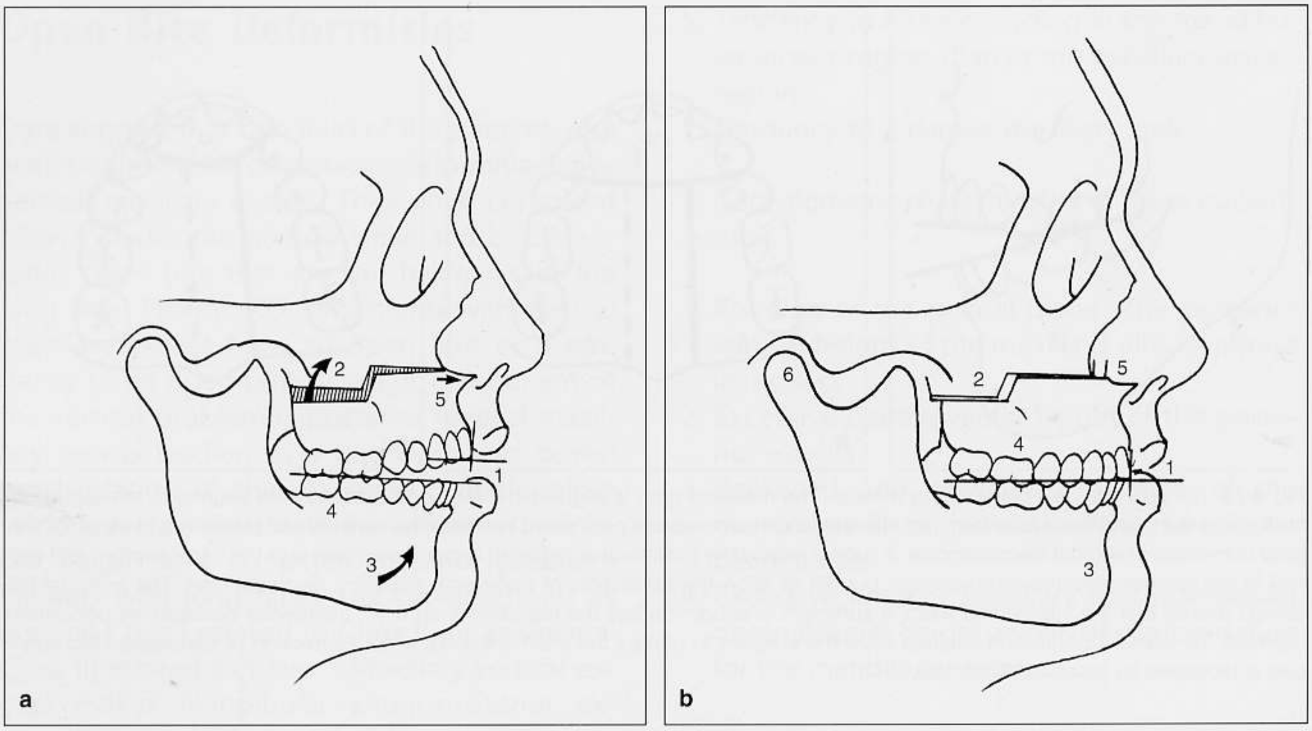


Fig 4-81 *(a)* (1) Maintenance of maxillary incisor–upper lip relationship (anteroposterior and vertical). (2) Superior repositioning of posterior maxilla. (3) Autorotation of mandible. (4) Occlusal plane of mandible, which determines the final occlusal plane. (5) Forward rotation of the anterior nasal spine. *(b)* (1) Maintenance of ideal maxillary incisor–lip relationship. (2) Posterior maxilla superiorly repositioned. (3) Mandible rotated counterclockwise (rotation around a point at the condyle). (4) Class I malocclusion. (5) Anterior nasal spine advanced. (6) Condyle-fossa relationship maintained.

existing dual occlusal plane is present, segmental orthodontic alignment followed by segmental surgical correction is indicated.

2. Surgically expand the maxillary buccal segments (segmental surgery). In cases with a dual occlusal plane and transverse maxillary deficiency, a three-piece Le Fort I osteotomy with interdental osteotomies between the lateral incisor and canine is usually performed. Single maxillary occlusal plane orthodontic preparation requires a two-piece Le Fort I osteotomy, and depending on the orthodontic preparation of the two segments, the interdental osteotomy is usually performed between the maxillary central incisors or unilaterally between the lateral incisor and canine.
3. The mandible will autorotate superiorly and anteriorly (the anterior vector is larger in high-angle cases than in low-angle cases).

Individuals with facial esthetic features indicative of maxillary anteroposterior deficiency (large nose, convex nasal dorsum, deficient paranasal anatomy, lack of supratip break, and poor lip support) would benefit from the obligatory maxillary advancement. Individuals with normal midface esthetic features will experience unesthetic changes with isolated superior and anterior repositioning of the maxilla. For these individuals, simultaneous mandibular setback is necessary to avoid undesirable maxillary advancement. Finally, the facial esthetics of a small percentage of individuals may necessitate

Fig 4-82 Case K.S. Presurgical frontal view *(a)*, profile view *(b)*, and occlusion *(c)*. Note the placement of white lingual buttons on the buccal surfaces of the maxillary teeth just prior to surgery.

more maxillary advancement than is dictated by the mandible after autorotation. In these cases, the clinician should consider additional advancement of the maxilla, which will require simultaneous surgical advancement of the mandible.

The anteroposterior position of the chin is not a primary determining factor in the cases discussed above. In most of these patients, excessive or deficient chin projection can be corrected by an appropriate genioplasty; however, the shape of the chin and the depth of the labiomental fold should be considered.

In summary, the surgical solutions may include:

1. Maxillary superior repositioning with or without genioplasty
2. Maxillary superior repositioning with mandibular setback, with or without genioplasty
3. Maxillary superior repositioning with mandibular advancement, with or without genioplasty
4. Possible maxillary superior repositioning in one piece (more posterior than anterior, as indicated by the mandibular occlusal plane after autorotation) or in segments, allowing differential superior repositioning of the anterior and posterior segments and simultaneous expansion of the buccal segments (again, as dictated by the occlusal plane of the mandible and the mandibular dental arch form)

Correction of a Class I anterior open bite is demonstrated in Figs 4-82 to 4-86 for Case K.S.

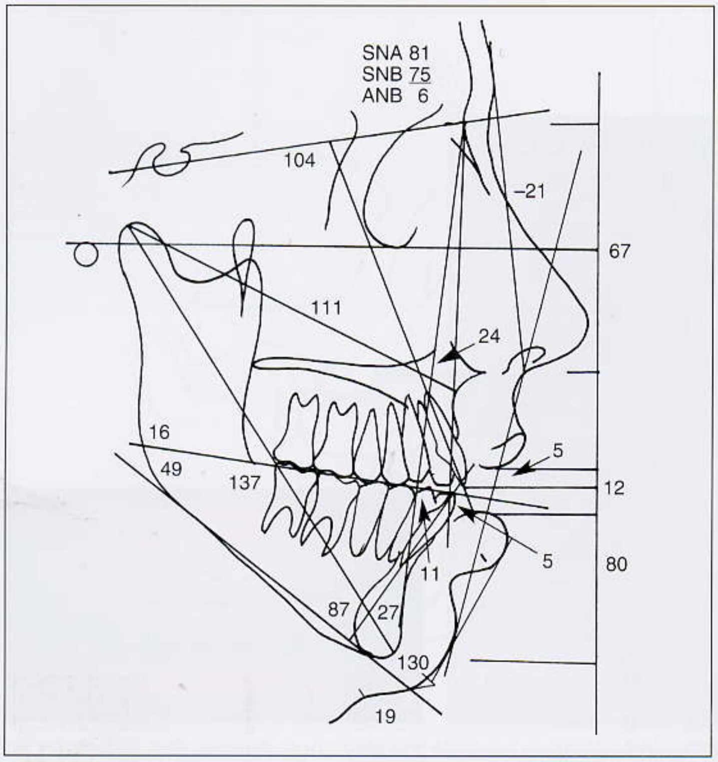


Fig 4-83 Case K.S. Presurgical cephalometric analysis. Posterior vertical maxillary excess: interlabial gap = 12 mm, increased lower facial height: middle to lower third = 67:80 mm; slight anterior maxillary vertical excess: maxillary incisor exposure = 5 mm; convex profile: facial contour angle = −21 degrees; mandible rotated clockwise because of vertical maxillary excess: mandibular plane = 49 degrees; microgenia: lip-chin-throat angle = 130 degrees, chin-throat length = 19 mm.

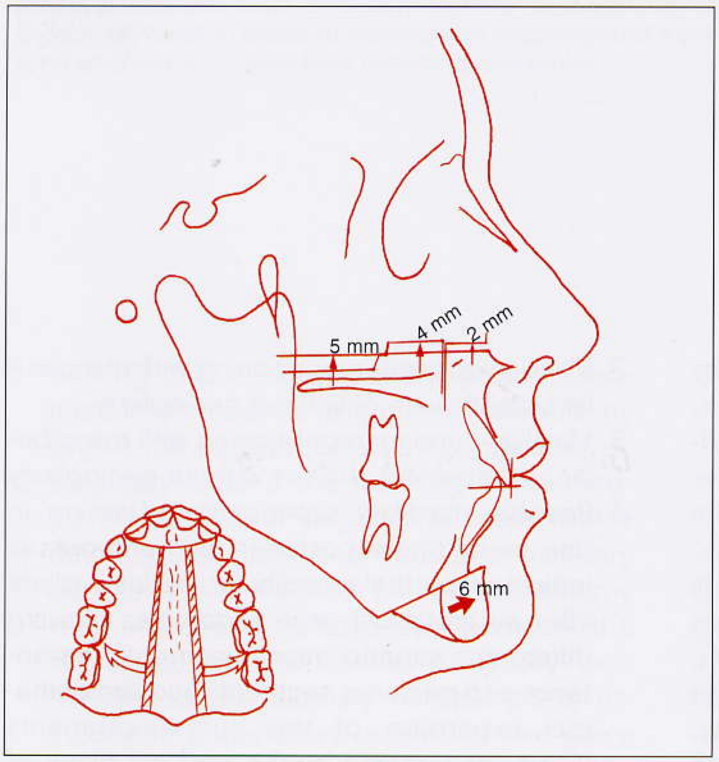


Fig 4-84 Case K.S. Surgical cephalometric visual treatment objective—Le Fort I maxillary osteotomy: superior repositioning of posterior maxillary segments (5 mm posterior and 4 mm anterior), superior repositioning of anterior maxillary segment (2 mm), expansion of the posterior segments *(inset)*, counterclockwise autorotation of the mandible, and advancement genioplasty (6 mm).

Fig 4-85 Case K.S. Immediate postsurgical occlusion. Note the interdental wires placed around the presurgically placed buccal brackets of the teeth next to the interdental osteotomies. Brackets are placed on all the teeth just prior to surgery to facilitate intermaxillary fixation during surgery and the placement of elastics after surgery.

Fig 4-86 Case K.S. Posttreatment frontal view *(a)*, profile view *(b)*, and occlusion *(c)*.

Class II open bite

Clinical characteristics

1. Increased lower facial height
2. Recessive chin
3. Vertical maxillary excess
4. Often, excessive exposure of maxillary incisors
5. Increased interlabial gap
6. Skeletal Class II relationship
7. Transverse maxillary deficiency (posterior crossbite)
8. Increased mandibular plane angle
9. Could be a skeletal Class I rotated to a Class II

Orthodontic preparation

1. One-piece Le Fort I osteotomy
   - Level, align, and coordinate the maxillary arch, and align the mandibular arch.
   - Do not attempt to close the open bite by expansion of the buccal segments, extrusion of the anterior teeth, or intrusion of the posterior teeth.
   - Expand buccal segments of teeth only where the teeth are palatally inclined in relation to the basal bone.
2. Segmental Le Fort I osteotomy
   - Level and align the maxillary dental arch in segments.

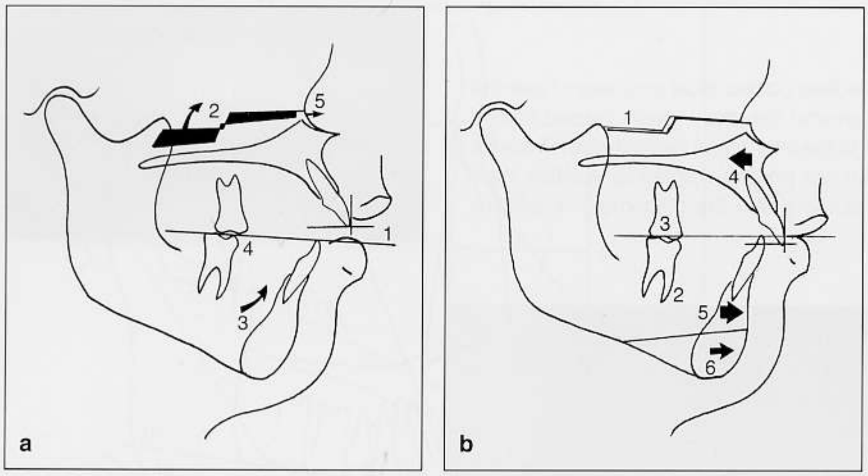


Fig 4-87 *(a)* (1) Maintain maxillary incisor–upper lip relationship (anteroposterior and vertical). (2) Superiorly reposition the posterior maxilla. (3) Mandible will autorotate. (4) The mandibular occlusal plane determines the final occlusal plane. (5) The anterior nasal spine is rotated forward. *(b)* (1) The posterior maxilla is superiorly repositioned. (2) The mandible has autorotated. (3) There is still a Class II malocclusion with an increased overjet. Options include maxillary setback (seldom used) (4), mandibular advancement (5), and genioplasty advancement (6).

- Align the segments to be compatible with the mandibular arch.
- Deviate the roots at the intended interdental osteotomy areas.
- Do not attempt to expand or close bites orthodontically.
- Level and align the mandibular arch.

Surgical solutions

Following are surgical solutions to Class II open bites (Fig 4-87):

1. Superior repositioning of the maxilla (total or segmental). The open bite can be corrected by more superiorly repositioning the posterior maxilla (segment) than the anterior maxilla.
2. Surgical expansion of buccal segments by segmental surgery.
3. Autorotation of the mandible.
4. Surgical advancement of the mandible.
5. Advancement genioplasty.

As a consequence of superior repositioning of the maxilla, the mandible will rotate counterclockwise (superiorly and forward) around a point at or just behind the condyle. The forward vector may be sufficient to allow only superior repositioning of the maxilla with no anteroposterior change. Cases with a high mandibular plane angle will have more forward rotation of the mandibular incisors than will low-angle cases.

Individuals who do not require mandibular advancement may require slight posterior movement of the maxilla; however, this movement will compromise the facial esthetic results. For patients with normal midface facial esthetics and especially for those with large noses, deficient concave paranasal areas, or obtuse nasolabial angles, maxillary setback should not be attempted. These patients require simultaneous superior repositioning of the maxilla and advancement of the mandible. The above principle is demonstrated in Fig 4-88.

Case K.P.

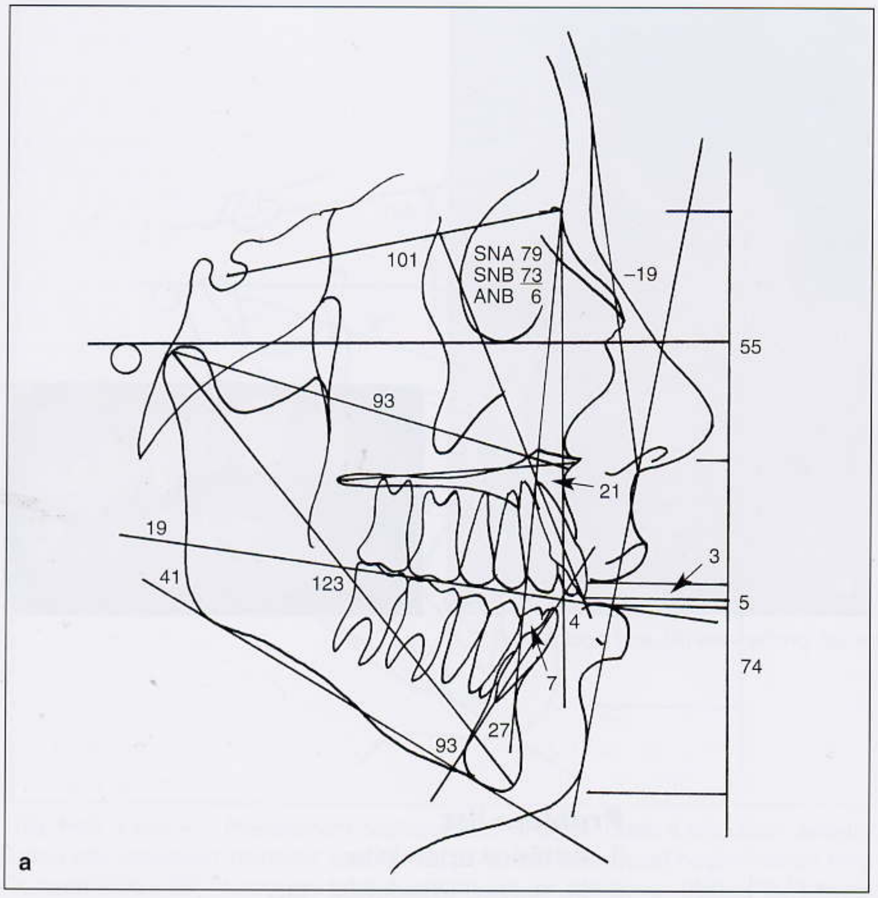
This 32-year-old patient sought treatment after being told by her general practitioner that she would eventually lose her teeth as a consequence of her open bite.

Main complaint

The patient's main complaint was her inability to maintain closure of her mouth and difficulty in chewing, which was sometimes socially embarrassing.

Medical history

The patient has asthma and takes medication only before physical exercise.



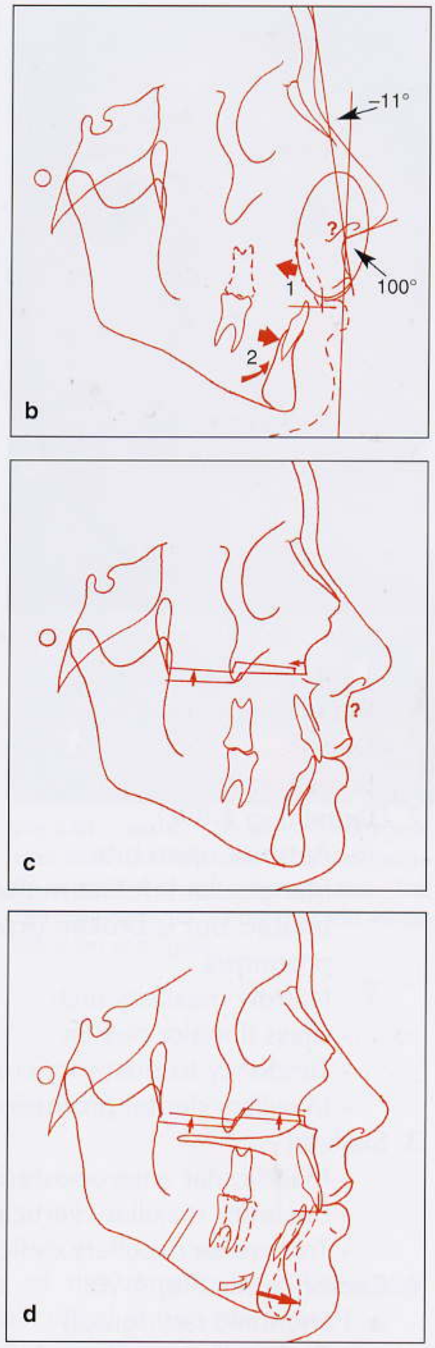


Fig 4-88 *(a)* Lateral cephalometric analysis of a patient with a Class II anterior open bite malocclusion requiring surgical correction. *(b)* On the surgical prediction tracing, the maxilla has been superiorly repositioned and the mandible autorotated around a point at the condyle. The occlusion is still Class II, with an increased overjet. The surgeon now has two choices: to set the maxilla back (1) or to advance the mandible (2). *(c)* Prediction tracing illustrating the expected hard and soft tissue changes after maxillary setback. The midface is flattened, the upper lip support is diminished, and the nasolabial angle is increased. *(d)* The maxilla has been superiorly repositioned, while the mandible has autorotated and has been advanced on the prediction tracing. A more esthetic result will be achieved with this treatment option.

Clinical examination

1. Soft tissue
   a. Frontal view (Fig 4-89a)
      - Increased interlabial distance
      - Increased lower facial third
      - Nasal asymmetry
   b. Profile view (Fig 4-89b)
      - Convex profile
      - Increased lower facial third height
      - Increased interlabial distance
      - Mandibular anteroposterior deficiency
      - Protruding upper lip
      - Acute lip-chin-throat angle

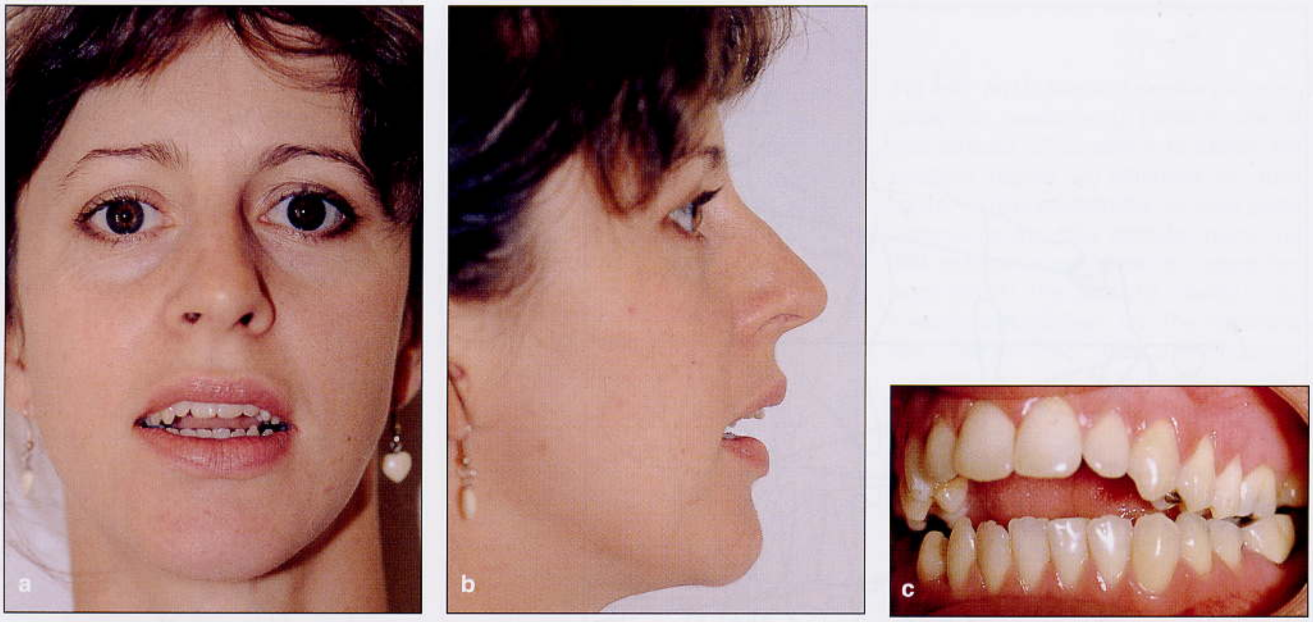


Fig 4-89 Case K.P. Pretreatment frontal view *(a)*, profile view *(b)*, and occlusion *(c)*.

2. Dental (Fig 4-89c)
   - Anterior open bite
   - Mandibular left first molar root has been treated but is broken down, with a poor prognosis
   - Narrow maxillary arch
   - Class II malocclusion
   - Tendency to posterior crossbites
   - Maxillary dental protrusion
3. Skeletal
   - Mandibular anteroposterior deficiency
   - Posterior maxillary vertical excess
   - Transverse maxillary deficiency
4. Radiographic (Fig 4-90)
   a. Panoramic radiograph
   - Broken-down crown of the left mandibular first molar (tooth has had root canal treatment)
   - Several restored teeth
   b. Cephalometric
   - Class II malocclusion
   - Mandible rotated clockwise
   - Vertical excess of the posterior maxilla
   - Increased lower facial height
   - Large interlabial gap
   - Ideal upper lip–maxillary incisor relationship (3-mm incisor exposure)

Problem list

1. Anterior open bite
2. Increased interlabial gap
3. Mandibular anteroposterior deficiency
4. Maxillary transverse deficiency
5. Posterior maxillary vertical excess
6. Broken-down left mandibular first molar
7. Maxillary dental protrusion

Presurgical orthodontics

- Maxillary arch (Fig 4-91)
  - Alignment of the maxillary arch in three segments, from the right second premolar to the right second molar, the right canine to the left canine, and the left second premolar to the left second molar.
  - Extraction of both first premolars at the time of surgery to allow ideal surgical positioning of the anterior maxillary segment.
  - Deviation of the roots of both canines and both second premolars to allow surgical closure of the extraction spaces of both first premolars.
- Mandibular arch (see Fig 4-91)
  - Extraction of the left mandibular first molar.

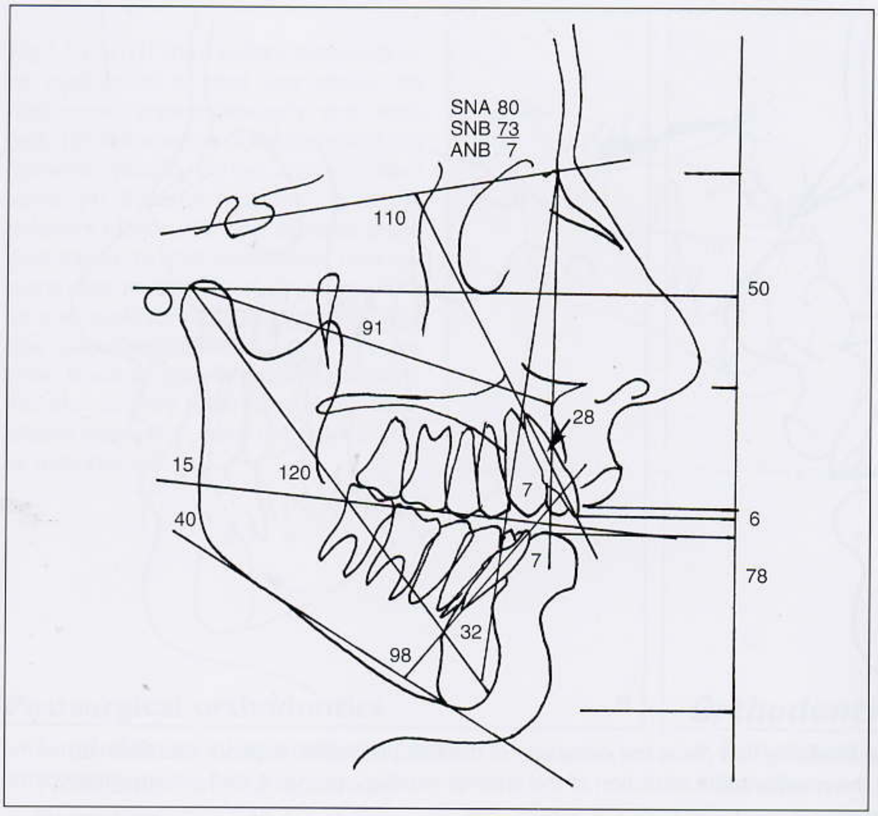


Fig 4-90 Case K.P. Pretreatment cephalometric analysis. Class II occlusion; anterior open bite; increased interlabial gap: 6 mm; increased lower facial height: middle third to lower third = 50:78 mm; mandibular anteroposterior deficiency: SNB = 73 degrees; increased mandibular plane angle: 40 degrees; maxillary incisor protrusion: maxillary incisor to S-N = 110 degrees, maxillary incisor to N-A = 28 degrees and 7 mm. The maxillary incisor–upper lip relationship is good (1.5-mm tooth exposure); it is important to maintain this relationship during treatment.

Fig 4-91 Case K.P. Immediate presurgical occlusion. Note the segmental orthodontic alignment of the maxillary arch. The first premolars are not banded and will be extracted at surgery.

- Closure of the space where the left first molar was extracted.
- Leveling and alignment of the arch.

Surgical treatment

- Extraction of both maxillary first premolars (Fig 4-92).
- Performance of a three-piece Le Fort I osteotomy with the interdental osteotomy through the extraction sites of the maxillary first premolars. Removal of bone in the extraction spaces allowed surgical closure of the spaces, and a palatal osteotomy allowed expansion of the posterior segments (see Fig 4-92).
- Repositioning of the anterior maxillary segment. This was critical in two respects:
  1. The vertical upper lip–maxillary incisor relationship had to be maintained.
  2. The segment could not be retracted excessively, as that would undermine lip support and increase the labiomental angle.
- Superior repositioning of the posterior segment to allow the mandible to autorotate (see Fig 4-92).
- Advancement of the mandible by means of a bilateral split osteotomy (see Fig 4-92).

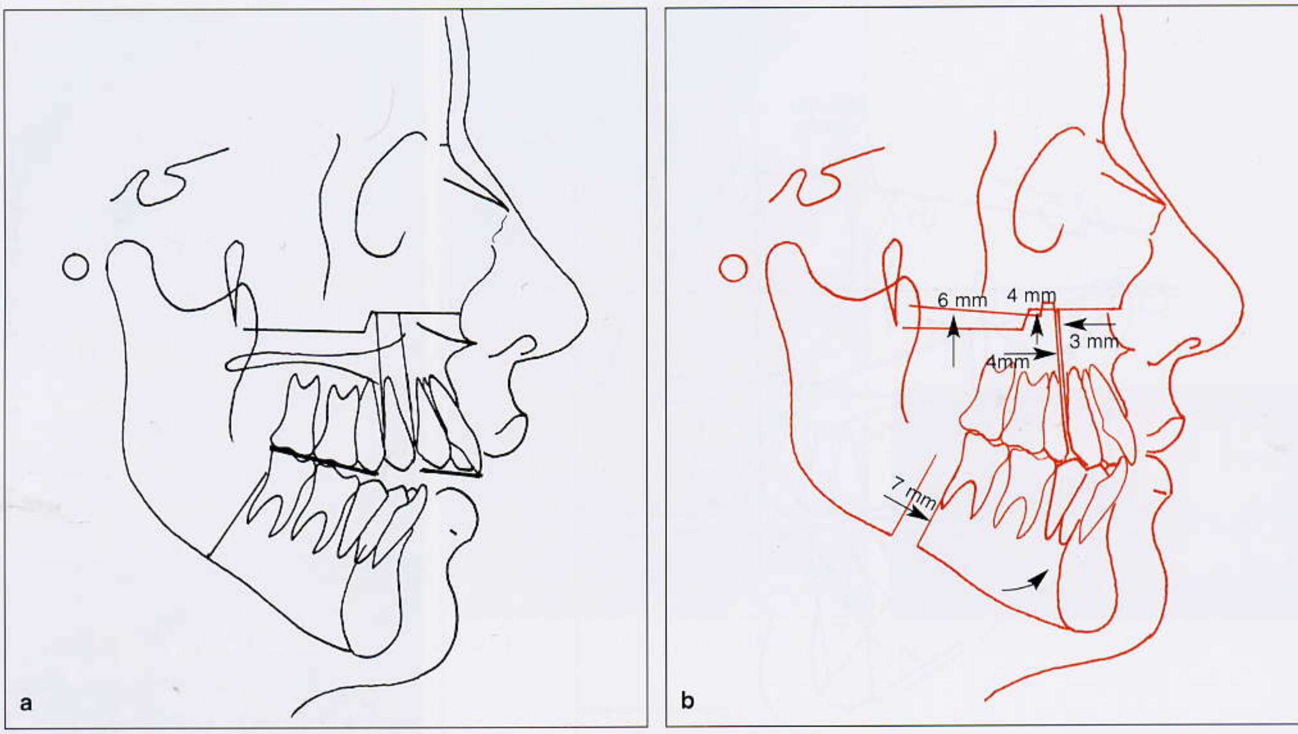


Fig 4-92 Case K.P. *(a)* Immediate presurgical tracing that plans the extraction of the first premolars, superior repositioning of the posterior maxillary segments, expansion of the maxilla, slight retraction of the anterior maxillary segment, and advancement of the mandible. *(b)* The predicted postsurgical result.

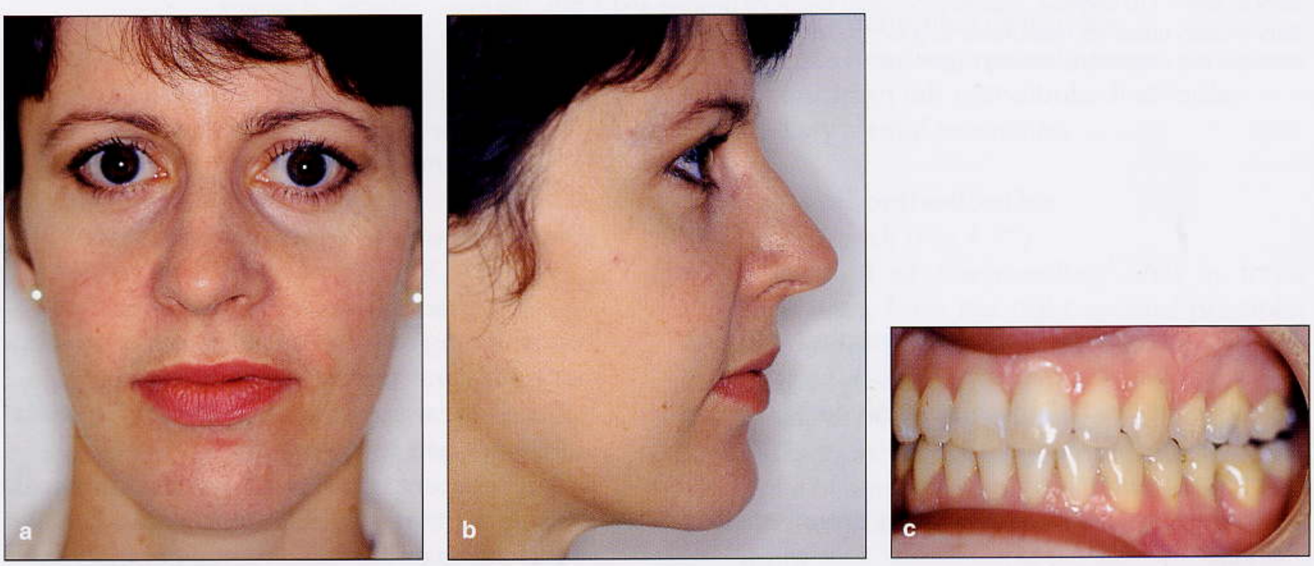


Fig 4-93 Case K.P. Posttreatment frontal view *(a)*, profile view *(b)*, and occlusion *(c)*.

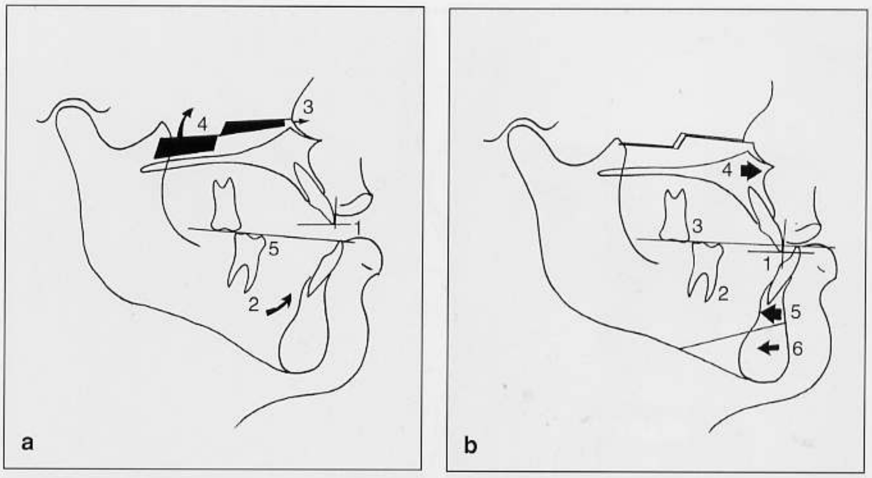


Fig 4-94 *(a)* (1) The maxillary incisor–upper lip relationship is ideal and should be maintained anteroposteriorly and vertically. (2) Autorotation of the mandible. (3) Forward rotation of the anterior nasal spine. (4) Superior repositioning of the posterior maxilla. (5) Final occlusal plane determined by the mandibular occlusal plane after rotation. *(b)* (1) Ideal maxillary incisor–upper lip relationship. (2) Mandible has autorotated. (3) Occlusion is more Class III with an anterior crossbite. Options include maxillary advancement (4), mandibular setback (5), both options 4 and 5, or genioplasty (6).

Postsurgical orthodontics

- Final closure of extraction spaces
- Finalization of the occlusion
- Retention

Closure of the extraction space of the mandibular left first molar prolonged the orthodontic preparation, and surgery was performed 25 months after commencement of orthodontic treatment. The orthodontic bands were removed 9 months after surgery. The 2-year postsurgical results are illustrated in Fig 4-93.

Class III open bite

Clinical characteristics

1. Mandibular anteroposterior excess (magnitude of the anteroposterior discrepancy masked by backward rotation of the mandible).
2. Maxillary vertical excess (more posterior than anterior).
3. Transverse maxillary deficiency.
4. Posterior crossbites.
5. Class III malocclusion.
6. Often, a reverse curve of Spee.
7. Increased mandibular plane angle.
8. Clockwise rotation of the mandible makes the Class III relationship better; vertical correction will make the Class III relationship worse.

Orthodontic preparation

- Remove any existing dental compensation.
- Where segmental surgery is contemplated, align the maxillary arch in segments, and deviate roots at interdental osteotomy areas.
- Level and align the mandibular arch.

Surgical solutions

Following are surgical solutions to Class III open bite (Fig 4-94):

- One-piece Le Fort I osteotomy with superior repositioning of the maxilla (more posterior than anterior) to achieve the ideal maxillary incisor–upper lip relationship
- Segmental surgery with differential superior repositioning of the maxilla (the posterior segments more superiorly than the anterior segment)
- Expansion of the buccal segments
- Mandibular setback
- Genioplasty

Comments on Class III open bite

Inferior repositioning of the anterior maxilla and superior repositioning of the posterior maxilla are often indicated. The anterior maxilla often may be vertically deficient in Class

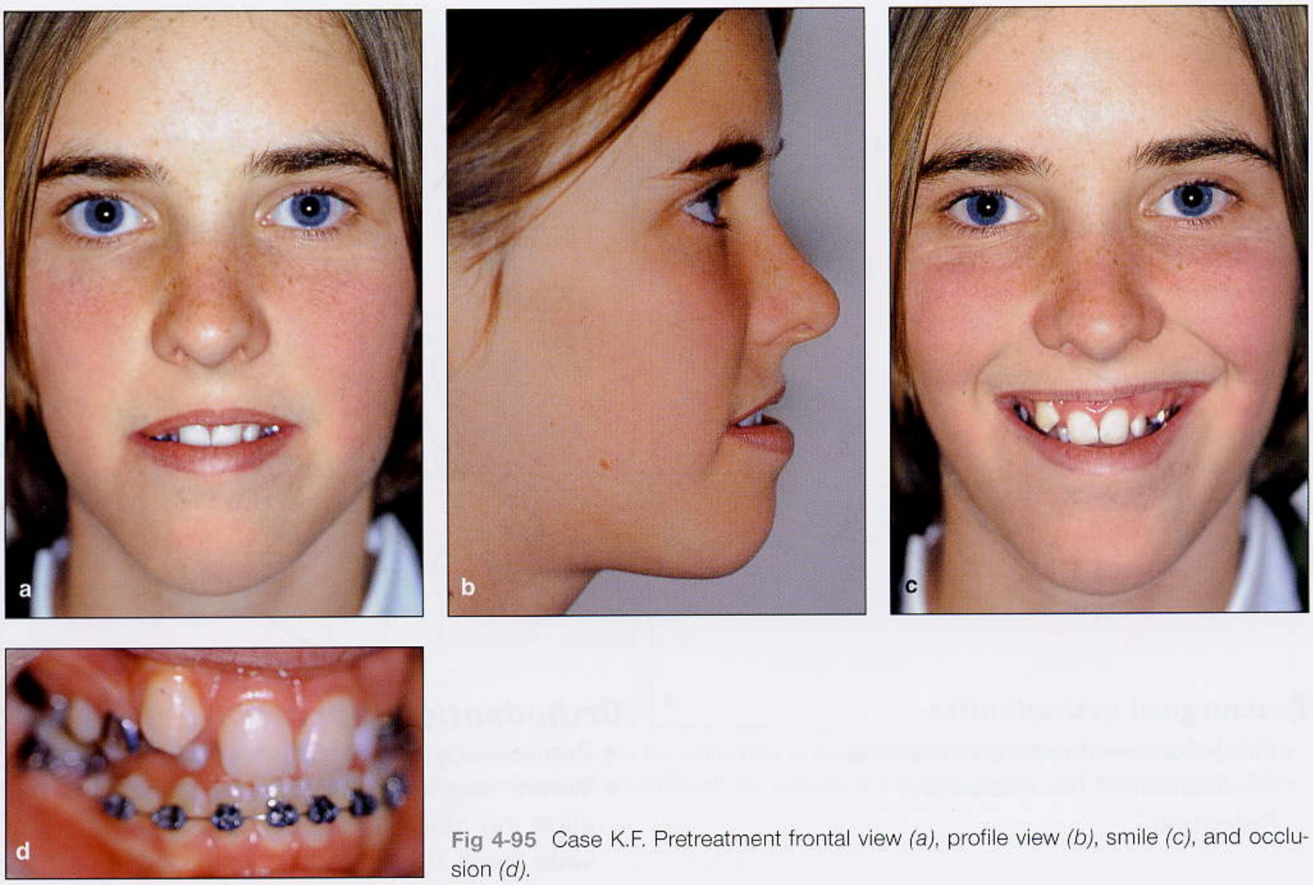


Fig 4-95 Case K.F. Pretreatment frontal view *(a)*, profile view *(b)*, smile *(c)*, and occlusion *(d)*.

III open bite cases, and the maxillary tooth-lip relationship is an important consideration in planning the final vertical position of the maxilla.

The mandible will autorotate, and the Class III occlusal relationship will worsen.

The anteroposterior discrepancy can be corrected by advancement of the maxilla, mandibular setback, both maxillary advancement and mandibular setback, and/or genioplasty. The treatment of choice depends on the esthetic requirements of the case.

Before treatment planning, the cause of the open bite should be determined. Open bites may develop because of:

1. Deficient eruption of maxillary incisors (anterior)
2. Deficient eruption of mandibular incisors (anterior)
3. Deficient eruption of maxillary and/or mandibular molars (posterior)
4. Excessive vertical development of the posterior maxilla

The key element of the analyses is evaluation of the vertical relationship of the maxillary incisors to the relaxed upper lip (keep lip length in mind). Deficient eruption of mandibular incisors with a reverse curve of Spee is often due to an abnormal size and resting posture of the tongue.

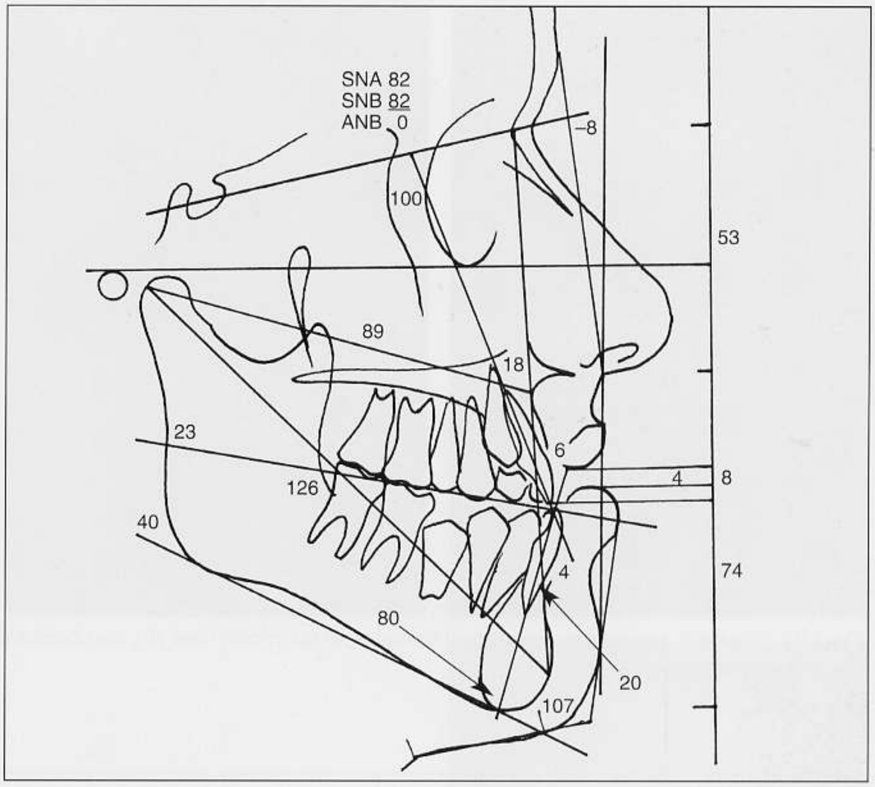


Fig 4-96 Case K.F. Pretreatment cephalometric analysis. Increased lower facial height: middle to lower facial height = 53:74 mm; maxillary-mandibular discrepancy in length: maxilla to mandible = 89:126 mm; mandibular anteroposterior excess: SNB = 82 degrees, ANB = 0 degrees; mandibular incisor compensated: mandibular incisor to mandibular plane = 80 degrees, mandibular incisor to N-B = 20 degrees.

Posterior open bites can develop in three ways:

1. Excessive vertical development on one side, often associated with facial asymmetry (eg, unilateral condylar hyperplasia)
2. Deficient eruption of teeth on one side (eg, impacted teeth), with normal symmetry
3. Bilateral deficient eruption of posterior teeth (eg, cleidocranial dysostosis or large tongue) with normal symmetry

Figures 4-95 to 4-99 demonstrate the correction of a Class III anterior open bite in a 15-year-old female patient (Case K.F.). Superior repositioning of her maxilla to facilitate autorotation of the mandible and correction of the open bite worsened the Class III relationship, which necessitated mandibular setback.

Maxillary expansion

The transverse dimension of the maxilla can be increased in four ways: *(1)* orthodontically, through dental tipping (torquing); *(2)* by rapid palatal expansion (in growing individuals); *(3)* through surgically assisted palatal expansion (in nongrowing individuals); and *(4)* through surgical expansion.

Dental tipping

Dental tipping is indicated where the skeletal base width is adequate and where the required transverse arch dimension can be achieved by moving the teeth buccally by orthodontic force.

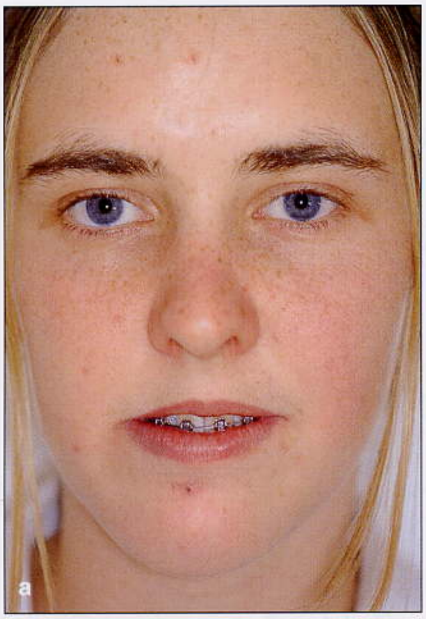
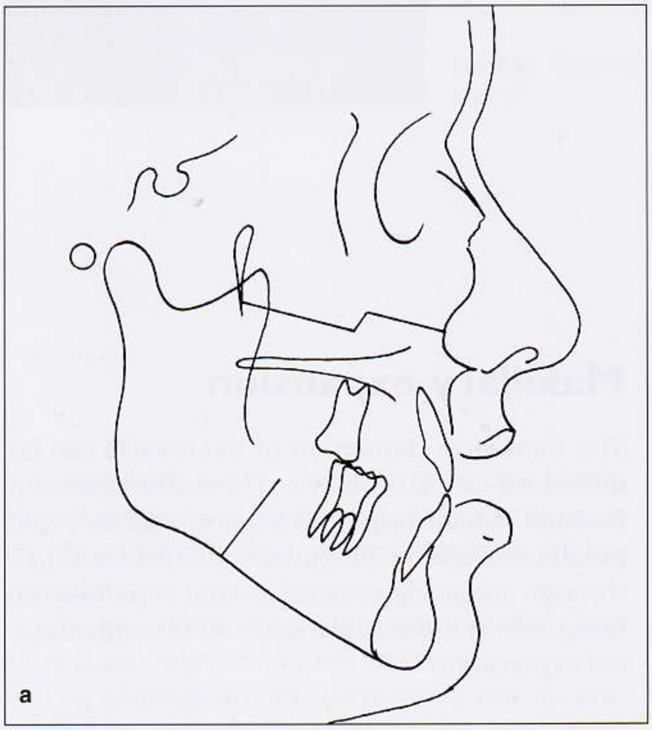


Fig 4-97 Case K.F. Immediate presurgical frontal view *(a)*, profile view *(b)*, and occlusion *(c)*. Note the worsening of the asymmetry and Class III dental relationship.



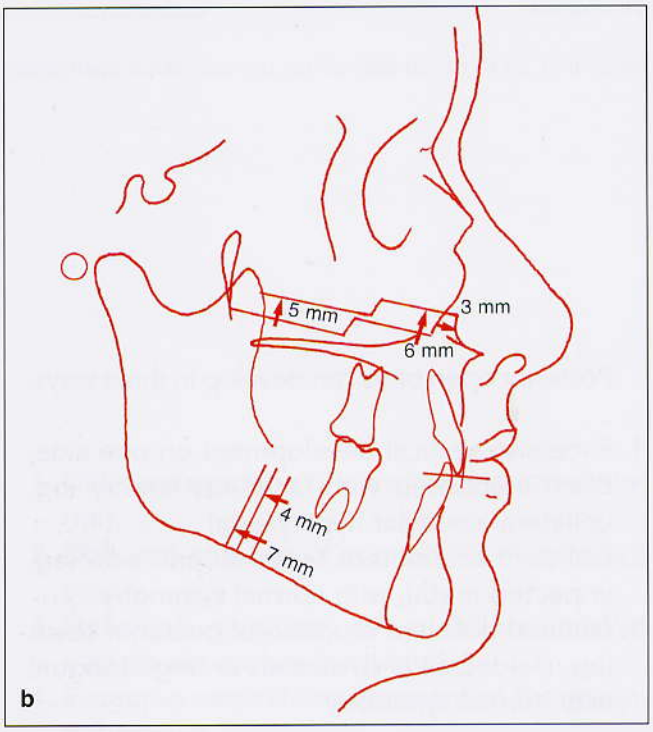


Fig 4-98 Case K.F. Presurgical cephalometric tracing *(a)* and the surgical visual treatment objective *(b)*. The maxilla will be superiorly repositioned by 6 mm anteriorly and 5 mm posteriorly. The maxilla will be advanced by 3 mm at the same time. The mandible will be set back by 7 mm on the left side and 4 mm on the right side.

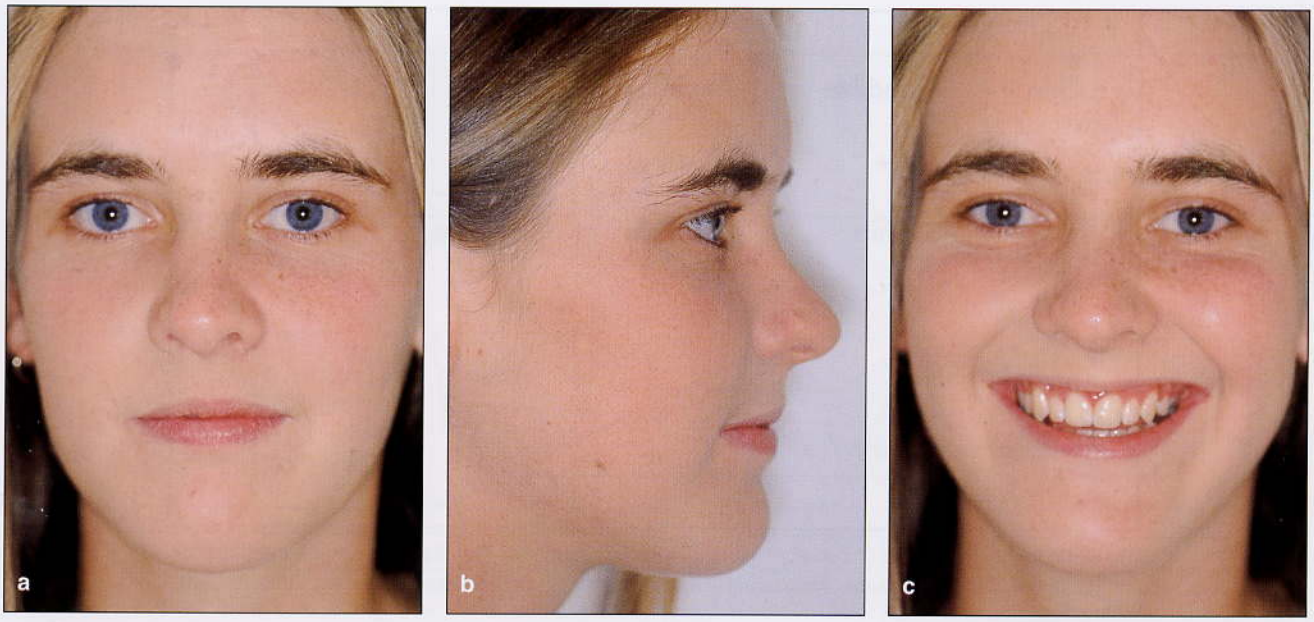


Fig 4-99 Case K.F. Posttreatment frontal view *(a)*, profile view *(b)*, smile *(c)*, and occlusion *(d)*.

Rapid palatal expansion

Rapid palatal expansion achieved by opening the midpalatal suture is indicated in young, growing individuals with narrow palatal vaults. An ideal patient for this form of expansion has a combination of transverse dental and skeletal deficiency because tooth movement is also produced by the force systems designed to open the suture. The expansion force has an age-dependent threshold; as a child matures, the resistance to suture separation increases. The ratio between sutural expansion and tooth movement is approximately 50:50. Depending on the bone-tooth relationship, between 40% and 60% of the distance gained by dental movement will be lost.

Surgically assisted palatal expansion

Surgically assisted palatal expansion is a form of distraction osteogenesis. This form of expansion is recommended in patients younger than 25 years who would not require any other orthognathic surgical procedures. The surgical technique involves reducing the skeletal resistance to orthodontic expansion by performing osteotomies at the lateral maxillary buttress and/or in the palate. Surgically assisted expansion is not recommended in patients older than 30 years because of the increased interdigitation of the remaining suture lines. The expansion appliance should remain in place at least 2 months after expansion has stopped, and a fixed retainer should remain in place after removal of the distraction device for another 6 to 12 weeks.

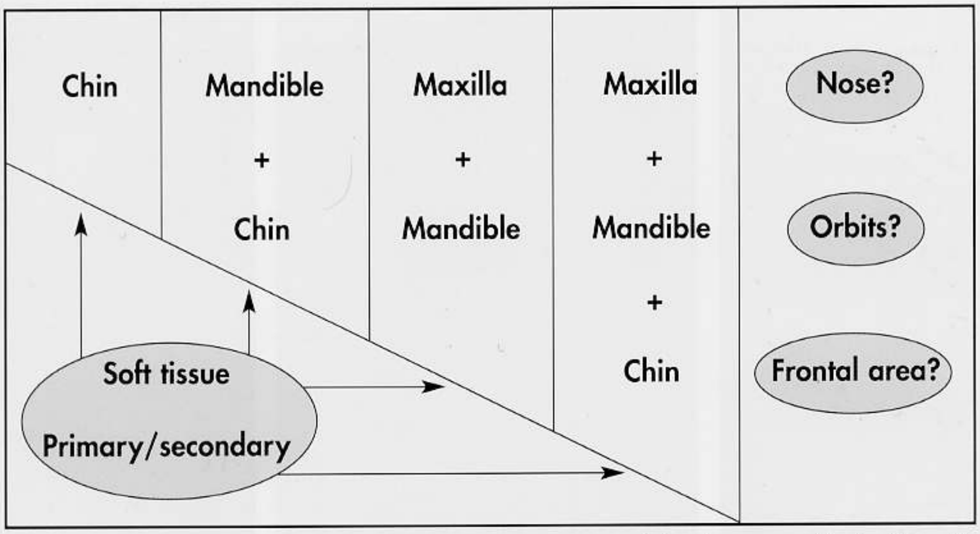


Fig 4-100 Categorization of possible facial asymmetry patterns. The diagram assists in differentiating between a specific area of asymmetry and a combination of areas influencing the symmetry of the face.

Surgical expansion

Surgical expansion can be accomplished by either posterior segmental osteotomies or a Le Fort I osteotomy, segmenting the maxilla in the down-fractured position. Where a large amount of expansion is required, bilateral palatal osteotomies should be performed. The osteotomy should be made just lateral to the nasal septum, where the palatal bone is thin and the mucosa thick. Soft tissue release may be helpful for large expansion and should be performed off the osteotomy line. Grafting and appropriate rigid fixation should be used in palatal expansions of more than 3 mm. Postsurgical orthodontic control of the expanded segments is paramount for optimal postsurgical stability.

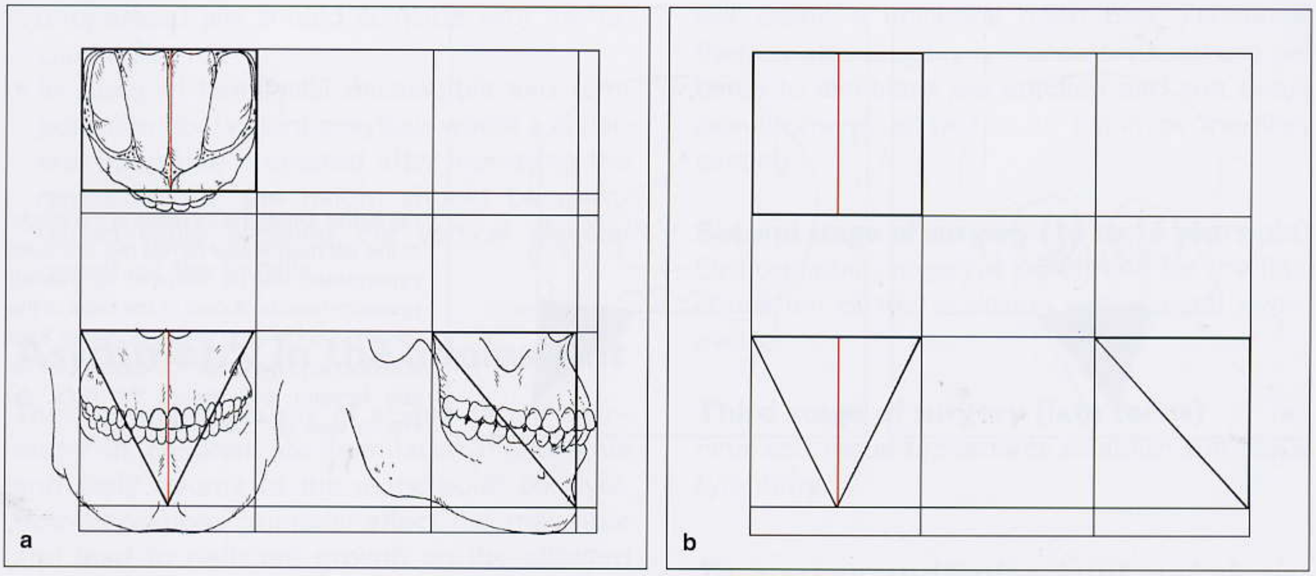
Dentofacial Asymmetry

Very few faces are perfectly symmetrical. Mild asymmetries of the dental arches and other facial structures are common and often clinically and functionally insignificant. Slight asymmetry of the face is often of little importance to patients, but some are very sensitive regarding facial asymmetry. Thus, the clinician should warn patients that very few faces are perfectly symmetrical and that it would be impossible to achieve perfect facial symmetry with treatment.

The many causes of facial asymmetry can be classified as congenital, developmental, posttraumatic, or the result of pathology. Some of the more common abnormalities affecting the face and leading to asymmetry are unilateral condylar hyperplasia, hemifacial microsomia, temporomandibular joint ankylosis, and deformities induced by trauma.

Like all orthognathic patients, individuals with facial asymmetry require a systematic and comprehensive examination, diagnosis, and treatment planning, as discussed in chapter 2. During the examination the clinician should pay special attention to three important factors: the location of the asymmetry, the tissues involved, and the dimensions involved.

The asymmetry of the face may be in the chin, mandible, maxilla, nose, orbits, zygoma, frontal areas, or a combination of these structures. Figure 4-100 presents a way to categorize facial symmetry patterns. The diagram should also assist the clinician in differentiating between the specific area and combination of areas of asymmetry. The involvement of other



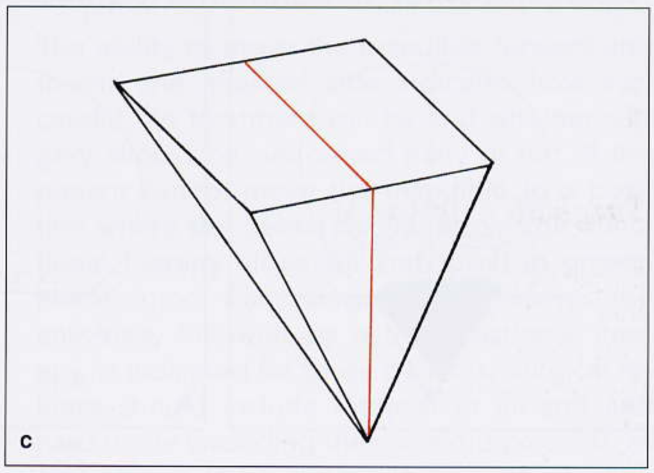


Fig 4-101 *(a)* Diagrammatic illustration of the three-dimensionality of the maxillomandibular complex. *(b and c)* Construction of a prism representing the maxillomandibular complex to assist in the visualization of three-dimensional alterations of the midface and lower face during the correction of facial asymmetry.

facial structures, ie, the nose, orbits, and frontal bone, should be considered, and the soft tissue involvement either primary or secondary to the skeletal asymmetry evaluated.

The clinician should determine what tissues are causing the asymmetry and whether the involvement is primary or secondary. This information will influence the treatment plan. For example, soft tissue asymmetry caused by mandibular asymmetry will be corrected by the skeletal correction, while the soft tissue deformity seen in hemifacial microsomia often requires further attention.

The dimensions involved in the asymmetry also should be determined. The maxillomandibular complex is a three-dimensional structure, as illustrated in Fig 4-101a. To simplify the determination of the three-dimensional skeletal, dental, and soft tissue alteration required for the correction of dentofacial asymmetries, a prism can be constructed to represent the maxillomandibular complex (Fig 4-101b). The prism helps the clinician visualize and evaluate the various three-dimensional surgical movements (Fig 4-101c). Figure 4-102 shows the effect of unilateral condylar hyperplasia on the spatial position of the prism. The opposite effect is demonstrated in Fig 4-103.

In the above cases, where facial asymmetry involves three dimensions, the transverse cant

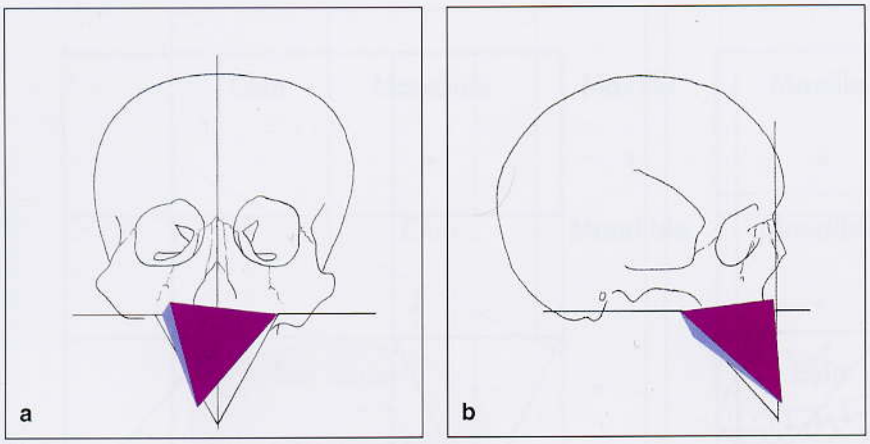


Fig 4-102 Unilateral increase in the height of the left mandibular ramus (eg, condylar hyperplasia) will be followed by the left posterior maxilla. A cant of the base of the "prism" will develop (more posterior than anterior), and the apex of the prism will rotate forward and toward the right. *(a)* Frontal view. *(b)* Lateral view.

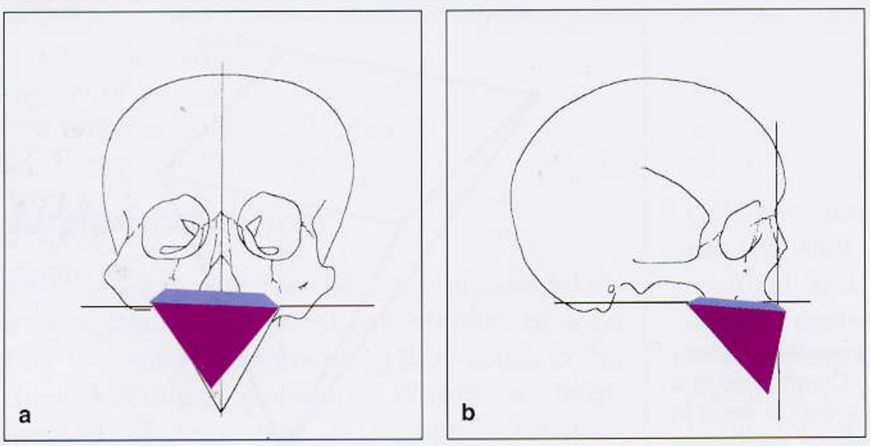


Fig 4-103 Unilateral lack of vertical development of the right mandible will inhibit vertical growth of the right posterior maxilla. The base of the "prism" will cant (more posterior than anterior), and the apex of the prism will rotate backward and toward the right. *(a)* Frontal view. *(b)* Lateral view.

of the occlusal plane obviously differs from anterior to posterior. Three-dimensional deformities can be best assessed by combining the data from the lateral, basal, and anteroposterior cephalometric radiographs with articulated dental casts (recorded with a facebow and articulated on an adjustable articulator) and clinical observations. As in the correction of other dentofacial deformities, the anteroposterior vertical and transverse positions of the maxillary incisors play an extremely important role in the final treatment planning (see chapter 2).

Neither presurgical nor postsurgical orthodontic treatment differs significantly from the orthodontic treatment in other dentofacial deformities. However, the clinician should consider the following guidelines for presurgical orthodontic treatment in cases with facial asymmetry:

- As in the previously discussed cases of dentofacial deformities, the dentition should not be orthodontically compensated for skeletal disharmony.
- An existing cant of the occlusal plane should not be corrected. The dental arch, however, should be leveled, and the orthodontist should ensure that the apical base midline and incisor midlines follow the cant.
- When skeletal asymmetry exists, the dental midlines should not be made to coincide but rather positioned in the midline of each jaw.
- Where facial asymmetry will be corrected by single-jaw surgery, the dental midline of the

unoperated jaw should coincide with the facial midline.

- In cases of hemifacial microsomia and temporomandibular joint ankylosis where a unilateral open bite is created after increasing the ramus height, the height should be maintained while allowing the vertical alveolar growth of the maxilla.

Asymmetry in the adolescent

The two major causes of severe facial asymmetry in children are hemifacial microsomia and early trauma to the mandibular condyle. Both conditions primarily affect the mandible and lead to deficient growth on the affected side. The maxilla is affected secondarily by the inhibition of vertical growth of the alveolar process on the affected side. The basic difference between the two conditions is that in hemifacial microsomia, missing soft and hard tissue structures may affect the growth potential, while in ankylosis, all structures are present but underdeveloped because of the lack of function. The basic principle in treating these conditions is to restore and maximize the expression of growth so that the development of both hard and soft tissue structures can be as normal as possible.

Hemifacial microsomia

The severity of this deformity varies widely. Both jaws and soft tissue in all three dimensions may be underdeveloped or missing. The surgical treatment can be divided into three stages.

First stage of surgery (5 to 7 years old)
In cases where the condyle is present but underdeveloped, it is better to accept the articulation regardless of the morphology. Distraction osteogenesis may be considered in these patients. When the proximal part of the mandible is missing, the missing elements should be reconstructed at this stage. To correct the vertical and anteroposterior dimension, the condyle can be reconstructed by a costochondral graft; this will create a unilateral open bite. Functional therapy after surgery is mandatory for these patients to stimulate jaw function and soft tissue development, as well as to minimize maxillary canting.

Second stage of surgery (14 to 16 years old)
Orthognathic surgery is performed for the final correction of the occlusion and skeletal asymmetry.

Third stage of surgery (late teens)
Final soft tissue procedures establish soft tissue symmetry.

Temporomandibular joint ankylosis

The ability to move the mandible forward and toward the affected side indicates how successful the treatment will be and whether surgery should be performed early or not. If the patient cannot move the mandible to a position where the dental midlines coincide, functional therapy alone will not result in growth modification. Early surgery that releases the ankylosis, followed by active functional therapy, is indicated for these patients. Surgical release should include removal of all soft and hard tissue (including the coronoid process), as well as mandible release. This may be technically difficult. It is futile to perform the above procedure without physical therapy to maintain the mouth opening obtained at surgery; either the joint will reankylose or soft tissue scarring will limit mouth opening. The surgical treatment for patients with ankylosis can be performed in two stages.

First stage of surgery (5 to 7 years old)
The first stage is surgical release of the ankylosis, followed by long-term physical therapy. A costochondral graft may be indicated to reconstruct the temporomandibular joint and correct the vertical and anteroposterior dimensions of the mandible on the affected side. This will create an open bite, which will allow vertical maxillary growth under orthodontic control.

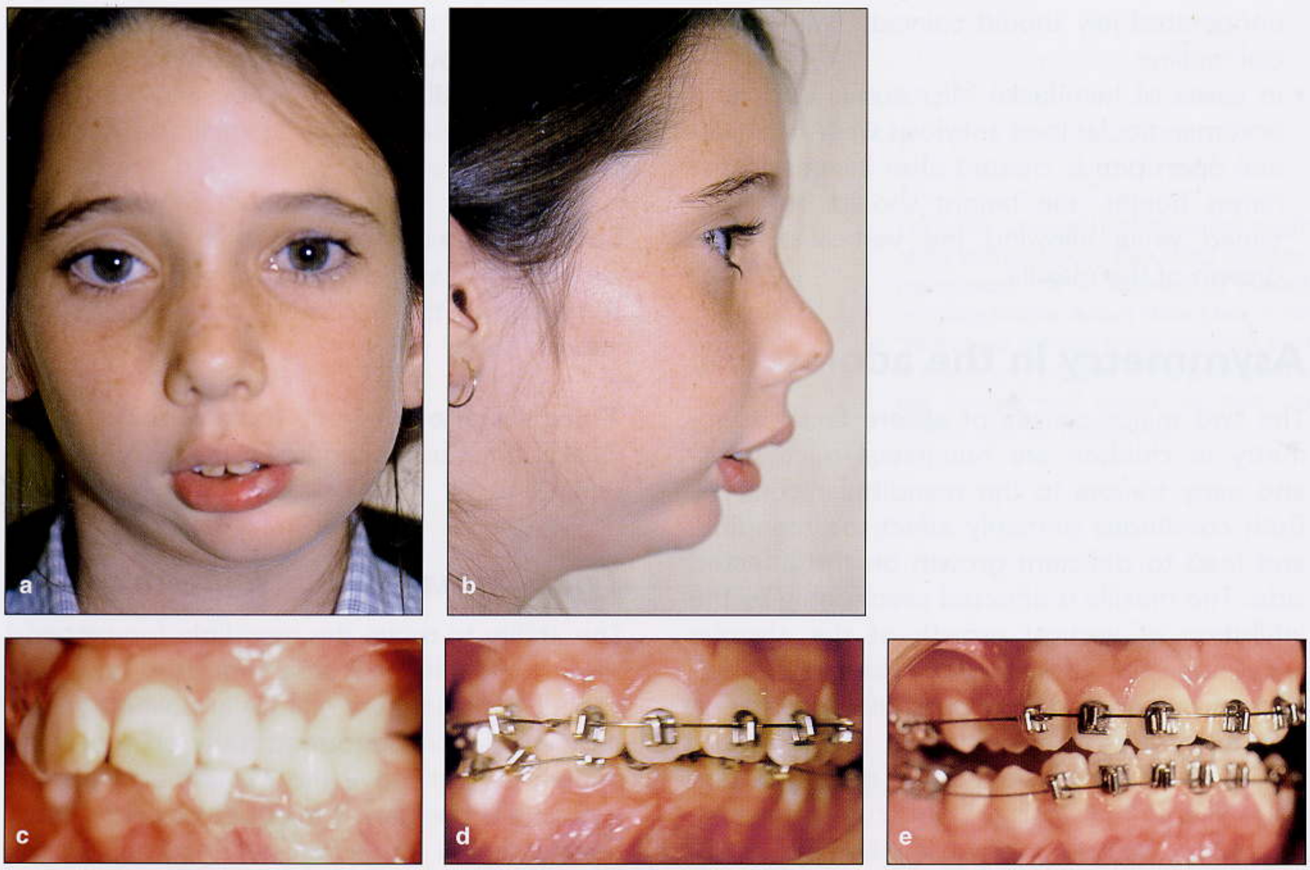


Fig 4-104 Case R.C. Pretreatment frontal view *(a)*, profile view *(b)*, and right side of the occlusion *(c)*. The presurgical occlusion *(d)* and maximal mouth opening before surgery *(e)* also are shown.

Second stage of surgery (14 to 16 years old)
The second surgical stage involves the final correction of facial asymmetry and occlusal cants by means of orthognathic surgery.

Case R.C.

Case R.C. was a patient who developed ankylosis of her temporomandibular joint after trauma to her chin at 3 years of age. When her orthodontist saw her at the age of 6, she had a severe malocclusion and a maximum mouth opening of 1 mm. Her parents recalled that she had fallen on her chin in a park when she was 3 years old. Although she experienced some pain at the time, she recovered uneventfully.

Main complaint
The patient's main concerns were limited mouth opening, an inability to eat properly, and a "crooked" face.

Medical history
The patient's medical history was noncontributory.

Clinical examination

1. Soft tissue
   a. Frontal view (Fig 4-104a)
      - Severe asymmetry of the mandible toward the left side
      - Everted lower lip
      - Flat appearance of the right side of the chin and mandible

   - Excessively rounded appearance of the left side of the mandible
 b. Profile view (Fig 4-104b)
   - Mandibular anteroposterior deficiency
   - Microgenia
   - Everted lower lip
   - Increased interlabial gap
2. Dental (Figs 4-104c and 4-104d)
   - Class II malocclusion, more on the left side
   - Increased overjet
   - Crowding in the maxillary and mandibular arches
   - Mandibular dental midline toward the left
   - Maximal mouth opening of 1 mm (Fig 4-104e)
3. Skeletal
   - Mandibular anteroposterior deficiency
   - Microgenia
   - Mandibular asymmetry toward the left
   - Ankylosis of the left temporomandibular joint
4. Radiographic
 a. Panoramic radiograph (Fig 4-105a)
   - A large, bony mass in the left temporomandibular joint area
   - An elongated coronoid process
 b. Lateral cephalometric (Fig 4-105b)
   - Severe mandibular anteroposterior deficiency
 c. Anteroposterior cephalometric (Fig 4-105c)
   - Severe asymmetry of the mandible toward the left
   - Transverse cant of the occlusal plane

Problem list

1. Ankylosis of the left temporomandibular joint
2. Deficiency of the left side of the mandible
3. Mouth opening of 1 mm
4. Slight cant in the maxillary occlusal plane due to deficient vertical growth of the maxilla on the left
5. Class II malocclusion

Treatment plan

1. Surgical removal of bony ankylosis and creation of an articular fossa (Figs 4-106a and 4-106b)
2. Surgical removal of scar tissue that may inhibit normal mouth opening
3. Coronoidectomy of the left coronoid process (see Figs 4-106a and 4-106b)
4. Harvesting of a costochondral graft from the left eighth rib
5. Placement of a costochondral graft to reconstruct the left temporomandibular joint (Figs 4-106c and 4-106d)
6. Physical therapy to maintain the mouth opening achieved at surgery and establish function to encourage growth of the deficient hard and soft tissues
7. Continuation of the orthodontic treatment to establish normal occlusion

Presurgical orthodontics

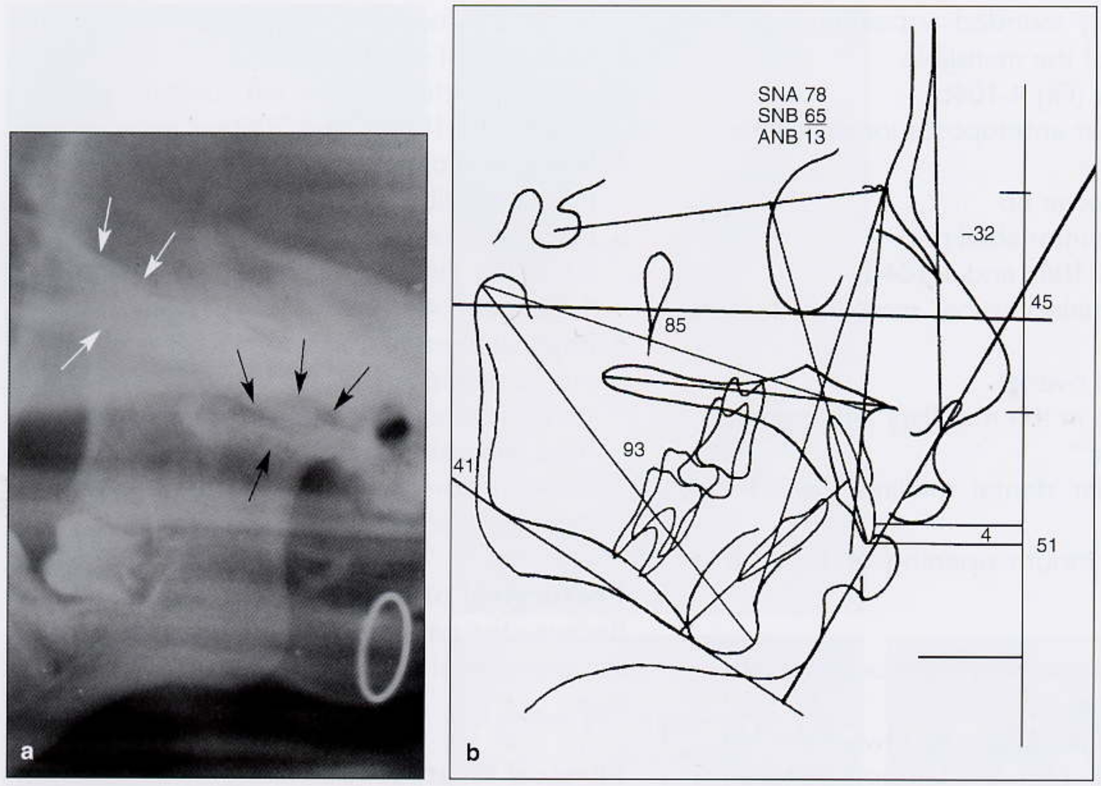
Because the patient could not open her mouth, the presurgical orthodontic treatment was limited.

Surgical treatment

- The left temporomandibular joint was reconstructed by means of a costochondral graft, and a mouth opening of 35 mm was achieved at surgery.
- A gap was created between the maxillary and mandibular teeth on the left and was maintained by means of a splint (Figs 4-107a and 4-107b).
- A coronoidectomy was performed on the left side.
- The patient followed an active physical therapy program, assisted by a mouth-opening appliance placed at the time of surgery. Excellent patient cooperation led to a mouth opening of 33 mm after 1 year.

Postsurgical orthodontics

Postsurgical orthodontic treatment began only 6 months after surgery and was completed after 15 months. The postsurgical growth of the hard and soft tissue on the affected side and the final mouth opening are evident in Fig 4-108. It is again important to stress that the success of surgical treatment of temporomandibular ankylosis is dependent on diligent postsurgical physical therapy.



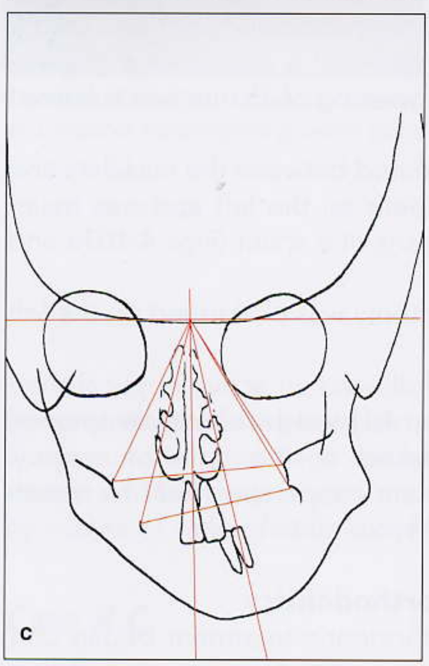
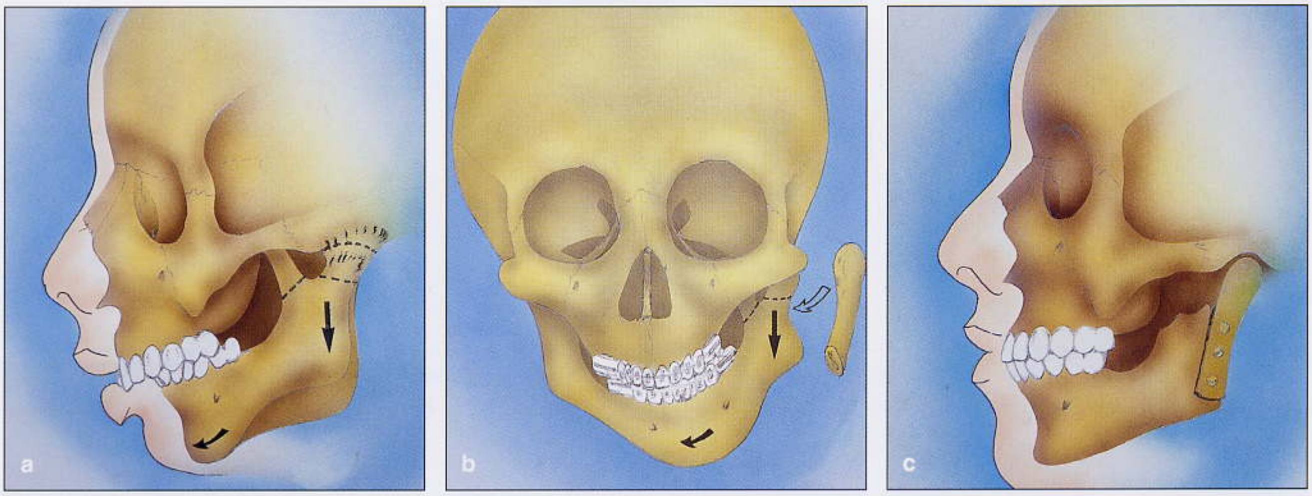


Fig 4-105 Case R.C. *(a)* Left side of the panoramic radiograph. The large bony mass obliterating the left temporomandibular joint *(black arrows)* and the elongated coronoid process *(white arrows)* are clearly visible. *(b)* The pretreatment lateral cephalometric tracing illustrating anteroposterior deficiency: SNB = 65 degrees, ANB = 13 degrees; convex profile: facial contour angle = −32 degrees; and the vertical difference of the left and right lower border of the mandible. *(c)* The presurgical anteroposterior cephalometric tracing clearly illustrates the severe asymmetry of the mandible. The transverse cant of the maxillary occlusion is only slightly affected at this stage and would probably respond favorably to functional correction of the mandible.



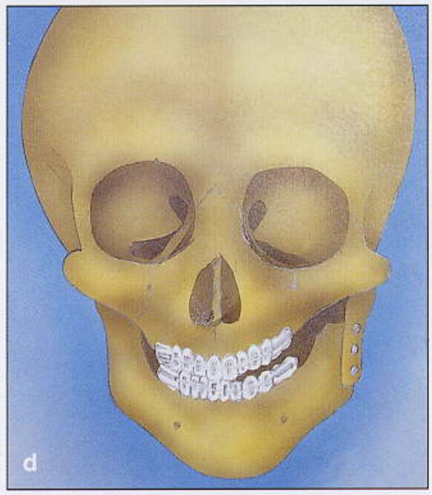


Fig 4-106 Case R.C. The extent of the joint surgery and coronoidectomy, as well as the surgical repositioning of the left side of the mandible, is indicated from a lateral view *(a)* and a frontal view *(b)*. Also depicted are the costochondral graft and mandibular position after surgery: lateral view *(c)* and frontal view *(d)*.

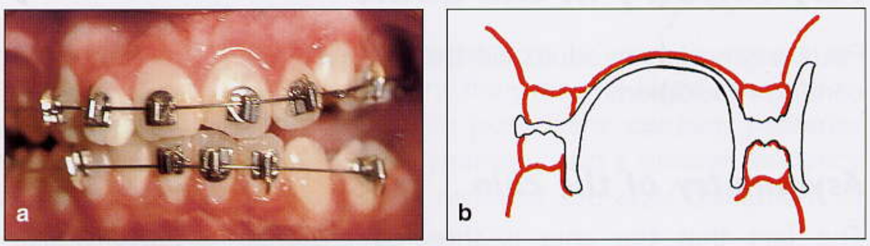


Fig 4-107 Case R.C. *(a)* The lateral open bite on the left was created by elongation of the left mandibular ramus by the rib graft. *(b)* The height of the left ramus is maintained by an acrylic splint placed at surgery.

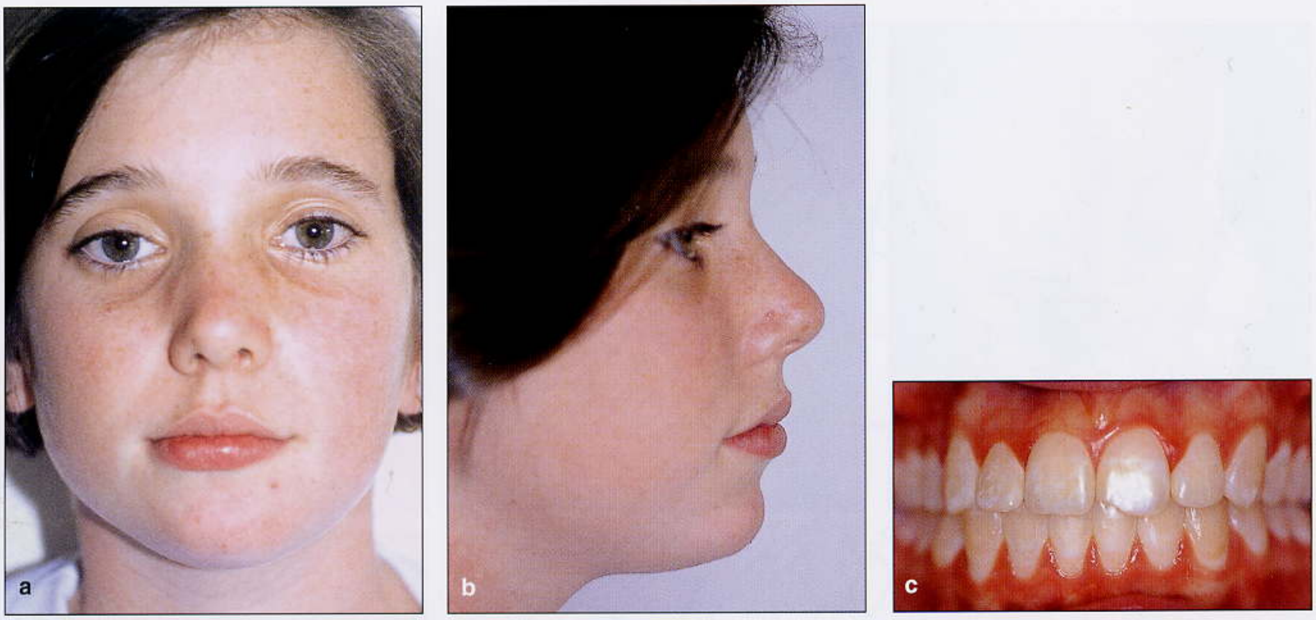
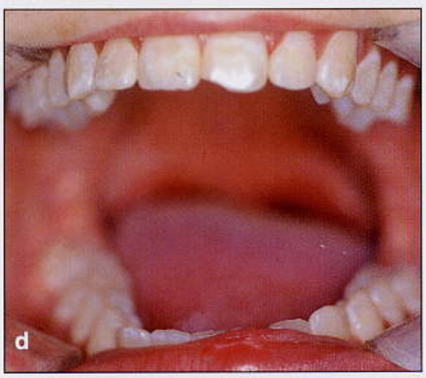



Fig 4-108 Case R.C. Postsurgical frontal view *(a)* and profile view *(b)* demonstrate the soft and hard tissue response to normal jaw function. The postsurgical occlusion *(c)* and mouth opening of 33 mm *(d)* are shown 2 years after surgery.

Asymmetry in the adult

Facial asymmetry in adults will be discussed according to location.

Asymmetry of the chin

The fact that the chin is three-dimensional should always be considered during assessment and correction of the chin asymmetry.

Transverse asymmetry

Transverse asymmetry of the chin is corrected by a sliding genioplasty that repositions the chin toward the left or right side (Fig 4-109a).

Cant of the lower border of the chin

A cant of the lower border of the chin is corrected by vertical change at the osteotomy site. The vertical height can be unilaterally reduced or increased by either downgrafting one side or performing an ostectomy on the other (Fig 4-109b). An alternative is a propeller osteotomy (see chapter 5).

Anteroposterior asymmetry

Anteroposterior asymmetry can be corrected by differential anterior or posterior repositioning of the chin (Fig 4-109c).

Case O.A. demonstrates the correction of asymmetry of the chin in a transverse and vertical dimension (Fig 4-110).

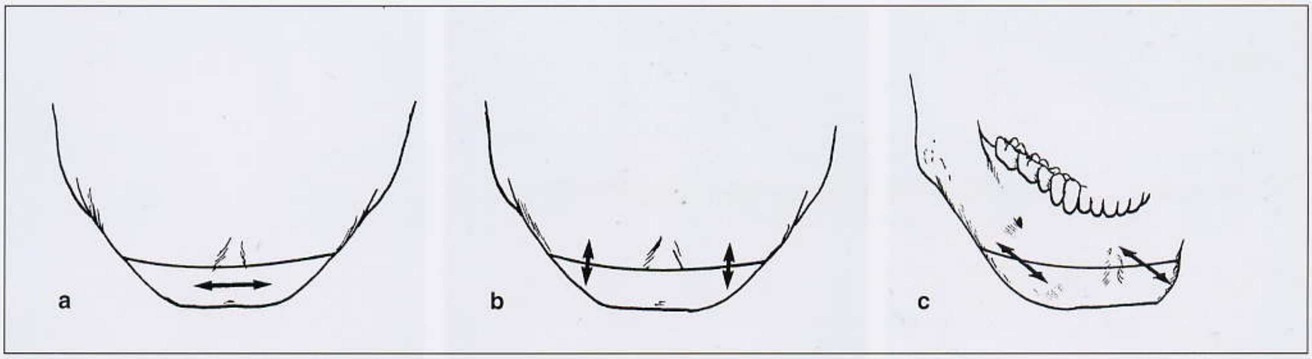


Fig 4-109 *(a)* Left or right sliding genioplasty for correction of transverse asymmetry of the chin. *(b)* Vertical reduction or downgraft of the chin to correct an asymmetrical cant of the lower border. *(c)* Differential anterior or posterior repositioning of the chin to correct anteroposterior asymmetries.

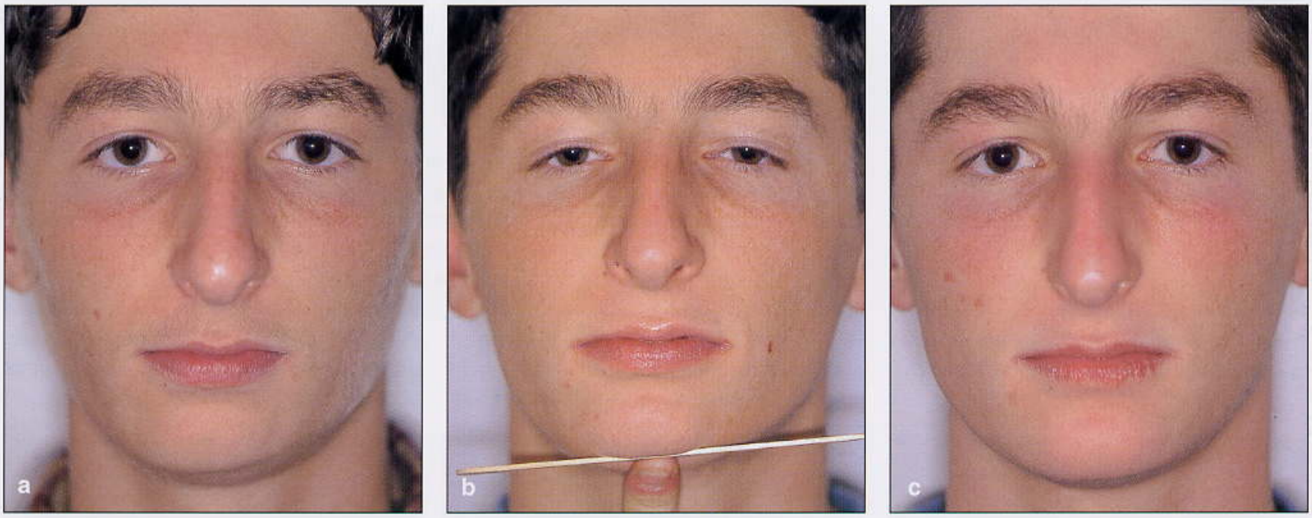


Fig 4-110 Case O.A. The transverse asymmetry of the chin toward the right *(a)* and the cant of the lower border of the chin *(b)* are evident. *(c)* A symmetrical chin has been established by means of a genioplasty, sliding the chin toward the left side and downgrafting it on the left.

Asymmetry of the mandible

Most patients with mandibular anteroposterior excess have some form of asymmetry. Facial asymmetry caused by mandibular asymmetry can be corrected by surgical repositioning of the mandible. It is important that the orthodontist position the lower incisors in the middle of the chin so that when the dental midlines are corrected, the middle of the chin is in the facial midline. The bilateral split ramus osteotomy is the procedure of choice for small corrections, whereas bilateral vertical osteotomies of the mandibular ramus are indicated for the correction of large asymmetries. When a bilateral sagittal split osteotomy is used to correct severe asymmetry, the proximal segments tend to flare, leading to poor bone contact, posterior mandibular asymmetry, and a greater tendency for peripheral condylar sag after placement of internal rigid fixation.

Case P.H. illustrates the correction of mandibular asymmetry. The mandible was asymmetrical toward the right, and there was mandibular anteroposterior excess (Fig 4-111). No attempt was made to correct the dental midlines during the preorthodontic preparation. The mandibular dental midline was positioned in the midline of the chin, while the maxillary incisor midline was positioned in the midline of

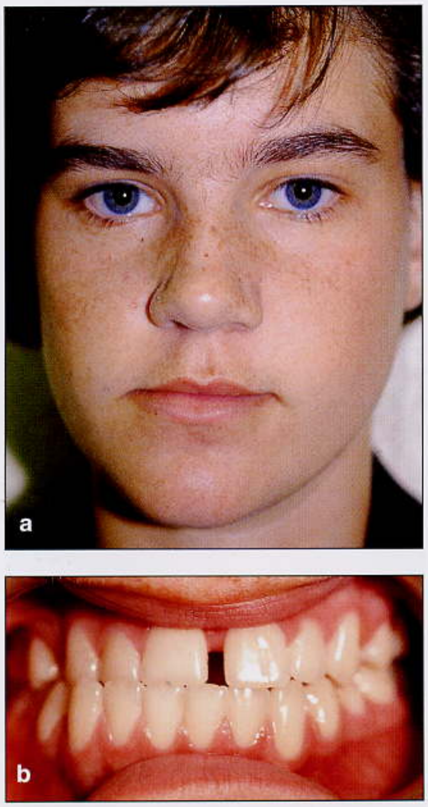


Fig 4-111 Case P.H. Facial asymmetry *(a)* and asymmetrical Class III malocclusion *(b)*.

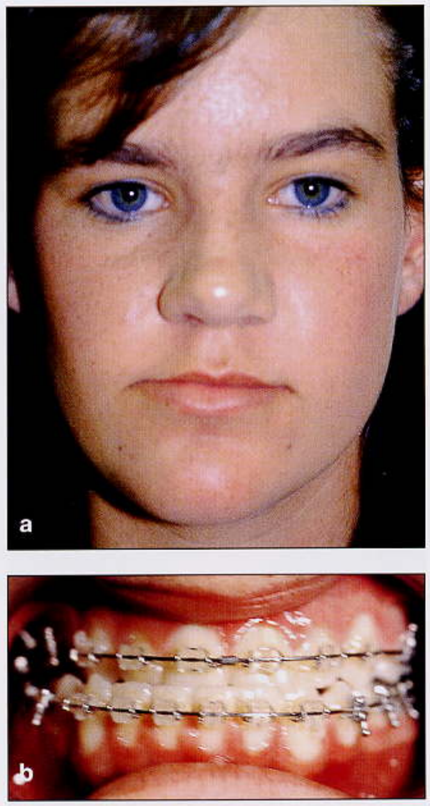


Fig 4-112 Case P.H. Slight worsening of the facial symmetry *(a)* and dental asymmetry after presurgical orthodontic treatment *(b)*.

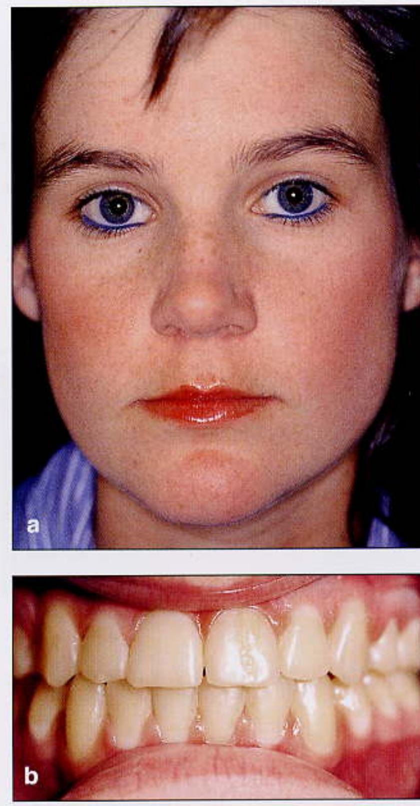


Fig 4-113 Case P.H. Posttreatment results are demonstrated in frontal view *(a)* and occlusion *(b)* 2 years after debanding.

the face (Fig 4-112). Facial and dental symmetry were established by a bilateral sagittal split ramus osteotomy. The treatment results 2 years after debanding are seen in Fig 4-113.

Asymmetry of the mandible and chin

Mandibular asymmetry often occurs in combination with chin asymmetry. When both kinds of asymmetry are present, the dental midline does not coincide with the midline of the chin. After surgical correction of the mandibular asymmetry with correction of the dental midline, additional correction of the chin midline will be necessary. Accurate presurgical assessment of dental and chin midlines in relation to the facial midline is essential. When facial asymmetry will be corrected by mandibular surgery, the orthodontist must ensure that the maxillary dental midline is corrected orthodontically before surgery.

Correction of a combination of mandibular and chin asymmetry is demonstrated in Case P.C. The patient's mandible was asymmetrical toward the right and anteroposteriorly deficient with a Class II malocclusion (more on the right side than the left side). The mandibular dental midline was 4 mm to the right of the maxillary incisor midline (facial midline); however, the midline of the chin was 11 mm to the right of the facial midline. There was a slight transverse cant in the maxillary occlusal plane, but it was not clinically significant (Fig 4-114). The mandibular asymmetry was corrected by a bilateral sagittal split ramus osteotomy, advancing the mandible and rotating it toward the left to correct the dental midlines. Final facial symmetry was established by a genioplasty, which slid the chin to the left, downgrafted it on the right, and reduced the chin height on the left. The treatment results are illustrated in Fig 4-115.

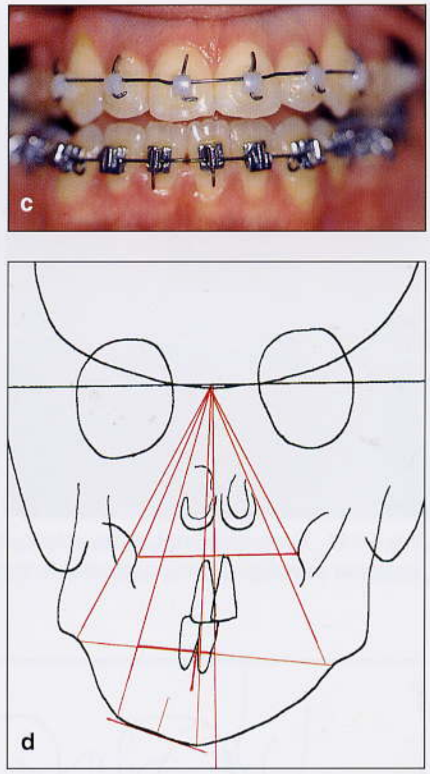


Fig 4-114 Case P.C. *(a)* Frontal view, in which the asymmetry of the mandible and chin are clearly visible. *(b)* Mandibular anteroposterior deficiency and microgenia. *(c)* Presurgical occlusion. *(d)* Anteroposterior cephalometric tracing showing that the facial midline and maxillary dental midline coincide, while the mandibular midline is displaced toward the right and the chin midline even further toward the right.

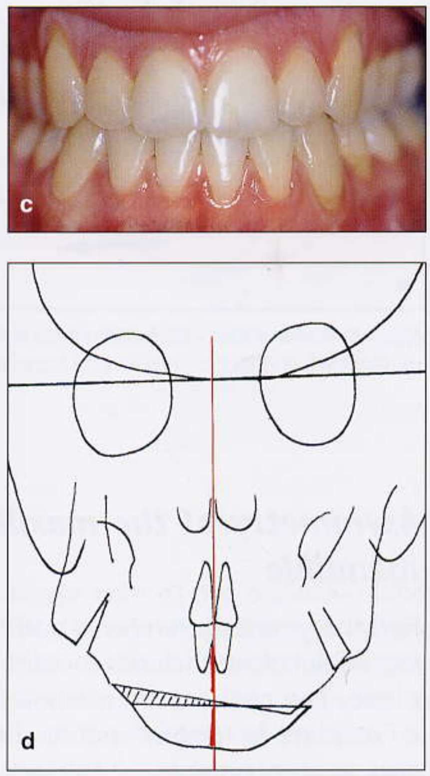


Fig 4-115 Case P.C. Posttreatment frontal view *(a)*, profile view *(b)*, occlusion *(c)*, and anteroposterior cephalometric tracing illustrating the surgical correction *(d)*.

Fig 4-116 Transverse cant of the anterior maxillary occlusal plane *(a)*, the lower border of the chin *(b)*, and the lower borders of the posterior mandible *(c)* are illustrated using a tongue spatula.

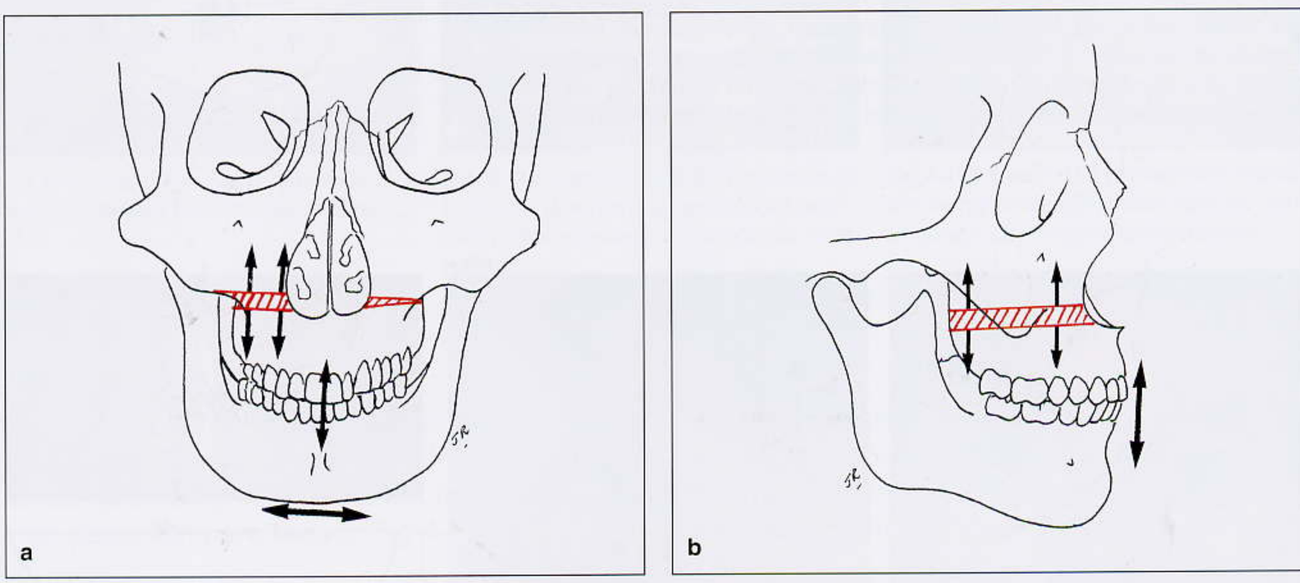


Fig 4-117 Correction of the cant of the occlusal plane in cases where the anterior and posterior cants are the same will involve two dimensions of change, vertical and transverse, as indicated by the *arrows* on the frontal view *(a)* and lateral view *(b)*.

Asymmetry of the maxilla and mandible

Facial asymmetry involving both the maxilla and mandible often includes a cant in the occlusal plane. The cant can be assessed clinically using a Fox plate or tongue spatula. Both the anterior and posterior cants of the occlusal plane, as well as the lower border of the mandible, should always be evaluated and noted (Fig 4-116). The cant in the occlusal plane of the maxilla is most easily and accurately evaluated on casts articulated on an adjustable articulator from a face-bow recording.

In cases where the anterior and posterior cants are equal, the correction involves two dimensions, transverse and vertical (Fig 4-117). The maxillary incisor–lip relationship is very important in the correction of the occlusal cant of the maxilla (see chapter 3).

Fig 4-118 The cant of the occlusal plane is demonstrated by the tongue spatula *(a)*, while the facial asymmetry involving the maxilla and mandible is seen in *(b)*. The postsurgical result after correction of the occlusal cant by means of a Le Fort I maxillary osteotomy and bilateral sagittal split ramus osteotomy is seen in *(c)*.

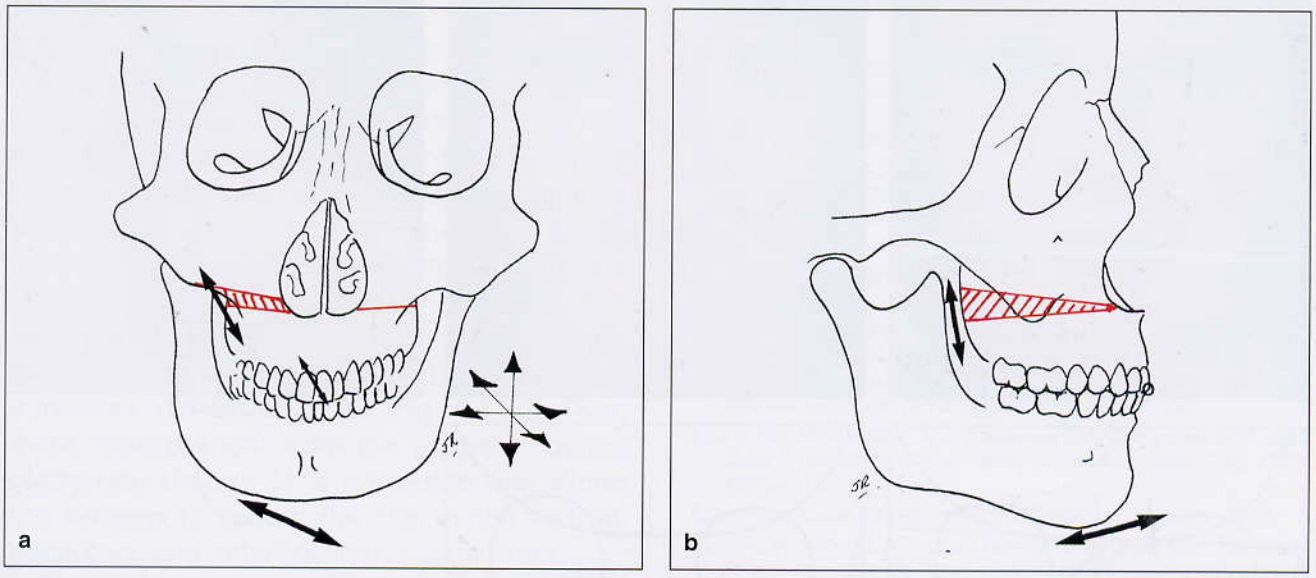


Fig 4-119 The three-dimensional changes are indicated by the *arrows* following correction of the different cants in the anterior and posterior maxilla. *(a)* Frontal view. *(b)* Lateral view.

When surgery will involve both jaws, the orthodontist should not waste treatment time by correcting the dental midlines, which can be corrected surgically. Arch form, however, should be maintained to accommodate the rotational movement during the correction of dental midlines.

An example of facial asymmetry involving the maxilla and mandible is illustrated in Fig 4-118. There is a transverse cant of the occlusal plane, and the mandible is asymmetrical toward the left. The patient has a Class I malocclusion, and the dental midlines coincide. The mandibular dental midline is in the middle of the chin. By correcting the occlusal cant (and, at the same time, the maxillary incisor–lip relationship), facial symmetry is restored (Fig 4-119).

Fig 4-120 The presurgical cant of the occlusal plane is illustrated by the tongue spatula *(a)*, while the presurgical transverse, vertical, and anteroposterior dimensions are demonstrated in frontal *(b)* and profile *(c)* views. The correction of facial asymmetry in all three dimensions is illustrated in frontal *(d and e)* and profile *(f)* views. *(g)* Presurgical anteroposterior cephalometric tracing. *(h)* Surgical correction.

Difference in anterior and posterior occlusal cants

A dual cant of the occlusal plane almost always results from unilateral excessive or deficient growth of the mandibular ramus—eg, patients with unilateral condylar hyperplasia or unilateral hypoplasia (hemifacial microsomia or temporomandibular ankylosis). The unilateral increase in, or lack of vertical growth of, the mandibular ramus secondarily influences the vertical growth of the maxilla and leads to a cant in the occlusal plane. The cant is more severe in the posterior than in the anterior maxilla, necessitating three-dimensional correction.

Asymmetry of the maxilla, mandible, and chin

When the maxilla, mandible, and chin are all involved in the facial asymmetry, three-dimensional correction is usually needed. Correction of the transverse cant of the maxillary occlusal plane will be more challenging than in cases where the anterior and posterior cants are equal. The posterior vertical change will differ on the right and left sides, as well as in the anterior maxilla. This correction will eventually have a profound effect on the chin in the anteroposterior, vertical, and transverse dimensions (see Fig 4-119). Thus, these cases benefit from the propeller genioplasty (see chapter 5), a procedure that allows the surgeon to control the chin in the vertical, transverse, and anteroposterior dimensions.

The patient shown in Fig 4-120 had unilateral condylar hyperplasia on the right side. The asymmetry involved the maxilla, mandible, and chin. Surgical correction included the correction of the occlusal cant with a Le Fort I maxillary osteotomy. This change in the cant was followed by a bilateral sagittal split ramus osteotomy in the mandible. A propeller genioplasty was performed to establish final chin symmetry. Better symmetry of the lower border of the posterior mandible was achieved with an ostectomy of the lower border of the right side of the mandible (after repositioning the inferior alveolar nerve) and the use of part of the ostectomized bone as a graft on the lateral side of the left mandibular body.

Asymmetry of the zygoma, nose, and frontal areas

The zygoma, nose, and frontal areas play an important role in the overall symmetry of the face and should be assessed carefully during the clinical examination. Correction of asymmetry in these areas should be an integral part of the correction of the total treatment of facial asymmetry; however, the treatment is outside the scope of this text.

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chapter 5

Surgical Technique

Our knowledge and understanding of all aspects of orthognathic surgery have grown considerably during the past two decades. Diagnostic skills and treatment planning have become more sophisticated, and we have developed surgical techniques that enable us to treat most complex jaw deformities with confidence. This chapter presents surgical techniques for the three procedures most often used in the correction of dentofacial deformities in a concise, step-by-step format. Complications and their possible solutions are included.

Orthognathic surgery requires not only sophisticated and accurate technique but also the utmost respect for the hard and soft tissues involved. The formulation of a treatment plan involving accurate tooth movement by the orthodontist does no good if what follows is inaccurate surgery, sloppy technique, and disregard for soft tissue that lead to unsatisfactory results.

Good surgical technique involves the following:

1. *Treatment planning*. Before surgery, accurate and comprehensive surgical treatment planning involving cephalometric treatment objectives and model surgery should be carried out.
2. *Surgical routine*. As much as possible, the surgeon should develop a routine for each procedure that will enable assistants and the rest of the surgical team to anticipate each step, thus increasing efficiency and decreasing operating time. The surgeon should clearly understand the surgical steps of each procedure and be aware of complications that may arise with each step. It is essential to have a basic routine, from the selection of scalpel blades to suture material. An established step-by-step operating technique also prevents intraoperative uncertainty and often eliminates postoperative complications. The details and sequence of a surgical procedure may vary from surgeon to surgeon, but the ultimate objective is the same. The surgeon must be able to clearly visualize every step, as well as the sequence of the surgical procedure, in order to operate with confidence and achieve the surgical goal and optimal results.
3. *Instrumentation*. A large number of instruments are available to help the surgeon achieve the same goals. When the surgeon uses a small, select group of instruments rather than a whole range of instruments, however, it is less confusing to both the surgeon and the surgical team.

Bilateral Split Ramus Osteotomy

The first report of surgical repositioning of the mandible was written by V. P. Blair and published in an American medical journal, *Surgery, Gynecology and Obstetrics*, in July 1907. Since then, the surgical correction of dentofacial deformities has developed into not only a well-defined science but also a fascinating art form.

The development of surgical repositioning of the mandible includes ingenious work by surgeons such as New and Erich; Dingman; and Burch, Bowden, and Woodward, who described body osteotomy procedures. Procedures to reposition the mandible using various ramus osteotomies were described by Caldwell and Letterman, Hinds and Girotti, and Robinson. In 1955, Obwegeser and Trauner described a surgical procedure involving a sagittal split osteotomy through the ramus of the mandible. This technique was later modified by Dal Pont and further refined by Epker in 1977.

The surgical repositioning of the mandible has developed from a life-threatening procedure to outpatient surgery (in some parts of the world). The ingenuity of the procedures, development of special instruments, and improvement of surgical skills have made it possible to achieve our surgical goals relatively quickly and atraumatically. The advent of rigid fixation has also made postoperative recovery safer and more comfortable. The technique described in the following text has evolved over many years and, because of its simplicity, has been found beneficial in the training of postgraduate students at the University of Witwatersrand, in Johannesburg, South Africa.

Step 1: Infiltration of soft tissue with a vasoconstrictor

Infiltrate the area of dissection with a local anesthetic containing a vasoconstrictor (epinephrine in a concentration of 1:100,000) 10 minutes before surgery. Place the needle deep in the soft tissue, aspirate, and infiltrate the area.

The patient's lips should be kept lubricated with steroid ointment throughout the surgical procedure.

Step 2: Soft tissue incision

Make an incision through mucosa, muscle, and periosteum from just lingual of the external oblique ridge halfway up the mandibular ramus superiorly to mesial of the second molar inferiorly (Fig 5-1). Leave at least 5 mm of nonkeratinized mucosa buccally at the lower end of the incision for ease of suturing later.

Third molars ideally should be removed 6 months before surgery. A partially erupted or erupted third molar present at the time of surgery, however, should be included in the soft tissue incision. The early removal of impacted third molars should be part of the treatment plan. If these teeth are still present at the completion of the preoperative orthodontic phase, the surgeon can either remove the impacted teeth at this stage and delay definitive surgery for at least 6 months to allow for bone healing or go ahead with the definitive treatment and deal with the third molars at the time of surgery.

Step 3: Buccal subperiosteal dissection

The dissection must remain subperiosteal, decisive, clean, and neat. The masseter muscle attachment should be maintained as far as possible without sacrificing adequate exposure. Strip enough of the masseter muscle to allow easy visualization of the osteotomy area. It is not necessary, however, to strip the entire masseter muscle attachment off the mandible. The proximal segments of the mandible will not be repositioned; in fact, it is important that apart from autorotation, this segment be maintained in its original position and not be totally detached from the masseter muscle. Total stripping of the muscle increases dead space, which encourages swelling and hematoma formation and may cause devascularization of part of the bone, leading to necrosis.

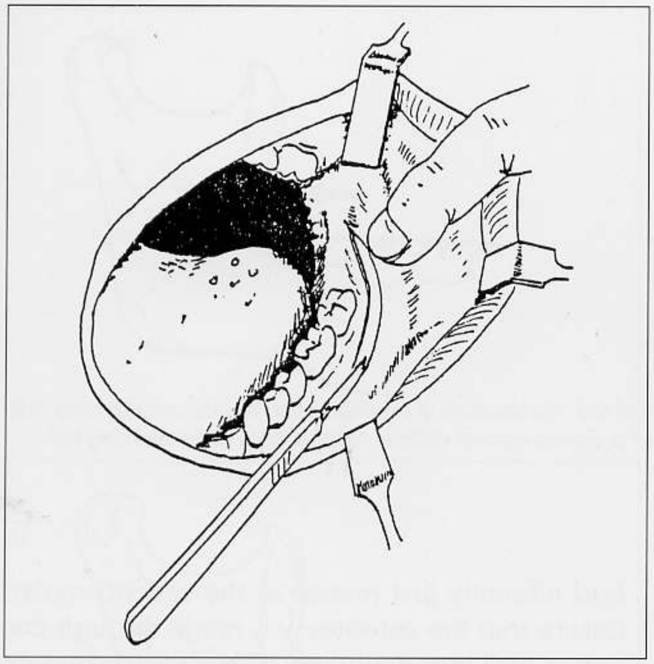


Fig 5-1 The soft tissue incision is made from just lingual of the external oblique ridge above to mesial of the second molar below. At least 5 mm of nonkeratinized mucosa is left buccally for ease of suturing.

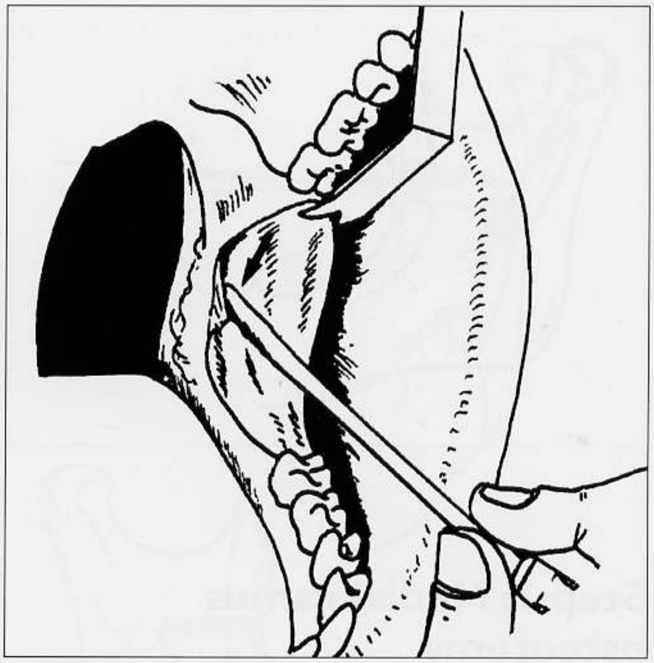


Fig 5-2 Subperiosteal dissection is carried posteriorly to identify the lingula. Start from above and dissect downward. The panoramic radiograph may be helpful in determining the relative position of the lingula.

Step 4: Superior subperiosteal dissection

Once the buccal and lingual sides of the anterior ramus have been exposed, place a notched ramus retractor over the anterior border of the mandibular ramus, and strip the lower fibers of the temporalis muscle attachment from the anterior border and coronoid process. Alternatively, a coronoid clamp may be used to retract the soft tissue superiorly. Dissect the periosteum from the internal oblique ridge down to the medial aspect of the retromolar area.

Step 5: Medial subperiosteal dissection and exposure of the lingula

The dissection must remain subperiosteal by keeping the periosteal dissector against the bone at all times. Start the dissection from the internal oblique ridge above, and then dissect inferiorly to the region of the lingula (Fig 5-2). The lingula must be carefully identified and well visualized (see Step 6).

Step 6: Identification of the lingula

The medial osteotomy should never be performed without positive identification of the lingula. The panoramic radiograph may be a helpful guide. However, the lingula is often difficult to visualize because of the convexity of the internal oblique ridge. If visualization is difficult, the ridge should be reduced with a large trimming bur (Fig 5-3). If the periosteum is perforated, a brisk hemorrhage may result and probably will originate from the vessels of the medial pterygoid muscle; however, it often subsides spontaneously. Do not stretch the inferior alveolar nerve at its entrance to the foramen, since this may result in prolonged anesthesia of the lower lip.

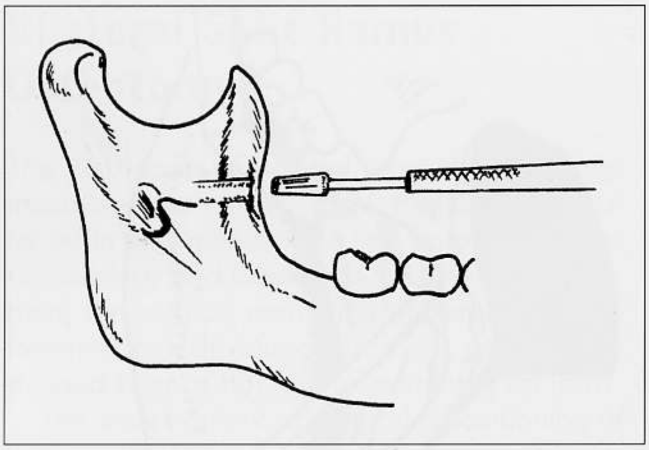


Fig 5-3 Visualization of the lingula can be improved by reduction of a convex internal oblique ridge using a large trimming bur.

Step 7: Medial ramus osteotomy

While aiming at the notch of the lingula, angle the medial ramus osteotomy parallel to the occlusal plane (Fig 5-4a) using a 701 fissure bur or a Lindeman bur. Terminate the osteotomy just posterior to the lingula (see Fig 5-4a), and ensure that the osteotomy is carried through the lingual cortex into the medullary bone of the mandibular ramus. When mandibular setback procedures will be performed, a small segment of bone should be removed superior to the horizontal osteotomy line (Fig 5-4b).

When the medial ramus osteotomy is terminated anterior to the lingula, the bone tends to split anterior to the lingula. The lingula and superior part of the alveolar canal (including the nerve) thus remain attached to the proximal segment during the splitting procedure (Fig 5-4c). This is one of the most common reasons surgeons have difficulty splitting at the superior aspect of the sagittal split osteotomy.

Step 8: Vertical section of the osteotomy

Start the vertical section of the osteotomy from the medial osteotomy superiorly, staying just inside the buccal cortex of the mandibular ramus. End inferiorly just mesial to the second molar. Ensure that the osteotomy is made through the cortex well into medullary bone (approximately 5 mm). The presence of an impacted third molar may make the osteotomy difficult. It should be treated as bone, however, and the osteotomy made through the tooth. Ideally, third molars should be removed at least 6 months before surgery.

Step 9: Removing the notched ramus retractor and placing a channel retractor

Place the channel retractor around the inferior border of the mandible. Remain subperiosteal at all times. Visibility may be increased by removing the mouth prop and closing the mandible slightly.

Step 10: Buccal osteotomy of the mandibular body

Start the buccal osteotomy of the mandibular body at the lower border, and join it superiorly with the vertical part of the ramus osteotomy (Fig 5-5a). Cut toward the mandible, "feel" the bur perforate the buccal cortex, and angle the osteotomy slightly obliquely and posteriorly

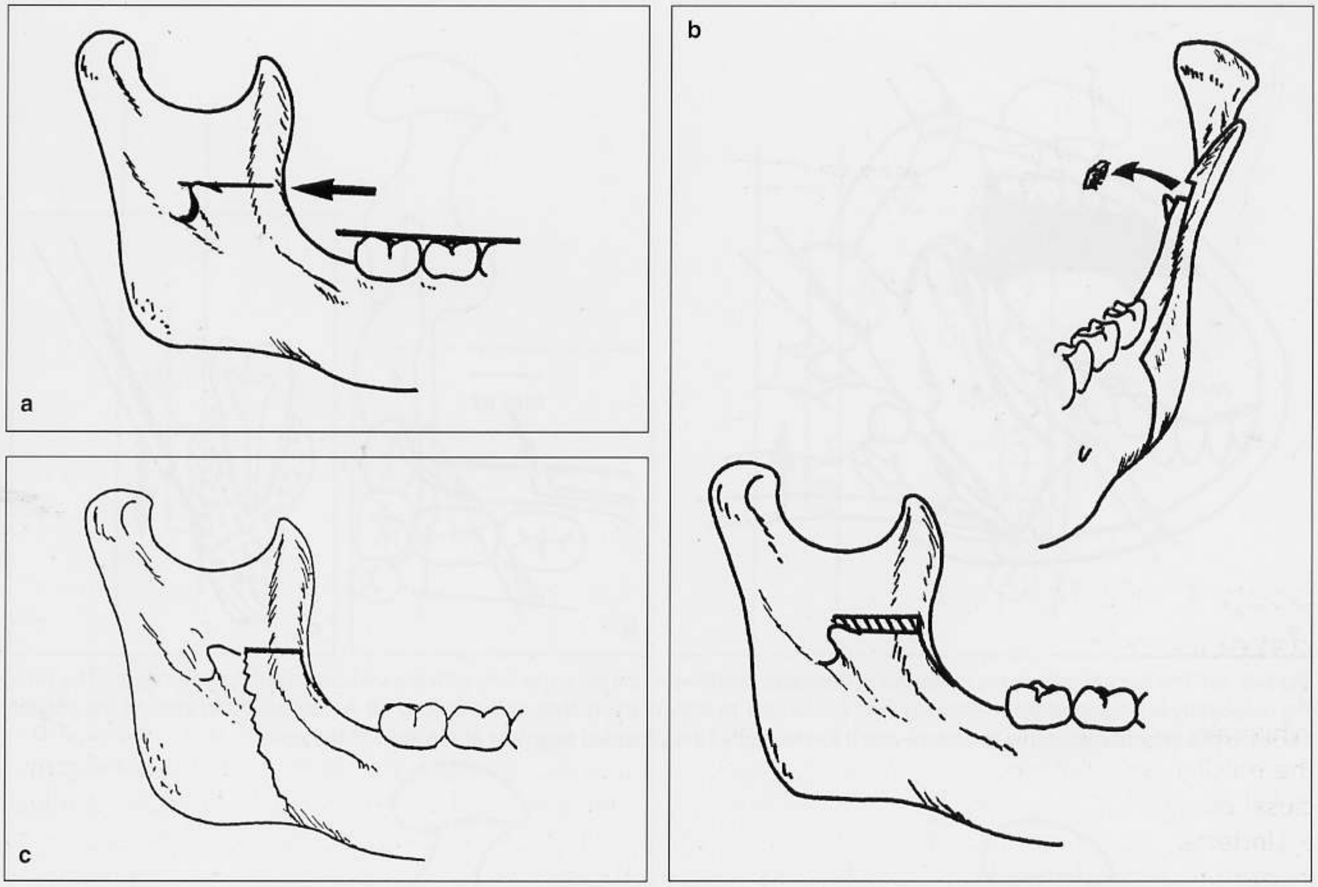


Fig 5-4 *(a)* The horizontal ramus osteotomy should be made parallel to the occlusal plane. The osteotomy should end posterior to the lingula in the fossa. *(b)* The distal segment will be positioned posteriorly and also tend to move superiorly in mandibular setback cases with high occlusal plane angles. In these cases, a small segment of bone should be removed superior to the horizontal osteotomy line to prevent interference between the segments. *(c)* The horizontal osteotomy should be carried past the lingula. Otherwise, there will be a strong tendency for the mandible to split anterior to the lingula.

(Fig 5-5b). Ensure that the cortex of the lower border of the body of the mandible is included in the osteotomy. The actual start of the sagittal split osteotomy should be at the lower border and must include part of the lingual cortex (Fig 5-5c). When placing the sagittal separator instrument, make sure it engages the lower border so that this part of the mandible stays attached to the proximal segment (see the discussion of the "bad" split in Step 16). The surgeon should be careful in cases with mandibular anteroposterior excess, mandibular asymmetry (the excessive side), and unilateral condylar hyperplasia, where the inferior alveolar neurovascular bundle tends to be situated very close to the buccal cortex and lower border.

Step 11: Drilling holes for a holding wire

The holes for a holding wire should be positioned in such a way that the proximal segment is directed distally. The direction of the anterior hole (proximal segment) should be posterior and that of the posterior hole (distal segment), anterior. The placement of holding wires is optional. The author, however, feels that condylar positioning (the most important step of the procedure) is more accurate if performed as a separate step prior to the placement of the screws. Once the condyle has been positioned (see Step 27), it is held in place using a condylar-

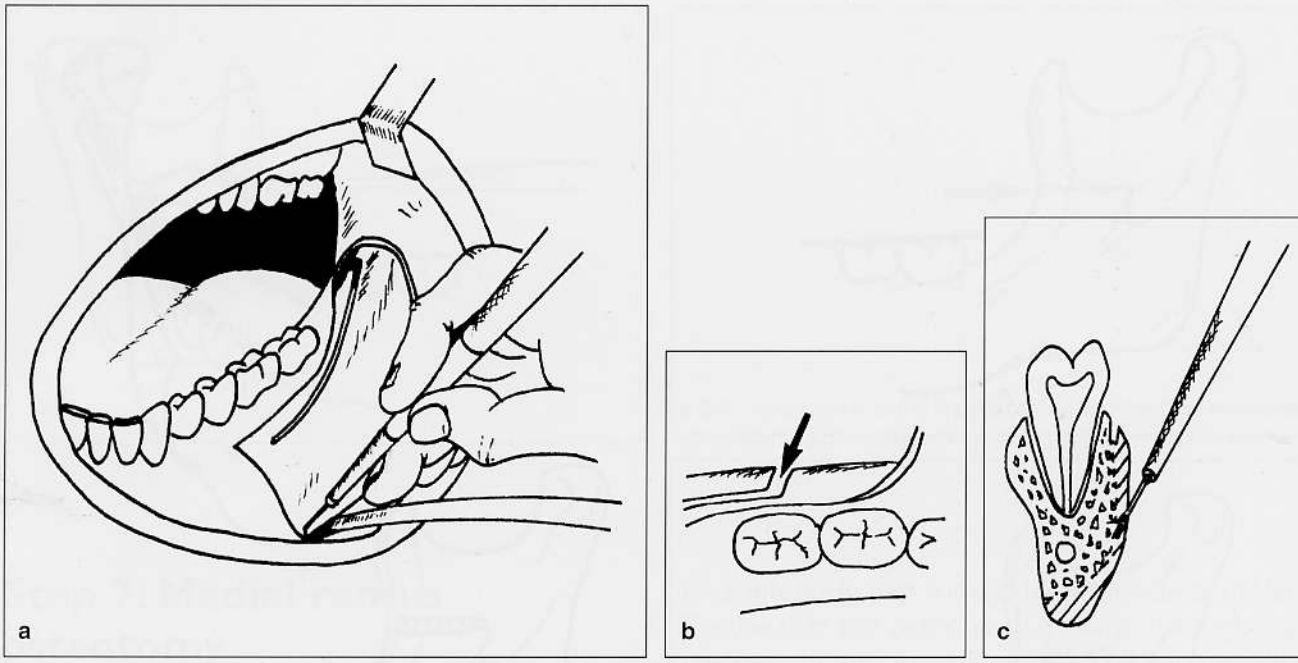


Fig 5-5 *(a)* The buccal osteotomy is started at the lower border and joined superiorly with the vertical ramus osteotomy. *(b)* The buccal osteotomy is angled slightly obliquely and posteriorly to enhance the start of the split. *(c)* It is mandatory to include the lingual cortex in the buccal osteotomy to ensure that it forms part of the proximal segment at the start of the split.

positioning instrument and digital pressure while the assistant tightens the holding wire. This process will be facilitated if the interrelationship of the segments and the condylar position was established and maintained by the holding wire at the time of rigid fixation. This is particularly helpful in the placement of resorbable fixation when the drilled holes have to be tapped before placement of the screws.

The ideal distance between the holes after repositioning the segments is 4 mm, with the hole in the proximal segment positioned anteriorly. The vectors of pull should always be in the proximal segment posteriorly and distal segment anteriorly (the direction of the wire must always be Class II). Two examples follow:

1. In a case where a mandibular advancement of 6 mm is planned, the holes should be drilled 10 mm apart (Fig 5-6a). After advancement of the distal segment by 6 mm, the holes will be 4 mm apart.
2. In a case where a mandibular setback procedure of 6 mm is planned, the holes should be drilled 2 mm apart, with the hole in the distal segment positioned anteriorly (Fig 5-6b). If the holes are more than 4 mm apart after jaw repositioning, bone approximation between distal and proximal segments will be less accurate because of the long span of the wire and may lead to inaccurate placement of rigid fixation.

Alternative techniques

A bone clamp may be used as an alternative to a holding wire. Some surgeons prefer simply to hold the proximal segment in position by means of a condylar positioner (ramus pusher or wire director) while placing the bicortical screws. Whatever method is used, the proximal segment (and condyle) must be secured in the ideal relationship to the glenoid fossa when the bicortical screws are placed (see Step 27).

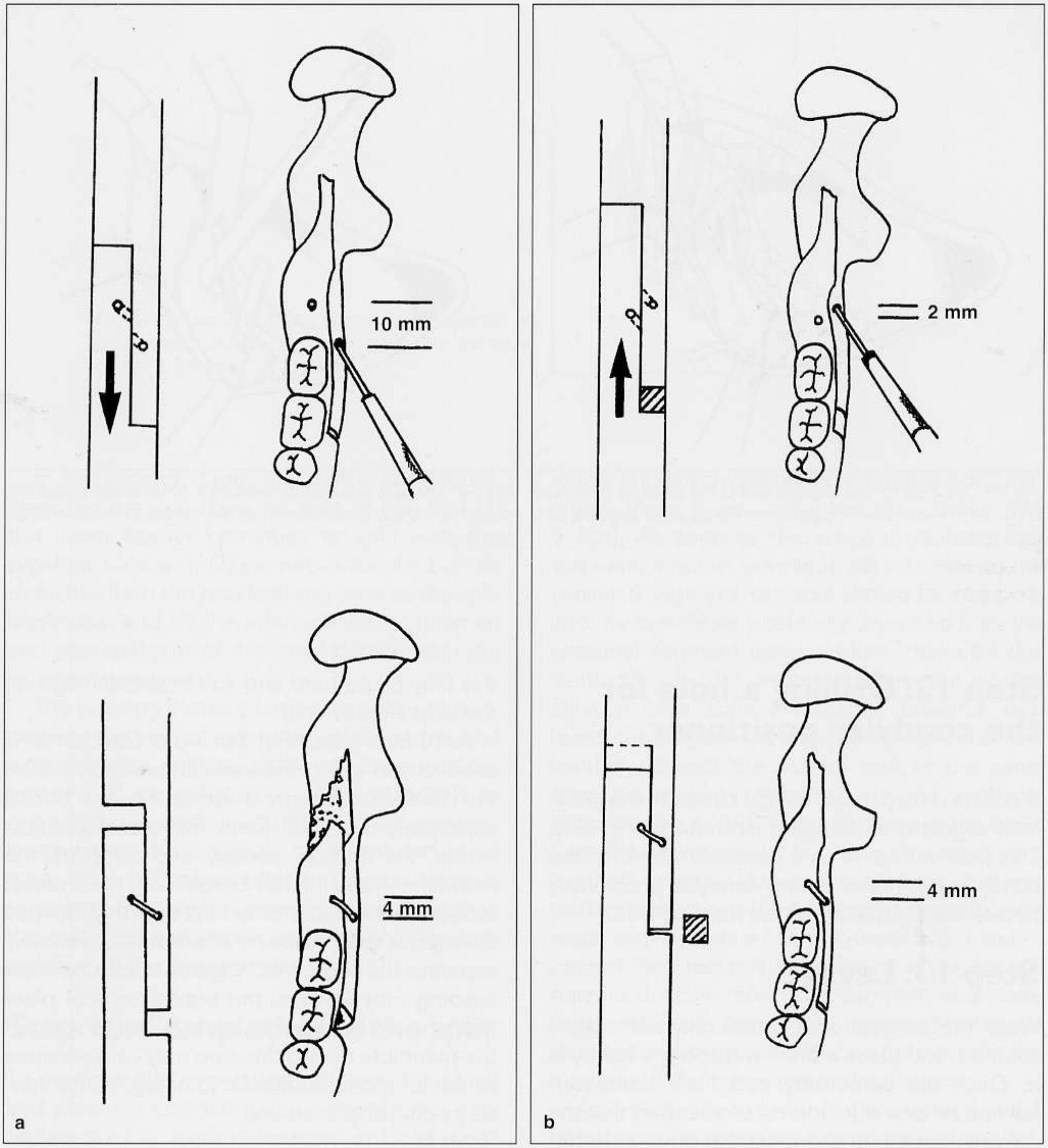


Fig 5-6 *(a)* Positioning of the holes for mandibular advancement. *(top)* For a 4-mm advancement, the holes are placed 10 mm apart (the hole in the distal segment should be posterior to that in the proximal segment). *(bottom)* After a 6-mm mandibular advancement, the holes will be 4 mm apart, ensuring a vector that will support the advancement of the tooth-bearing segment and seat the condyle. *(b)* Positioning of holes for mandibular setback. *(top)* For a mandibular setback of 6 mm, the holes are placed 2 mm apart, with the hole in the proximal segment posterior to that in the distal segment. *(bottom)* After a 6-mm setback, the holes will be 4 mm apart with the vector of the holding wire supporting the tooth-bearing segment and the condyle.

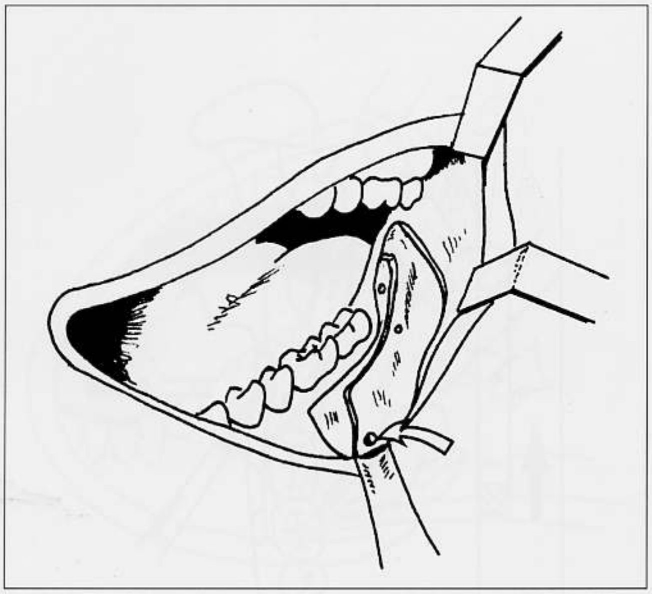


Fig 5-7 The hole for the engagement of the condylar positioner is placed in a low, anterior position on the proximal segment (see Step 28).

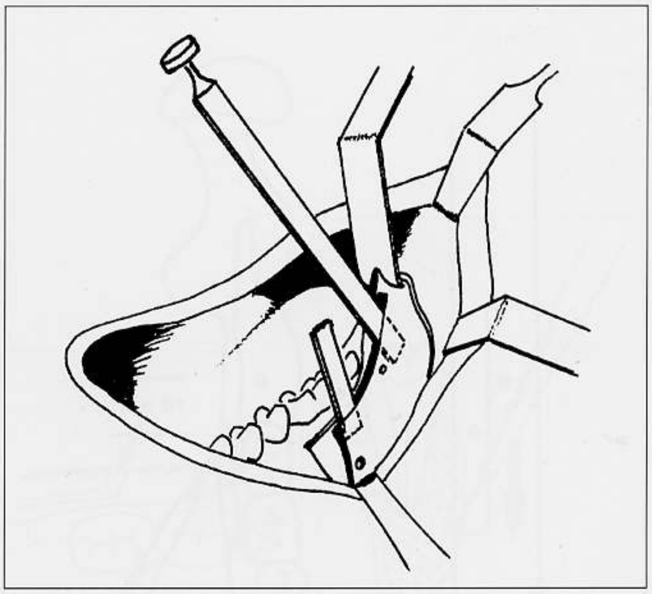


Fig 5-8 The split is started by tapping a 10-mm-wide osteotome along the vertical osteotomy, from the medial to the buccal osteotomy.

Step 12: Drilling a hole for the condylar positioner

A hole is drilled in the buccal cortex of the proximal segment and angled posteriorly (Fig 5-7). This hole will serve as a purchase point for the condylar positioner during condylar positioning before the tightening of the holding wire.

Step 13: Lavage

Wash the surgical area thoroughly with saline solution, and place a small wet sponge lightly in it. Once the osteotomy cuts have been performed on one side, it is recommended that the surgeon complete them on the other side before splitting the mandible.

Step 14: Defining the osteotomy cut with an osteotome

It is important not to manipulate the jaw unnecessarily when splitting the contralateral side, since this may cause hard and soft tissue damage on the side already split.

A 10-mm-wide, thin but rigid osteotome is used to tap along the vertical osteotomy from the medial osteotomy downward to the buccal osteotomy (Fig 5-8). Keep the osteotome just inside the buccal cortex, and support the mandible at the inferior border with the channel retractor. The osteotomy cuts are only *defined* during this step; make no attempt to completely separate the segments. Vigorous indiscriminate tapping may fracture the buccal cortical plate from the distal segment, while failure to support the mandible during this step may cause trauma to the temporomandibular joint (eg, hemarthrosis or disc displacement).

Step 15: Splitting the mandible

The actual splitting of the mandible can be divided into two stages. The first stage involves the initiation of the split. At the start of the split, the surgeon must be able to see that *(1)* the lower border of the mandible splits toward the proximal segment and *(2)* the neurovascular bundle is intact and separates from the proximal segment.

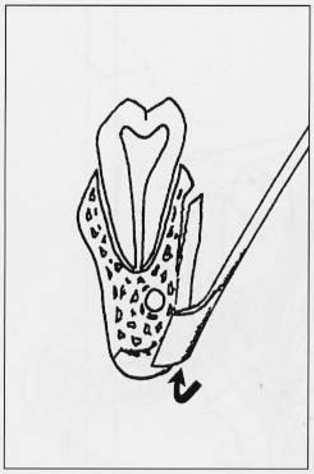


Fig 5-9 A small Reyneke sagittal split separator is placed deep into the buccal osteotomy and the lower border is engaged.

In the second stage, the split is completed. Here the surgeon must be able to see that *(1)* the lower border continues to split with the proximal segment, *(2)* the neurovascular bundle detaches from the proximal segment as the split continues, and *(3)* the inferior alveolar foramen and proximal part of the canal detach from the proximal segment.

The surgeon places a large osteotome superiorly into the vertical osteotomy of the ramus and a small sagittal split separator into the buccal osteotomy of the lower body of the mandible to engage the lower border (Fig 5-9). It is very important that the mandible be supported at all times by a channel retractor and digital pressure to protect the temporomandibular joint. In case the split does not start spontaneously, stop and redefine all the osteotomies.

Step 16: Completion of the split

To continue the separation between the distal and proximal segments, the osteotome is now replaced by a larger osteotome and the small sagittal split separator by a larger separator, and the instruments are rotated. Always ensure that the lower border continues to split with the proximal segment and that the neurovascular bundle is protected and intact.

The neurovascular canal is often attached to the proximal segment, especially in cases where the mandible is anteroposteriorly excessive or asymmetrical (excessive side), where there is unilateral condylar hyperplasia (excessive side), and where there is an unerupted third molar (Fig 5-10a). As soon as the surgeon realizes that the neurovascular bundle is still attached to the proximal segment, the split should be stopped, and the bundle very carefully dissected from the proximal segment using a blunt (Howarth) dissector (Fig 5-10b). In cases where the inferior alveolar canal splits toward the proximal segment, the surgeon should stop the split and very carefully dissect the medial wall of the canal from the proximal segment using a small osteotome (Fig 5-10c). Carefully remove the bone from the neurovascular bundle with a small nontoothed forceps. During the splitting, it is important not to use the retromolar bone (on the distal segment) as a fulcrum, especially if an impacted third molar is still present, since this will fracture the thin retromolar segment and make fixation difficult. Again, it is important to handle the proximal segment with care to maintain the integrity of the temporomandibular joint.

Any resistance to the split encountered at the latter stage is probably due to one of the following:

1. A greenstick fracture of the bone, in which the lower border starts fracturing superiorly toward the distal part of the medial ramus osteotomy, posterior to the lingula. The solution is to use a large osteotome to carefully separate the bone attachment between the segments under good visualization.

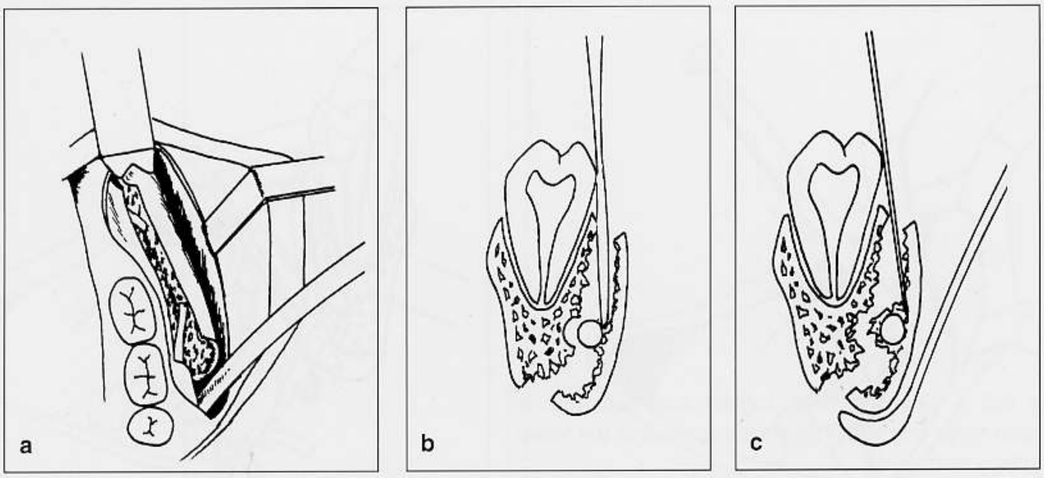


Fig 5-10 *(a)* The neurovascular bundle is attached to the proximal segment. *(b)* Before continuing with the split, the neurovascular bundle should be carefully dissected from the bone using a blunt instrument. *(c)* The neurovascular bundle may still be encased in the bony canal. An osteotome should be used very carefully to dissect the canal from the proximal segment and the bundle from the canal.

2. A fracture of the vertical osteotomy of the ramus anterior to the inferior alveolar foramen (due to the medial osteotomy of the ramus stopping short of the lingula). The solution is to revise the horizontal osteotomy and carefully separate the canal and foramen from the distal segment using a small osteotome.

Support both segments during detachment to prevent nerve damage.

The "bad" split

Prevent an unfavorable split by following the surgical steps meticulously. If the split does not seem to be proceeding favorably, however, stop and identify the problem area under good visualization. It is much easier to salvage the split if a potential problem is diagnosed early. The following sections describe the clinical features of an unfavorable split, which occur either singly or in combination.

Fracture of the buccal cortex of the body of the mandible

Early diagnosis If a fracture of the buccal cortex of the body of the mandible is diagnosed early, the beginning of a fracture that does not include the lower border is seen (Fig 5-11a). If this is detected, redefine the buccal osteotomy, especially around the lower border. Place the sagittal split separator down low into the osteotomy, and recapture the lower border to fracture it with the buccal cortex. When applying rigid fixation, place bicortical screws in the nonfractured part of the proximal segment while also securing the buccal cortex (Fig 5-11b).

Late diagnosis If a fracture of the buccal cortex of the body of the mandible is diagnosed late, the buccal cortex will have fractured unfavorably and be totally separated from the mandible (Fig 5-11c). In this case, remove the buccal plate, and save the bone in a wet saline sponge. Redefine the remaining part of the buccal osteotomy, especially around the lower border. The osteotomy at the buccal cortex fracture line may also be redefined, paying particular attention not to damage the inferior alveolar neurovascular bundle. Proceed with the split, using a straight osteotome positioned at the superior aspect of the vertical ramus osteotomy and placing the sagittal split separator down low in the buccal osteotomy (Fig 5-11d). The separated buccal cortex can be replaced when rigid fixation is completed (Fig 5-11e). Use a lag screw to secure this bone segment back into position.

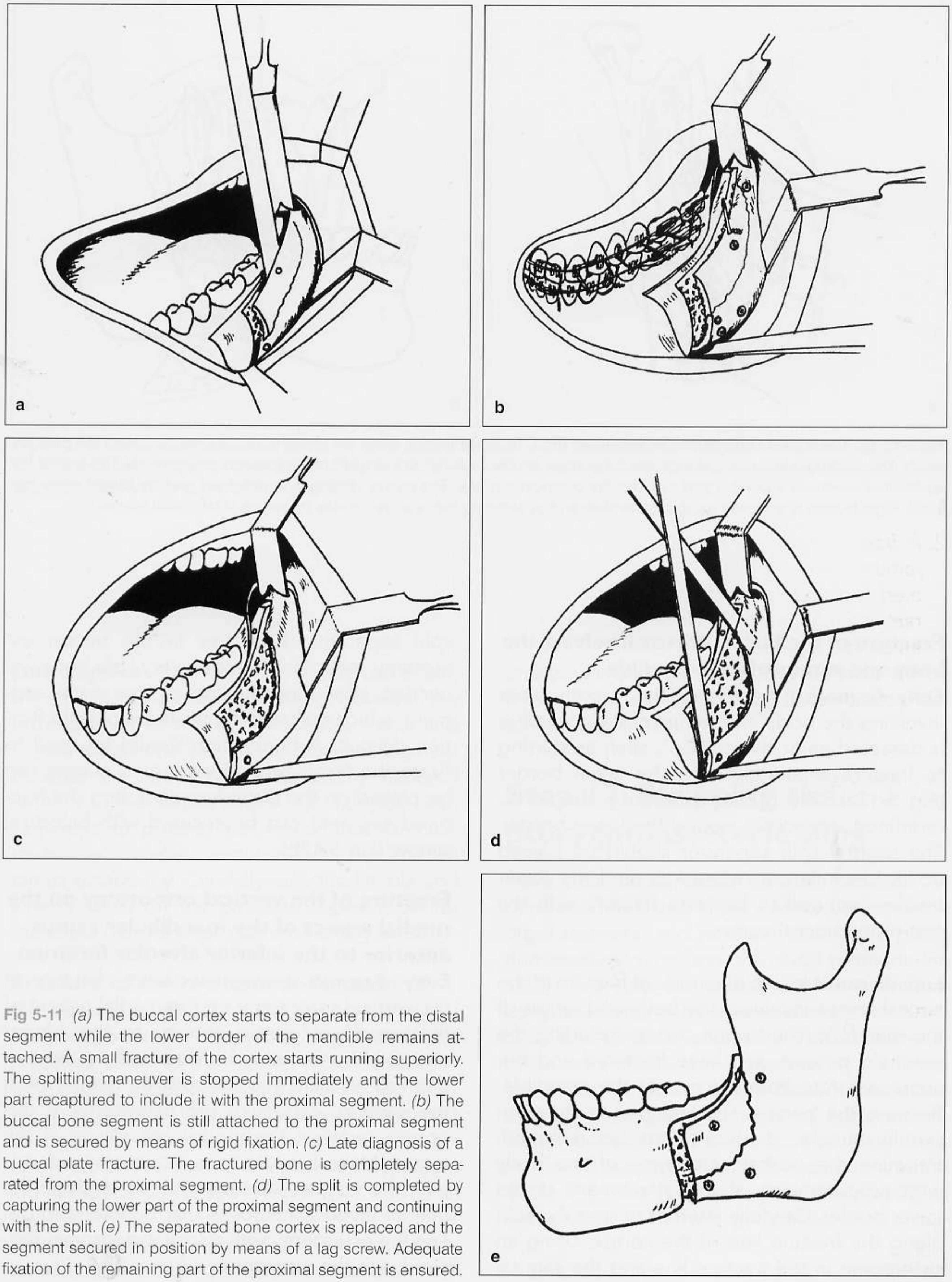


Fig 5-11 *(a)* The buccal cortex starts to separate from the distal segment while the lower border of the mandible remains attached. A small fracture of the cortex starts running superiorly. The splitting maneuver is stopped immediately and the lower part recaptured to include it with the proximal segment. *(b)* The buccal bone segment is still attached to the proximal segment and is secured by means of rigid fixation. *(c)* Late diagnosis of a buccal plate fracture. The fractured bone is completely separated from the proximal segment. *(d)* The split is completed by capturing the lower part of the proximal segment and continuing with the split. *(e)* The separated bone cortex is replaced and the segment secured in position by means of a lag screw. Adequate fixation of the remaining part of the proximal segment is ensured.

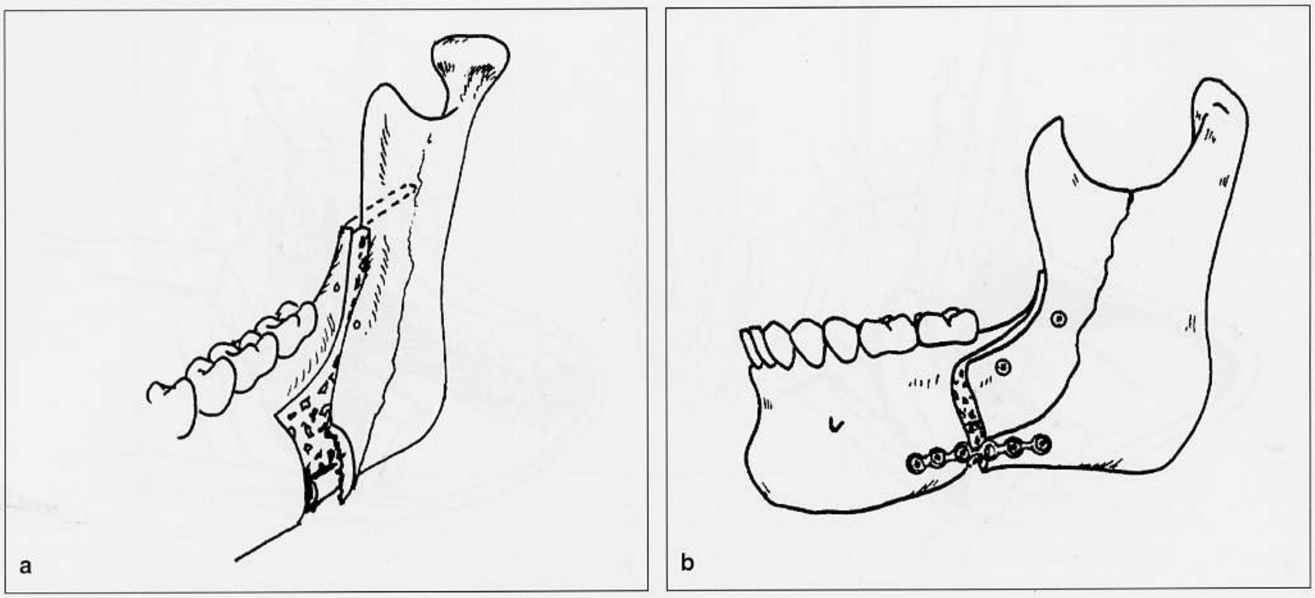


Fig 5-12 *(a)* The buccal cortex fractures separately from the lower border, while the fracture runs superiorly toward the coronoid notch. The splitting maneuver is stopped and the lower border captured to form part of the proximal segment. *(b)* The buccal cortex fracture continues superiorly and includes the coronoid process. The buccal osteotomy is redefined and the lower border captured. Rigid fixation is achieved using a bone plate and by securing the fractured cortex by means of bicortical screws.

Fracture of the buccal cortex involving the body and ramus of the mandible

Early diagnosis If fracture of the buccal cortex involving the body and ramus of the mandible is detected early, the cortex is seen as starting to fracture separately from the lower border (Fig 5-12a). The buccal osteotomy should be redefined, especially around the lower border. The sagittal split separator should be placed down low into the osteotomy, and the lower border captured to facilitate fracture with the rest of the buccal cortex.

Late diagnosis In late diagnosis of fracture of the buccal cortex involving the body and ramus of the mandible, the buccal cortex, including the coronoid process, will have fractured and become separate from the rest of the mandible. Because the bone is still attached to the temporalis muscle, it should not be removed. Redefine the buccal osteotomy of the body with what remains of the attachment at the lower border. Carefully attempt to start the split along the fracture line of the cortex. Using an osteotome in the fracture line and the sagittal split separator down low in the buccal osteotomy, recapture the split. Very little bone will overlap after repositioning of the distal segment, which makes the placement of rigid fixation difficult. A bone plate should be used to fixate the fragments. Monocortical screws can be placed on the distal fragment, and the fractured segment can be secured with bicortical screws (Fig 5-12b).

Fracture of the vertical osteotomy on the medial aspect of the mandibular ramus anterior to the inferior alveolar foramen

Early diagnosis If diagnosed early, fracture of the vertical osteotomy on the medial aspect of the mandibular ramus anterior to the inferior alveolar foramen may be detected by the surgeon as resistance to the splitting maneuver at the superior aspect of the osteotomy. If this occurs, redefine the medial osteotomy of the ramus. Make sure that the osteotomy extends past the lingula. Take care not to damage the inferior alveolar neurovascular bundle, and define the osteotomy with a small osteotome. Proceed with the osteotomy.

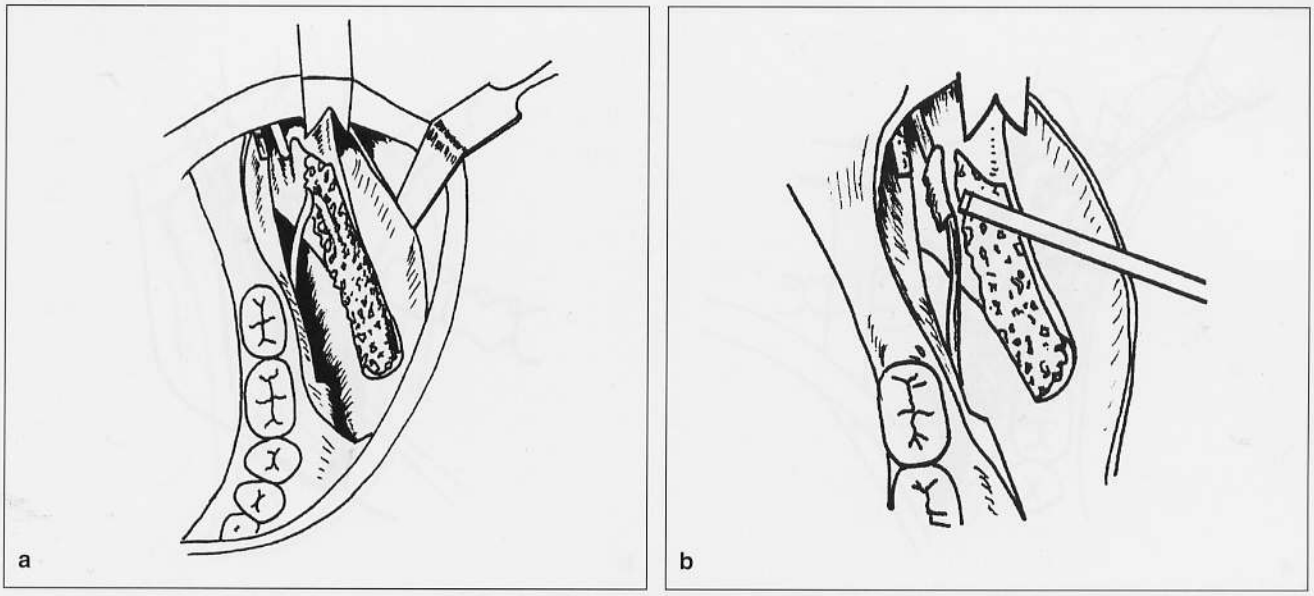


Fig 5-13 *(a)* The lingula and proximal part of the nerve canal is still attached to the proximal bone segment. This usually occurs when the horizontal osteotomy is terminated short of the lingula. *(b)* The canal containing the inferior alveolar neurovascular bundle is carefully dissected from the proximal bone segment.

Late diagnosis If the condition is diagnosed late, the split will have been completed. However, the proximal part of the inferior alveolar canal and lingula will be attached to the proximal segment because the vertical ramus osteotomy fractured anterior to the lingula (Fig 5-13a). Support both segments to protect the inferior alveolar neurovascular bundle, and redefine the medial ramus osteotomy. Carefully split the lingula and inferior canal off the proximal segment of the mandible using a small osteotome (Fig 5-13b).

Fracture of the retromolar segment of the mandible distal to the second molar

Early diagnosis The retromolar segment of the mandible distal to the second molar is particularly fragile, especially when an impacted third molar is present. When the surgeon finds that this segment is fragile, extreme care should be taken not to lever against this part of the jaw during the splitting procedure (Fig 5-14a).

Late diagnosis If this aspect of the bone is fractured (Fig 5-14b), rigid fixation with bicortical screws will be impossible. The surgeon will be forced to use bone plates, as previously described (Fig 5-14c).

Step 17: Stripping the pterygomasseteric sling

Place a curved periosteal elevator between the bone segments and at the inferior border of the distal segment, and proceed to strip the pterygomasseteric sling from the distal segment (Fig 5-15). This step will ensure that no greenstick bony attachments have remained between the distal and proximal segments. The neurovascular bundle should be protected at all times. Insufficient stripping of the pterygomasseteric sling or inadequate removal of bony attachments between the proximal and distal segments will lead to difficulty in repositioning the distal segment and inaccurate positioning of the condyle.

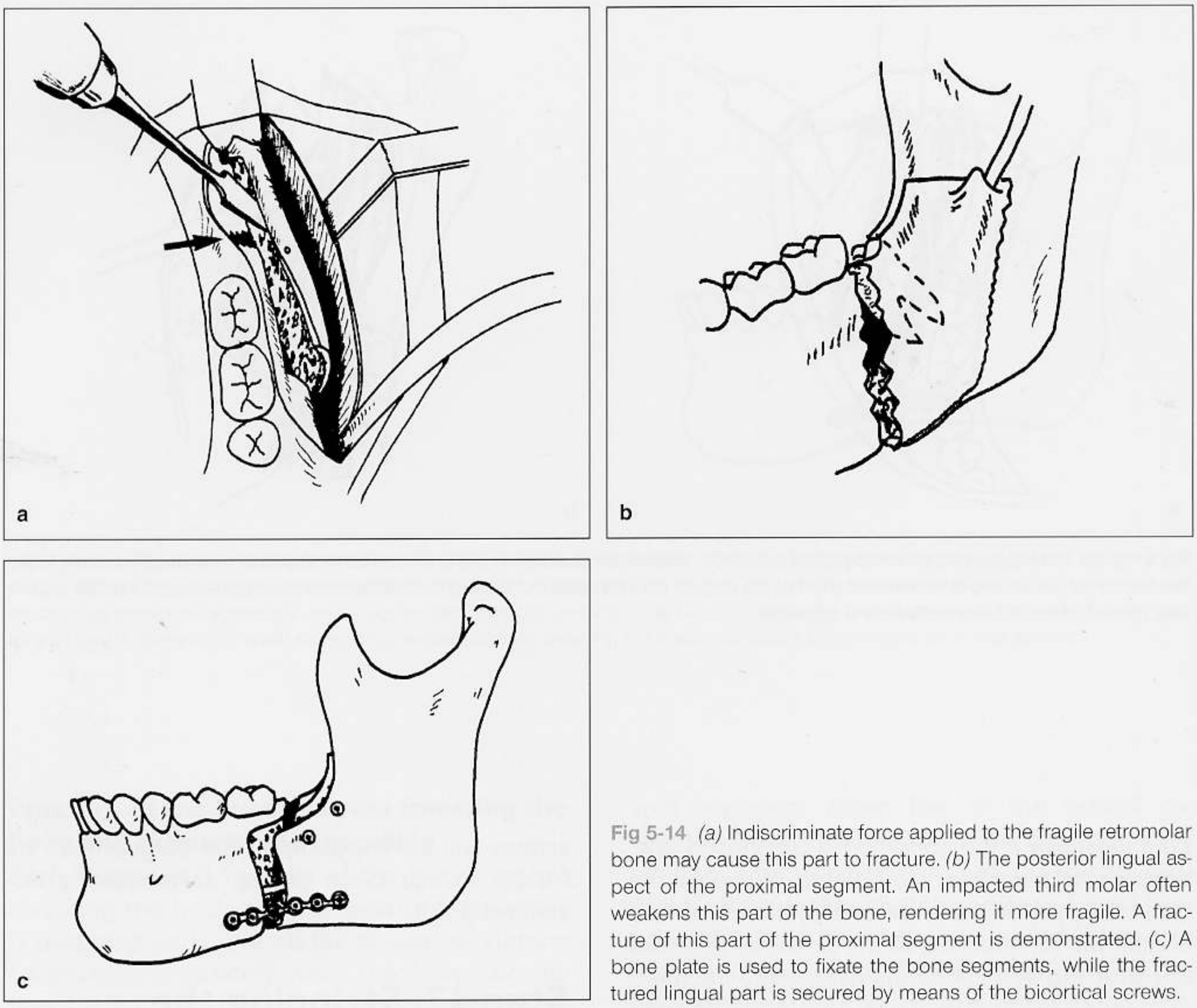


Fig 5-14 *(a)* Indiscriminate force applied to the fragile retromolar bone may cause this part to fracture. *(b)* The posterior lingual aspect of the proximal segment. An impacted third molar often weakens this part of the bone, rendering it more fragile. A fracture of this part of the proximal segment is demonstrated. *(c)* A bone plate is used to fixate the bone segments, while the fractured lingual part is secured by means of the bicortical screws.

Step 18: Stripping the medial pterygoid muscle and stylomandibular ligament

The medial pterygoid muscle and the stylomandibular ligament are attached to the medial side of the angle of the mandible. Failure to strip them from the bone may interfere with the posterior repositioning of the distal segment (Fig 5-16). This may distract the condyle from the glenoid fossa or rotate the proximal segment posteriorly, thereby increasing the relapse potential.

Step 19: Removal of impacted third molars

It is the author's policy to remove impacted third molars at least 6 months before performing a bilateral sagittal split osteotomy. Because this is not always possible, it is often necessary to remove third molars during the sagittal split procedure if they prevent optimal bone contact between the proximal and distal segments. The clinician should be careful not to fracture the retromolar bone (lingual cortex) or damage the neurovascular bundle during tooth removal.

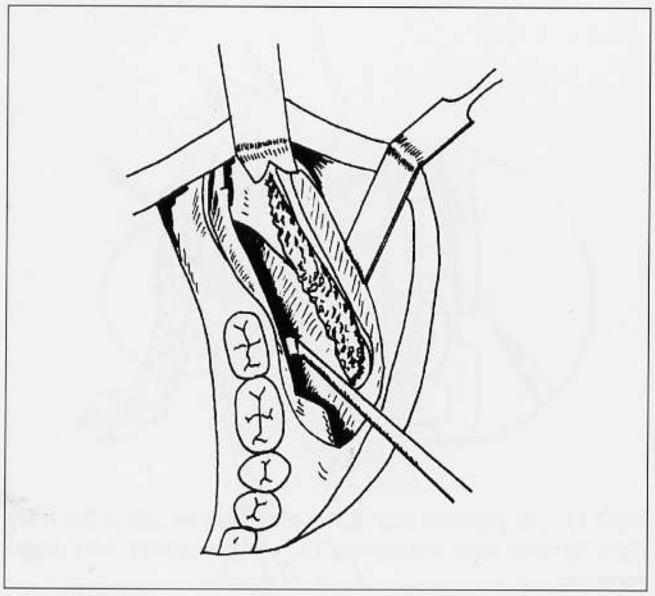


Fig 5-15 A curved periosteal elevator is used to strip the pterygomasseteric sling from the distal bone segment and also to ensure that the split is complete at the lower and posterior borders.

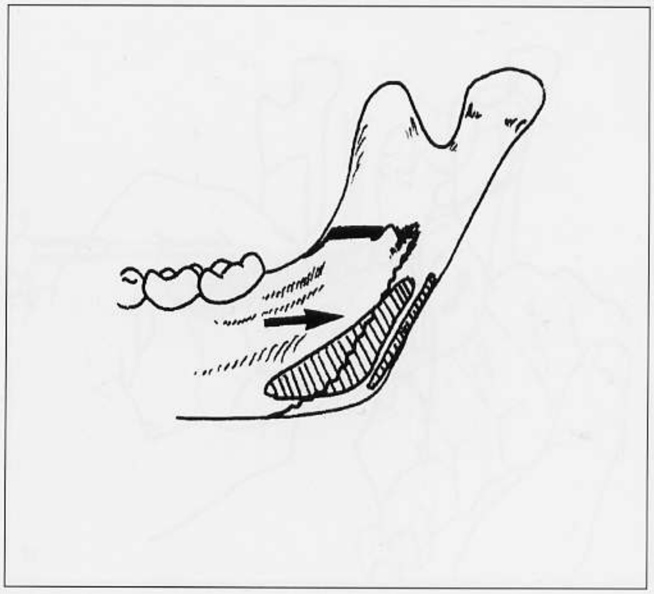


Fig 5-16 The attachments of the medial pterygoid muscle (anterior) and the stylomandibular ligament (posterior) on the medial aspect of the mandibular angle are demonstrated. These attachments will interfere when the proximal segment is set back and therefore should be stripped in mandibular setback cases.

The presence of an impacted third molar or an empty tooth socket (after removal of the tooth) will limit the availability of bone and thus the placement of bicortical screws.

Step 20: Smoothing contact areas of bone segments

A large pear-shaped vulcanite bur is used to smooth the medial aspect of the proximal segment to ensure good bone contact between the segments and prevent nerve damage by sharp bony edges. Bone should not be removed from the lateral aspect of the distal segment because of potential damage to the alveolar neurovascular bundle.

Step 21: Placement of a holding wire

Place a 0.018-inch wire through the holes (see Step 11) in the distal (medial) segment. Support the distal segment when the wires are pulled through to prevent any damage to the temporomandibular joint.

Step 22: Noting the position of the inferior alveolar neurovascular bundle

The inferior alveolar neurovascular bundle is often visualized (and dissected) during the splitting procedure. The surgeon should take advantage of this visualization and make a mental note of the position of the neurovascular bundle to ensure safe placement of bicortical screws.

Step 23: Noting the position of the third molar (or its socket)

The third molar (or its socket after removal of the tooth) will influence the placement of the bicor-

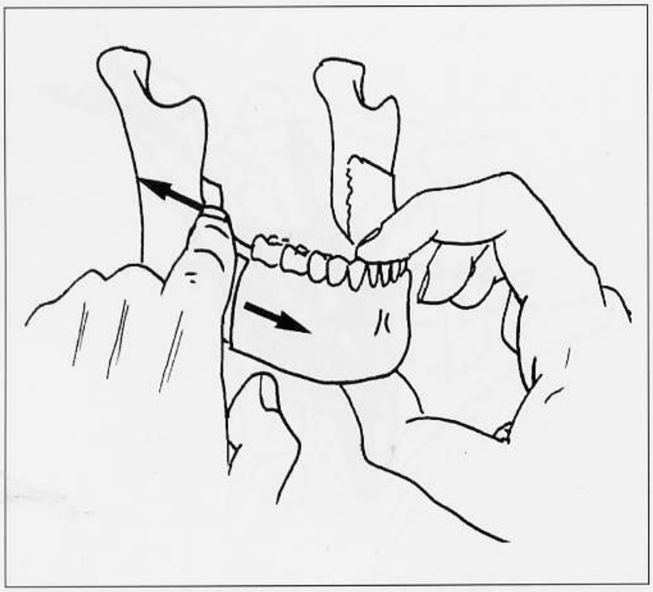


Fig 5-17 The proximal segment is mobilized by pulling the mandible forward while supporting the distal segment with digital pressure.

tical screws. Thus, the position and size of the tooth or socket should be noted to ensure later safe placement of efficient bicortical screws.

Step 24: Mobilization of the distal segment

Remove the sponge placed during lavage (see Step 13). Mobilize the distal segment on each side by pulling it anteriorly while supporting the proximal segment with the index finger (Fig 5-17).

Step 25: Selective odontoplasty and maxillomandibular fixation

The selective odontoplasty should now be performed as indicated by the model surgery using a diamond bur and copious water cooling. Maxillomandibular fixation is then applied with the teeth in the planned occlusion. A prefabricated splint may be used when necessary. The use of an acrylic splint is not always indicated. Where it is possible to achieve a stable occlusion and no segmental surgery is contemplated, the use of an acrylic splint is superfluous. The intercuspation of the teeth can be observed better without the use of a splint. The central incisors are fixated first to establish the planned incisor relationship; the maxillomandibular fixation is then applied to the posterior teeth. It is important to place the wires with a vector assisting the surgical repositioning.

Ensure that the teeth are placed into the planned occlusion without any bony or soft tissue interference. At this stage, interference may be caused by *(1)* an incomplete split; *(2)* a pterygomasseteric sling that has not been completely stripped; or *(3)* sharp, bony interference between the proximal and distal segments that prevents free movement between segments. Forcing the teeth into occlusion against muscular, bony, or dental interference will result in inaccurate positioning and poor stability. Poor immediate preoperative orthodontic prepara-

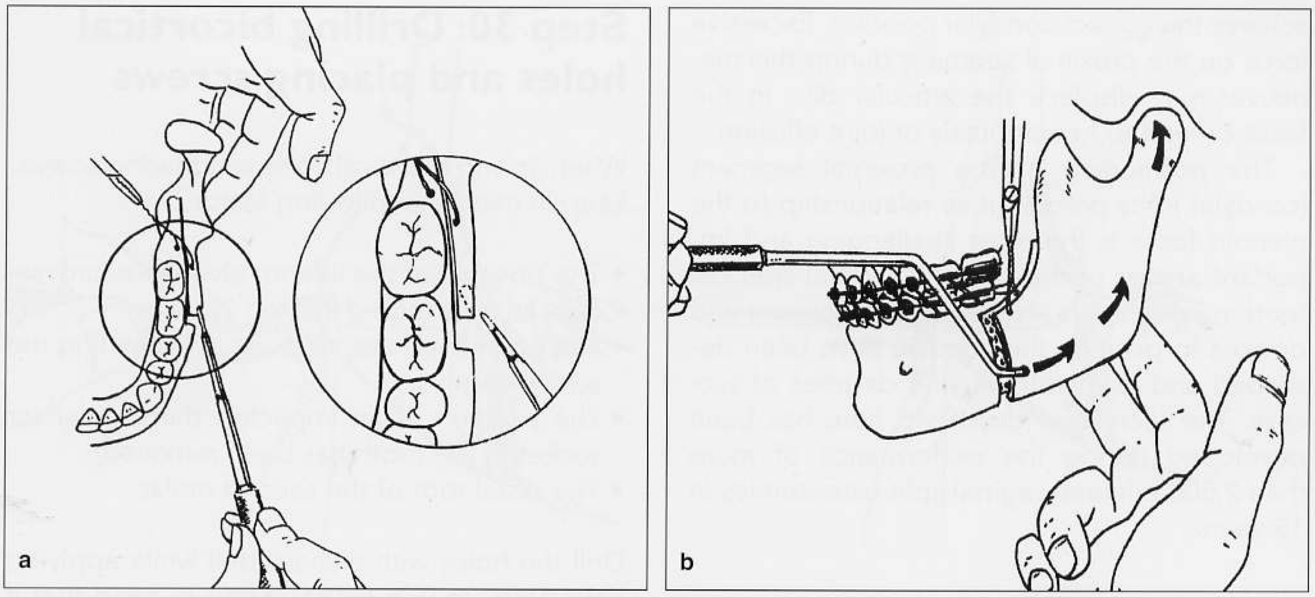


Fig 5-18 *(a)* The condylar positioner is placed in a hole drilled into the buccal cortex (see Step 12). *(b)* The condyle is carefully pushed superiorly and slightly anteriorly in the fossa by the condylar positioner and digital force on the mandibular angle. The assistant can now tighten the positioning wire.

tion (loose orthodontic brackets, lack of or too few K-hooks, or incorrect positioning of the K-hooks) may make it impossible to maintain the occlusion because of inadequate wire fixation.

Step 26: Removal of bone from the proximal segment

When the teeth have been wired into occlusion and the proximal segment has been pushed back gently, the bony overlap (which should coincide with the planned setback amount) will be evident. The overlapping bone should now be removed, with the surgeon taking care not to damage the neurovascular bundle or facial artery during bone removal. There is no advantage to an accurate fit of bone at the buccal osteotomy. In contrast, if the proximal segment is forced to fit tightly against the distal segment at the buccal osteotomy site, the condyle may be forced too far posteriorly or eccentrically in the fossa, leading to condylar sag. The result will also be less stable if the segments are forced together at the vertical osteotomy, because the proximal segment may also rotate backward and downward. The small piece of bone removed may be used as a bone graft in other areas (eg, where there are intersegmental bone defects in bilateral sagittal split osteotomies or Le Fort I osteotomies).

Step 27: Condylar positioning

A condylar positioner is placed into the hole drilled into the buccal cortex (see Step 12), and while the angle of the mandible is supported by extraoral digital pressure (Fig 5-18a), the condyle should be positioned in its preoperative relationship to the fossa. Posterior digital pressure on the positioning instrument and superior and slightly anterior extraoral digital pressure at the angle of the mandible will give the surgeon control of the proximal segment (Fig 5-18b). This control, combined with an awareness of the anatomic relationship of the condyle and glenoid fossa, should enable the surgeon to achieve the correct condylar position. Excessive force on the proximal segment during this maneuver may displace the articular disc in the fossa or lead to hemarthrosis or joint effusion.

The positioning of the proximal segment (condyle) in its preoperative relationship to the glenoid fossa is the most challenging and important aspect of the bilateral sagittal split osteotomy procedure. Numerous techniques and devices to position the condyle have been described and used with varying degrees of success. The technique described here has been developed during the performance of more than 2,800 bilateral sagittal split osteotomies in 15 years.

Step 28: Tightening the holding wire

Hold the proximal segment in its desired position (described in Step 27) while the assistant gently tightens the holding wire. Visualize the segments while carefully tightening the holding wire, and ensure that the wire is twisted until it *passively* holds the segments in position. Do not force the segments together. Incorrect positioning of the holes may place unfavorable vectors of force on the bony segments and thus prevent correct condylar positioning. Excessive tightening of holding wire may cause undesirable force on the condyle and lead to condylar sag.

Step 29: Placement of the trocar

An extraoral stab incision is made on the lower border of the mandible, just behind the gonial notch. The surgeon places the trocar through the skin incision, ensuring that the tip of the trocar perforates the periosteum intraorally. The initial placement should be superior to the bone, avoiding damage to the neurovascular bundle or bony segments. Incorrect placement of the skin incision may damage the mandibular branch of the facial nerve, resulting in palsy of the lower lip.

Step 30: Drilling bicortical holes and placing screws

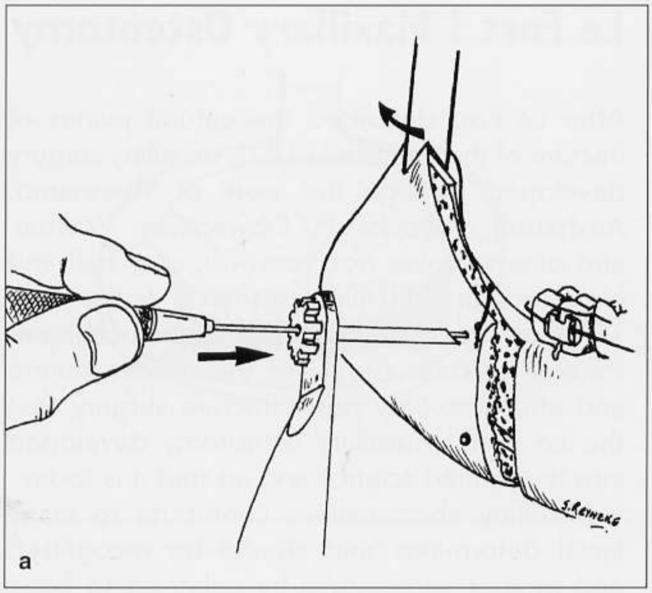
When drilling bicortical holes and placing screws, keep in mind the following factors:

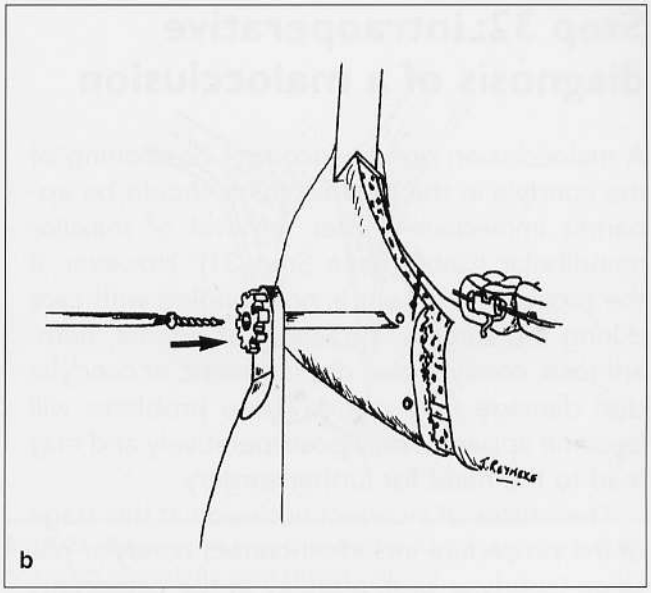
- The position of the inferior alveolar neurovascular bundle (noted in Step 22)
- The bone thickness, to assist in estimating the screw length
- The position of an impacted third molar (or socket, if the tooth has been removed)
- The distal root of the second molar

Drill the holes with a sharp drill while applying light pressure (Fig 5-19a). Keep in mind that if the shaft of the bur is forced against the trocar while drilling, it will generate heat and, without sufficient water cooling, may burn the skin and subcutaneous tissue in contact with the tube of the trocar. Position three holes in either a triangle or a straight line along the superior border. Angle the holes slightly backward to support the repositioning of the condyle.

Once a hole has been drilled, keep the trocar absolutely still to avoid "losing" the hole or its direction. While keeping the trocar in position, measure the depth of the hole. (With increased experience, the surgeon may estimate the length of the screw.) The screw is now "fed" into the trocar and gently tightened (Fig 5-19b). Visualize the cortex of the distal segment while tightening the screw to ensure that the screw engages the lingual cortex. If the two segments are pushed apart, the screw should be removed and a new hole drilled. The screwdriver should be pushed gently; keep in mind that positioning screws are self-tapping and need only be turned to engage.

After placing the first screw, place two more screws in appropriate positions. Make sure the screws do not compress the bone segments or close any intersegmental gaps, since this may result in displacement of the condyle and peripheral condylar sag (Fig 5-19c; see discussion of peripheral condylar sag, pages 299 to 301).





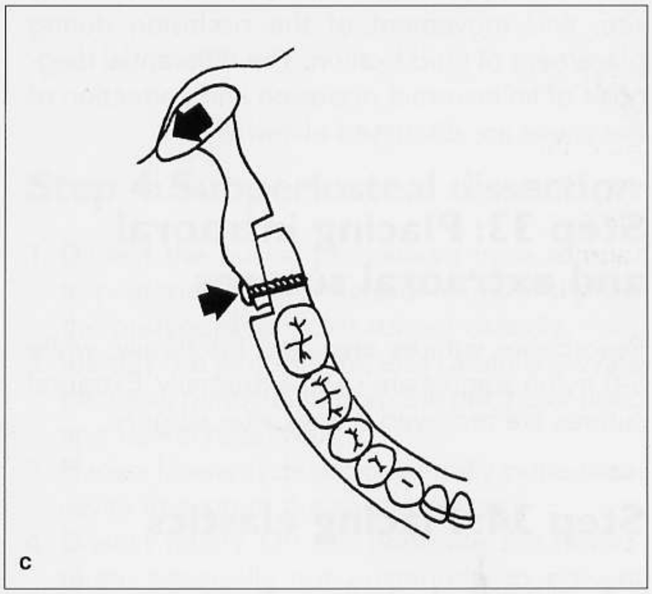


Fig 5-19 *(a)* With the transbuccal trocar in position, bicortical holes are drilled at the appropriate positions. *(b)* Bicortical screws are placed though the trocar. Be careful not to force the trocar against the bone, which may displace the segments or the occlusion. *(c)* Bone defects should not be eliminated by tightening the screws since this may displace the condyle in the fossa (peripheral sag).

Step 31: Removing maxillomandibular fixation and checking the occlusion

The occlusion should not be checked immediately after removal of fixation wires. Before assessing the final occlusion, open and close the mandible, and gently translate it to the left and right. Then wait a minute, and with light digital pressure under the chin, close the mandible and assess the occlusion. The occlusion should be exactly as planned; do not accept an incorrect occlusion. There is no better time to correct a problem than at this stage.

Step 32: Intraoperative diagnosis of a malocclusion

A malocclusion due to incorrect positioning of the condyle in the glenoid fossa should be apparent immediately after removal of maxillomandibular fixation (see Step 31). However, if the proximal segment is not handled with care during the surgery, intracapsular edema, hemarthrosis, condylar disc displacement, or condylar disc damage may result. These problems will become apparent only postoperatively and may lead to the need for further surgery.

The causes of incorrect occlusion at this stage of the procedure include incorrect condylar position (condylar sag), mobility at the osteotomy site, and movement of the occlusion during placement of rigid fixation. The differential diagnosis of an incorrect occlusion and correction of the cause are discussed elsewhere.

Step 33: Placing intraoral and extraoral sutures

Resorbable sutures are used intraorally, while 5-0 nylon sutures are used extraorally. Extraoral sutures are removed 2 days after surgery.

Step 34: Placing elastics

A 4-oz, 0.25-inch elastic is placed on each side to assist in directing the surgical positioning of the jaw. The direction of the elastics should reinforce the movement (ie, use Class II elastics for mandibular advancement cases and Class III elastics for mandibular setback cases). Immediate postoperative placement of a strong vertical component is advocated.

Step 35: Placing a pressure bandage

A pressure bandage should remain on the face for 2 days.

Le Fort I Maxillary Osteotomy

After Le Fort described the natural planes of fracture of the midface in 1901, maxillary surgery developed through the work of Wassmund, Auxhauser, Schuchardt, Obwegeser, Willmar, and others. It was not, however, until Bell and his coworkers' excellent research in the mid-1970s on the biologic basis of the hemodynamics and vascular supply of the maxilla during and after maxillary down-fracture surgery that the Le Fort I maxillary osteotomy developed into the refined science and art that it is today.

Maxillary abnormalities contribute to many facial deformities that should be recognized and treated successfully by adhering to basic biologic and technical treatment principles. Numerous techniques for Le Fort I maxillary osteotomy have been described and reflect a strong tendency to operator preference. The technique described here has been developed during the performance of more than 2,600 Le Fort I maxillary osteotomies over the course of the last 17 years. It has been found to be beneficial in the training of many residents participating in the oral and maxillofacial program at the University of the Witwatersrand, Johannesburg, South Africa.

Step 1: Infiltration of the soft tissue with a vasoconstrictor

Infiltrate the area of dissection with local anesthetic containing a vasoconstrictor (epinephrine in a concentration of 1:100,000) 10 minutes before surgery. Inject the soft tissue areas at the intended osteotomies by placing the needle deep into the maxillary buccal sulcus, aspirating, and then injecting the anesthetic as the needle is withdrawn.

Step 2: Mucosal incision

Make an incision in the maxillary buccal sulcus, through the mucosa only, with a No. 15 blade or

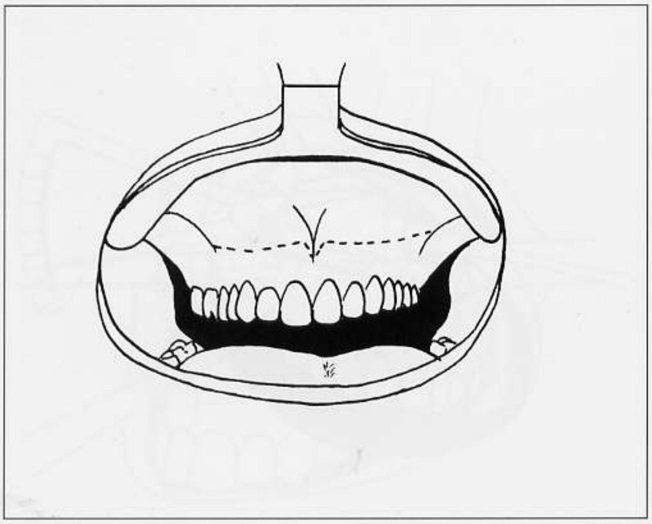


Fig 5-20 The mucosal incision *(dotted line)*.

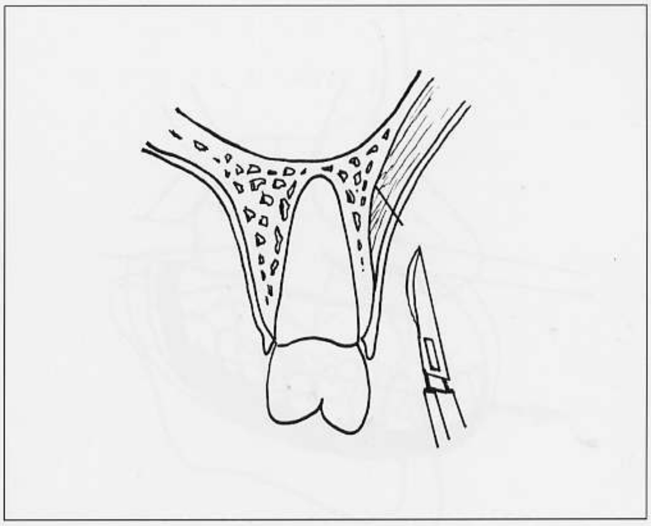


Fig 5-21 Because the incision is angled superiorly, more soft tissue is left inferiorly for ease of later suturing.

diathermy knife. The incision is started at the buttress area and then carried forward to the center line, leaving approximately 5 mm of nonkeratinized mucosa on the alveolar side for later ease of suturing. This incision should be increased posteriorly to approximately 10 mm at the buttress area. A V-shaped incision at the labial frenum helps with alignment in later suturing (Fig 5-20).

Step 3: Completing the soft tissue incision through periosteum

The blade is angled superiorly to leave more submucosal tissue on the alveolar side for submucosal suturing later (Fig 5-21). The incision onto bone should be clean and decisive to facilitate neat subperiosteal dissection. If the incision is carried too far posteriorly or too high, it may cause herniation of the buccal fat pad and make surgery cumbersome.

Step 4: Subperiosteal dissection

1. Dissect the buccal periosteum from anterior to posterior around the tuberosity, and place the pterygoid retractor subperiosteally.
2. Identify the piriform rim, and carefully elevate the nasal periosteum from the rim, nasal floor, and lateral nasal wall.
3. Place a Howarth dissector laterally in the nasal cavity to protect the nasal mucosa.
4. Dissect neatly. Do not perforate the periosteum, especially not posteriorly, to prevent herniation of the buccal fat pad through the periosteum.
5. Push the nasal mucosa inward with the back of the periosteal dissector to tent the mucosa for the beginning of the nasal dissection.
6. Continue the nasal dissection from the floor of the nose laterally to the lateral wall of the nose and medially to the nasal septum.
7. Identify the position of the infraorbital foramen and nerve—first, to protect the nerve, and second, to influence the height of the osteotomy cut (especially with superior repositioning of the maxilla) (Fig 5-22).
8. If the buccal fat pad is exposed, it should be covered with a small wet sponge and retracted with the pterygoid retractor.

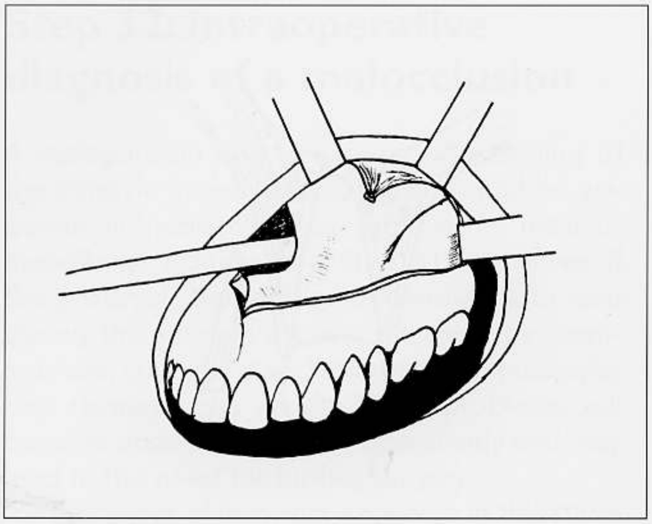


Fig 5-22 The subperiosteal dissection is carried superiorly and posteriorly to identify the piriform rim, infraorbital nerve, zygomatic buttress, and posterior maxilla.

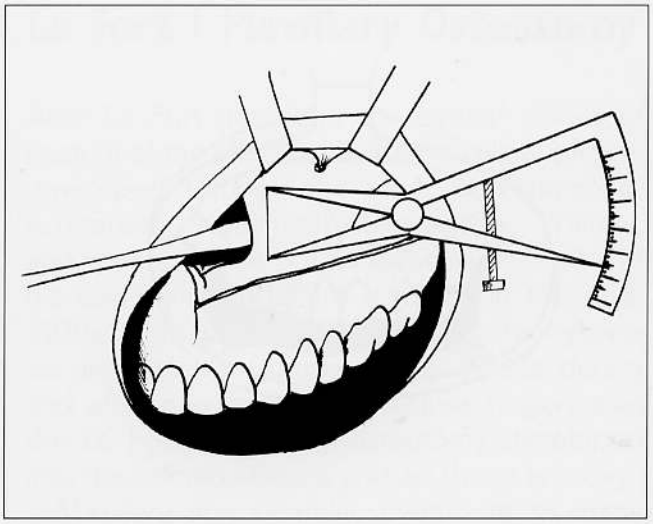


Fig 5-23 Vertical and horizontal reference marks are scored on the bone and the distances between them measured.

Step 5: Placement of reference marks

Vertical and horizontal reference marks are scored (approximately 10 mm apart) on either side at the canine and buttress area using a 701 bur. The distance between the marks is recorded (Fig 5-23). The height of the osteotomy is significant in more than one way, and the reference marks should be made accordingly:

1. With maxillary advancement procedures, osteotomy height depends on the esthetic requirements of the case. The osteotomy can be made high (just inferior to the infraorbital nerve, in the "high Le Fort I" osteotomy) or low (not less than 5 mm above the tooth apexes).
2. When superiorly repositioning the maxilla, the amount of bone removed dictates the positioning of the osteotomies. Other determining factors include structures such as the infraorbital nerve and tooth apexes, as well as the positioning of rigid fixation.

Step 6: Anterior buccal osteotomy

Use a reciprocating saw to perform the osteotomy from the buttress to the piriform rim at least 5 mm superior to the apex of the canine (Fig 5-24a). In principle, horizontal Le Fort I osteotomies should be parallel to the occlusal plane to allow repositioning to take place along it. Therefore, during the planning phase, the osteotomy must be performed on the same plane, both in model surgery and cephalometric visual treatment objective tracing. Measurements on these records are then more accurate when applied at surgery. The osteotomy, however, may be angled intentionally in the downsliding Le Fort I technique (Fig 5-24b). Incorrect angulation of the osteotomy will make it difficult to achieve the surgical treatment objective, since the maxilla will be moved along this plane, which may vertically shorten the maxilla as it is advanced (Fig 5-24c).

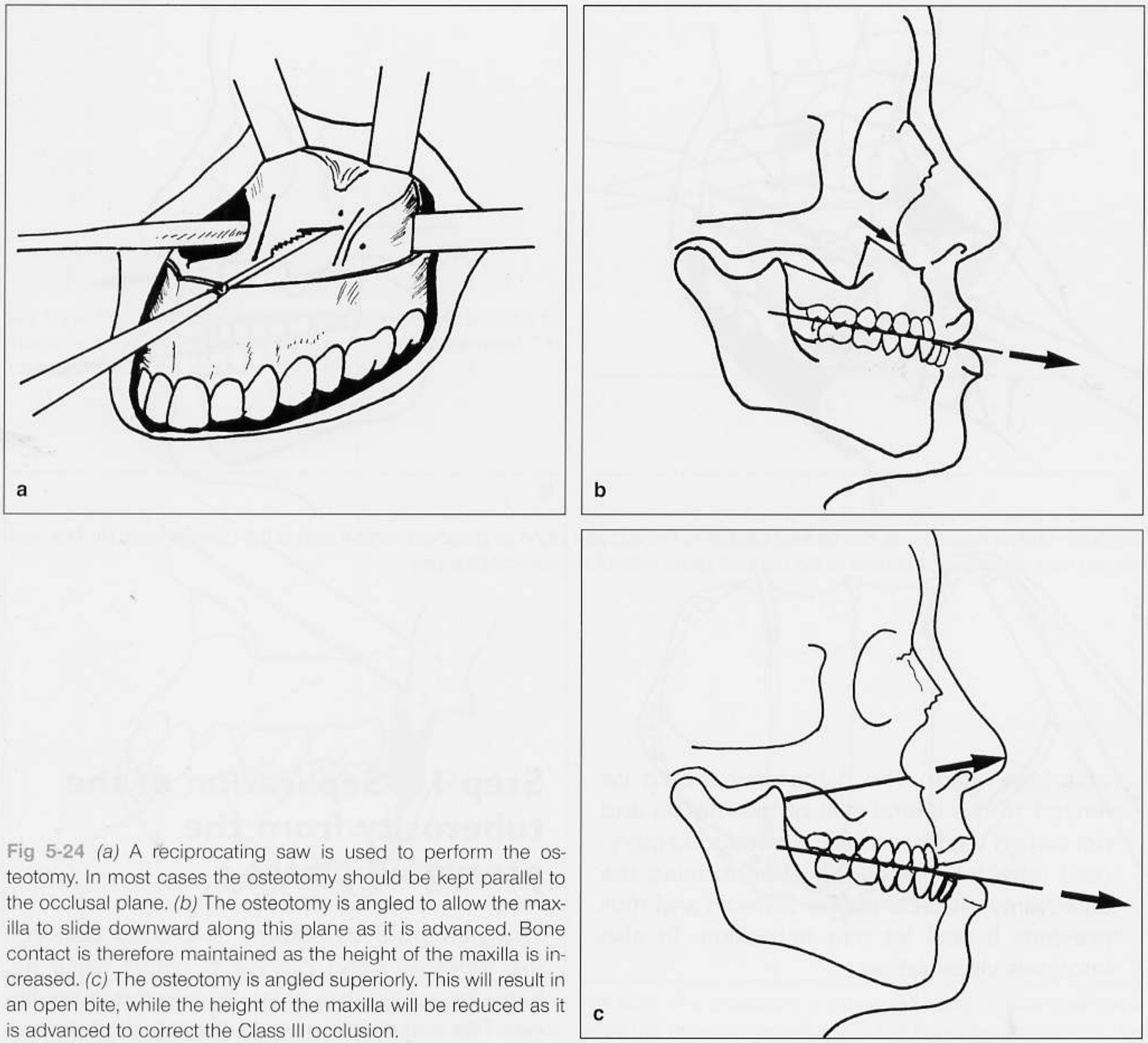


Fig 5-24 *(a)* A reciprocating saw is used to perform the osteotomy. In most cases the osteotomy should be kept parallel to the occlusal plane. *(b)* The osteotomy is angled to allow the maxilla to slide downward along this plane as it is advanced. Bone contact is therefore maintained as the height of the maxilla is increased. *(c)* The osteotomy is angled superiorly. This will result in an open bite, while the height of the maxilla will be reduced as it is advanced to correct the Class III occlusion.

Step 7: Posterior buccal osteotomy

Perform the posterior buccal osteotomy with a reciprocating saw on a plane approximately 3 mm lower than the anterior osteotomy extending from the buttress to the tuberosity. This will create a step between the anterior and posterior osteotomies. This osteotomy design has certain advantages:

1. It enables the surgeon to keep the osteotomies parallel to the occlusal plane (Fig 5-25a).
2. It enables the surgeon to make the posterior osteotomy lower at the tuberosity, thus facilitating easy and safer down-fracture.
3. The steps act as a guide in repositioning the maxilla. The extent of the advancement or any rotations of the maxilla can also be measured and monitored at the steps (Fig 5-25b).
4. After advancement of the maxilla, the defect created at the step area facilitates placement

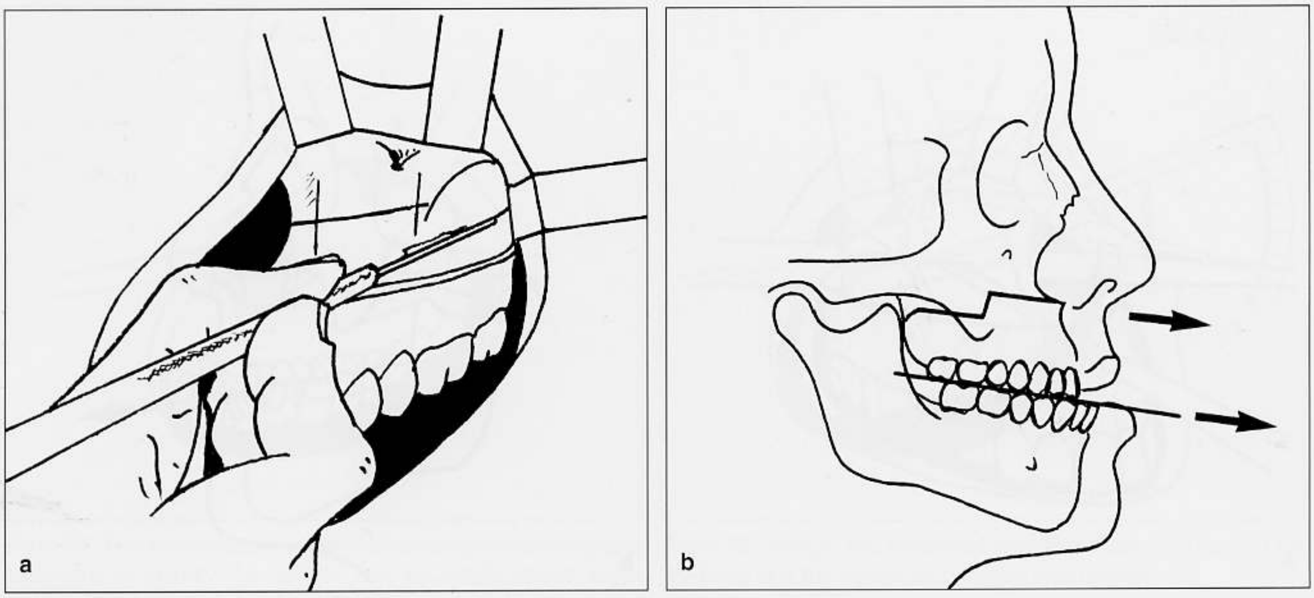


Fig 5-25 *(a)* The osteotomies can be kept parallel to the occlusal plane by placing a vertical step at the buttress area. *(b)* The maxilla can now be advanced parallel to the occlusal plane without any vertical changes.

of a bone graft. The osteotomy should be limited to the lateral wall of the maxilla and not carried too far medially. Rotating the pterygoid retractor upward when performing the osteotomy protects the periosteum and thus prevents buccal fat pad herniation. (It also improves visualization.)

Step 8: Connecting the anterior and posterior osteotomies

Connect the two horizontal osteotomies with a vertical osteotomy at the buttress using a 701 bur.

Step 9: Placing the holes for interosseous wires

The holes should be placed in thick bone at the buttress areas and positioned in such a way that the vector of the positioning wire will support the repositioning of the maxilla (Fig 5-26).

Step 10: Separation of the tuberosity from the pterygoid plates

The pterygoid osteotome is placed between the tuberosity and pterygoid plates while the hamulus is palpated palatally with the index finger. The assistant then taps the osteotome carefully. The osteotome is directed medially and downward (Fig 5-27). Avoid overstretching the buccal mucosa and periosteum. Take extreme care not to damage the palatal soft tissue; perforation of the palatal mucosa with the osteotome may compromise the blood supply and lead to catastrophic consequences. Failure to separate the tuberosity from the pterygoid plates will lead to failure or difficulty in downfracturing the maxilla or to an unfavorable fracture (through the palatine bone or through the pterygoid plates).

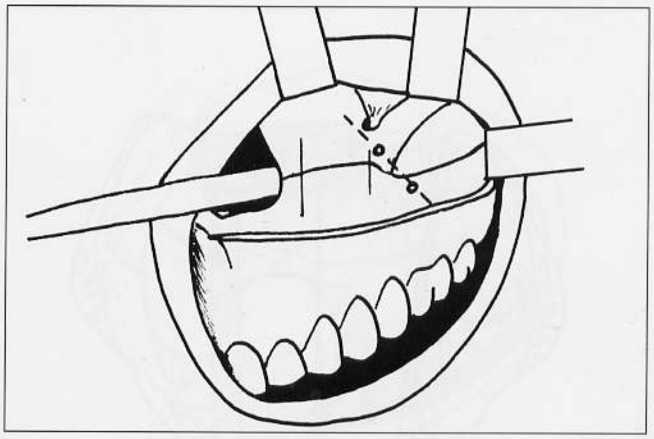


Fig 5-26 For maxillary advancement procedures, the holes for interosseous wires are positioned to support the movement. The lower hole is placed posterior to the top hole.

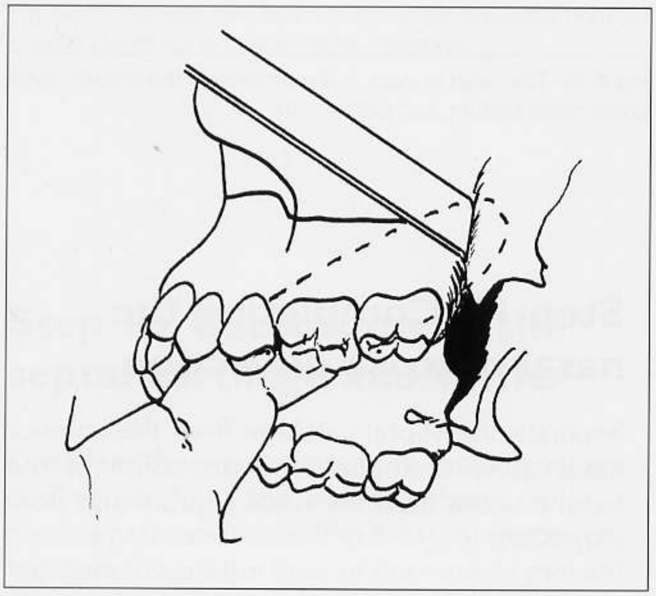


Fig 5-27 The contents of the pterygoid maxillary fissure and soft palate are protected by placing the index finger at the hamulus palatally to feel the osteotome as it separates the tuberosity and the pterygoid plates. Note that the osteotome is directed medially and downward.

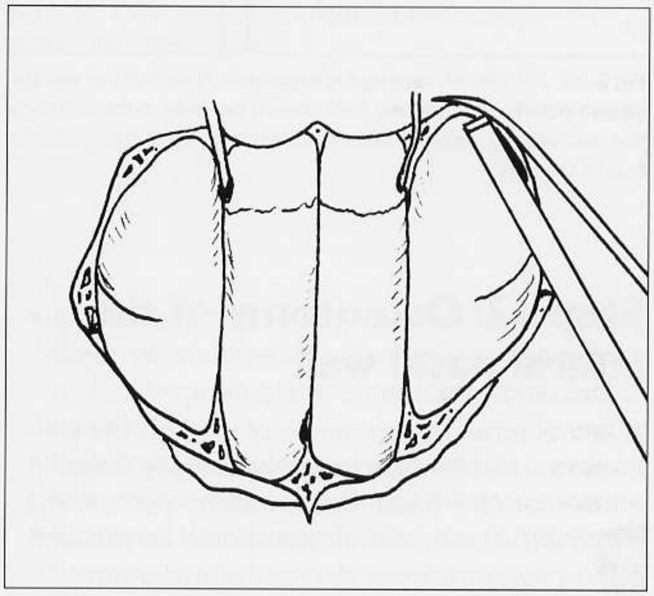


Fig 5-28 The osteotomy is completed using a small osteotome while the pterygoid osteotome is still in position, protecting the soft tissue behind the maxilla.

Step 11: Completion of the posterior osteotomy

With the pterygoid osteotome still in position, use a thin osteotome to complete the osteotomy of the posterior wall of the maxilla. The osteotome should protect the contents of the pterygopalatine fossa during completion of the osteotomy (Fig 5-28). Do not stray too far medially, because the osteotome may damage the descending palatine artery or tear the soft palate.

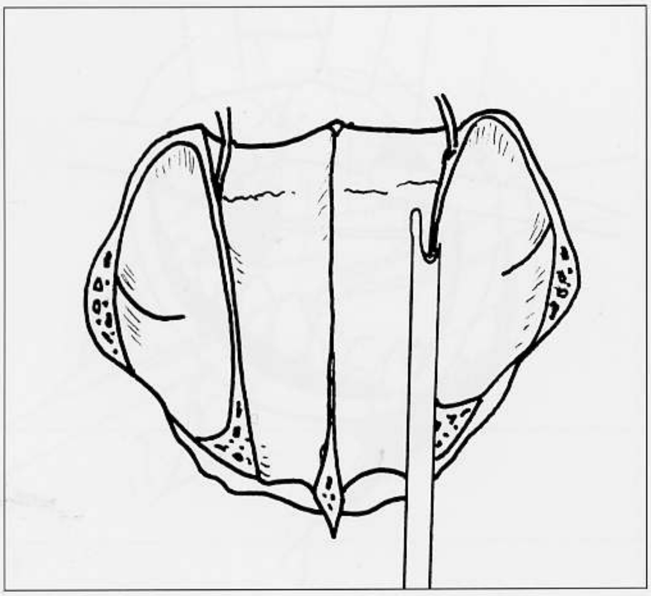


Fig 5-29 The lateral nasal wall is separated. Note that the wall deviates posteriorly; therefore, care should be taken not to damage the descending palatine neurovascular bundle at the posterior end of the wall.

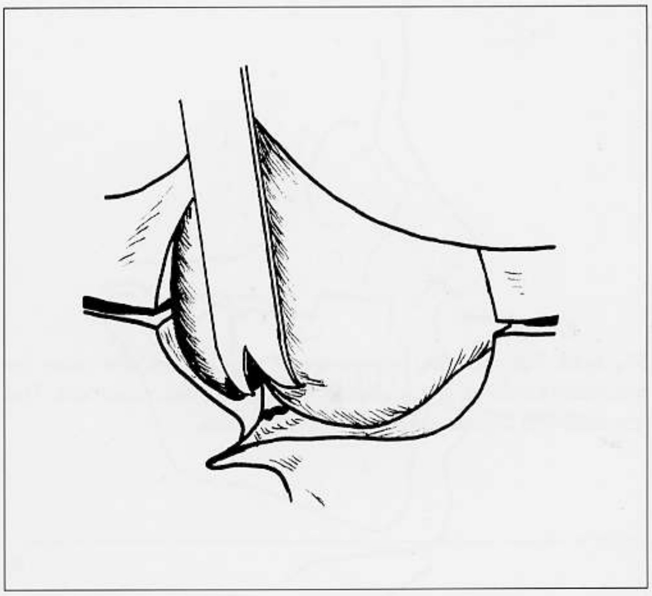


Fig 5-30 The nasal mucosa is dissected from the anterior nasal spine, nasal septum, and piriform rim.

Step 12: Osteotomy of the lateral nasal wall

A lateral nasal osteotome is placed on the piriform rim and directed slightly laterally (keep in mind that the nasal fossa widens posteriorly) (Fig 5-29). The nasal mucosa should be protected to prevent tearing during the osteotomy.

Step 13: Repeating the procedure on opposite side

A small wet sponge is placed on the completed side. The osteotomies should be placed at the same level and angle on both sides, according to the surgical treatment plan.

Step 14: Completing the nasal spine subperiosteal dissection

Place a ramus retractor subperiosteally in the midline over the anterior nasal spine. Dissect the rest of the periosteum from the anterior nasal spine.

Step 15: Completing the nasal mucosa dissection

Separate the septal cartilage from the anterior nasal spine. Complete the dissection of the nasal mucosa from the nasal septum and floor (Fig 5-30):

- Protect the nasal mucosa; do not perforate or tear it.
- A light tug on the ramus retractor (swallowtail retractor) will separate the septal cartilage from the anterior nasal spine and facilitate further dissection.
- Dissection of the nasal mucosa from the septum and floor will be facilitated by removal of the anterior nasal spine.
- Remove the anterior nasal spine with a bone nibbler, but leave enough bone at the base of the spine to accommodate a hole, which will later be used for a cinch and septal suture.
- Keep in mind that removal of the nasal spine will have soft tissue implications.

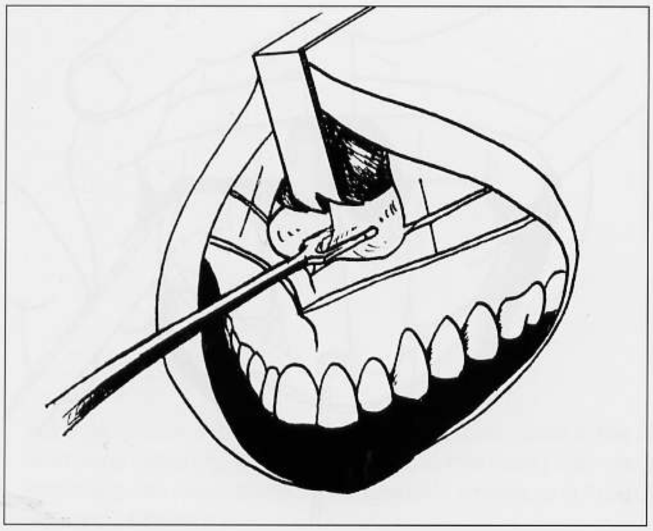


Fig 5-31 The nasal cartilage and vomer are separated from the maxillary bone using a nasal septal osteotome.

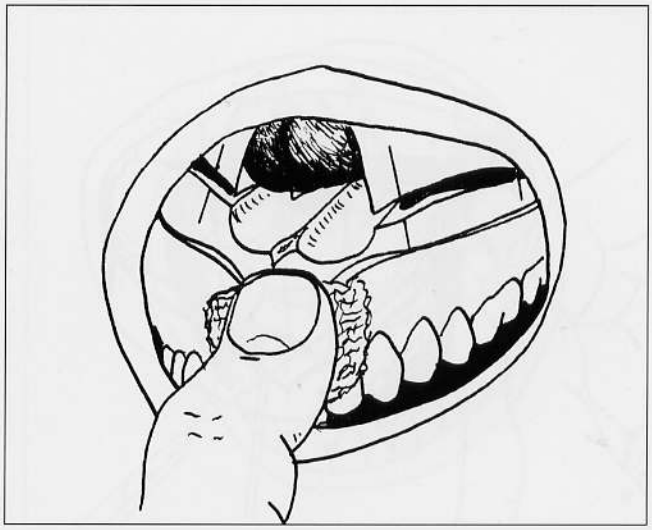


Fig 5-32 The maxilla is down-fractured with downward pressure on the anterior maxilla.

Step 16: Osteotomy of the septal cartilage and vomer

Complete the separation of the septal cartilage and vomer from the maxillary bone using a nasal septal osteotome (Fig 5-31). Angle the osteotome toward the floor of the nose to prevent tearing the nasal mucosa.

Step 17: Maxillary down-fracture

Down-fracture the maxilla by pushing downward on the anterior maxilla. Place a small wet sponge between the thumb and the maxilla (Fig 5-32). The assistant should stabilize the patient's superior midface. The maxilla should down-fracture easily. If it does not, revise all the osteotomies, especially at the junction between the tuberosity and the pterygoid plates (see Step 18). If necessary, complete the elevation of the nasal mucosa from the nasal floor under direct visualization once the maxilla has been down-fractured. Do not use excessive force for the following reasons:

- Excessive pressure may mobilize the maxillary teeth. (Remember that the teeth may be slightly mobile because of the orthodontic tooth movement.)
- Prolonged and excessive pressure on the maxillary gingiva may compromise the blood supply.
- Excessive force may loosen the orthodontic brackets on the anterior teeth.
- Excessive force may cause the maxilla to fracture unfavorably (eg, fracture through the palatine bone or the pterygoid plates, resulting in excessive hemorrhage and/or difficult repositioning of the maxilla).

Step 18: Redefining osteotomies when maxillary down-fracture fails

The maxilla should down-fracture with ease. If it doesn't, following are the most probable reasons for the failure:

1. The pterygoid plates and tuberosity are not sufficiently separated.

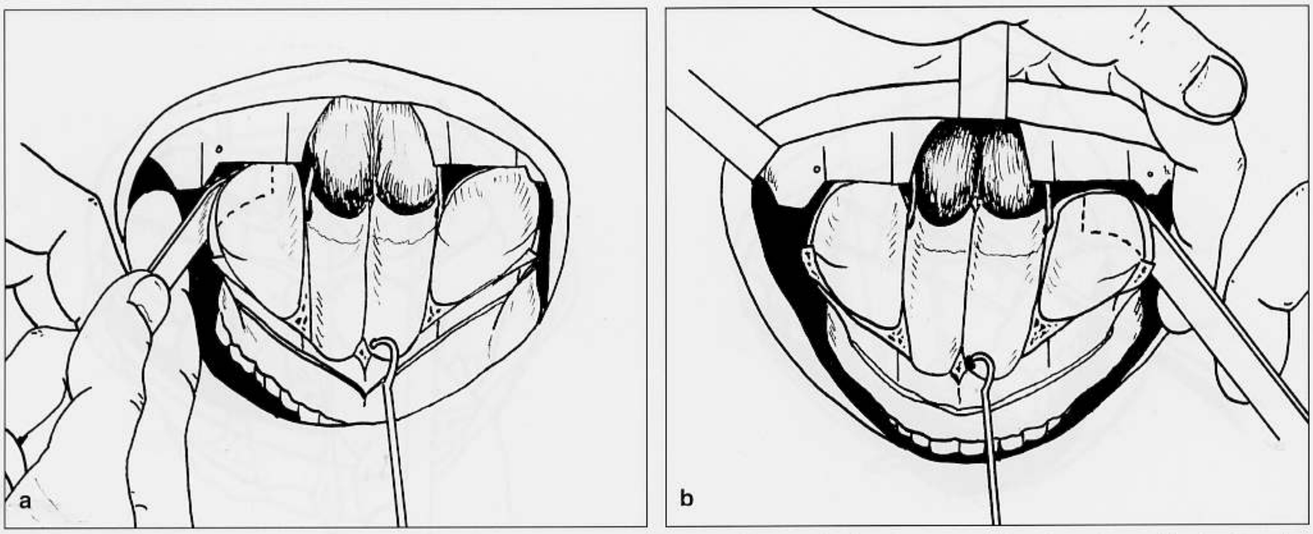


Fig 5-33 *(a)* The right side of the maxilla is mobilized by pushing the maxilla anteriorly using a mobilizer (or pterygoid osteotome). *(b)* The left side of the maxilla is mobilized, using a finger as a fulcrum and protecting the soft tissue at all times.

2. The lateral nasal wall osteotomy is incomplete (too short).
3. Occasionally, the bone of the maxilla is very thick, making down-fracture difficult. In such cases, tap the lateral nasal wall osteotomes into position (bilaterally), and carefully push down on the osteotomes to assist in the down-fracture.

Step 19: Mobilization of the maxilla

Place the maxillary mobilizer securely behind the tuberosity while the assistant pulls the maxilla downward using a cricoid hook placed in the incisive canal. Push the maxilla carefully anteriorly, finally separating the maxilla from the pterygoid plates (Fig 5-33). Mobilization can also be completed by placing a sponge on each side at the posterior osteotomies and then pushing the anterior maxilla superiorly so that the posterior maxilla is distracted, thus separating it from the pterygoid plates.

A few helpful hints at this stage follow:

- Protect the soft tissue; take care not to tear the buccal mucosa with the mobilizing instrument.
- Ensure that the maxilla is completely mobile and separated from the pterygoid plates.
- Ensure that the cricoid hook is positioned securely in the incisive canal.
- Use controlled force.
- Keep the osteotome securely down behind the tuberosity to prevent fracture of the posterior maxillary wall and keep the instrument from slipping.
- Support the instrument with one finger, using it as a fulcrum, while pushing forward with the other hand (see Fig 5-33).

Step 20: Placement of a maxillary positioning wire

Drill a hole through the lateral part of the piriform rim on each side of the down-fractured maxilla. Feed a 0.018-inch wire through the holes, and attach a wire twister to the wire (Fig 5-34). The wire is removed when rigid fixation has been completed. The positioning wire is helpful to *(1)* assist with the final mobilization of the maxilla; *(2)* pull the maxilla anteriorly for better visualization of, and access to, the posterior area of the maxilla; and *(3)* assist in the final positioning of the maxilla.

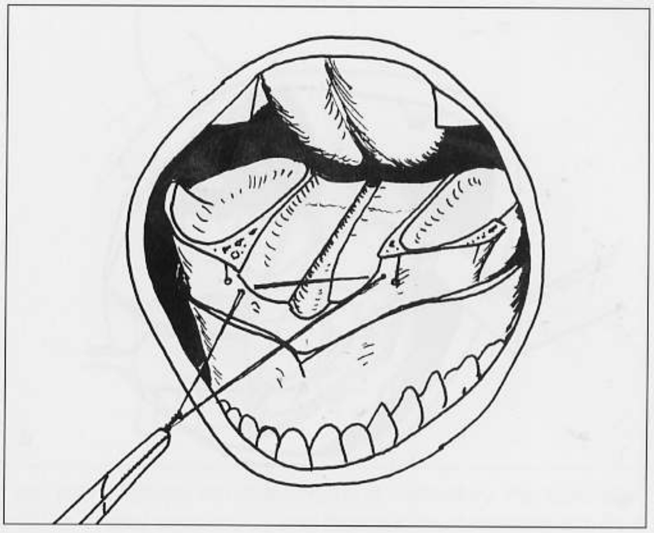


Fig 5-34 Attach a 0.018-inch wire through holes lateral to the piriform rims bilaterally. This wire is helpful in mobilizing the maxilla, improving the visualization of the posterior maxilla, and final positioning of the maxilla.

Step 21: Exposure of the posterior maxilla

Place one pterygoid retractor on the medial side of the lateral nasal wall to completely visualize the posteromedial area of the maxillary sinus. Place another pterygoid retractor subperiosteally on the buccal aspect of the maxilla around the tuberosity (Fig 5-35a). This retraction will expose one side of the posterior maxilla sufficiently to allow the surgeon to do the following:

1. Identify the descending palatine neurovascular bundle.
2. Examine the osteotomies for refinement.
3. Recheck all the osteotomies, especially the level of the fracture in the area of the perpendicular plate of the palatine bone and posterior wall of the maxilla.
4. Examine the maxillary sinus mucosal lining and, when necessary, remove pathological mucosa.

It is extremely important to be able to visualize the posterior wall of the maxilla, the descending palatine neurovascular bundle, the posterior part of the lateral nasal wall (containing the neurovascular bundle), and the anterior aspect of the pterygoid plates. Bony interference in these areas is often the cause of incorrect maxillary repositioning and condylar sag. Sharp bony edges may perforate blood vessels (ie, descending palatine vessels) and lead to intraoperative or postoperative hemorrhage. Removal of irregular bony edges in this area without adequate visualization may damage the contents of the pterygopalatine fossa (ie, the maxillary artery) (Fig 5-35b).

Step 22: Checking fracture level in the perpendicular plate of the palatine bone

The fracture ideally should be at the junction between the tuberosity and pterygoid plates. If the fracture is high and not visible, an osteotomy should be performed lower, at a visible level. The fracture may also be too short, occurring through the tuberosity (involving an unerupted third molar) and continuing between the horizontal plate of the palatine bone and the maxilla. Using the pterygoid chisel placed between the tuberosity and pterygoid plate, the separation should be carefully established at the correct site. A short fracture involving the horizontal plate of the palatine bone will make accurate repositioning of the maxilla impossible.

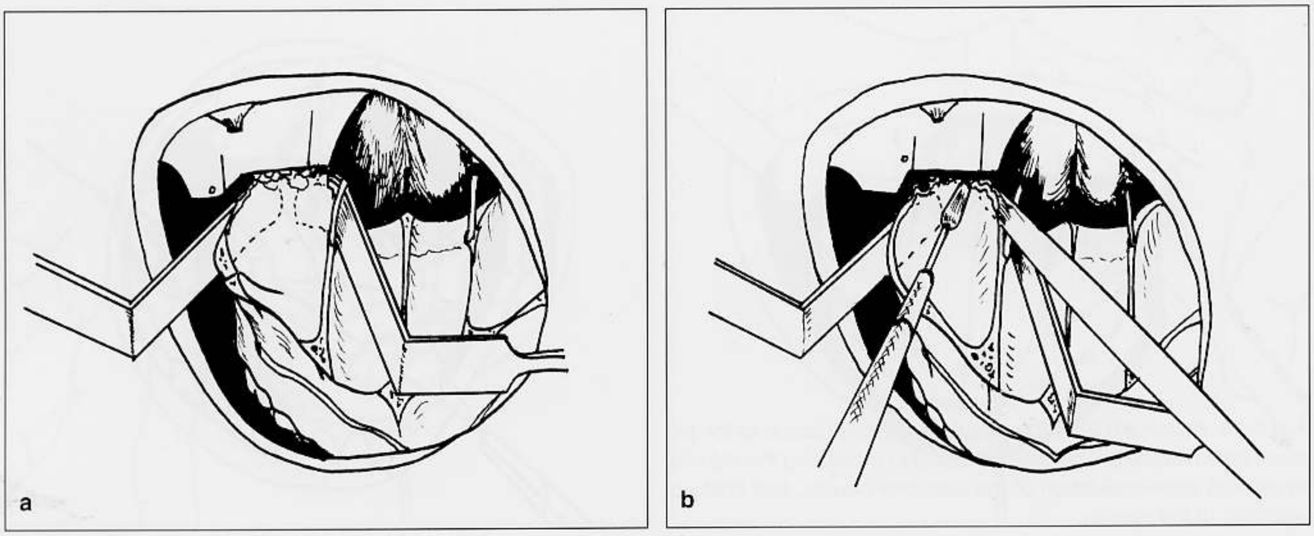


Fig 5-35 *(a)* Visualization of the posterior maxilla is improved by placing pterygoid retractors around the tuberosity. *(b)* Bone irregularities at the posterior wall of the maxillary sinus should be removed under good vision while the soft tissue is protected adequately.

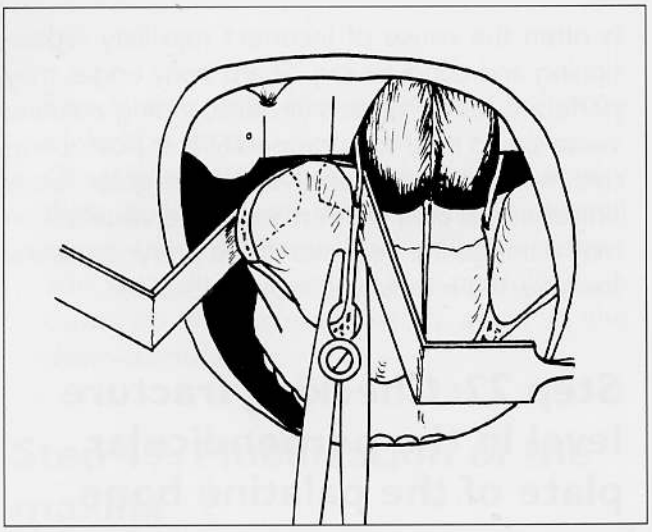


Fig 5-36 The lateral nasal wall is trimmed using a bone nibbler; care is taken to carefully remove bone around the descending palatine neurovascular bundle.

Step 23: Trimming the lateral nasal wall

Next, the lateral nasal wall should be trimmed according to the treatment plan using a bone nibbler and a vulcanite bur. Take care not to damage the descending palatine neurovascular bundle (Fig 5-36).

Step 24: Refining the osteotomy at the posterior maxillary wall

Refining the osteotomy at the posterior maxillary wall is an important step. Take special care in removing bony interference in the following areas (Fig 5-37): the posterior part of the lateral wall, the palatine bones, the maxillary tuberosities,

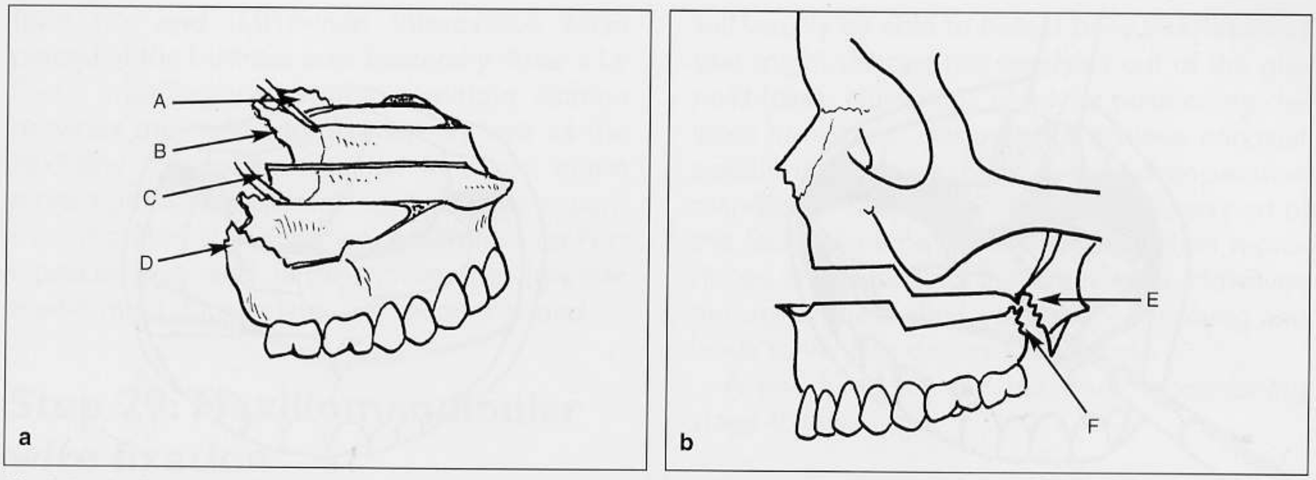


Fig 5-37 *(a)* Refinement of the osteotomy at the posterior maxillary wall and adequate removal of bone is mandatory. Pay special attention to the posterior part of the lateral wall (A), the palatine bone (B), the nasal septum (C), and the maxillary tuberosity (D). *(b)* It is important to remove adequate bone from the pterygoid plates (E) and the tuberosities (F), especially in cases where the maxilla will be superiorly repositioned. It is preferable to remove bone from the tuberosities rather than from the pterygoid plates.

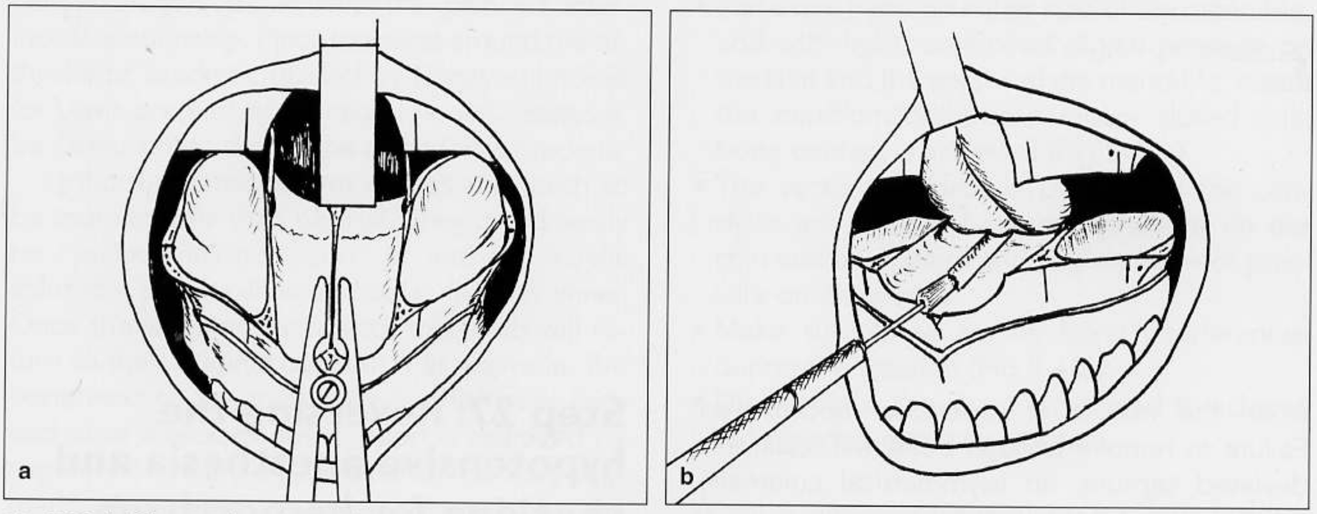


Fig 5-38 *(a)* The nasal septum and remaining part of the vomer is trimmed from the nasal floor using a bone nibbler. *(b)* Adequate trimming of the vomer and even creation of a trough in the nasal floor is essential to accommodate the nasal septum after maxillary repositioning. This is especially important when the maxilla will be superiorly repositioned.

the posterior wall of the maxilla, the pterygoid plates, and the nasal septum.

It is important to remove all bony interferences to facilitate unhindered and accurate repositioning of the maxilla. Bone should be removed from the posterior maxilla at the inferior aspect rather than from the superior aspect of the maxilla or pterygoid plates. The descending palatine neurovascular bundle should be protected at all times, especially when removing the bony interferences posterior to this structure.

Step 25: Reduction of the palatal aspect of the nasal septum

The remaining part of the nasal septum is removed from the nasal floor using a bone nibbler (Fig 5-38a). Then, using a large trimming bur, a trough is created on the nasal floor to accommodate the nasal septum after maxillary repositioning (Fig 5-38b). This is especially important

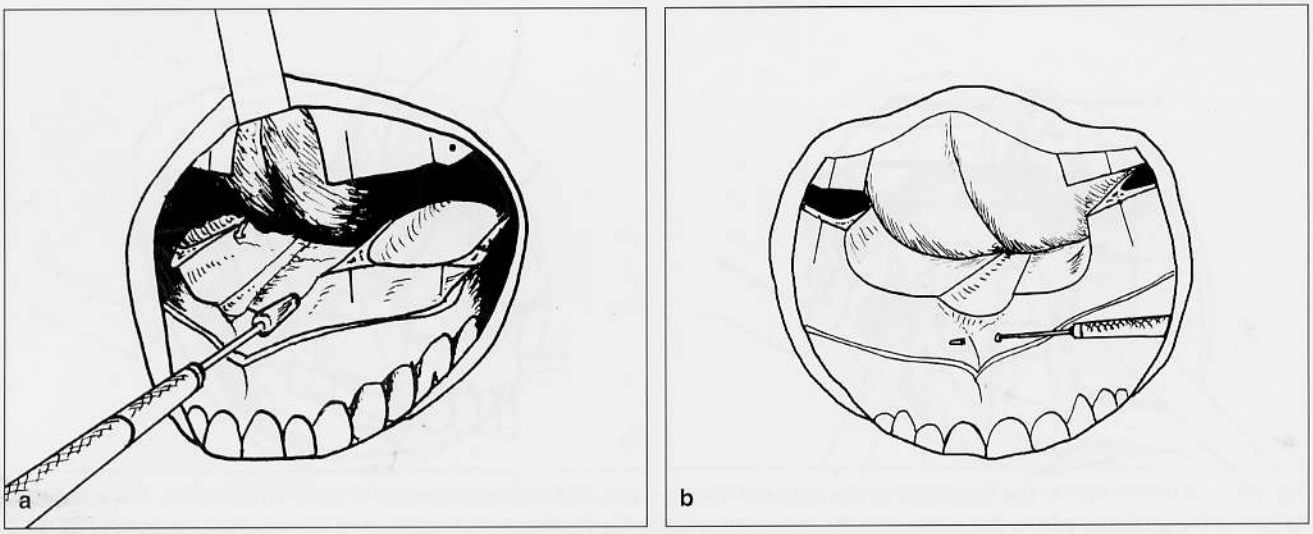


Fig 5-39 *(a)* The piriform rim should be contoured using a vulcanite bur to accommodate the soft tissue of the base of the nose after maxillary repositioning. *(b)* A hole is drilled horizontally through the anterior nasal spine. This hole will be used later for the placement of a cinch suture and for securing the nasal septum.

when the maxilla is superiorly repositioned. Failure to remove enough bone will result in a deviated septum, an asymmetrical columella, and an unpredictable soft tissue result.

Step 26: Contouring the piriform rim

The piriform rim should be contoured to accommodate the nasal tissue after maxillary repositioning (Fig 5-39a). At the same time, a hole is drilled horizontally through the base of the anterior nasal spine (Fig 5-39b). This hole will be used later to position and secure the nasal septum, as well as to assist in the placement of a cinch suture. Insufficient removal of the bone at the piriform rim areas, especially in cases where the maxilla will be superiorly repositioned, may lead to flaring of the alae, lifting of the nasal tip, and/or asymmetry of the nose.

Step 27: Reversing the hypotensive anesthesia and checking for hemorrhage

Before the maxilla is finally repositioned and fixated, it may be wise to reverse the hypotensive anesthesia. At this time, while the patient is normotensive, undetected arterial hemorrhage can be discovered and addressed. This will help prevent postoperative hemorrhage.

Step 28: Feeding a wire through the holes at the buttress

Semirigid fixation is used in most cases. The maxilla is fixated with two bone plates (1.5 mm) placed anteriorly in the thick bone of the piriform rim and 0.018-inch interosseus wires placed at the buttress area bilaterally. After a Le Fort I maxillary osteotomy, semirigid fixation provides the necessary fixation, as well as the flexibility for optimal results. In cases where more rigidity is required (eg, maxillary expansion, maxillary downgrafting, multipiece Le Fort I procedures, and large movements [greater than 6 mm]), more plates are recommended.

Step 29: Maxillomandibular wire fixation

The vector of pull of the fixation wires should support the direction of jaw positioning. Place the first maxillomandibular wire around the four central incisors to achieve the planned interincisal relationship. Place the wires around the orthodontic brackets, guided by Kobayashi hooks (or Lewis brackets with integral hooks). However, be careful not to detach the orthodontic brackets.

Orthodontic movement causes the teeth to be more mobile than normal. They could easily be "pulled into occlusion" or into the acrylic splint by the maxillomandibular fixation wires. Once the wires are removed, the teeth will return to their original position. For example, the bone next to the midpalate is often very thin, and once alveolar bone support is removed by segmental surgery (eg, an anterior maxillary segment), the palate may be bent easily by the force of the maxillomandibular fixation. When maxillomandibular fixation is removed, however, relapse will occur immediately because the maxilla will return to its original shape.

Step 30: Maxillary repositioning

Rotate the maxillomandibular complex closed, and check the reference marks for accurate maxillary positioning. Positioning the condyles in their ideal relationship to the fossa while the maxilla is positioned in its new planned position is the most challenging and difficult part of the procedure. The surgeon, with experience, will develop a feel for positioning the condyles and will usually be able to detect bony interferences that might distract the condyles out of the glenoid fossa. Numerous condylar positioning devices have been designed to achieve condylar positioning by recording the preoperative mandibular position in relation to a fixed part of the facial skeleton. This position is then reproduced after repositioning the maxilla. However, the use of these devices is time consuming and leads to varying degrees of success.

A few hints for the maxillary repositioning stage follow:

- Take great care during this step to ensure that the maxilla is in its planned position while both mandibular condyles are in an ideal relationship with the glenoid fossa.
- Place one hand on either side of the mandible, and with light, controlled digital pressure on the chin and the angles of the mandible, rotate the maxillomandibular complex closed until bone contact is achieved (Fig 5-40a).
- The vectors of force in positioning the condyles are a slight backward pressure on the chin and an upward and slightly anterior pressure on the angles.
- Make sure there are no bony interferences during the rotation (Fig 5-40b).
- Do not force the mandible closed to achieve the planned maxillary position.

When any bony interferences are detected, rotate the mandible open, inspect the area where interferences are suspected, and remove them under good visualization (see the discussion of condylar sag, pages 304 to 306).

Step 31: Turbinectomy

If an enlarged inferior turbinate interferes with superior repositioning of the maxilla, it should be reduced. Enlargement of the turbinate could be caused by soft tissue hypertrophy alone or both soft tissue and bone hypertrophy. A turbinectomy could be performed from a ventral approach through an incision or tear in the nasal mucosa by grasping the hypertrophied soft tissue with an artery clamp and resecting the tissue

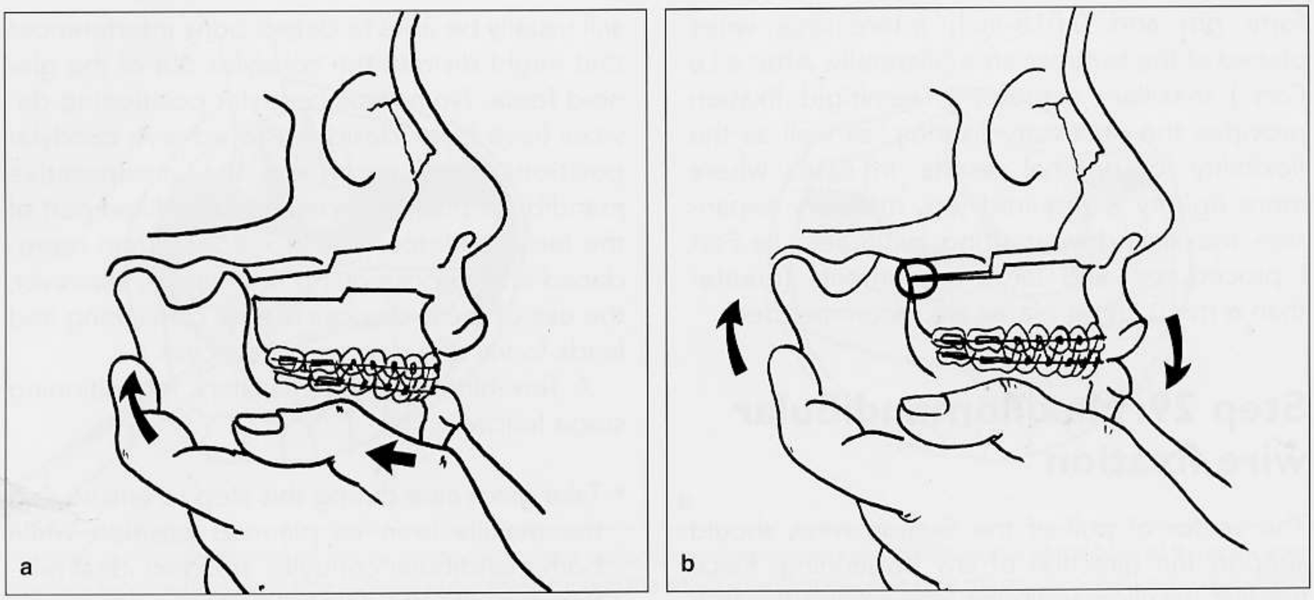


Fig 5-40 *(a)* With intermaxillary fixation in position, the maxillomandibular complex is rotated to achieve bone contact. The vector of force on the condyle should be superior and slightly anterior. There should be no bony interferences during the rotation. *(b)* Bony interferences usually occur at the posterior maxilla *(circle)*. As the maxilla is rotated, the interference will cause the condyle to be distracted downwards. Once the intermaxillary fixation is removed, the condyle will move superiorly, creating an anterior open bite (see the section on intraoperative diagnosis of condylar sag during Le Fort I osteotomy, pages 304 to 306).

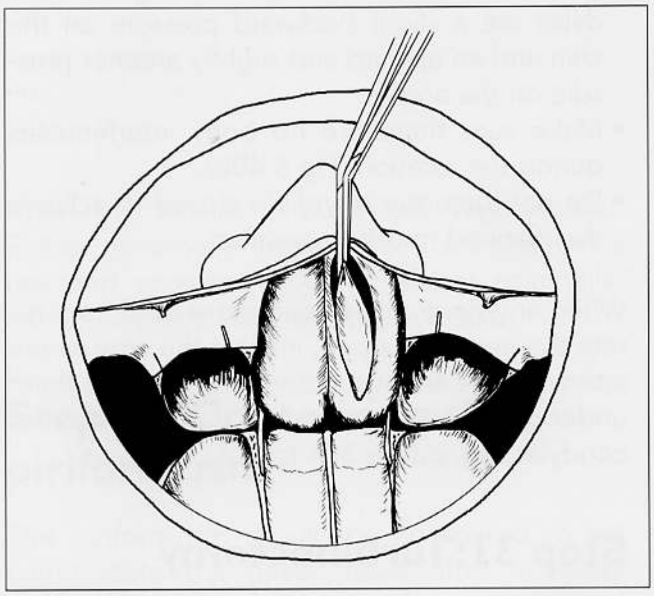


Fig 5-41 The hypertrophied turbinate is grasped with a tissue clamp and then removed using a diathermy knife.

above the clamp using a diathermy knife (Fig 5-41). Hypertrophied bone may be removed by elevating the mucoperiosteum above the bone and then removing the desired portion of bone with a small bone nibbler. The overlying hypertrophied mucoperiosteum may be removed with a diathermy knife and need not be sutured. The nasal mucosa incision (tear) is sutured with a 4-0 chromic suture.

Step 32: Suturing the nasal mucosa

Identify any tears in the nasal mucosa, and repair them with a 4-0 chromic suture. Failure to repair a tear in the nasal mucosa may cause excessive intraoperative and/or postoperative hemorrhage and may also jeopardize the success of any bone grafts in the palate.

Step 33: Checking the position of the nasal septum

Rotate the maxillomandibular complex closed to achieve the predetermined maxillary position. Ensure that the condyles are seated in the glenoid fossa, and then check the position of the nasal septum. The septum should lie freely, without any interference in the trough created in the nasal floor (see Step 25). The nasal septum cartilage and vomer may be trimmed to ensure that the septum lies passively. The nasal septum may be secured in position by placing a suture through it and through the horizontal hole in the base of the nasal spine after maxillary fixation (see Step 39). If nasal reconstruction with cartilage graft is contemplated, the cartilage can be harvested from the septum at this stage. If nasal reconstruction will be deferred for a second operation, the harvested cartilage can be "stored" subperiosteally on the lateral wall of the maxilla for later use.

Step 34: Tightening the buttress wires

Copious lavage of the maxillary sinuses and nasal floor with saline solution should be carried out before tightening the buttress wires; small bone fragments remaining in the sinus or nasal cavities will lead to postoperative infection. Retract the soft tissue bilaterally away from the osteotomy line using pterygoid retractors to allow the necessary bone contact and avoid soft tissue entrapment. Carefully rotate the maxillomandibular complex superiorly to achieve bone apposition, and tighten the interosseus buttress holding wires. Avoid overtightening the wires in an attempt to achieve better bone apposition, since the tension it would place on the bone would result in displacement and occlusal discrepancy once maxillomandibular fixation was removed.

Step 35: Checking maxillary position using a caliper

If there is any doubt about the condylar position at this stage, the maxillomandibular fixation should be removed and the occlusion checked by referring to intraoral bony reference marks or to an extraoral reference point (eg, a Kirschner wire in the frontal bone). The interosseous wires are usually sufficient (in single-piece maxillary or segmental surgery with the teeth wired into an acrylic splint) to maintain the maxilla in position while the occlusion is checked. If necessary, small adjustments in the maxillary position can now be made to achieve the planned occlusion. An unacceptable occlusion should be corrected by removing the interosseous wires, finding the reason for the discrepancy, and correcting the problem.

Step 36: Replacing the maxillomandibular fixation

Recheck the position of the maxilla using a caliper and the reference marks made in Step 5. If the maxillary position and occlusion are satisfactory, replace the maxillomandibular fixation.

Step 37: Placement of bone plates

Selection and adaptation of plates

Use 1.5-mm titanium bone plates or resorbable bone plates. The decisions about the method of stabilization and type of plate (titanium or resorbable) are influenced by several factors, including bone thickness, bone quality and contact, amount of surgical movement, and direction of movement. The methods of fixation are interosseous wires, suspension wires, bone plating (titanium or resorbable), and a combination of the above.

Most cases use semirigid fixation, which consists of bilateral titanium (1.5-mm) bone plates or resorbable (2.0-mm) plates placed anteriorly in the thick bone at the piriform areas and two interosseous (0.018-inch) wires placed at the zygomatic buttresses. Some cases, however, may demand additional fixation—for example, cases with large movements (more than 6 mm) and poor bone contact, downgrafting procedures, or segmental osteotomies of the maxilla. Suspension wires are seldom used today.

The plates should be adapted to fit passively. Two screws should be placed on either side of the osteotomy, and care should be taken not to place screws into the roots of teeth, too close to the edge of the bone, or in thin bone. If thin bone must be used, self-drilling screws are recommended.

Segmental maxillary surgery

Segmental surgery should be used to facilitate narrowing or widening of the maxillary dental arch, close interdental spaces, or surgically level the occlusal plane.

Interdental osteotomy

The surgeon should ensure that there is sufficient space between the roots of the teeth adjacent to the proposed interdental osteotomy site. For vertical movements of the segments, the roots should be at least parallel; when closure of an interdental space is contemplated, the roots should be divergent. The interdental osteotomy should be initiated before the maxilla is down-fractured. This technique has two distinct advantages. First, when the maxilla is stable, the initial bur cut and tapping with the interdental osteotome are easier. Second, because the osteotome is tapped while the maxilla is stable, the technique prevents stretching of the vital soft tissue pedicle of the maxilla.

The interdental bone should be exposed by careful reflection of the mucoperiosteum inferiorly. Using a small fissure bur (701), penetrate only the cortical bone between the roots of the adjacent teeth (Fig 5-42a). Place a finger on the palate to palpate the osteotome as the interdental osteotomy is completed with a thin spatula osteotome. Hold the osteotome in one hand while placing a finger of the other hand in the palate. The assistant should then tap the osteotome carefully. As the osteotome passes through the alveolar bone and thick palatal bone, the resistance to the tapping helps in determining the position of the osteotome tip. To avoid damaging the periodontal tissue, do not tap the osteotome right down to the alveolar crest (Fig 5-42b). The segment should be mobilized only once the maxilla is down-fractured; mobilization should be achieved by completion of the palatal osteotomy through the nasal floor. Mobilize the segment using finger pressure or rotation of a flat instrument placed into the line of the interdental osteotomy.

Nasal floor or palatal osteotomy

The palatal osteotomy in the nasal floor is performed once the maxilla is down-fractured. Protect the mucoperiosteal pedicles by supporting the maxilla while the osteotomies are performed. Perimidline sagittal osteotomies are performed lateral to the nasal septum, where the bone is thin and the palatal mucosa is slightly thicker than in the midline of the palate. Use a fissure bur to drill through the bone lateral to the nasal septum, taking care not to perforate the palatal periosteum (Fig 5-43). The palatal osteotomy is connected to the interdental osteotomy and completed with a thin osteotome. Be extremely careful not to tear the palatal mucosa, especially in a transverse direction, because this will limit blood supply. Mobilize the segments with finger pressure or by placing a small, flat instrument in the interdental osteotomy areas and rotating it. Bilateral osteotomies should be contemplated for palatal expansion of more than 5 mm.

For large expansions, it may be desirable to graft the defect. When doing so, ensure that

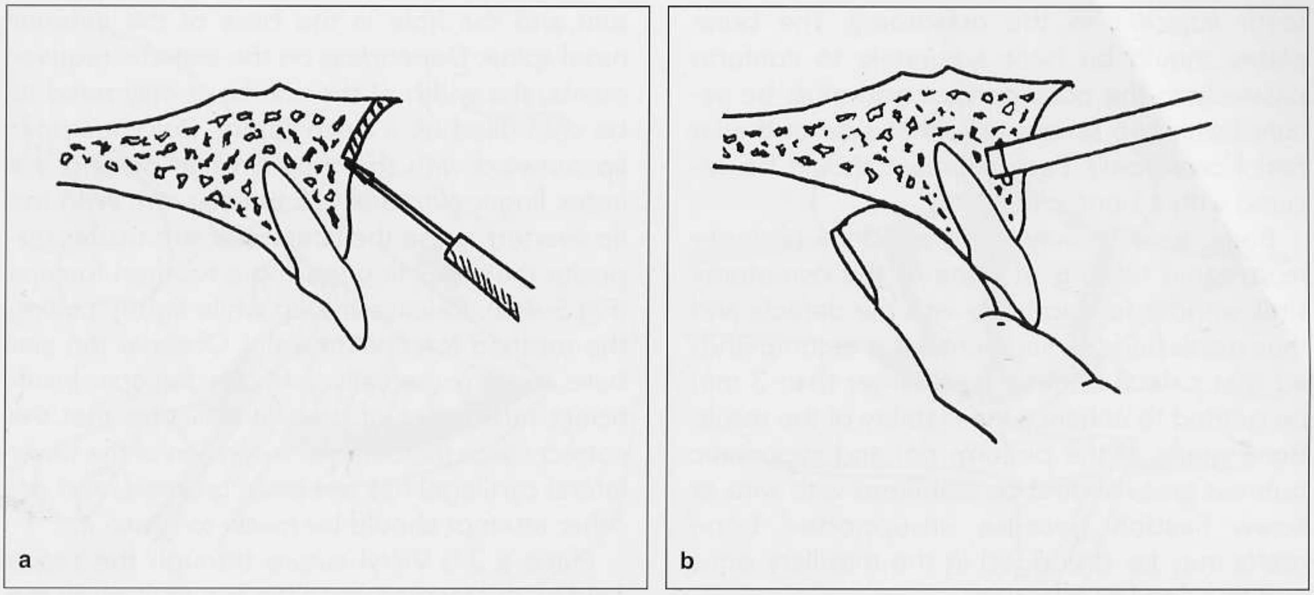


Fig 5-42 *(a)* Interdental osteotomy. First only the cortical bone between the roots of the adjacent teeth is penetrated by the drill. *(b)* The interdental osteotomy is completed by tapping a thin, sharp osteotome between the roots. The position of the osteotome is monitored by placing a finger on the palate behind the teeth.

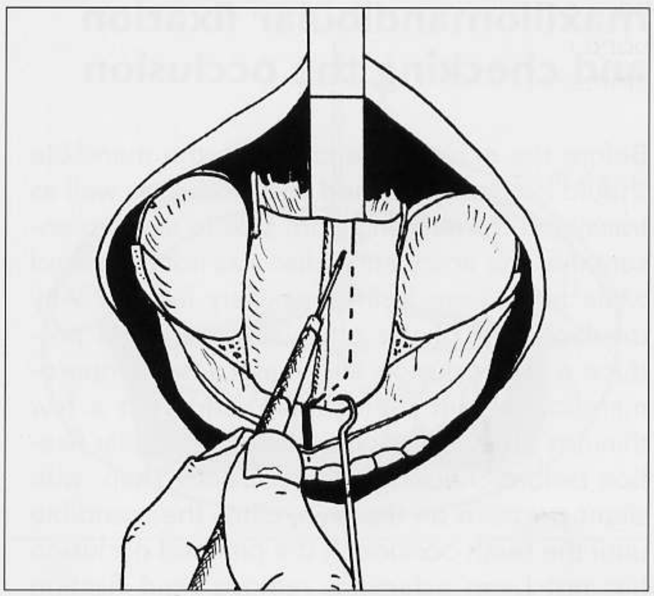


Fig 5-43 The palatal osteotomy is placed just lateral to the nasal septum. The bone is thin here and the mucosa thick. Placement of the osteotomy too far laterally may damage the greater palatine neurovascular bundle.

the nasal and palatal mucosa are intact. Large palatal expansions may result in tension in the palatal soft tissue, which may be released by further lateral mucoperiosteal dissection or by incising the periosteum (anteroposteriorly) in an area that is not overlying the osteotomy. Ensure that the nasal mucosa is intact, and *never* incise or tear the palatal mucosa transversely.

Fixation and stabilization after segmental osteotomies

To establish the planned occlusion, use an acrylic splint prefabricated according to the model surgery. Place a two-hole bone plate across the interdental osteotomy, one screw on either side, to secure the segment. Using the orthodontic brackets, place an interdental wire around the teeth adjacent to the osteotomy. The bone plates should be bent accurately to conform passively to the bony contour and must be secured with two screws on either side of the Le Fort I osteotomy. Each segment should be secured with a bone plate.

Bone defects may be grafted to promote more rapid healing of bone at the osteotomy sites without forcing bone into the defects and thus displacing the segments. It is recommended that palatal bone defects larger than 3 mm be grafted to enhance the stability of the result. Bone grafts at the piriform rim and zygomatic buttress areas should be stabilized with wire or screw fixation because unsupported bone grafts may be dislodged in the maxillary sinus and thus lead to infection.

Step 38: Removing the maxillomandibular fixation and checking the occlusion

Before the occlusion is checked, the mandible should be gently opened and closed, as well as translated forward and from side to side, to ensure that the articulating disc was not displaced while teeth were in intermaxillary fixation. Any displacement of the articulating disc will produce a malocclusion and may cause temporomandibular joint dysfunction later. Wait a few minutes after removing maxillomandibular fixation before checking the occlusion. Then, with slight pressure on the chin, close the mandible until the teeth occlude. If the planned occlusion has not been achieved, remove rigid fixation and diagnose and correct the reason for failure. Keep in mind that the occlusal splint may be at fault. Accepting an incorrect occlusion may necessitate another operation. *There is no better time to correct a problem than now.*

Step 39: Placement of nasal septum and cinch sutures

Secure the septum in the trough created in the floor of the nose by a suture through the septum and the hole in the base of the anterior nasal spine. Depending on the esthetic requirements, the width of the alar base may need to be controlled by a cinch suture. Roll the upper lip outward with the thumb while placing the index finger extraorally at the alar rim. With the lip everted, grasp the lateral alar soft tissues opposite the index finger using a toothed forceps (Fig 5-44a). Release the lip while lightly pulling the toothed forceps medially. Observe the alar base moving medially with the forceps. Insufficient movement of the alar indicates that the correct tissue (fibroareolar extension of the lower lateral cartilage) has not been grasped, and another attempt should be made to grasp it.

Place a 3-0 Vicryl suture through the tissue held by the forceps, feed the suture through the hole at the base of the anterior nasal spine, and repeat the procedure on the contralateral side in a figure-eight configuration (Fig 5-44b). Tighten the suture to narrow the base to approximately 3 mm less than the desired width to allow for postoperative widening.

Step 40: Submucosal suturing

The soft tissue incision is closed in layers—first the submucosal tissue and then the mucosa. Suturing is one of the most important steps of the procedure and should be performed meticulously. It is the last step of the surgical procedure, and the surgeon may be tired at this stage and not give this important step enough attention. It is essential to realize that incorrect suturing may result in poor esthetic results. Start posteriorly and end at the piriform rim on both sides by pulling the superior tissues slightly forward.

Step 41: Mucosal suturing

Perform a V-Y closure (Fig 5-45), and reapproximate the mucosal midline using 4-0 chromic sutures. Place two interrupted sutures on both sides of the midline to reapproximate it. Complete the mucosal suturing using a continuous suture starting posteriorly and pulling the superior tissue slightly forward. When lip lengthening is indicated, more horizontal sutures (or even bilateral V-Y suturing) may be used.

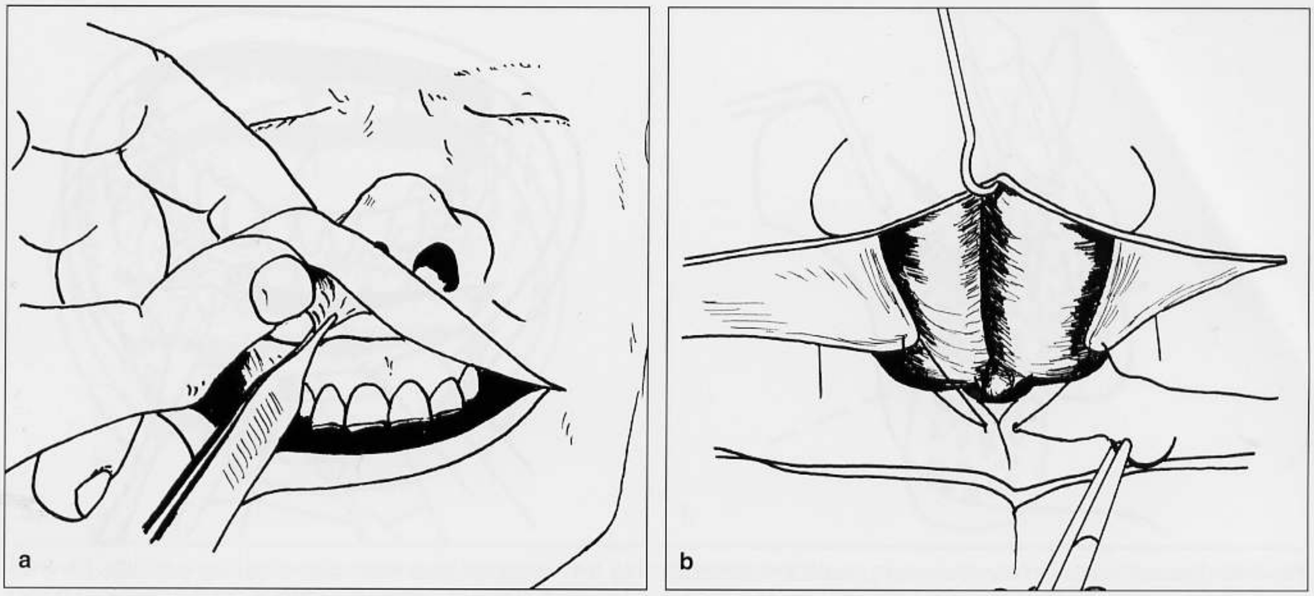


Fig 5-44 *(a)* The lateral alar soft tissue is grasped with a toothed forceps. *(b)* The cinch suture is placed in a figure-eight fashion through the hole in the anterior nasal spine.

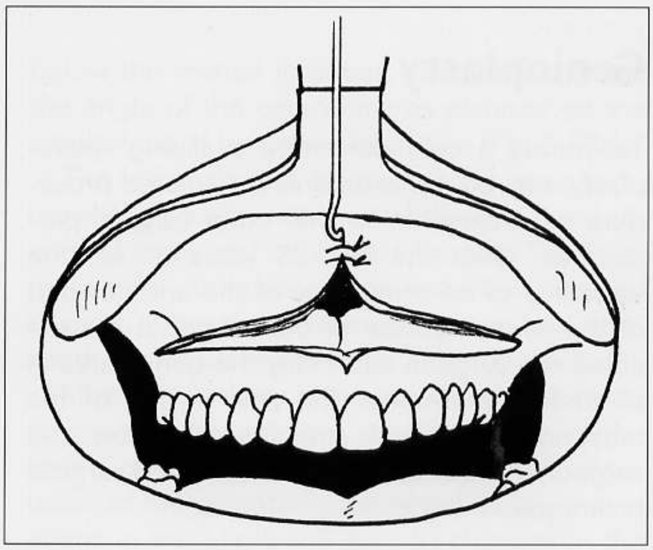


Fig 5-45 V-Y closure of the upper lip.

Step 42: Placement of elastics or maxillomandibular fixation

Maxillomandibular fixation is seldom used and may be reserved for patients requiring immobilization because of multiple segmental surgery or large movements that require an occlusal splint. The period of maxillomandibular fixation may vary from a few days to 3 weeks. Alternatively, for most patients, two to four elastics may be placed interocclusally to guide the teeth into the new occlusion. The direction of the elastics should support the repositioning.

Step 43: Applying a pressure dressing

A pressure dressing is applied to help control swelling and/or prevent hematoma formation.

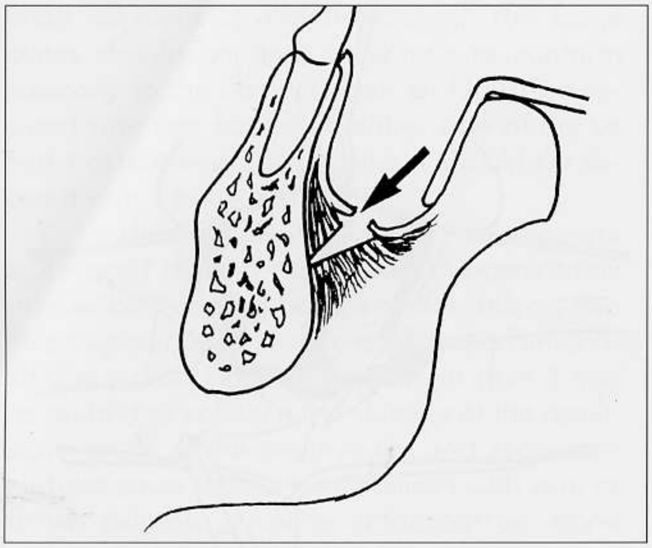


Fig 5-46 The soft tissue incision is angled to maintain more submucosal tissue for ease of later suturing.

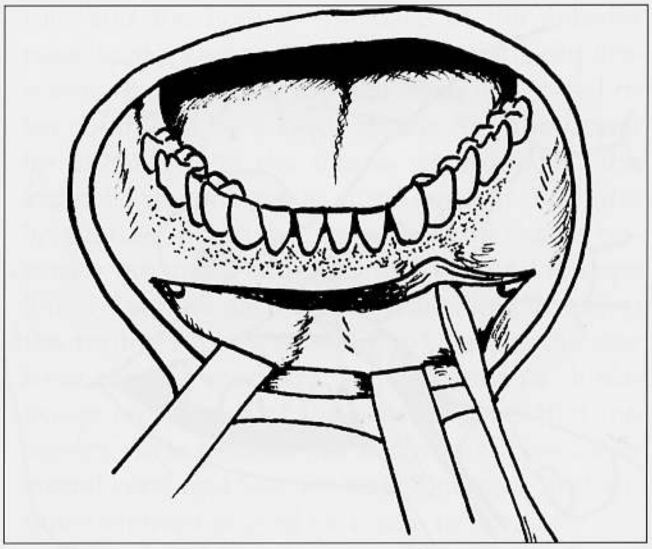


Fig 5-47 Subperiosteal dissection is carried downward and laterally to identify the mental nerve. The mucoperiosteum at the superior aspect is also elevated to make reapproximation of the mentalis muscle and mucosa easier.

Genioplasty

To correct a chin deformity, a sliding genioplasty may be performed as an isolated procedure or in conjunction with other surgical procedures. Over the last 25 years or so, the versatility of an osteotomy of the anterior part of the inferior border of the mandible has enabled the surgeon to modify the genial area in all three dimensions. The chin is one of the most noticeable facial structures; therefore, the surgeon must develop both artistry and surgical technique.

Step 1: Infiltration of soft tissue with a vasoconstrictor

Infiltrate the area of dissection with 2 mL of local anesthetic containing a vasoconstrictor (epinephrine in a concentration of 1:100,000) 10 minutes before surgery.

Do not inject more than 2 mL of local anesthetic into this tissue because a large volume will distort the shape of the chin and make clinical judgment of the esthetics difficult at the time of surgery. Avoid injecting anesthetic into the mental neurovascular bundle.

Step 2: Mucosal incision

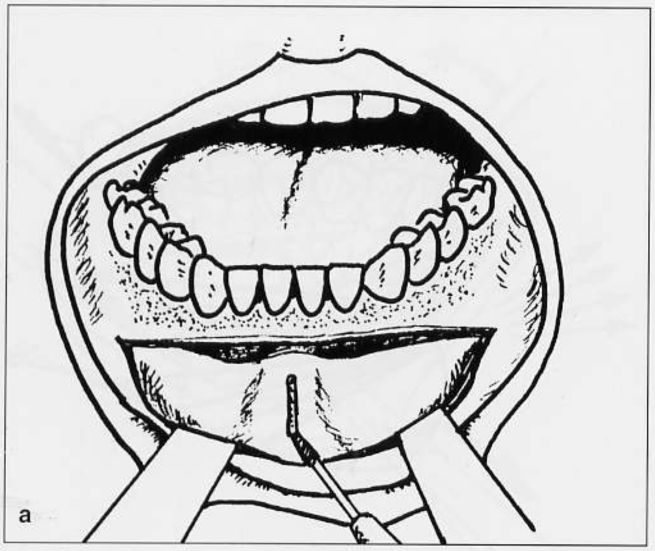
Make the first soft tissue incision through the labial mucosa of the mandible from just distal to the canine to a similar point on the contralateral side. Branches of the mental nerve can often be identified in the submucosal tissue laterally. Leave at least 5 mm of nonkeratinized mucosa superiorly to make later suturing easier.

Step 3: Submucosal incision

Make the second incision through the submucosal tissue and periosteum onto the bone, avoiding damage to the mental nerve at the lateral aspects of the incision. This incision is angled at 45 degrees to the bone so that more submucosal tissue and periosteum remain at the superior aspect to make later suturing easier (Fig 5-46).

Step 4: Mucoperiosteal dissection

Start the mucoperiosteal dissection from the center, and dissect laterally and inferiorly. Identify



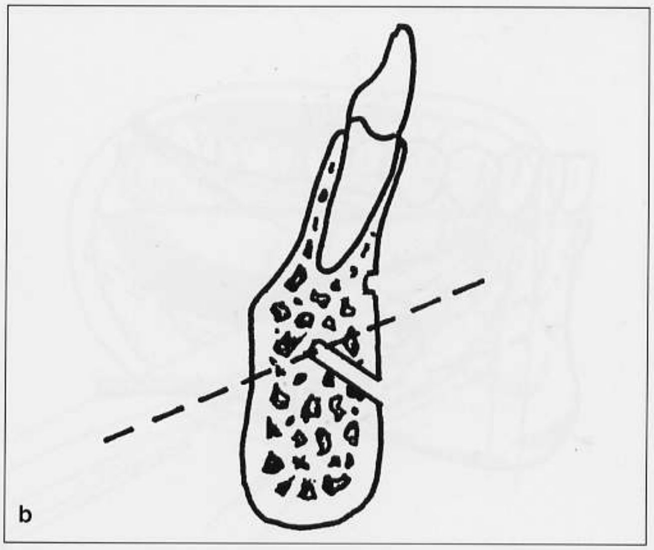


Fig 5-48 *(a)* The dental midline is marked on the bone. Two vertical reference lines are placed lateral to this line. *(b)* A superiorly angled hole is drilled in the midline below the intended osteotomy line. A positioning wire will be placed through this hole once the chin has been mobilized.

the mental nerves bilaterally. Also elevate the mucoperiosteum at the superior aspect (Fig 5-47) to make later suturing easier.

Step 5: Establishing reference points

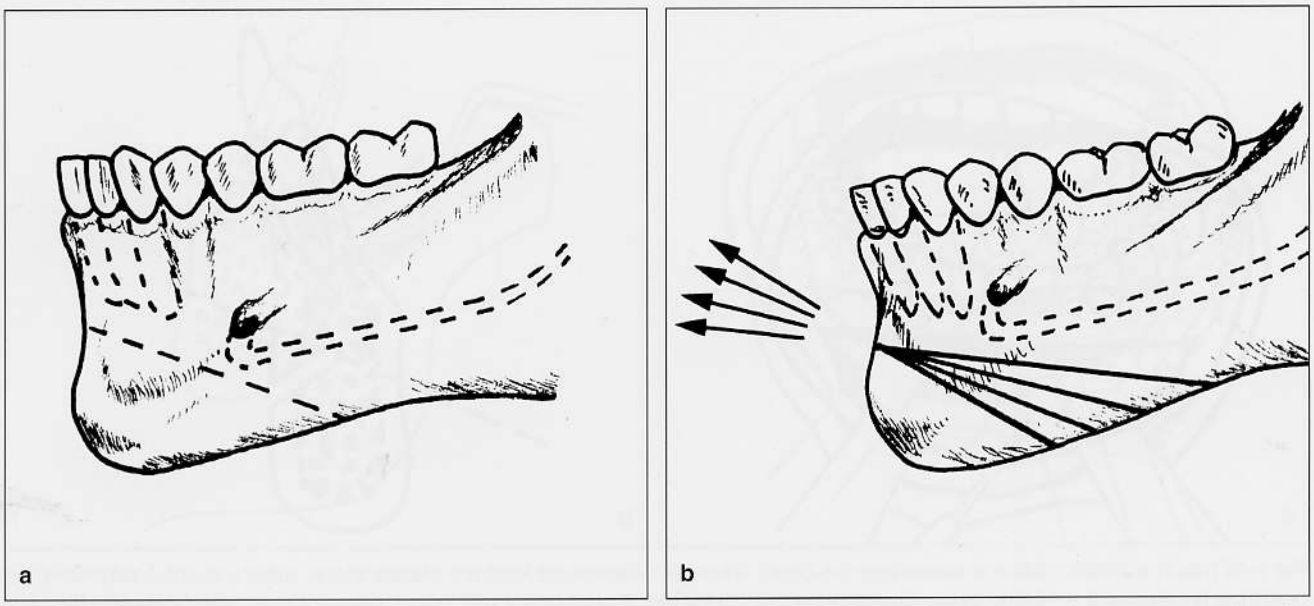
Use a 701 bur to mark the dental midline on the bone superiorly and inferiorly to the intended osteotomy. Make small, shallow holes, keeping the roots of the incisors in mind, and score a line into the cortex to connect the holes (Fig 5-48a). Deepen the inferior hole by angling the bur superiorly and extending the hole well through the cortex. This hole is intended for the placement of a positioning wire later in the procedure. Place the hole in thick bone to ensure that the wire will not pull through (Fig 5-48b). For accurate repositioning of the chin, place reference marks approximately 15 mm lateral to the midline to assist with symmetrical repositioning.

Step 6: Osteotomy design

The osteotomy should be performed at least 5 mm below the roots of the incisors and 5 mm below the mental foramen. Visualize and mark the angle of the osteotomy as planned on the surgical visual treatment objective (Fig 5-49a).

The following text will discuss the basic technique for the advancement of the chin using tricortical screw and bone plate fixation. The techniques for anteroposterior reduction, vertical change, correction of asymmetry, and change in width are discussed in steps 16 through 20.

Most genioplasty procedures are performed to improve the anteroposterior position of the chin. Consideration must be given to the angulation of the osteotomy, however, because variations in the angle will lead to changes in the vertical dimension of the chin, with obvious esthetic consequences. The angle of the osteotomy creates a plane along which the bony segment will slide (Fig 5-49b). The steepness of the angle of the osteotomy will be influenced by the esthetic requirements, the roots of the incisor and canine teeth, and the position of the mental foramen. Keep in mind that the course of the mental nerve prior to its exit through the mental foramen is approximately 5 mm inferior and anterior to the foramen.



a b

Fig 5-49 *(a)* The angle and position of the osteotomy is visualized. Note that the position of the mental nerve and the roots of the incisor and canine teeth should be kept in mind. *(b)* The change of the angulation of the osteotomy and its effects on the vertical dimension after repositioning are demonstrated.

Step 7: Osteotomy of the chin

Perform the osteotomy with an oscillating saw by starting in the center and cutting laterally. Ensure that both cortices are osteotomized. Failure to include the lower border in the osteotomy will lead to an unfavorable fracture at the inferior border of the bone segment and thus inaccurate repositioning of the chin (unless contoured).

Step 8: Mobilization of the chin

After completion of the osteotomy, the chin segment should be mobile.

However, it may be necessary to finally mobilize it with a light tap and then rotate a small osteotome in the osteotomy line. The need for excessive force to mobilize the chin indicates that the osteotomy is not completely through both cortices or the inferior border of the mandible, which may lead to an unpredicted fracture of the lower border.

When the genioplasty is combined with a bilateral sagittal split osteotomy of the mandible, it is preferable to perform the genioplasty after completing the sagittal split osteotomy. At this stage, the mandible is still held in position by maxillomandibular fixation. Performing the genioplasty at this point allows the surgeon to evaluate the esthetics and, if necessary, make small positional changes to the chin to improve the appearance. Keeping the teeth in occlusion while performing the genioplasty provides the added advantage of supporting the mandible and reducing the forces on the recently placed rigid fixation screws. Avoid applying too much force to the mandible, however, because this may dislodge the orthodontic brackets. (An alternative method is to perform the genioplasty before the sagittal split osteotomy.)

Step 9: Engaging the positioning wire

Place a 0.018-inch wire through the hole drilled in the osteotomized segment during marking (Step 5), and attach a wire twister to it. This wire will be helpful during the mobilization phase (Step 10) and in accurate repositioning of the chin.

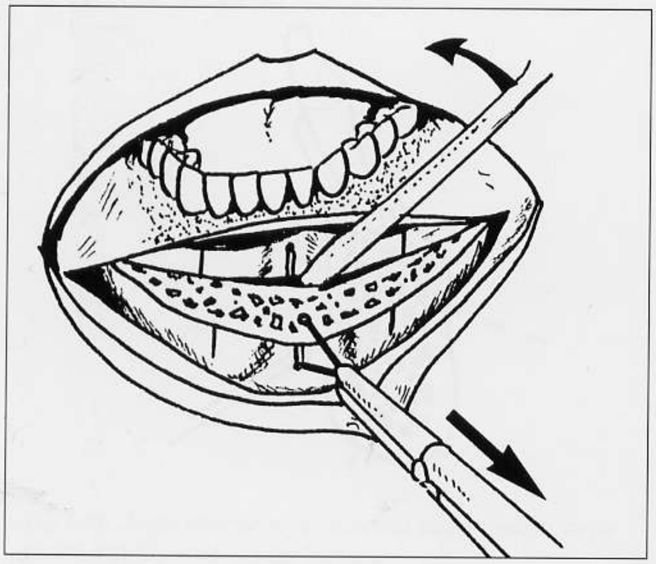


Fig 5-50 Mobilizing the chin. A Howarth elevator is placed behind the chin segment while the chin is pulled forward by the positioning wire.

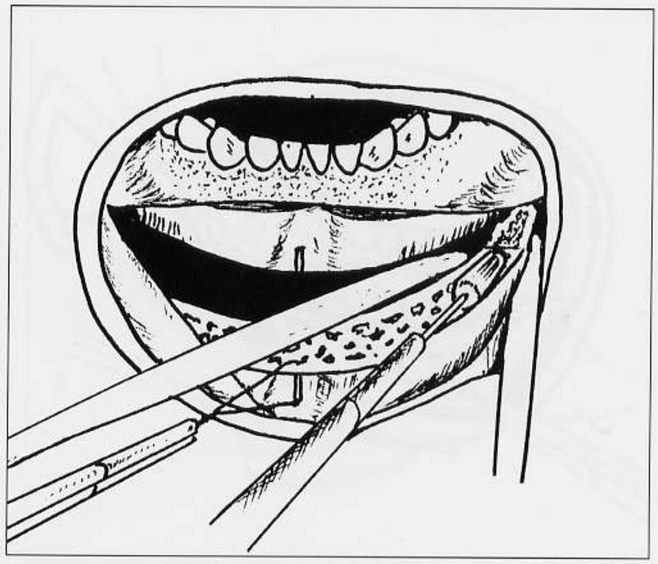


Fig 5-51 All bony interferences should be removed and irregularities smoothed prior to repositioning. Note that special attention should be given to the posterior area of the chin segment.

Step 10: Final mobilization of the chin segment

Place a Howarth elevator behind the lingual cortex, and pull the chin forward by stretching the soft tissue (the suprahyoid muscles and periosteum) (Fig 5-50). Adequate mobilization of the segment will facilitate easy and accurate repositioning of the chin.

Step 11: Refinement of the osteotomy

Check the posterior aspect of the osteotomized segment for any sharp or irregular edges, and remove the interferences using a large round vulcanite bur (Fig 5-51). Failure to smooth any irregularities will prevent accurate repositioning of the chin. Interferences are often found at the posterolingual area of the mobilized segment and the soft tissue; the sublingual salivary gland, facial artery, mentalis nerve, and geniohyoid muscles should also be protected during removal of these bony interferences.

Step 12: Repositioning the chin

Use the positioning wire and extraoral digital pressure to accurately reposition the chin according to the treatment plan (Fig 5-52).

Although a golden rule in orthognathic surgery is "Never change your treatment plan on the operating table," genioplasty may be the exception. The surgeon may use clinical judgment at the time of surgery to slightly alter the repositioning of the chin for a better esthetic result.

Step 13: Countersinking holes for tricortical screw fixation

When tricortical bone screw fixation is contemplated, countersink two holes in the buccal cortex approximately 8 mm on either side of the marked midline of the osteotomized segment. Position the countersink holes at least 5 mm

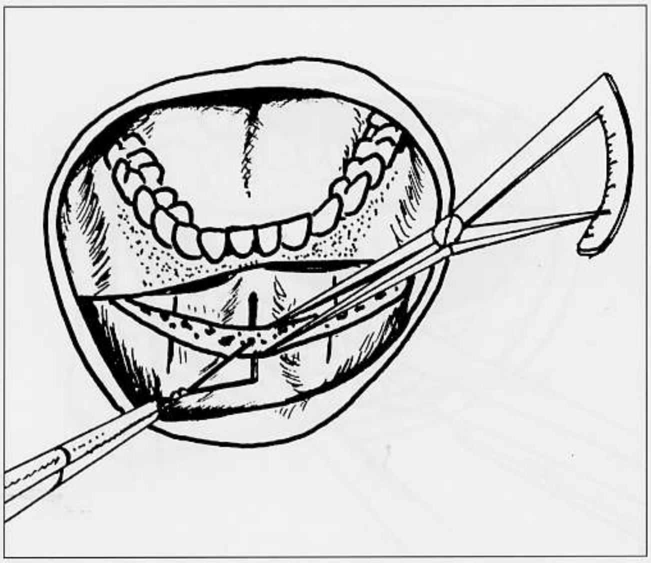


Fig 5-52 The chin segment is placed in its planned position using the positioning wire.

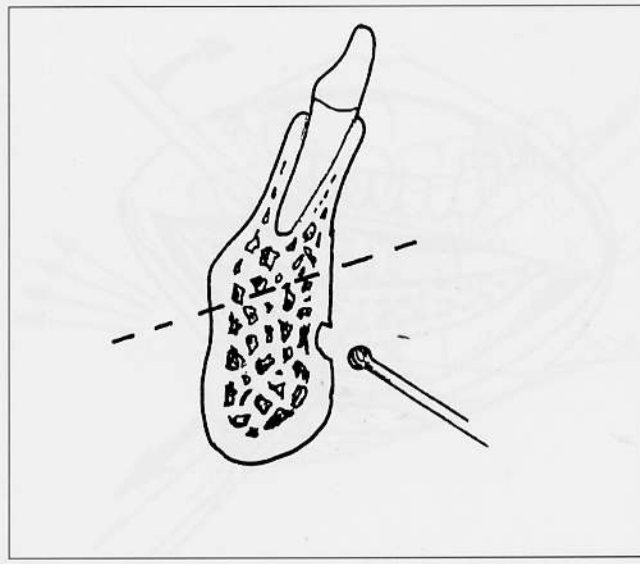


Fig 5-53 Placement of a countersink hole to accommodate the head of the screw.

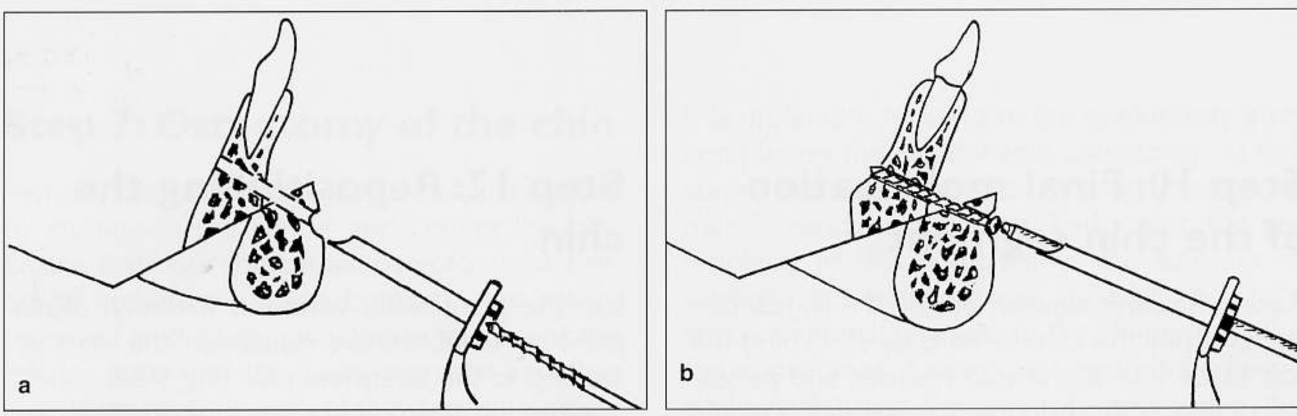


Fig 5-54 *(a)* A hole is drilled through all three cortices using a trocar to protect the soft tissue. *(b)* A trocar is used to place a tricortical screw to fixate the chin segment. At least two screws should be placed to secure the bone segment.

from the superior edge of the segment to accommodate the head of the screw (Fig 5-53).

Step 14: Placement of tricortical screws

Drill the holes and place the bone screws while the assistant holds the chin in its planned position using the holding wire and digital pressure. Drill the holes into the center of the countersink hole using a trocar to protect the soft tissue, and simultaneously guide the drill at an appropriate angle to engage all three cortices (Fig 5-54a). Ensure that the screw is long enough to engage all three cortices (Fig 5-54b).

Step 15: Bone plate fixation as an alternative to screw fixation

Use a prefabricated chin fixation plate or an X- or H-shaped bone plate or two straight bone plates with two screws on either side of the

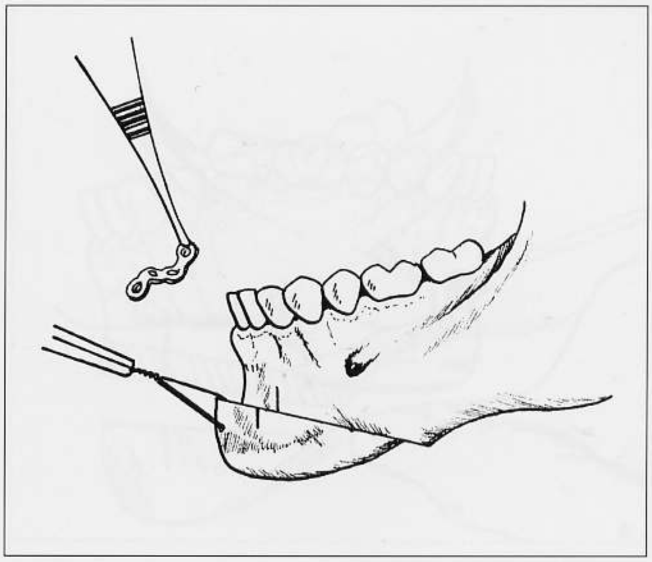


Fig 5-55 As an alternative to tricortical screw fixation, bone plates may be used as rigid fixation.

osteotomy. The positioning wire and digital pressure help stabilize the chin segment in its planned position (Fig 5-55) while the bone plates are bent to fit accurately and passively. Avoid damaging the roots of the incisors with the screws. It is recommended that fixation be placed on each side of the midline.

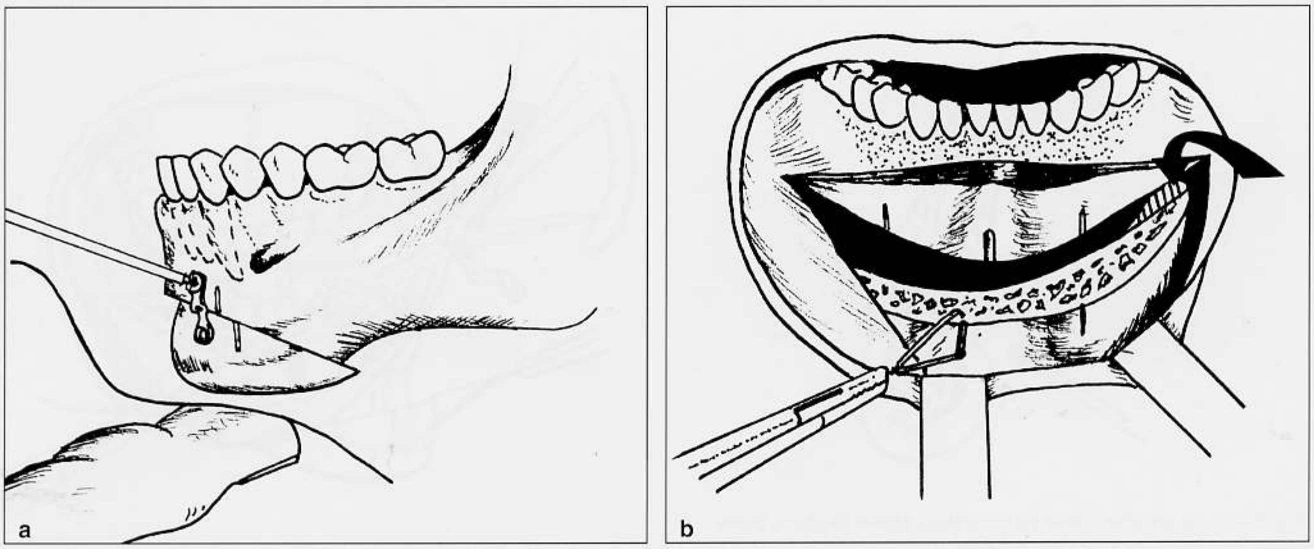
Step 16: Anteroposterior reduction of the chin

Position the chin using extraoral digital pressure, check the position of the bone using a caliper, and use a prefabricated chin fixation plate or bend the appropriate plate to fit accurately and passively (Fig 5-56a). Use a prefabricated chin fixation plate or an X- or H-shaped bone plate or two straight plates. When the chin is set back, the posterolingual area often has a palpable step defect at the inferior border of the mandible, which may concern the patient. To contour this area, the osteotomized segment is pulled downward and forward, and the posterolingual aspect of the chin segment is contoured (Fig 5-56b). Protect the soft tissue at all times during this step.

Anteroposterior reduction of the chin may result in flattening of the labiomental fold. The sharp anterior edge on the superior aspect may be contoured to counter this effect and enhance the depth of the labiomental fold and chin shape (Fig 5-56c).

Step 17: Vertical increase of the chin

Using a 701 fissure bur, drill reference holes recording the vertical dimensions of the chin. To maintain the symmetry of the chin, the reference marks should be made in the midline, as well as approximately 15 mm lateral to the midline, and the distances between them recorded. Place a bone plate while the assistant uses the positioning wire and an instrument wedged between the segments to maintain the required space between the bony segments (Fig 5-57). At least two screws should be placed superiorly and inferiorly to the osteotomy using an H- or X-shaped plate or two straight plates to secure the segment and maintain the vertical height. It is recommended that a bone graft be placed in the defect. Do not force the bone graft into the defect, since doing so might displace or mobilize the chin segment.



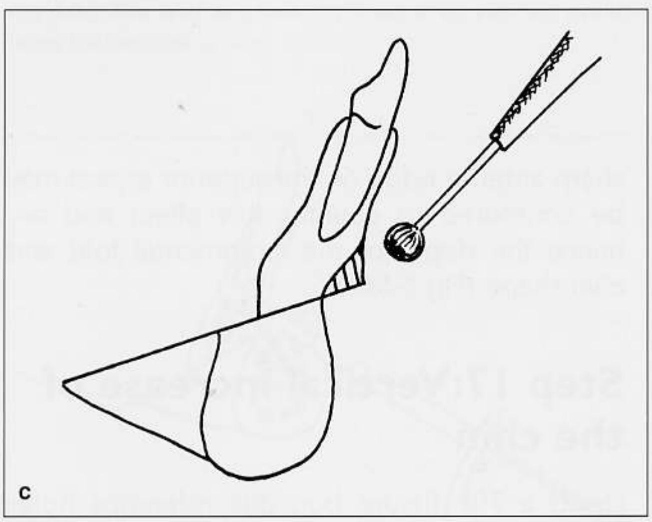


Fig 5-56 *(a)* For setback procedure of the chin, bone plate fixation is the method of choice. In setback procedures, the use of a positioning wire is impractical. *(b)* The medial aspect of the posterior area of the chin segment is removed to prevent a palpable step defect on the lower border of the mandible. *(c)* The labiomental fold is enhanced by contouring the anterior edge on the superior aspect of the mandible.

Step 18: Vertical reduction of the chin

Drill reference marks recording the vertical dimensions of the chin. To maintain symmetry of the chin, place the marks in the midline and approximately 15 mm lateral to the midline, and record the distances between them. Perform the first osteotomy low enough to facilitate performing the second osteotomy from the superior aspect (Fig 5-58). Complete the lower osteotomy, and mobilize the chin. Mark the amount and shape of bone to be removed, and then complete the superior osteotomy. The shape of the ostectomized bone will influence the final anteroposterior position of the tip of the chin; that is, if the ostectomy is wider anteriorly, the chin will rotate anteriorly, whereas an ostectomy that is wider posteriorly will rotate the chin posteriorly. Maintain as much soft tissue attachment to the chin as possible to ensure good blood supply to the repositioned bone and reduce dead space. This will also yield a more predictable esthetic result.

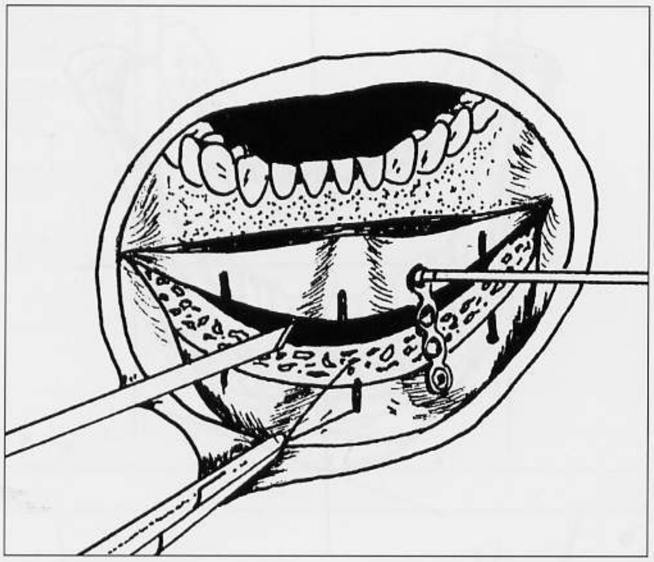


Fig 5-57 Vertical increase of the chin. The chin segment is held at the planned height using a positioning wire. Two bone plates are then placed to fixate the segment. Finally, the defect is grafted.

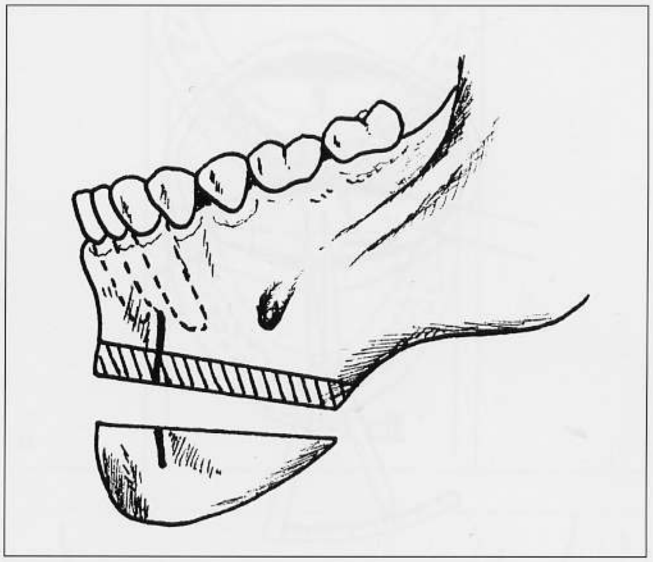


Fig 5-58 Vertical reduction of the chin. The lower osteotomy is performed first and the planned amount of bone then removed superiorly.

Step 19: Correction of asymmetry of the chin

Drill reference holes recording the dimensions of the chin. For lateral movement of the chin, the dental midline is marked on the superior aspect of the osteotomy line, while the midline of the chin is marked on the inferior aspect (Fig 5-59a). When correction of asymmetry requires vertical change as well, marks are placed lateral to the midline to record vertical dimensions on both the left and right sides. Large cants in the chin contour (eg, in unilateral condylar hyperplasia or hypoplasia) may have to be corrected by a propeller osteotomy. The first osteotomy is performed superior and parallel to the occlusal plane or interpupillary plane. A second osteotomy is performed parallel to the lower border of the chin (Fig 5-59b). The small, triangular segment is rotated 180 degrees while its muscle attachment is maintained (Fig 5-59c). The inferior segment can now be secured by rigid fixation (Fig 5-59d).

Step 20: Altering the width of the chin

Using a 701 fissure bur, drill reference marks recording the presurgical chin dimensions.

Widening or narrowing the chin (altering the posterior dimension)

Before the chin is mobilized, fixate a four-hole straight plate horizontally across the midline to the labial cortex of the chin. To widen the chin, perform a midline osteotomy through the buccal and lingual cortex, and complete the osteotomy with a small osteotome. The chin can now be widened by using the bone plate as a hinge (Fig 5-60a). To narrow the chin, perform a triangular midline ostectomy on the lingual aspect of the chin segment, and narrow the chin by using the bone plate as a hinge (Fig 5-60b).

Once the desired shape of the chin has been achieved, further fixation can be placed. Fixation should be placed on both sides of the midline osteotomy.

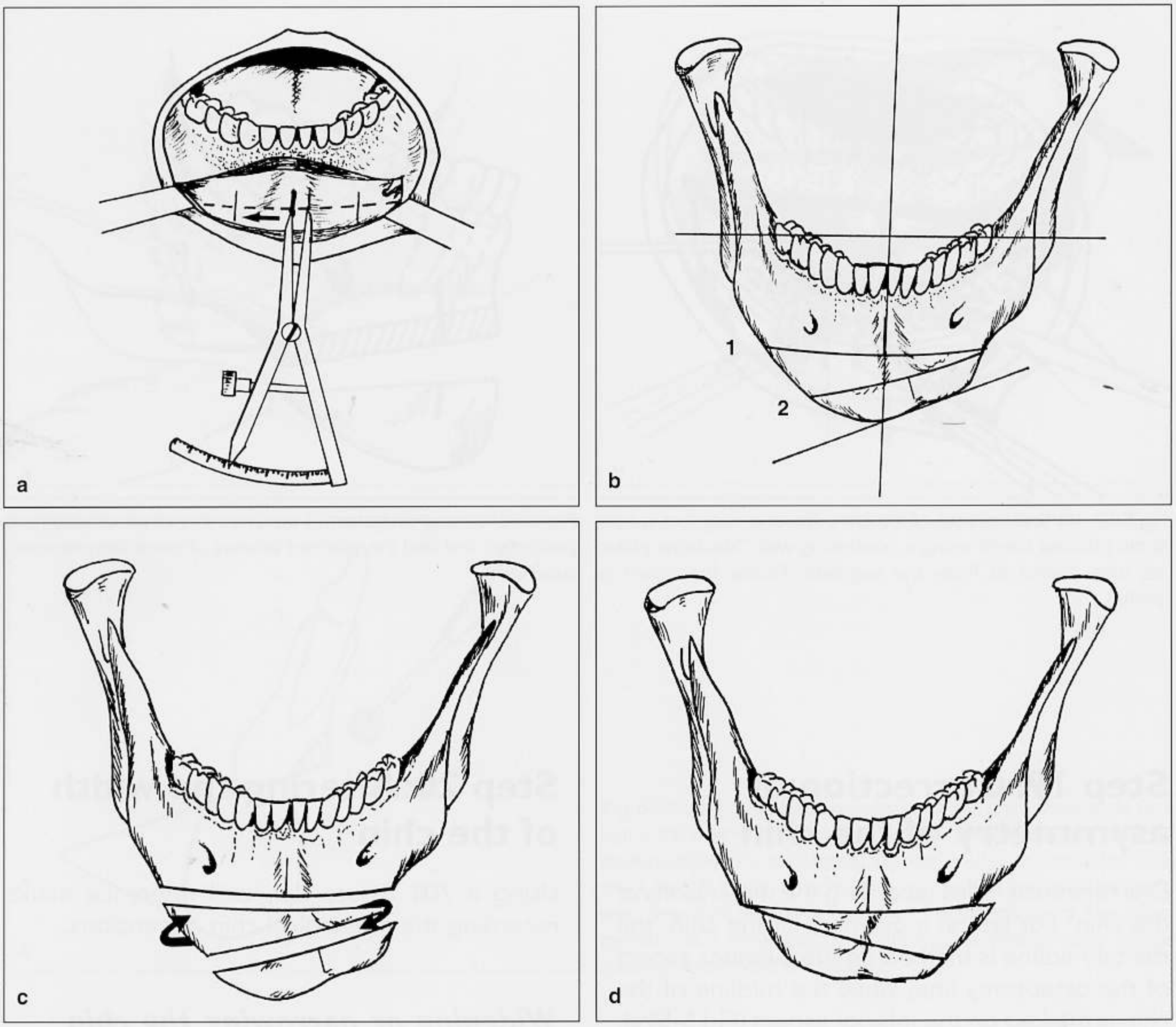


Fig 5-59 *(a)* Lateral movement of the chin. The midline of the chin is marked below the osteotomy line and the facial midline above the osteotomy line. After mobilization of the chin, the chin segment is moved laterally until the lines coincide. *(b)* The propeller osteotomy. A first osteotomy (1) is performed parallel to the interpupillary line. A second osteotomy (2) is then performed parallel to the lower border of the chin. *(c)* The triangular segment, pedicled to the hyoid muscles, is rotated 180 degrees. *(d)* The two segments are secured by rigid fixation.

Widening or narrowing the chin (altering the anterior dimension)

To narrow the chin, a predetermined amount of bone is ostectomized from the mobilized segment. To simplify the removal of the ostectomized bone from the center of the chin, complete all the osteotomies before mobilizing the segments (Figs 5-60c and 5-60d).

In widening the chin, a predetermined width can be achieved by performing a midline osteotomy and increasing the anterior width by moving the segments laterally (Fig 5-60e). Secure the graft between the segments with a bone plate before fixating the segments to the mandible (Fig 5-60f).

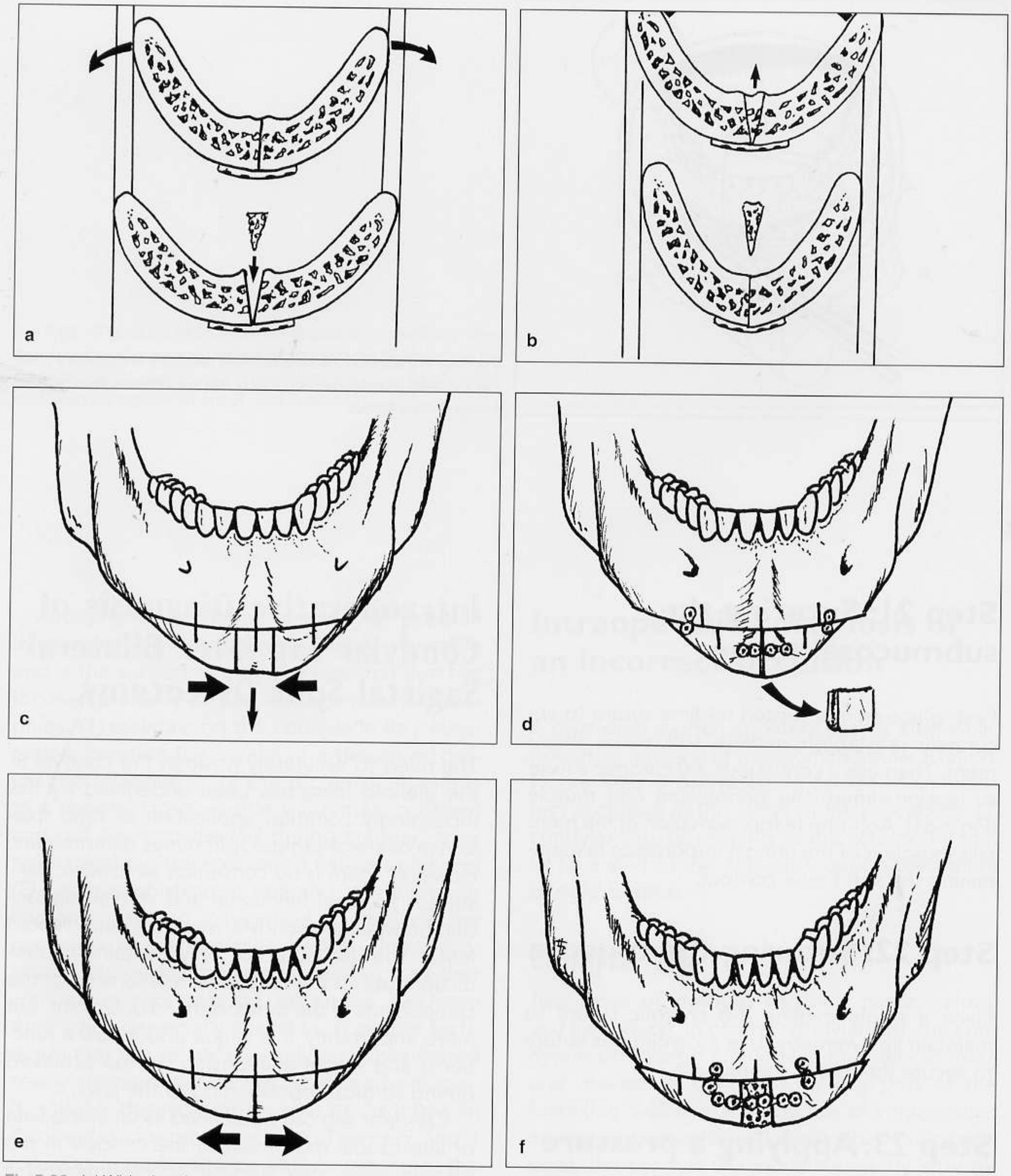


Fig 5-60 *(a)* Widening the posterior dimension of the chin. A midline osteotomy is performed through the chin segment after placement of a bone plate on the anterior surface. The plate is now used as a hinge, widening the posterior chin, and a small bone graft placed in the midline defect. *(b)* Narrowing the posterior dimension of the chin. A bone plate is placed on the anterior surface of the chin and a triangular midline ostectomy performed. The segment is now bent medially to narrow the chin. *(c)* Narrowing the anterior dimension of the chin. A midline ostectomy is performed in the center part of the chin. *(d)* After removal of the ostectomized bone, the lateral segments are moved medially. *(e)* Widening the anterior dimension of the chin. An osteotomy is performed in the center of the chin segment. *(f)* After increasing the anterior width of the chin, a bone graft is placed between the segments.

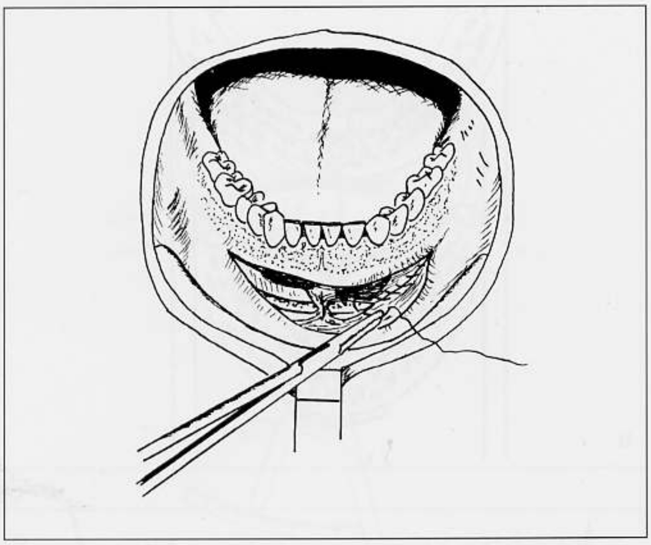


Fig 5-61 To achieve the best esthetic results, it is mandatory that the mentalis muscles be accurately reapproximated. Mucosal suturing should follow.

Step 21: Suturing the submucosal tissue

First, place an interrupted midline suture to accurately reestablish midline soft tissue alignment. Then use a continuous 3-0 chromic suture to reapproximate the periosteum and muscle (Fig 5-61). Accurate reapproximation of the mentalis muscle is of the utmost importance in maintaining the soft tissue contour.

Step 22: Suturing the mucosa

Place a single midline 4-0 chromic suture to maintain lip symmetry. Use a continuous suture to secure the rest of the mucosa.

Step 23: Applying a pressure dressing

Vertical and horizontal pressure is applied to the chin via a pressure bandage. Postoperative hematoma formation and swelling is limited by keeping the bandage in place for approximately 3 days.

Intraoperative Diagnosis of Condylar Sag After Bilateral Sagittal Split Osteotomy

The need to accurately position the condyle in the glenoid fossa has been underlined by the increasingly common application of rigid fixation in bilateral sagittal split ramus osteotomies. However, there is no consensus as to what constitutes an ideal functional and stable relationship between the condyle, meniscus, and glenoid fossa. The literature not only contains contradictions about the functional relationship of the components of the temporomandibular joint, but more importantly, it is vague about how a functional and stable relationship can be achieved during surgical repositioning of the jaws.

Condylar sag can be defined as an immediate or late caudal movement of the condyle in the glenoid fossa after surgical establishment of a preplanned occlusion and rigid fixation of the bone fragments, leading to a change in the occlusion. Relapse of the occlusion due to change in the condylar position may occur immediately after removal of maxillomandibular fixation or later, during the postoperative course.

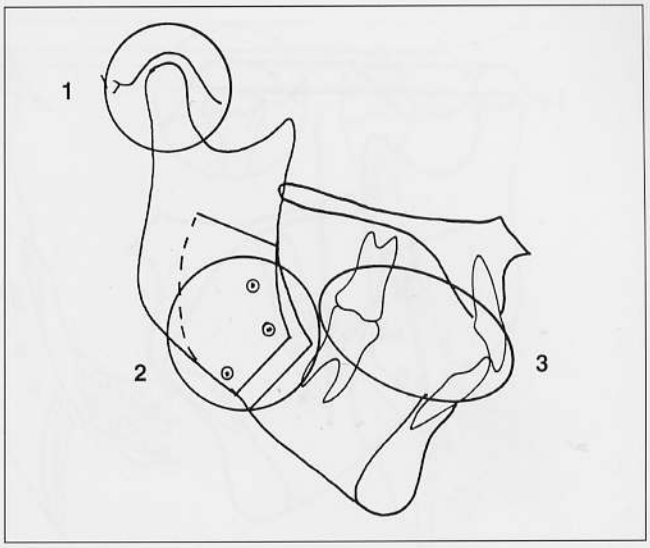


Fig 5-62 The cause of an incorrect occlusion immediately after the intraoperative removal of maxillomandibular fixation may be condylar sag (1), mobility at the osteotomy site (2), or a shift in the occlusion during placement of rigid fixation (3).

Avoiding an unfavorable condylar position intraoperatively is obviously highly desirable and is the subject of ongoing research that has focused primarily on two management philosophies: *(1)* maintaining the condyle in its preoperative position (by means of a device recording the relationship of the proximal segments to a skeletal structure that will remain constant and not be repositioned during surgery) prior to bilateral sagittal split ramus osteotomies and *(2)* using sophisticated imaging modalities or computer-assisted navigation to replace the condyle in its preoperative position. These techniques, although relatively successful, are either cumbersome or rely on expensive hardware that is not universally available. A simple technique that can reliably identify a malpositioned condyle intraoperatively has obvious advantages. It is highly desirable to be able to diagnose an incorrect occlusion at the time of surgery, and it is just as important to be able to recognize the cause of the problem. The following text discusses possible etiologies of malocclusion after intraoperative removal of intermaxillary fixation and patterns of malocclusion that should assist the clinician in differentiating the various etiologic factors.

Intraoperative diagnosis of an incorrect occlusion

A disclusion is often apparent shortly after intraoperative removal of maxillomandibular fixation. Figure 5-62 shows possible causes of an incorrect occlusion at this stage of the procedure: *(1)* condylar sag, *(2)* mobility at the osteotomy site, or *(3)* a shift of the occlusion during placement of rigid fixation.

Condylar sag

Two types of condylar sag may occur: central and peripheral. In central condylar sag, the condyle is positioned inferiorly in the glenoid fossa and makes no contact with any part of the fossa (Fig 5-63a). In the absence of intracapsular edema or hemarthrosis (causing hydraulic pressure), the condyle will move superiorly after removal of maxillomandibular fixation, leading to a malocclusion (Fig 5-63b).

Two types of peripheral condylar sag may occur. In Type I, the condyle is positioned inferiorly, with some fossa contact (lateral, medial, posterior, or anterior) with the maxillomandibular

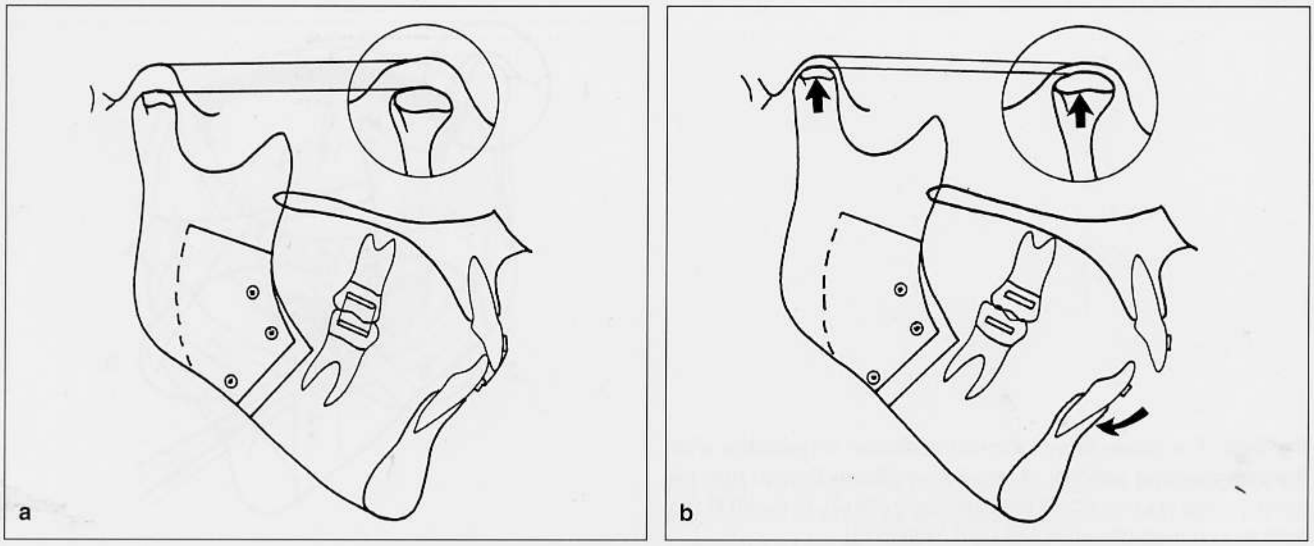


Fig 5-63 *(a)* Central condylar sag. The condyle is positioned inferiorly in the glenoid fossa with no bone contact while the teeth are in occlusion (maxillomandibular fixation) and rigid fixation is placed. *(b)* After removal of maxillomandibular fixation, the condyle will move superiorly, causing immediate relapse.

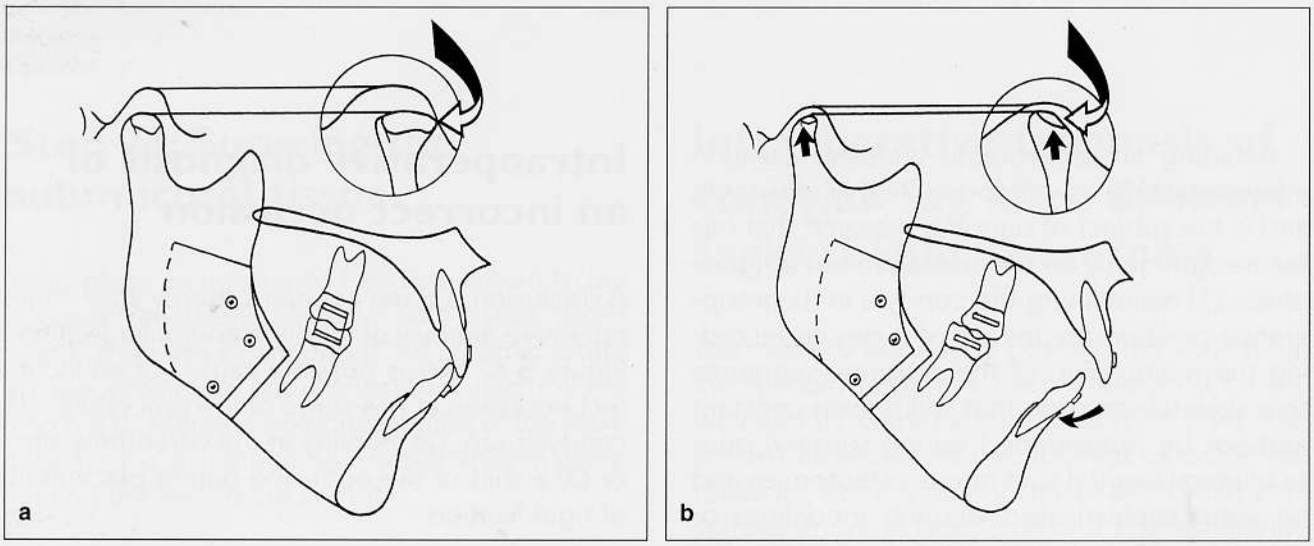


Fig 5-64 *(a)* Type I peripheral condylar sag. The condyle is displaced inferiorly with (in this case) medial fossa contact. After removal of the maxillomandibular fixation, the condyle-fossa contact provides physical support to the occlusion. *(b)* Postoperative condylar resorption will lead to superior positioning of the condyle, which will later cause relapse.

fixation in position (teeth in occlusion) and rigid fixation placed. This type of condylar malpositioning provides physical support to the occlusion (Fig 5-64a). Postoperative resorption or change in condylar shape will lead to late relapse (Fig 5-64b). In Type II, the condyle is positioned correctly in the fossa with the maxillomandibular fixation in position (teeth in occlusion); however, with the placement of rigid fixation, a torquing force is applied to the condyle and ramus of the mandible (Figs 5-65a and 5-65b). The tension on the ramus is released when the maxillomandibular fixation is removed, and the condyle will move either laterally or medially and slide inferiorly in the fossa (Fig 5-65c).

Peripheral sag occurs more often in bilateral sagittal split ramus osteotomy procedures where a defect develops between the two bone

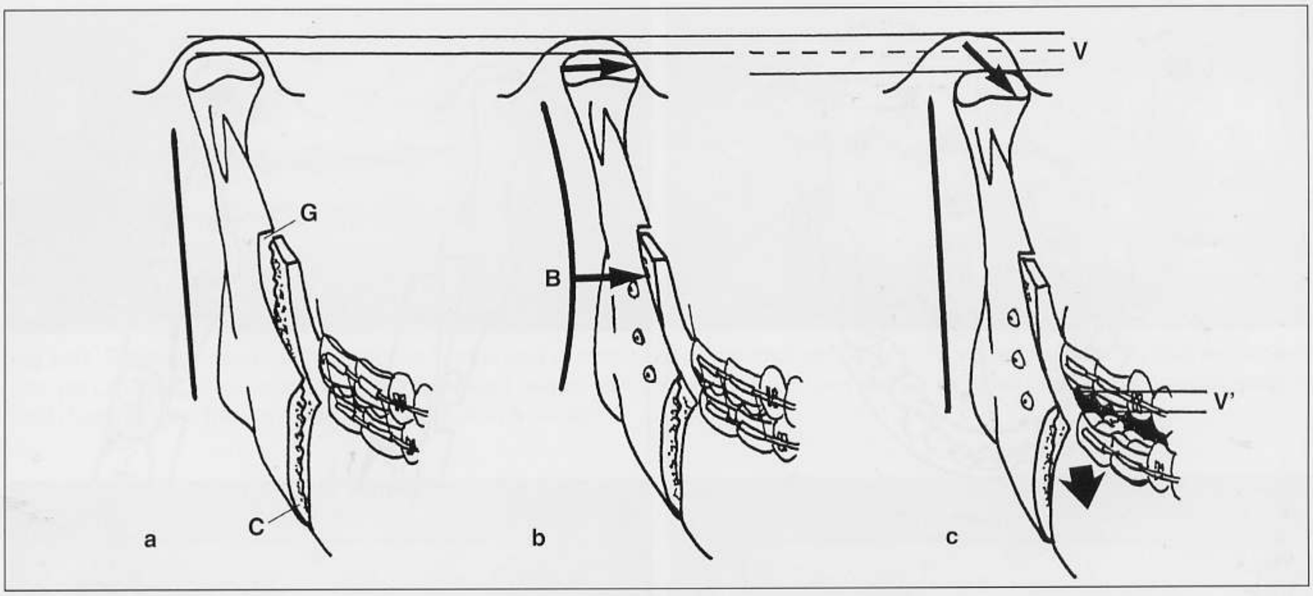


Fig 5-65 Frontolateral view of the glenoid fossa, condyle, and proximal and distal bone segments. *(a)* The condyle is in the correct relationship to the glenoid fossa. Note, however, the gap (G) and the contact area (C) between the bone segments. *(b)* The placement of rigid fixation forces the bone segments together, which applies tension on the condyle and ramus, causing a bowing effect (B). *(c)* Once the maxillomandibular fixation is removed, the tension on the ramus is released, causing the condyle to move medially and slide inferiorly on the medial wall of the fossa; this creates a posterior open bite. The vertical change in condylar position (V) is equal to the posterior open bite (V').

segments because of the repositioning of the distal segment. When these intersegmental defects are closed by forcing the segments together during the application of rigid fixation, the condyle is often displaced in the glenoid fossa. In procedures for the correction of mandibular asymmetry (Fig 5-66a)—large setback or advancement procedures (especially in V-shaped mandibles) with the use of lag screws for rigid fixation—special care should be taken not to displace the condyle in the fossa during the placement of fixation (Figs 5-66b and 5-66c). The step at the horizontal osteotomy on the medial side of the mandibular ramus may also interfere with bone contact (Fig 5-66d) and act as a fulcrum during placement of rigid fixation.

An occlusal shift may be identified by careful clinical examination following the removal of maxillomandibular fixation. Condylar sag produces repeatable patterns of occlusal shift that will help the surgeon identify the offending condyle. Following are the clinical signs of condylar sag:

A. Central condylar sag (see Fig 5-63)
   1. Bilateral central condylar sag (Fig 5-67)
      - Dental midlines correct
      - Overjet increased
      - Anterior open bite
      - Class II malocclusion (bilaterally)
   2. Unilateral central condylar sag (Fig 5-68)
      - Mandibular dental midline toward the offending side
      - Overjet increased (more on the offending side)
      - Class II dental relationship on the offending side
      - Overjet corrected and the correct occlusion reestablished if the mandible is moved until the midlines coincide

B. Peripheral condylar sag
   1. Type I (see Fig 5-64): this type of sag is difficult to diagnose intraoperatively because the contact between condyle and glenoid fossa supports the occlusion; may lead to late relapse due to condylar resorption

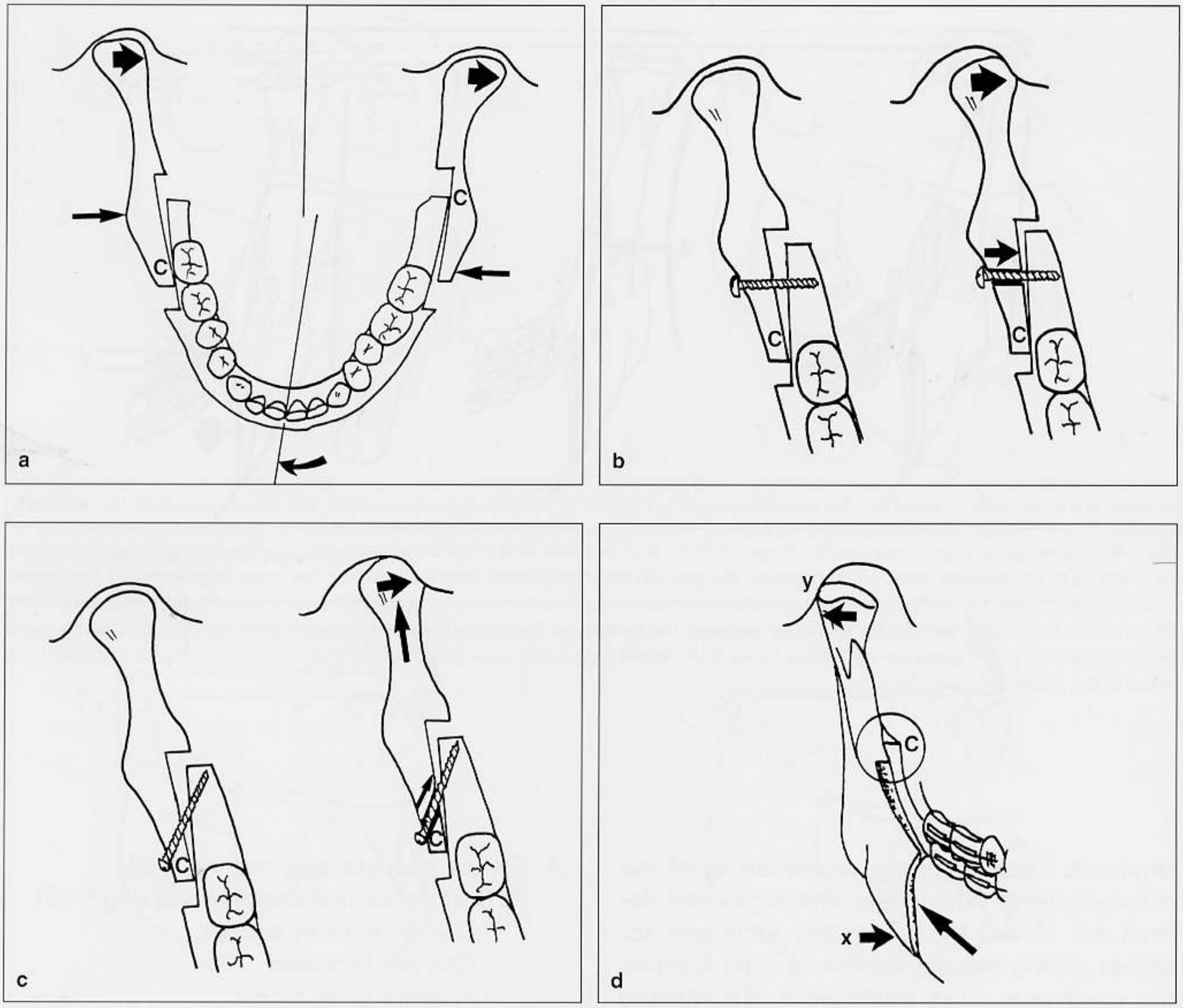


Fig 5-66 *(a)* The intersegmental defects are demonstrated after correction of mandibular asymmetry. The only bone contact is at C, which acts as a fulcrum if the segments are forced together by rigid fixation. Both the condyles will be forced to the left side in the glenoid fossa. *(b)* The positioning screw *(left)* will tend to maintain the intersegmental gap, while a lag screw *(right)* readily allows the bone segments to be forced together, secondarily displacing the condyle medially in the fossa. *(c)* Bicortical screws must be placed at an angle when the procedure is done intraorally. The lag screw *(right)* will tend to force the condyle medially and distally in the fossa, while the positional screw *(left)* will maintain the intersegmental position. *(d)* During large setback procedures with shortening of the mandibular ramus, the horizontal step (of the medial osteotomy) may act as a fulcrum (C). Medial force to achieve bone contact (x) will displace the condyle laterally in the fossa (y).

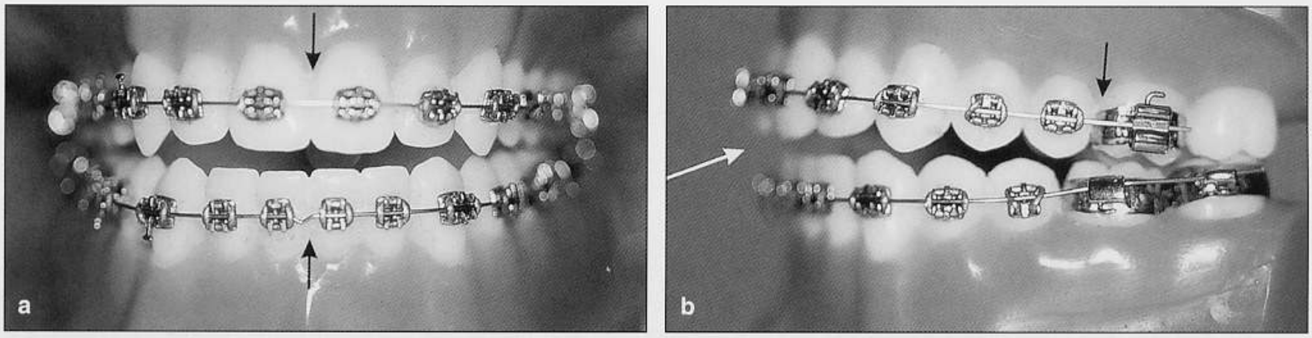


Fig 5-67 Bilateral central condylar sag. *(a)* Frontal view of occlusion; dental midlines correct *(arrows)* and a tendency to anterior open bite. *(b)* Left view of occlusion. Note the increased overjet, tendency to anterior open bite *(white arrow)*, and Class II dental relationship *(black arrow)*. The right side of the occlusion is similar.

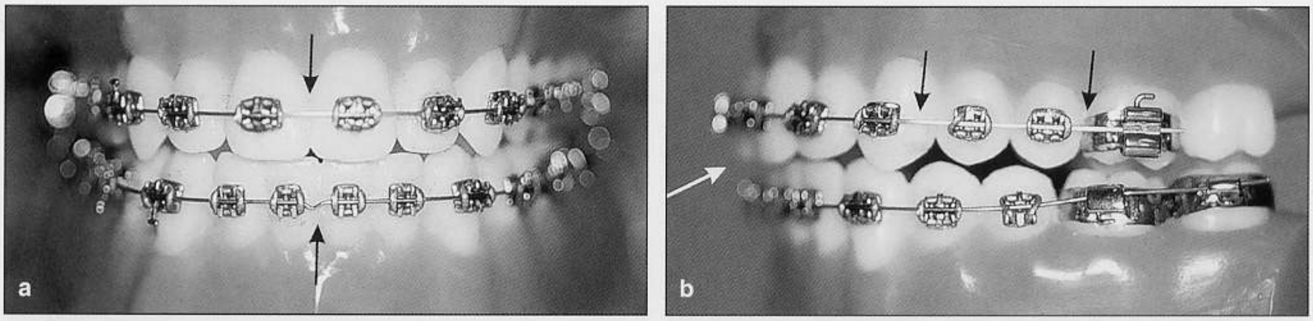


Fig 5-68 Unilateral central condylar sag, left condyle. *(a)* Frontal view of occlusion; mandibular dental midline displaced toward the left *(arrows)*. *(b)* Left side of occlusion; increased overjet *(white arrow)* and Class II dental relationship *(black arrows)*. The right side of the occlusion has a Class I dental relationship.

2. Type II
   a. Bilateral peripheral condylar sag (Fig 5-69)
      - Dental midlines correct
      - Anterior crossbite or edge-to-edge incisal relationship
      - Tendency to Class III dental relationship
      - Tendency to bilateral posterior open bites
   b. Unilateral peripheral condylar sag (Fig 5-70)
      - Dental midline of the mandible toward the contralateral side
      - Edge-to-edge incisor relationship with tendency to crossbite on the offending side
      - Posterior open bite on the offending side with teeth in occlusion
      - When the mandible is moved toward the left to correct the dental midlines, incisal relationship edge to edge or in crossbite, with canines and molars tending to a Class III dental relationship

It is possible to diagnose central condylar sag and Type II peripheral condylar sag intraoperatively immediately after removal of the maxillomandibular fixation. With Type I peripheral condylar sag, however, where condyle–glenoid fossa contact supports the occlusion, the malrelationship will become apparent only when resorption of the condyle has taken place.

Mobility at the osteotomy site

Inadequate rigid fixation at the osteotomy site will lead to mobility between the distal and proximal segments of the mandible. The occlusal signs will mimic those of central condylar

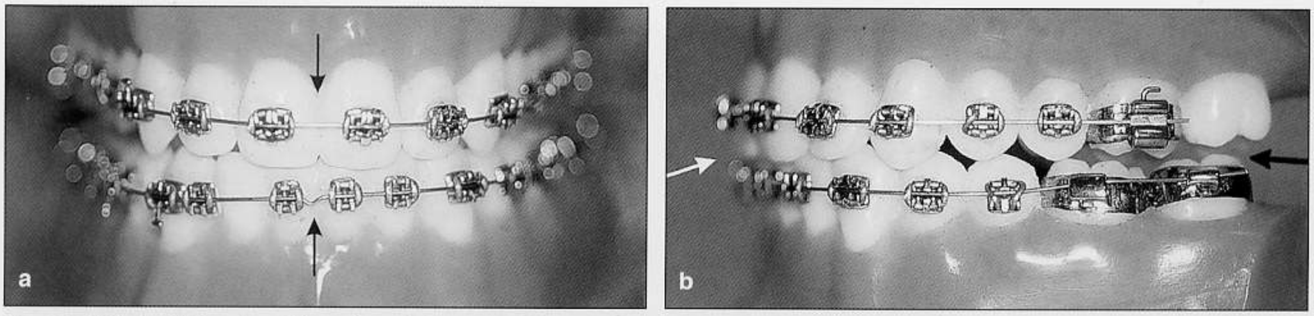


Fig 5-69 Bilateral Type II peripheral condylar sag. *(a)* Frontal view of occlusion; the dental midlines are correct *(arrows)*, and there is a tendency toward an edge-to-edge incisal relationship. *(b)* Left side of occlusion; there is a tendency toward a Class III dental relationship, posterior open bite *(black arrow)*, and edge-to-edge incisal relationship *(white arrow)*. The right side of the occlusion is similar.

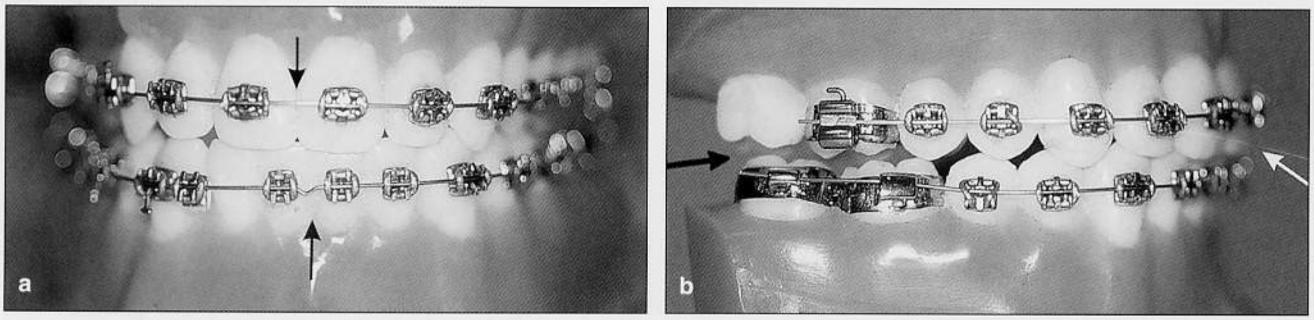


Fig 5-70 Unilateral Type II peripheral condylar sag of the right condyle. *(a)* Frontal view of occlusion; dental midline of the mandible displaced toward the left *(black arrows)*. *(b)* Right side of occlusion; edge-to-edge incisal *(white arrow)*, Class III dental relationship, and posterior open bite *(black arrow)*. The left side of the occlusion has a Class I dental relationship.

sag on the same side. The surgeon should consider this complication when a malocclusion occurs after the removal of maxillomandibular fixation. By applying light, controlled force on either side of the osteotomy site, the surgeon should be able to detect mobility between the two bone segments.

Shift of the occlusion during placement of rigid fixation

Inadequate occlusal fixation combined with excessive lateral force during placement of bicortical screws may displace the occlusion. This displacement may go undetected until after maxillomandibular fixation has been removed and the occlusion checked. Thus, the occlusion should be checked before the removal of maxillomandibular fixation.

Intra-articulator hemorrhage or edema

The step-by-step description of the surgical technique stressed careful handling of and respect for hard and soft tissue during surgery. This is especially important during the actual splitting procedure and in handling the proximal segment after splitting. Rough, indiscriminate manipulation of this segment (and the condyle) may lead to intracapsular hemorrhage and/or edema or may displace the articulating disc.

Hemorrhage or edema in the temporomandibular capsule may cause increased intracapsular pressure. Increased pressure that develops before condylar positioning makes the positioning difficult. Also, when the hemorrhage or edema resolves postoperatively, the condyle will move superiorly in the fossa (condylar sag)

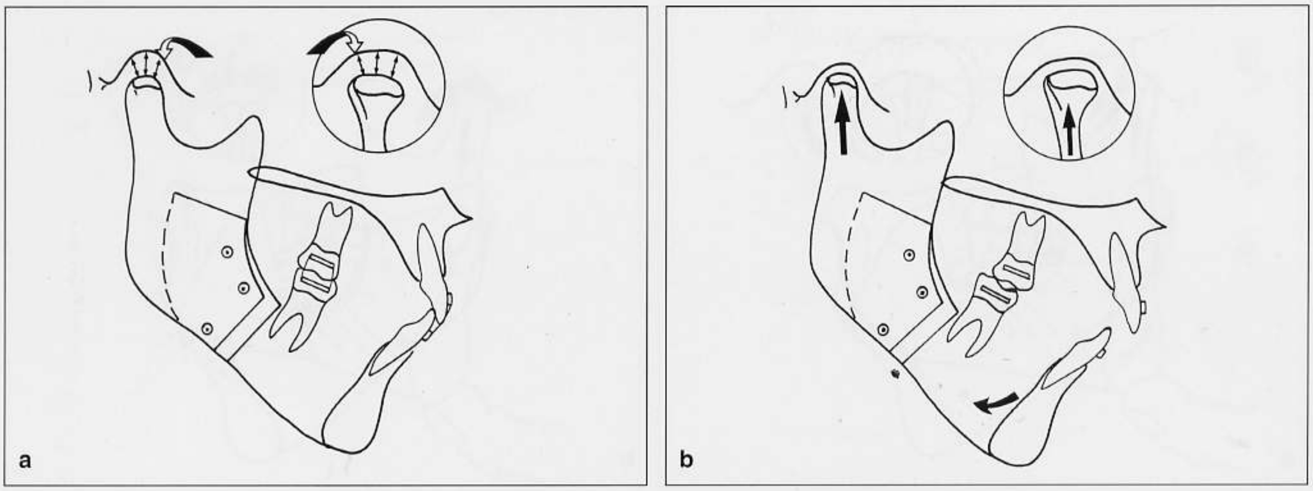


Fig 5-71 *(a)* Intracapsular hemarthrosis and/or edema *before* condylar positioning. The increase in intracapsular hydraulic pressure tends to displace the condyle inferiorly and make condylar positioning difficult. This may lead to postoperative central sag. *(b)* As the hemarthrosis and/or edema resolves postoperatively, the condyle moves superiorly, leading to malocclusion.

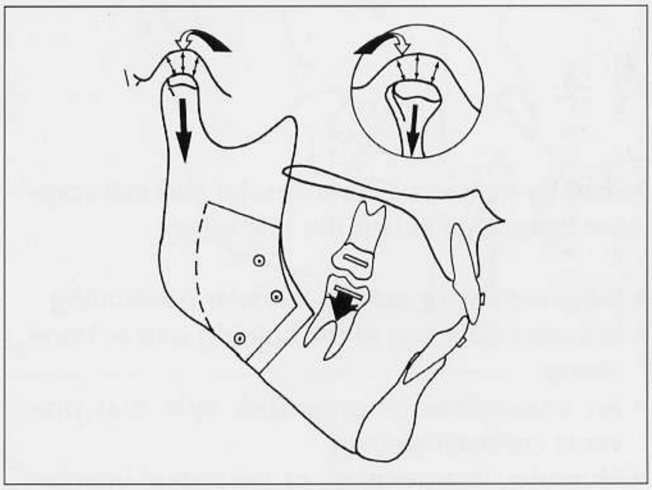


Fig 5-72 Intracapsular hemarthrosis and/or edema *after* condylar positioning. The increased intracapsular hydraulic pressure tends to push the condyle inferiorly, leading to postoperative posterior open bite (mimicking peripheral sag). With resolution of the intracapsular hemarthrosis and/or edema, the condyle will move superiorly, reestablishing the occlusion.

(Fig 5-71). If increased pressure develops postoperatively, the condyle will be pushed inferiorly in the fossa, a situation that is usually accompanied by pain. The clinical signs mimic those of peripheral condylar sag. There is a posterior open bite on the affected side; the bite will improve as the intracapsular hemorrhage or edema resolves (Fig 5-72).

Disc displacement

A preoperative history of temporomandibular clicking or locking signals that the proximal segment (temporomandibular joint) should be handled with even more care than usual during surgery. The integrity of the joint structures must be carefully maintained, and, as much as possible, displacement of the articulator disc must be avoided. If the disc is not in its normal relation to the condyle and fossa during condylar positioning, the bite will open posteriorly once the disc returns to its normal position in the fossa (Fig 5-73).

Condylar orientation in the glenoid fossa is a critical and probably the most demanding step of the bilateral sagittal split ramus osteotomy procedure. During the condylar-positioning maneuver, the surgeon cannot see the condyle or glenoid fossa. However, its position is influ-

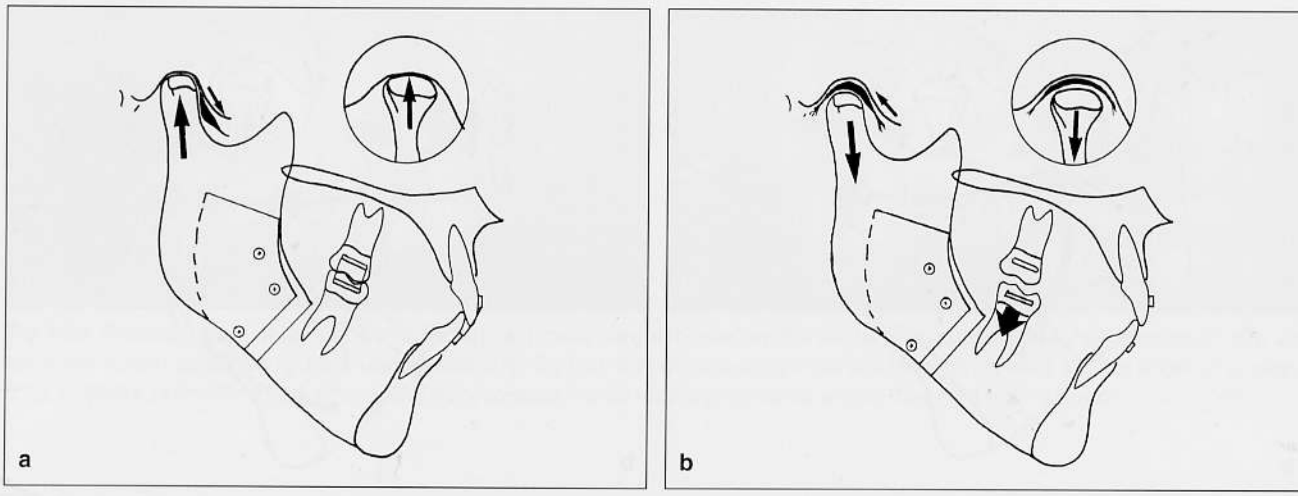


Fig 5-73 *(a)* The articulator disc is displaced anteriorly in the fossa during condylar positioning. *(b)* Once the disc returns to its normal position in the fossa, the condyle will be pushed downward, leading to a posterior open bite on the affected side.

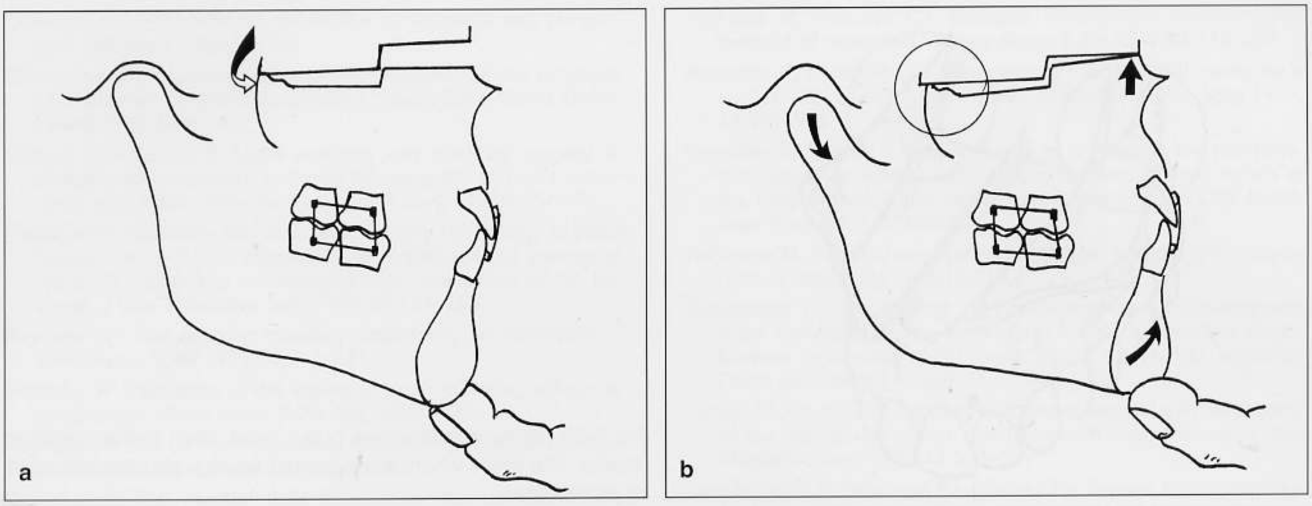
enced by numerous intracapsular and extracapsular factors, including the following:

- Incorrect vector during condylar positioning
- Incorrect direction of the holding wire or bone clamp
- An incomplete or greenstick split that prevents condylar seating
- Muscular, ligamentous, or periosteal interference
- Intra-articular hemorrhage or edema
- Flexing the proximal segment while placing rigid fixation (the stress in the segment is released once the maxillomandibular fixation is removed)
- Displacement of the articulator disc
- Resistance to movement between the distal and proximal segments during condylar positioning

The technique for condylar positioning is discussed in the surgical technique section. As previously emphasized, the surgeon who develops the ability to diagnose an incorrect occlusion and understands what leads to malocclusion during surgery has immense advantages. Intraoperative correction will prevent a disappointing occlusal result, many hours of hard work and irritation for the orthodontist, and probably a second operation. The surgeon should not depend on extensive, prolonged postoperative orthodontics to correct a poor surgical outcome.

Intraoperative Diagnosis of Condylar Sag During Le Fort I Maxillary Osteotomy

During condylar positioning, the maxillomandibular complex (the mobilized maxilla fixed to the mandible by maxillomandibular fixation with the teeth in the planned occlusion) must rotate around a point at the condyle. If not enough bone is removed at the posterior maxilla, the bone will act as a fulcrum, which will interfere with the rotation (Fig 5-74a). To achieve bone contact at the osteotomy site, the maxillomandibular complex is forced superiorly, which pulls the condyles inferiorly in the fossa (Fig 5-74b). Once the maxillomandibular fixation is released, the condyles will move superiorly into their normal position in the fossa, causing the mandible to rotate clockwise and the



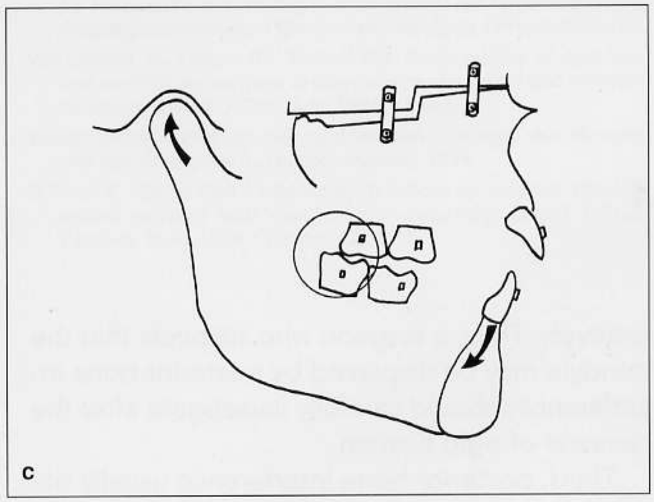


Fig 5-74 *(a)* The bony interference *(arrow)* at the posterior maxilla prevents rotation of the maxillomandibular complex around a point at the condyle to achieve ideal bone contact. *(b)* To achieve bone contact at the anterior maxilla, the maxillomandibular complex is rotated around the bony interference *(circle)*, while the condyle moves inferiorly in the fossa. *(c)* Once the maxillomandibular fixation is released, the mandible rotates back in a clockwise direction, this time with the posterior molars *(circle)* as the fulcrum. An anterior open bite and Class II dental relationship results.

bite to open anteriorly, with a Class II tendency (Fig 5-74c). Slight upward force on the chin will allow the mandible to rotate counterclockwise, with the fulcrum now at the second molars.

The surgeon should be extremely critical when evaluating the occlusion at this stage. In the evaluation, the following should be kept in mind. First, the mandibular condyles should be treated with great care during the entire procedure to prevent intracapsular edema, hemarthrosis, or disc displacement—problems that would make condylar positioning difficult.

Second, during the placement of rigid fixation after Le Fort I maxillary osteotomies, the condyle may not be in its correct position. Sometimes the placement of rigid fixation takes a substantial amount of time, during which the condyle is held in an "abnormal" position. After the release of maxillomandibular fixation, the condyle may tend to remain in this position and make it appear that the occlusion and condyle are well positioned. Therefore, the mandible should be translated gently laterally and anteroposteriorly after removal of maxillomandibular fixation. Then, by light digital pressure on the chin, the mandible is rotated closed and the occlusion assessed. Any tendency to an anterior open bite due to interference of the molars signals possible incorrect condylar positioning. This effect will only get worse postop-

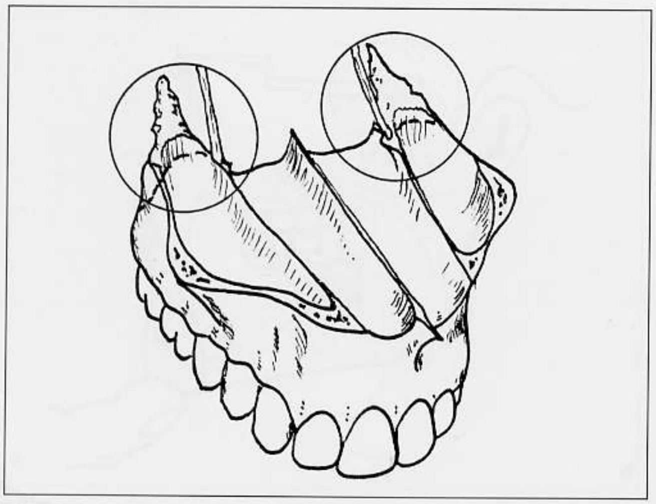


Fig 5-75 Bone interferences occur most often at the posterior maxilla. The areas where bone should be removed are indicated by *dotted lines*.

eratively. Thus, a surgeon who suspects that the condyle may be displaced by posterior bone interferences should carefully investigate after the removal of rigid fixation.

Third, posterior bone interference usually occurs in the posteromedial area of the maxillary tuberosities (Fig 5-75).

Finally, it is better to remove bone inferiorly at the posterior area of the downfractured maxilla than at the superior aspect (see Fig 5-75).

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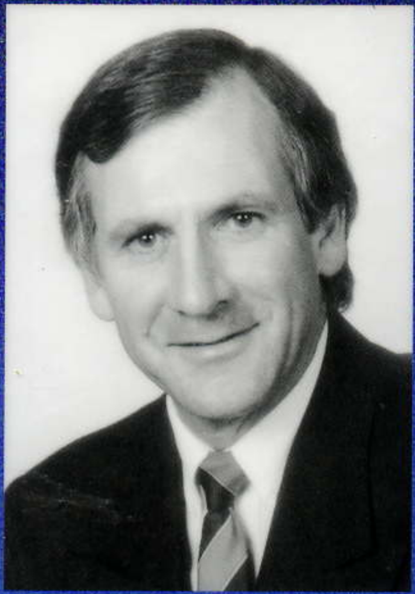

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