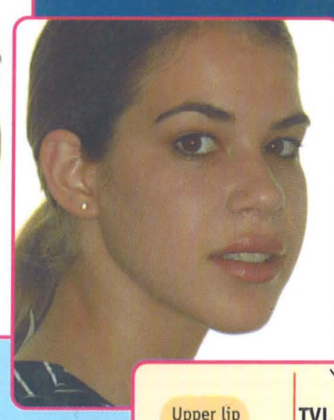
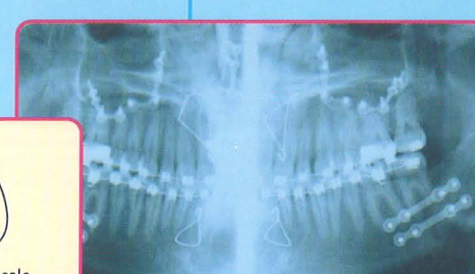
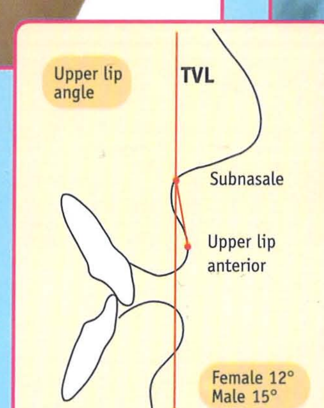
Facial and Dental Planning for Orthodontists and Oral Surgeons

Arnett · McLaughlin







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Dedication

This book is dedicated to our families who have been supportive through long hours of our absence during the preparation of this book. We want to thank our wives, Sally and Dorene, and our wonderful children, Chad and Katherine in Santa Barbara, and John, Cindy and Casey in San Diego. We love you and thank you for your patience and understanding.

Additionally, I (GWA) would also like to dedicate this book to the late John (Jack) S. Rathbone (1917-2003). My orthognathic surgery journey started in 1975 when I met Jack in Santa Barbara, California. He had recently finished his tenure as president of the American Board of Orthodontics and stood as an immeasurable figure in his field. Jack's ever present desire to improve his treatment led him to orthognathic surgery and he took a chance on a new and inexperienced 28 year-old surgeon. Jack shared with me his vast knowledge of orthodontics, which greatly improved my surgery, and my orthognathic surgery experience improved his orthodontic care. Jack and I grew together on this journey, but he was always the engine pulling the train. He instilled in me his drive to always improve patient care, to never be satisfied with today's results, and to always look for a better way. This text would not be in your hands today if it were not for this wonderful friend and fabulous human being. Thank you, Jack.

Preface

There is a need for a systemized and objective approach to facial planning. Such an approach should emphasize goal-directed treatment planning for the orthodontist and surgeon. This would lead to correction of the occlusion, and at the same time leaving teeth in a healthy periodontal position, a face that is balanced, joints that are stabilized, and an optimized airway. The orthodontic and surgical changes would be achieved in the most stable manner and, most importantly, the patient's chief complaints would be addressed. This approach should also reflect the difference between female and male human faces, and be applicable to cases at all levels of difficulty. Finally, it should have the potential to be developed and applied to different ethnic and age groups.

This book describes such an approach – one which, we believe, fully meets these requirements. The recommended methods of record taking, diagnosis, and treatment planning have been successfully applied to a wide range of patients for more than twenty years, with the results speaking for themselves.

Facial beauty can be recognized, but objectively defining the components of this beauty is difficult. At first encounter the recommended facial planning method may seem complex. However, it should be remembered that the human face is complex, and only in-depth analysis of this type can be relied upon to achieve proper facial balance and harmony at the end of treatment. Interestingly, when facial balance and harmony are achieved with a proper diagnosis and treatment plan, other errors, such as occlusal relapse, periodontal decline and TMJ dysfunction, are often avoided. This is because excessive 'orthodontic' dental movements are avoided. This book aims to provide both a practical protocol for the diagnosis and treatment planning of routine cases, but also to offer more thorough methods of evaluating the difficult and challenging cases.

Objectivity is clouded by personal preferences, cultural bias and a general view that beauty comes in different forms and with different features. But objectivity is a most important concept for orthodontists and surgeons who are attempting to maximize facial harmony and balance. The recommended approach, therefore, describes an objective method of analysis and treatment planning, to balance any input from subjective evaluations.

Conveniently, the recent decade has seen enormous improvements in computer technology, and in many practices digital record taking has become the preferred method. This in turn has allowed an easy transition towards the computerized method of facial analysis and treatment planning advocated here in this book. Importantly, the same facial and treatment planning techniques can be successfully incorporated into the non-computerized office with equal benefit.

However, all the high technology is of little value without a methodical and standardized method of case documentation. This is essential to support a proven method of facial analysis and treatment planning. The condyles have to be correctly positioned in the fossae throughout record taking, and special attention is required to record consistently and accurately the all-important relaxed soft tissue features, such as resting lip position. Natural head position needs to be precisely documented.

The book, therefore, includes an exact protocol for case documentation. It offers clear guidelines in the important areas of record taking and case analysis, with a renewed focus on patient examination – an area which we believe is deserving of more attention than in the past. It also emphasizes the need to establish and note the patient's chief complaints from the outset, because the orthodontist and surgeon need to keep these concerns in mind throughout treatment.

The opening chapter reviews the current thinking on treatment goals. It provides a clear statement of treatment objectives, explaining the historical difficulties in deciding which patients should receive orthognathic surgery and which can be well treated by orthodontics only. A form-based protocol for history taking is recommended in Chapter 2, and the series of forms have been designed to obtain the full information needed. This leads on to the third chapter, which restates the importance of the clinical examination, particularly the facial examination from the frontal view, and the need to carefully examine the TMJs.

A standardized approach to record taking is described in Chapter 4. We hope that this will be widely adopted by orthodontists and orthognathic surgeons worldwide, leading to a generally accepted method of documentation. This in turn may be based on the digital Dolphin™ system, components of which have been approved by the American Board of Orthodontics, and which is ideal for facial planning.

Chapter 5 is at the very heart of the book, covering the four main areas of diagnosis: the TMJs, the frontal view of the face, the facial profile, and the teeth and intra-oral structures. Facial planning can proceed only after careful diagnosis in these areas.

An overview of treatment planning for the TMJs is given in Chapter 6. This is against a background where condylar remodeling is rightly receiving much more attention than in the past, because it can undermine even the best treatment plans and treatment. Today's orthodontists and surgeons need to have a high level of awareness of this increasingly important topic.

The preparatory information in the earlier chapters leads to Chapter 7, arguably the most important section of the book. Here, the need for double assessment of the difficult borderline surgery cases is comprehensively described. Facial planning for cases at all levels of difficulty is explained in full detail.

Interestingly, the final chapter covers orthodontic treatment planning! Only at this stage, after all the other considerations in previous chapters, is it possible to focus on what should happen to the teeth behind the face and incisors. It may be that in the past it has been a frequent mistake to place these considerations near the top of list of priorities. We firmly believe that this is the correct order.

Two years in the writing, we believe that this book represents a turning point in facial planning for orthodontic and orthognathic surgery cases, offering as it does a main emphasis on the True Vertical Line, and a movement away from the traditional cranial base measurements. We feel this is an improved approach, leading the orthodontic and orthognathic surgery specialties in a new and better direction for facial planning.

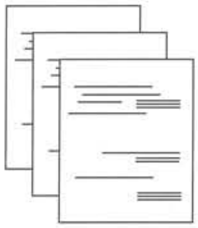
A visual summary of the structure of the book, highlighting its main concepts, is included on the following pages.

G. William Arnett
Richard P. McLaughlin

AN OVERVIEW OF THE FACIAL PLANNING PROCESS

I Gather information

Take a history



Chapter 2

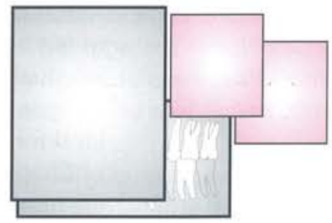
Personal information
Chief concerns
Medical, dental and TMJ histories
Growth assessment

Examine the patient

Chapter 3

TMJ examination
Front facial
Profile facial
Dental examination

Take records



Chapter 4

Quality of records
Natural head position
Photographs
Radiographs
Mounted models

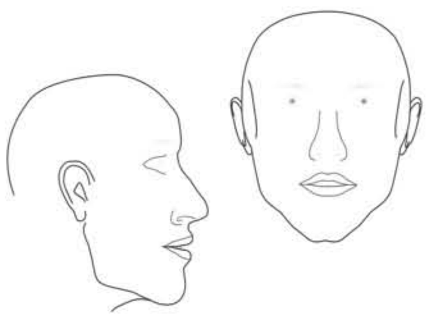
II Identify the problems

The joints

Chapter 5

Are the joints healthy or unhealthy?
Free of symptoms?
Normal on radiographs?
Will the condyles support Class II correction?
Potential to grow?
(can be an advantage in Class II or a disadvantage in Class III)
Potential to melt away?

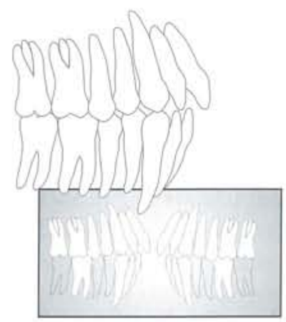
The face



Chapter 5

Is the face in harmony or not in harmony?
Is there a need to improve harmony?
What are the patient's concerns in this area?
If not in harmony, what changes are desirable?

The teeth



Chapter 5

Does the patient have good teeth?
Cusps, size, color, and general condition?
Crowding, spacing?
Missing teeth?
Unerupted teeth?
Does incisor position adversely affect facial harmony?

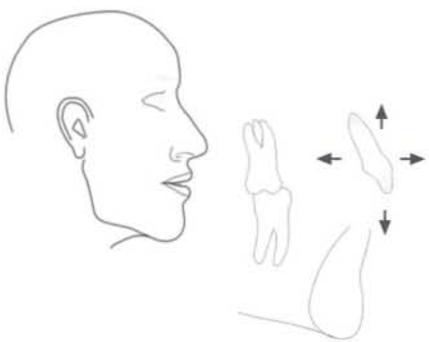
Now to resolve the existing problems without creating new ones

Chapter 6

If the joints are healthy, plan treatment to keep them so. Aim to position the teeth and jaws to support the healthy joints.

Are the joints healthy now, but likely to become unhealthy if a Class II mandible is improved by functional appliances or surgery? Are they able to support a new size/position for the mandible? A judgment call is necessary, explaining all aspects to the patient.

If the joints are clearly unhealthy at the outset, a diagnosis needs to be made, with a plan to restore and maintain health before orthodontic or surgical correction.



Chapter 7 (three sections)

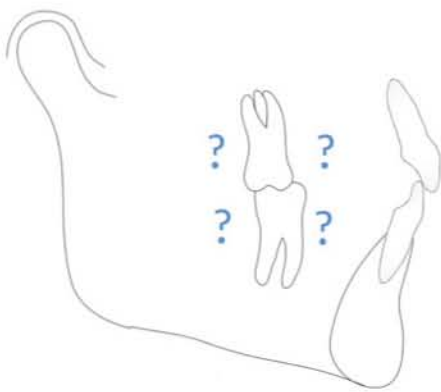
Decide where to position the incisors (PIP) and jaws to support the soft tissues of the face. This will be to maintain or improve facial harmony.

Can we do this orthodontically, by tooth movements and growth modification? Yes / No / Maybe

1. If 'Yes' — plan for orthodontics (G1 case)

2. If 'No' — plan for orthodontics plus surgery (G3 case)

3. If 'Maybe' — separately assess the case for orthodontics for orthodontics plus surgery, compare the outcomes and make a judgment call, explaining all aspects to the patient (the G2 / G3 decision).



Chapter 8

During planning of the face, a planned incisor position (PIP) was decided for the case.

In this final stage, the dental VTO is used to decide how to arrange the rest of the teeth around the PIP for the incisors. Extractions may be needed.

Some cases may require modification of jaw positions - by natural growth, growth modification, or surgery. Some cases may need restorations, build-ups, or enamel reduction. Ancillary dental or surgical procedures may be indicated, such as uncovering of unerupted teeth.

Acknowledgements

This book would never have been published had it not been for the help of a number of individuals. The authors would like to acknowledge them at this time.

Much of the material for this book was obtained in the Santa Barbara and San Diego practices, and the authors wish to acknowledge the hard work and dedication of all of their staff members during documentation of the book cases. Particular thanks go to Michaele Carnahan and Nancy Christensen in Santa Barbara, and Patty Knecht in San Diego, who played a vital role in case preparation, communications, proofreading and editing.

A number of the surgical cases were completed in combination with various orthodontists. These individuals are acknowledged at the completion of their specific cases, however, a general thanks for their excellent contribution is also in order at this time.

Important contributions were made by Dr Stephen Milam, Dr Thomas Eggleton and Dr Richard Gevirtz in Chapter 6. The authors are most grateful for their valuable insights into their respective specialist areas of TMJ management.

Dr John Bennett was involved in the early planning of the book. This involved the collection and organization of material, as well as many aspects of the writing and layout of the book, and the creation of most of the line drawings. He and Cath West carried out much of the communication with the publishers throughout the production of the book. The authors wish to thank them for their significant contribution.

All of the photographs, radiographs and cephalometric tracings for the text were either converted to digital form or originally collected digitally. The authors would like to thank Chester Wang and the staff of Dolphin Imaging for their invaluable help in this process. Also, thanks are in order to 3M Unitek for their help in promotion and distribution of the book.

Finally, the authors would like to thank Mike Parkinson, Barbara Simmons and the other staff members of Elsevier who worked on the book for their professionalism, efficiency and extensive effort in producing this book. It was a pleasure working with them.

G. William Arnett
Richard P. McLaughlin

Contents

1 Overview – treatment goals re-stated

TYPES OF CASE – GROUPS 1, 2 AND 3 (G1, G2, G3)

Patients present with a wide range of orthodontic and/or surgical needs. For some group 1 (G1) cases, diagnosis and treatment planning is straightforward, and subsequent treatment proceeds to completion without complications (Case MS, p. 285). Group 2 (G2) cases present with more difficult facial patterns and malocclusions, but these patients can often be well treated by dental compensation and growth management (Case MC, p. 264). Group 3 (G3) cases present with moderate to severe facial imbalance and malocclusion (Fig. 1.1), and these cases should be treated with a combined surgical/orthodontic approach (Case RS, p. 247).

This textbook aims to avoid overstating the diagnostic and treatment planning protocol for routine cases, but to provide thorough methods of evaluating the more difficult G2 and G3 cases. Therefore, throughout the text, routine screening procedures will be discussed for routine cases, followed by more 'in-depth' methods for the difficult G2 and G3 cases. An additional, and important, intention of this text is to provide the means to differentiate between groups 2 and 3.

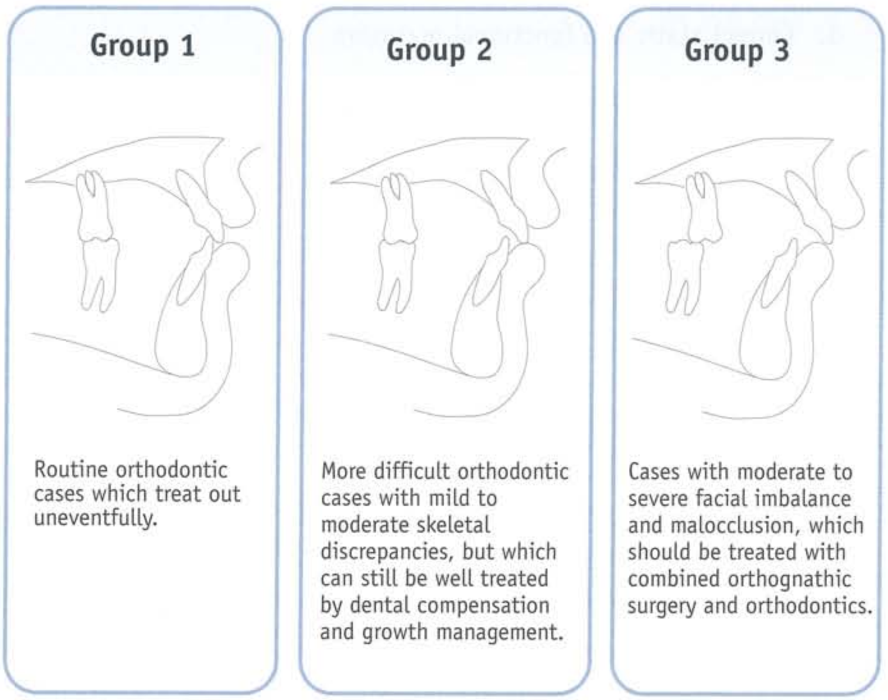


Fig. 1.1 Patients present with a wide range of orthodontic and/or surgical needs.

In the past, the most common errors have been made in the management of borderline group 2 and group 3 cases (Fig. 1.2).

It is an error to attempt a G2 treatment approach, involving dental compensation, for a G3 type of patient. Frequently this will lead to additional problems for the patient, rather than resolution of the existing problems.

Additional problems may include occlusal and facial relapse, inability to completely correct the malocclusion, facial imbalance, periodontal decline, temporomandibular joint decline, inadequate airway space, and patient dissatisfaction with the treatment outcome. It is equally an error to provide G3 treatment for a G2 patient, except when:

- the patient desires facial change which cannot be achieved by dental compensation, or
- dental compensation would produce facial change which would be unacceptable to the patient.

It is inappropriate to treat a patient surgically if a good result can be reached by orthodontics alone with dental compensation. In this situation, all options should be carefully shown and explained to the patient.

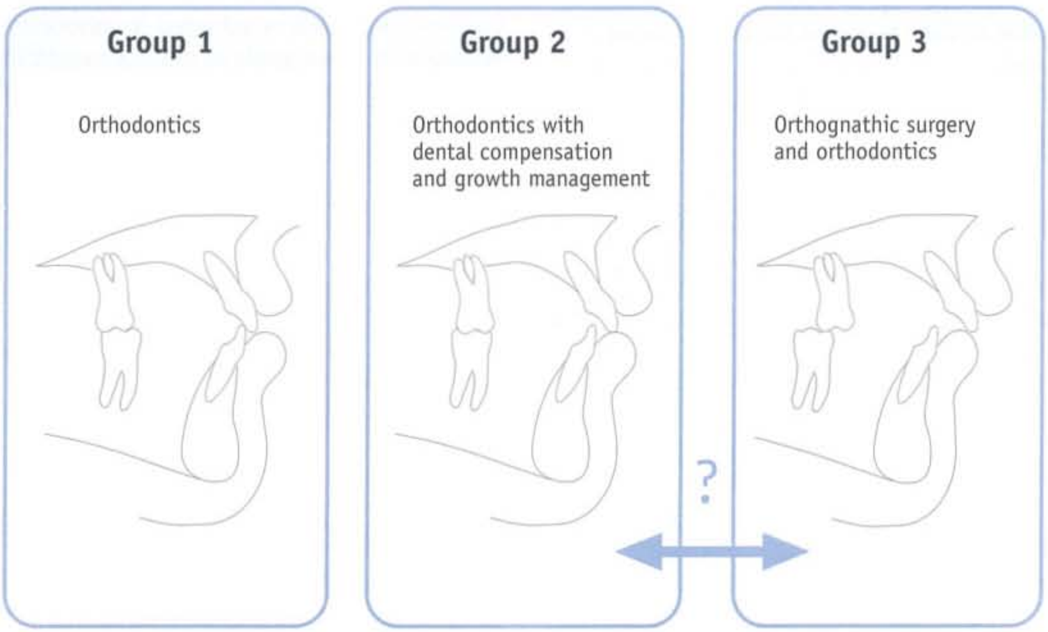


Fig. 1.2 In the past, errors have been made in delineating the borderline between group 2 and group 3 cases. It is a mistake to attempt a group 2 treatment for a group 3 case, because complications occur.

The borderline between G2 and G3 cases

Delineating the borderline between group 2 and 3 cases is complicated by a number of variables, which have to be acknowledged:

- Cultural differences – some patients may decline recommended extractions or even modest enamel reduction, due to their cultural background. A choice for orthognathic surgery is generally out of the question.
- Personal preferences – some patients arrive at the practice wanting perfect facial patterns and dentitions, while others are less concerned about optimal facial harmony.
- The orthodontist's view – among orthodontists there is individual variation in attitude towards orthognathic surgery. Some are more inclined than others to refer their patients to surgeons, and this may be influenced by previous good or bad experiences with orthognathic surgery cases.
- Surgical expertise – some orthodontists, after determining that the patient would benefit from orthognathic surgery, are unable to arrange this, due to a suitably expert surgeon not being available in their area, and the patient being unwilling to travel.
- Financial – 'That all sounds very interesting, but I cannot afford to follow the recommended treatment plan.' This is a valid comment from many patients.

Despite these variables, it remains the responsibility of the clinician to be objective, and to provide the patient with all the realistic treatment alternatives, including the ideal treatment approach. This is an essential part of informed consent.

CRITERIA FOR SUCCESS

1. Healthy musculature and temporomandibular joints
2. Facial balance
3. Correct static and functional occlusion
4. Periodontal health
5. Resolving the patient's chief complaints
6. Stability of dental, skeletal, and growth changes
7. Maintaining or increasing airway

The seven general criteria for success will be discussed in turn, because they guide the G2/G3 decision. When deciding whether a patient requires G2 treatment (orthodontics only) or G3 treatment (combined surgery and orthodontics), careful consideration must be given to the probability of achieving each of these seven important goals. Will achievement of one goal produce unacceptable change in another area? Generally, the best results will be achieved if orthodontic treatment is started with all the goals in mind. Complications can occur if occlusal correction is the only goal of orthodontic or surgical treatment.

1. Healthy musculature and temporomandibular joints (TMJs)

Establishing a harmony between the teeth, the musculature, and the TMJs, is an important aspect of preventing potential problems. This is a key criterion for success.

If muscular dysfunction is detected before treatment, or if it arises during treatment, it can normally be managed with conservative methods of splint therapy, physical therapy, and anti-inflammatory regimes. Management of condylar remodeling and temporomandibular joint damage is more difficult. This text covers diagnostic methods (Ch. 5, p. 147), and treatment planning techniques (Ch. 6) relative to this area. However, a few preliminary comments are in order in this chapter.

The TMJs are the foundation for any form of occlusal correction, including orthodontics, and orthognathic surgery. Therefore, key requirements for success include temporomandibular joints which:

- have a normal range of movement
- have structural stability
- are free from pain.

When discussing healthy TMJs, the concept of joint remodeling needs to be reviewed, and there are two main categories:

1. *Local remodeling.* This has also been termed 'functional remodeling'.[1,2] The morphological changes that occur in this process are limited to a local area on the condylar head (Case TW, p. 86).
2. *Total remodeling.* This has also been referred to as 'dysfunctional remodeling'.[1,2] The morphological changes that occur in this process involve the entire head of the condyle (Fig. 1.3; Case AD, p. 216).

The causes of condylar remodeling

There are a number of accepted causes of the condylar remodeling process (p. 144). These may act individually or in combination and there are three main categories:

- The adaptive capacity of the patient
- Joint compression
- Joint anatomy which is prone to remodeling.

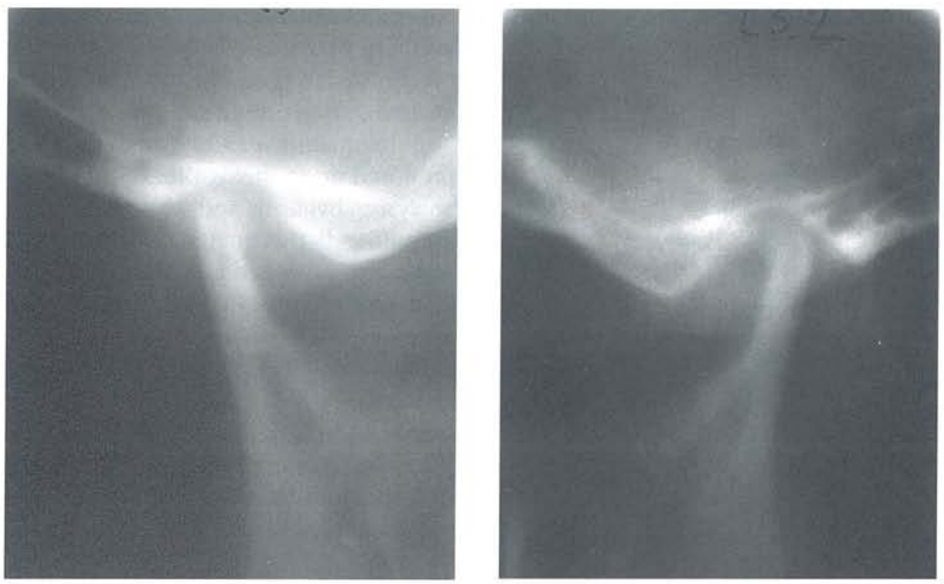


Fig. 1.3 Total condylar remodeling.

2. Facial balance

Recognizing facial beauty is innate to the human eye. However, objectively defining the components of this beauty is difficult. Objectivity is clouded by personal preferences, cultural bias and a general attitude that beauty comes in different forms and with different features. Objectivity may be of little importance to most individuals. However, it is a most important concept for orthodontists and surgeons who are attempting to maximize facial harmony and balance (Figs 1.4 & 1.5).

If we apply objectivity to our patients, we are able to inform both ourselves and them of treatment alternatives that we may not have realized possible. This, of course, must be discussed with tact and sensitivity.

With the advent of cephalometric headfilms, numerous cephalometric analyses were developed in an attempt to more objectively define the direction of treatment. Soft tissue normals, in the form of facial lines and angles were established in some traditional analyses, but they were limited in their number and description – emphasis was placed on skeletal and dental structures within the headfilm.

Dental and skeletal normals or averages were established for the general population.[3,4,5,6] It became convenient to define facial beauty based on these normals, and this had inherent problems[7,8] for the following reasons:

- An assumption was made that if the dental and skeletal values were normal, the face would also be normal. Studies[9,10] have shown that there is no correlation for this.
- The normals were obtained from patient samples which included individuals with malocclusions. The findings were not based on ideal faces and occlusions.
- The position of the dentition within the skeletal pattern was related primarily to cranial base structures. While these references were helpful in normal facial patterns, the cranial base landmarks themselves (for example sella, porion and orbitale) showed significant variability of position in patients with more severe facial disharmony, and the landmarks were often difficult to locate.

As a result of these weaknesses, treating to skeletal normals did not always lead to facial balance. In some cases it led to facial decline. It was a difficult challenge to position the teeth within the dental arches, in a functional and stable position, and at times soft tissue considerations became a secondary factor. All of these circumstances led to less than satisfactory outcomes for many patients.

More recently, there has been a re-emphasis on facial balance, and this subject will be a primary focus of this book.

In 1993 a two-part paper was published entitled 'Facial keys to orthodontic diagnosis and treatment planning'.[7,8] This paper drew attention to the shortcomings of the cranial base for facial planning. The authors advocated a greater emphasis on clinical facial examination and analysis to avoid facial decline during orthodontics or surgery.

Subsequently, in 1999, a new cephalometric analysis was proposed in a paper entitled 'Soft tissue cephalometric analysis: Diagnosis and treatment planning of dentofacial deformity'.[11] This analysis was developed from the 1993 work, and suggested a method of soft tissue cephalometric analysis (STCA, p. 151) and soft tissue cephalometric planning (CTP, p. 240). The new analysis was based on true vertical line (TVL). This line (Fig. 1.6) was drawn through subnasale (p. 151) and was perpendicular to natural head position (NHP, p. 95). Significantly, the new concept was published at a time when PC computer power was sufficient to record and analyze the required 45 measurements for the recommended STCA.

In the study, 46 adult Caucasian individuals were evaluated to establish female and male normals for facial balance. A system of colors was used to indicate facial balance or lack of balance (Fig. 1.7). This concept is fully explained in Chapter 5, but it is helpful to review key aspects here. It is possible to use the STCA to easily establish normals for different ages and ethnic groups.

Fig. 1.4

Fig. 1.5

Figs 1.4 and 1.5 Orthodontists and surgeons are attempting to maximize facial harmony and balance, and objectively defining the components of beauty is difficult.

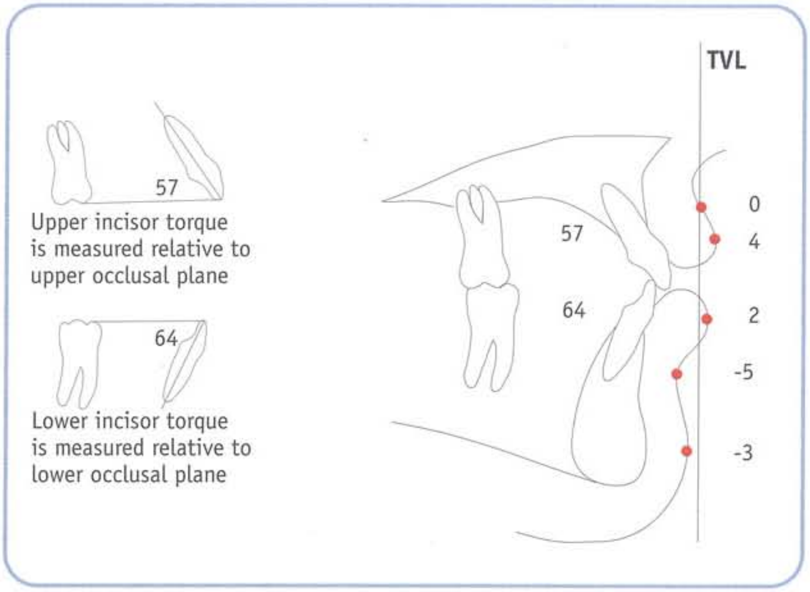


Fig. 1.6 In this illustration a patient with good occlusion and facial balance is analyzed using seven of the STCA measurements. Soft tissue measurements are relative to true vertical line. Incisor torque is measured relative to the occlusal planes. All numbers are black, indicating that they are within one standard deviation of ideal.

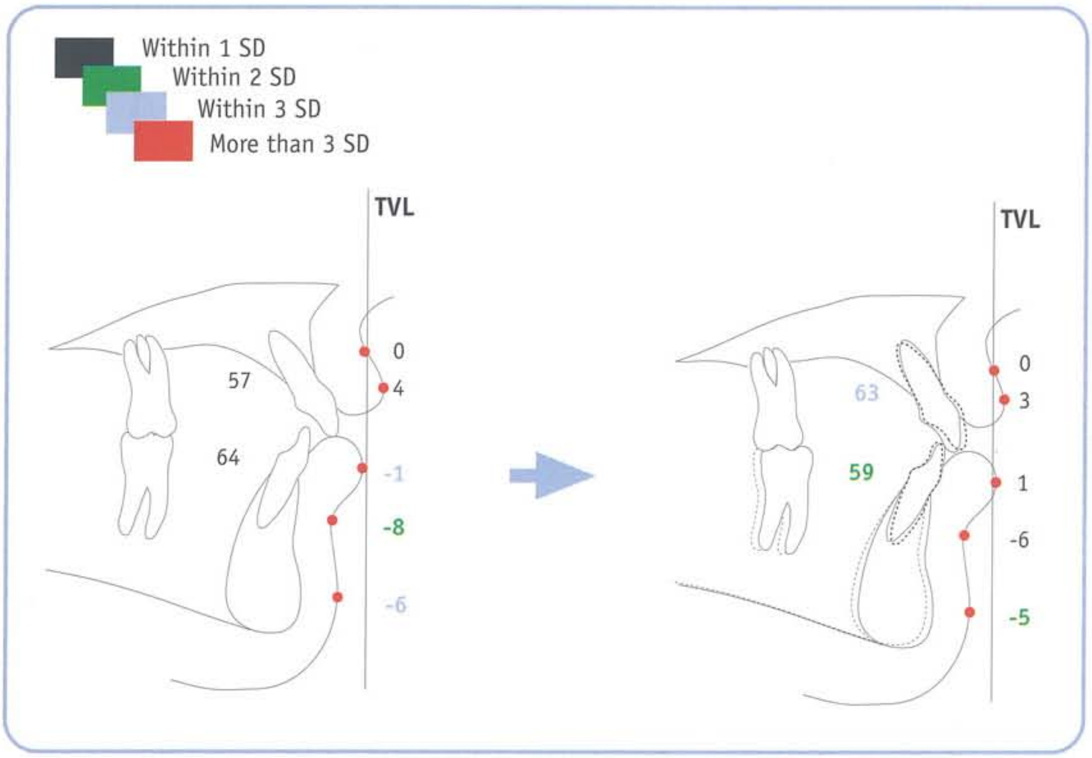


Fig. 1.7 A group 2 patient with a mild skeletal discrepancy. Facial balance was not ideal, as revealed by blue and green numbers. The case was treated orthodontically by dental compensation and growth management. A small amount of mandibular growth occurred. After treatment the incisor torque numbers have become blue and green, confirming the compensation. Soft tissue numbers are mostly black, showing improved facial balance.

The new STCA is able to quantify the changes in facial balance which occur during occlusal correction (Fig. 1.8). In particular, the facial harmony values – a concept that is totally new, relative to other analyses – are most helpful in this regard. These will be discussed in Chapter 5 (p. 160). If facial decline occurs it can readily be identified. The STCA may be used for facial planning, to ensure that facial decline does not occur during occlusal correction (Fig. 1.8).

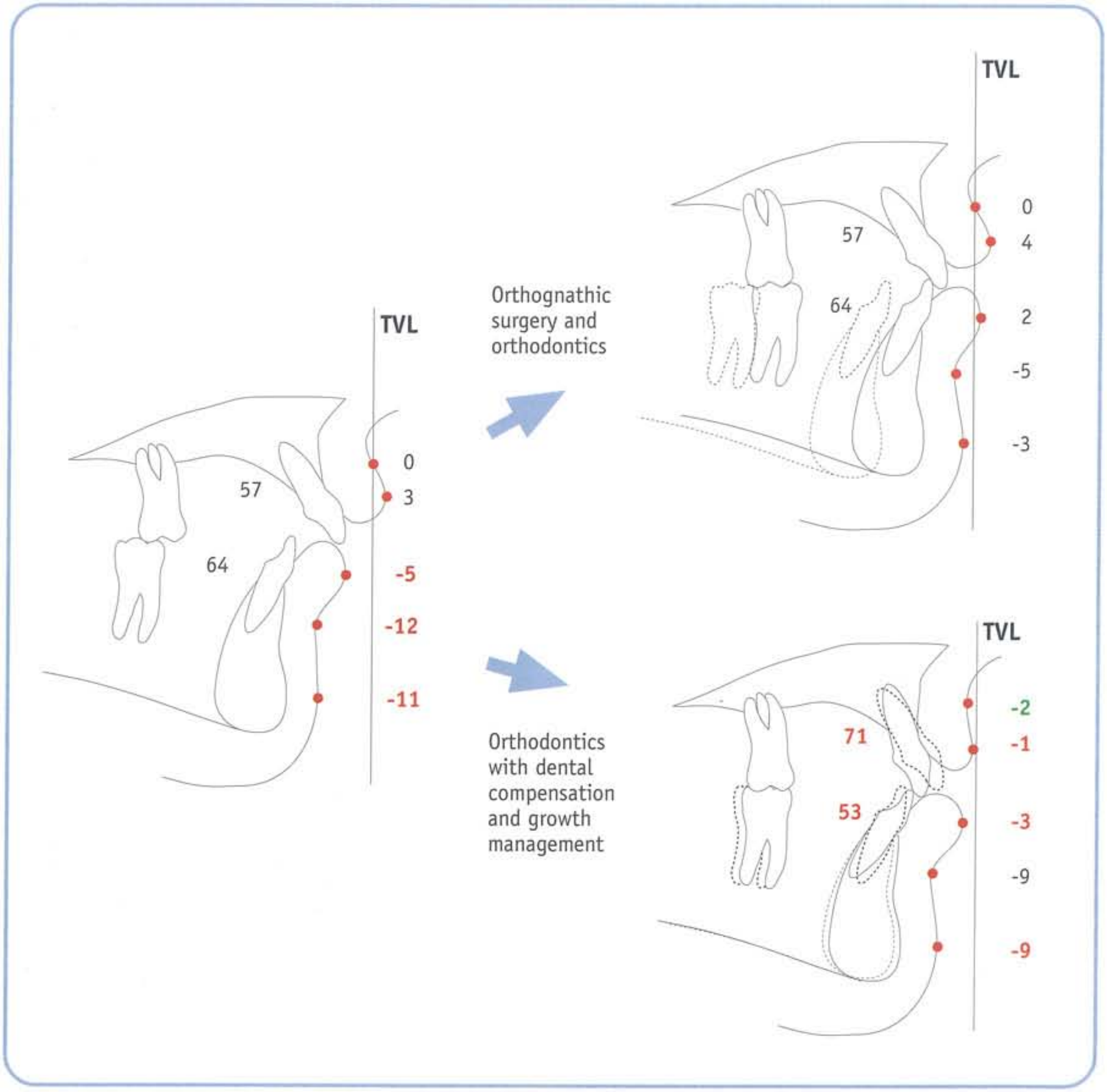


Fig. 1.8 A group 3 patient with a Class II skeletal discrepancy. There was severe facial imbalance, as revealed by the red numbers. Orthodontics with orthognathic surgery would give an ideal result, with improved facial balance, as suggested by the black numbers. Treatment orthodontically, by dental compensation and growth management, would lead to facial decline, as shown by the red numbers.

3. Correct static and functional occlusion

The goals for static occlusion are well established and documented, based on the 'six keys' of Andrews.[12] To these goals must be added correct overjet, overbite, and symmetrical midlines. Additionally, arch form needs to be correct, with the arches well coordinated. Condyles should be seated within the glenoid fossae, and movements from this centric position should occur without interferences. A mutually protected scheme of occlusion,[13] or occasionally a group function scheme of occlusion, is preferred.[14]

4. Periodontal health

The patient's periodontal status must be evaluated both before and during treatment. All attempts should be made to maintain or even improve alveolar bone levels and gingival tissue. Of particular concern in this area are the issues of arch form change and over-expansion. The problems related to these areas are well documented,[15] and are frequently associated with instability and periodontal decline in both orthodontic and surgical cases (Fig. 1.9).

Fig. 1.9 Orthodontic arch expansion can lead to instability and periodontal decline in both orthodontic and surgical cases. The above 22-year-old patient was treated by orthodontic expansion and shows gingival clefting with obvious relapse.

5. Resolving the patient's chief complaints

At the start of treatment it is essential to determine and note the patient's chief complaints (Fig. 1.10). Throughout treatment the orthodontist and surgeon need to keep these concerns in mind. This will be discussed in the next chapter, and a patient motivation questionnaire will be reviewed. Treatment success requires the elimination of any presenting symptoms, and fulfillment of the patient's facial and dental aspirations.[16]

6. Stability

Orthodontic instability in the A/P, transverse, and vertical dimensions is frequently related to the magnitude of tooth movement carried out. Relapse is therefore more likely to occur in these three planes in cases where excessive dental compensation has been attempted. Group 3 cases treated only by orthodontics often require substantial amounts of tooth movement, and therefore show greater potential for instability and relapse.

Disproportionate growth can occur after treatment, especially in cases of true mandibular hyperplasia. This has to be considered when planning the timing of treatment.

In addition to the orthodontist meeting stability requirements, measures need to be followed by the surgeon to ensure surgical stability. For example, the surgeon will be concerned with areas frequently associated with surgical relapse:

1. Orthodontic compensation – a common source of surgical relapse – should be identified and reduced before surgery.
2. Before surgery, the stability of the temporomandibular joints should be assured with mechanical and medical protocols.
3. Surgical techniques should be used to seat the condyles without compression, because compression leads to late remodeling and relapse of the occlusion.[1,2]

7. Maintaining or increasing the airway space

Current knowledge of obstructive sleep apnea requires that the airway should be maintained or increased with orthognathic surgical procedures. This is particularly true when mandibular setback surgery is contemplated. The size of the airway space should be observed on the lateral headfilm and the patient should fill out the sleep apnea setion of the in-depth head, neck and TMJ symptoms questionnaire in Chapter 2.

Fig. 1.10 It is essential to note the patient's main complaints, and to endeavor to resolve them during treatment.

Each of the seven general criteria for success will be developed in more detail later in the book. Emphasis will be given to facial examination and analysis of facial profile during treatment planning. A thorough method of clinical analysis, based on the STCA will be described in Chapter 5. Facial treatment planning using the CTP will be explained in Chapter 7.

A graphic overview is included on pages viii and ix. This summarizes the organization of the facial planning process, as described in this book.

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CASE AT

This 12.6-year-old female presented with a severe Class II, division 1 malocclusion. Due to a thumb sucking habit, the patient had protruded upper incisors and retroclined lower incisors. Her first phase consisted of a functional appliance (Twin Blocks). This was only marginally successful.

Fig. 1.11

Fig. 1.14

Fig. 1.17

Fig. 1.12

Fig. 1.13

Fig. 1.15

Fig. 1.16

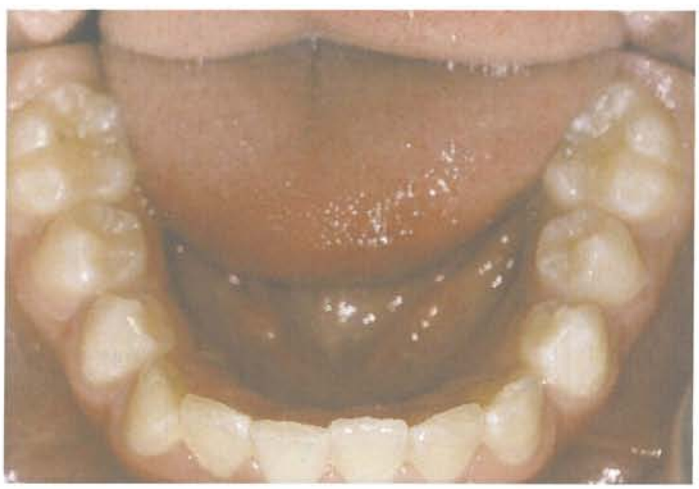


Fig. 1.18

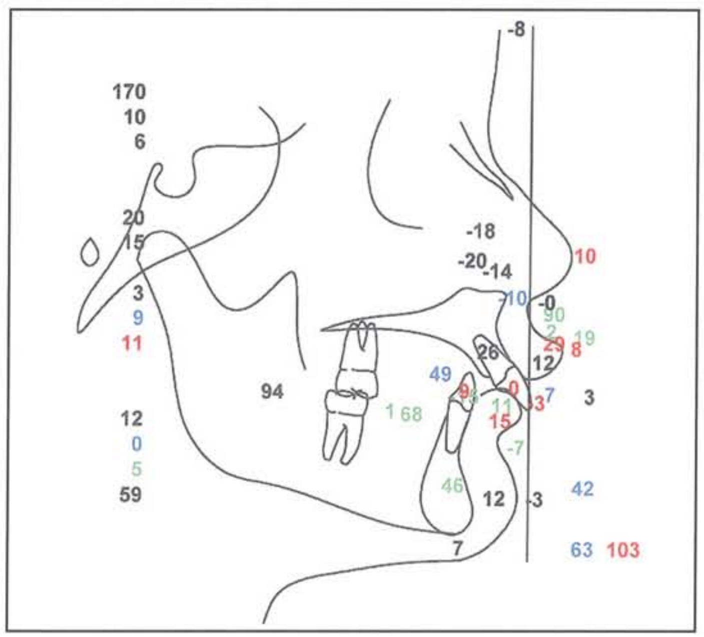


Fig. 1.19 The pre-treatment soft tissue cephalometric analysis (STCA). The analysis is fully discussed in Chapter 5.

The second phase of treatment consisted of full banded orthodontic appliances and a fixed functional appliance. The patient's correction was the result of significant dento-alveolar change as well as a positive mandibular growth pattern.

Figures 1.20 to 1.26 show the end of treatment result.

Fig. 1.20

Fig. 1.21

Fig. 1.24

Fig. 1.27 The post-treatment STCA numbers show only one red figure. This compares favourably with the measurements before treatment (Fig. 1.19, page 13).

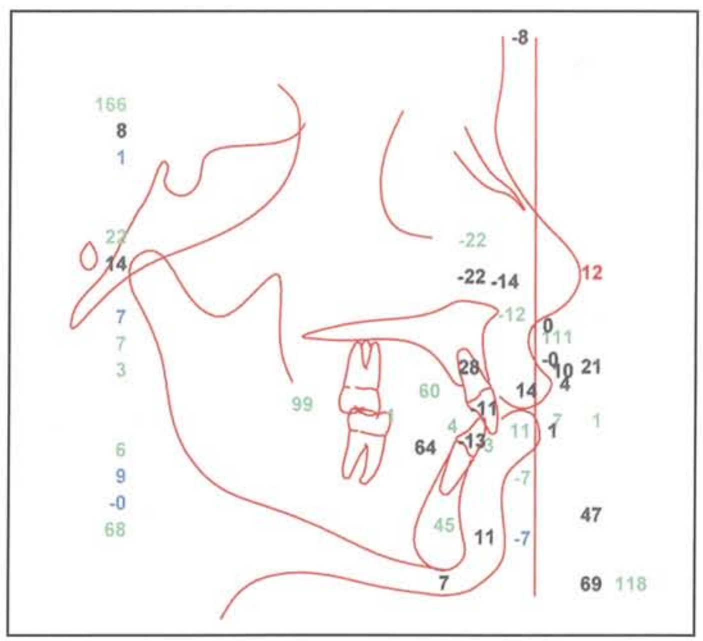


Fig. 1.27 The post-treatment STCA.

Fig. 1.22

Fig. 1.23

Fig. 1.25

Fig. 1.26

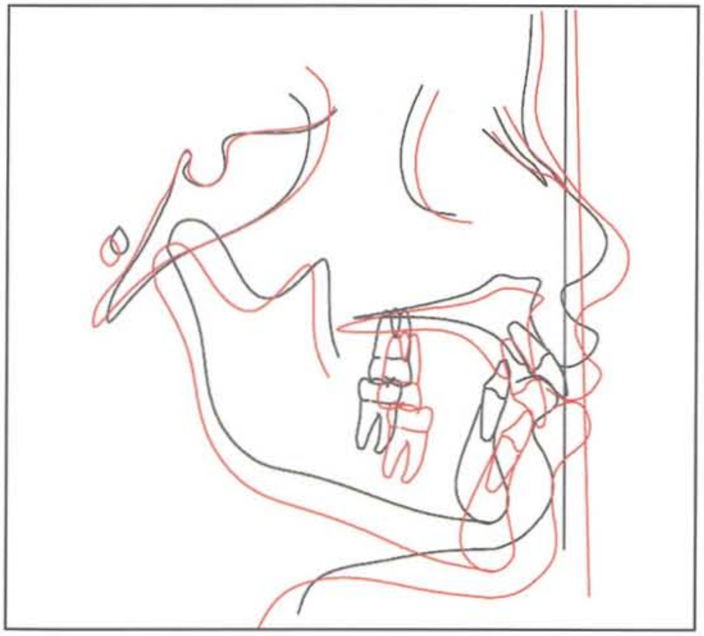


Fig. 1.28 Post-treatment superimpositions on SN at sella.

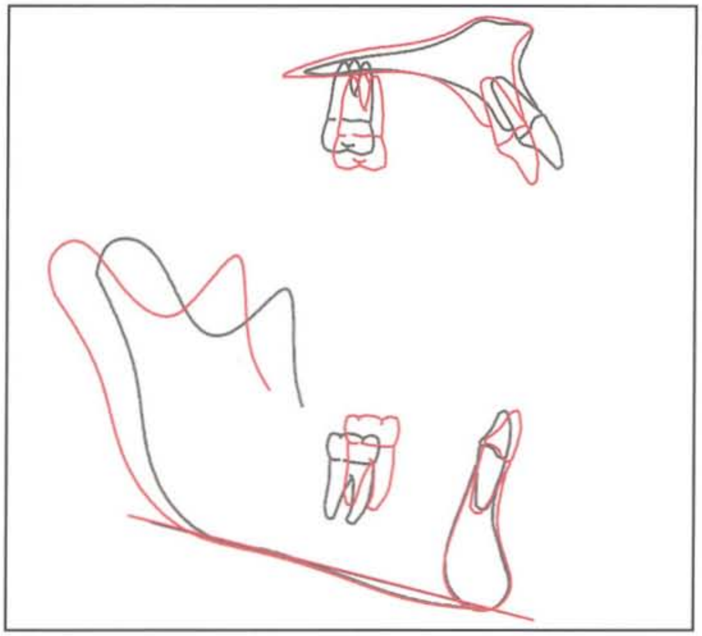


Fig. 1.29 Superimositions on the maxilla and the mandible.

CASE HH

This 23-year-old male with a Class III malocclusion was seen for consultation. He was referred for surgery by his orthodontist. Diagnosis and treatment were started with the intention of fulfilling the seven goals of treatment. His patient motivation form indicated that he requested straightening of the front teeth and back teeth. Facially, he wanted the chin moved back and to the right, and his lower lip retracted. He wanted to show less gingival tissue when smiling. He had no TMJ symptoms. TMJ examination and history, clinical facial examination, soft tissue cephalometric examination, and model examination were obtained.

The problem list and treatments were as follows: A diagnostic splint was utilized prior to orthodontic treatment to seat the TMJs and reveal the true mandibular position. Pre-surgical orthodontics was completed in 12 months. Antero-posterior diagnosis and treatment planning were accomplished utilizing the seven-step CTP. The frontal midlines, levels, and outline were treatment planned using

PROBLEM	TREATMENT
1. High midface	
• Soft cheekbones	• Heat treated HA augmentations
2. Maxilla	
Dental	
• Slight excess labial crown torque	• Lingual crown torque
• Mild crowding	• Orthodontics
Skeletal/facial	
• Concave nasal base	• Maxillary advancement
• Upper lip protrusion	• Upper incisor palatal crown torque
• 6.5 mm of relaxed incisor exposure	• Le Fort I (LFI) impaction
• Flat occlusal plane	• Plan with CTP to produce nasal base + chin harmony
• Width mismatch in a Class I position	• Multi-segment LFI
• Accentuated curve of Spee	• Multi-segment LFI
3. Mandible	
Dental	
• Incisors with lingual crown torque	• Labial crown torque
• Accentuated curve of Spee	• Flatten orthodontically
• Crowding	• Interproximal stripping
Skeletal/facial	
• Adequate chin prominence	• Maintain
• Flat occlusal plane	• Plan with CTP to produce nasal base + chin harmony
• 2 mm left deviation	• 2 mm right rotation of the midline
• Normal throat length	• Maintain
4. TMJ	
• Normal	• No treatment
5. Growth potential	
• 24.6 years old	• Non-factor

the frontal clinical examination. A multi-segment LFI and bilateral sagittal split osteotomy (BSSO) were necessary to correct the occlusion and produce basic facial balance. The occlusal plane was steepened to increase the nasal base. Additional improvement of facial balance was achieved with a 2 mm chin advancement and Interpore 200 Avitene heat treated cheekbone augmentations.

Fig. 1.30

Fig. 1.31

Fig. 1.32

Figs 1.30 to **1.32** The pre-orthodontic facial photographs taken in centric relation show a Class III facial pattern.

Figs 1.33 to 1.37 Pre-orthodontic intra-oral photographs taken in centric occlusion indicate a Class III malocclusion with anterior open bite.

Fig. 1.33

Fig. 1.36

Fig. 1.39 The pre-orthodontic soft tissue cephalometric analysis (STCA) shows a flat occlusal plane of 90° (red), a long lower face height of 96 (red), and an anterior open bite measuring -5 mm (red).

Fig. 1.40 The pre-orthodontic cephalometric treatment plan (CTP) calls for correction of the upper incisor torque, proclination of the lower incisors, impaction and advancement of the maxilla, steepening of the occlusal plane, and a set-back of the mandible.

Fig. 1.41 The overlay of the cephalometric treatment plan (CTP) on the pre-orthodontic soft tissue cephalometric analysis (STCA). The bimaxillary occlusal plane was steepened from 90° (red) to 95° (black). This change in the angle of the occlusal plane increased the nasal base and maintained the chin projection, both to aesthetically desirable positions.

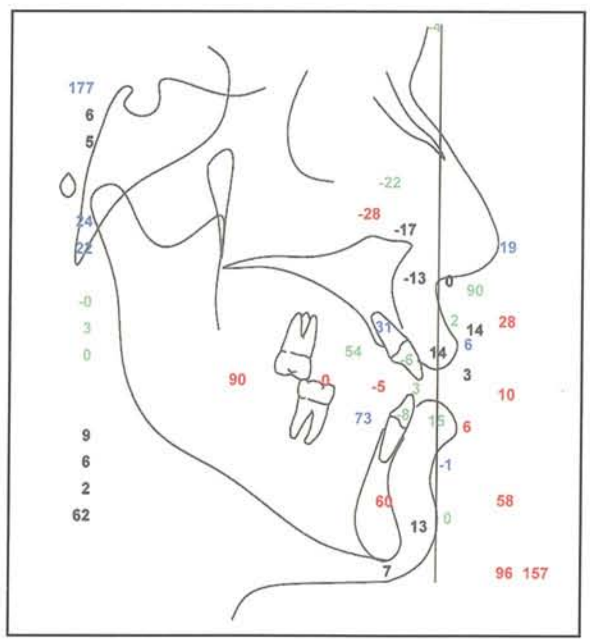


Fig. 1.39 The pre-orthodontic STCA.


Fig. 1.34


Fig. 1.35


Fig. 1.37

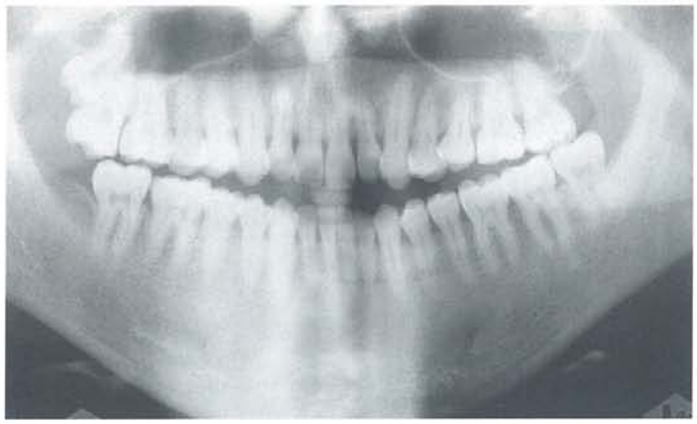


Fig. 1.38 The pre-orthodontic panoral radiograph showing a healthy dentition.

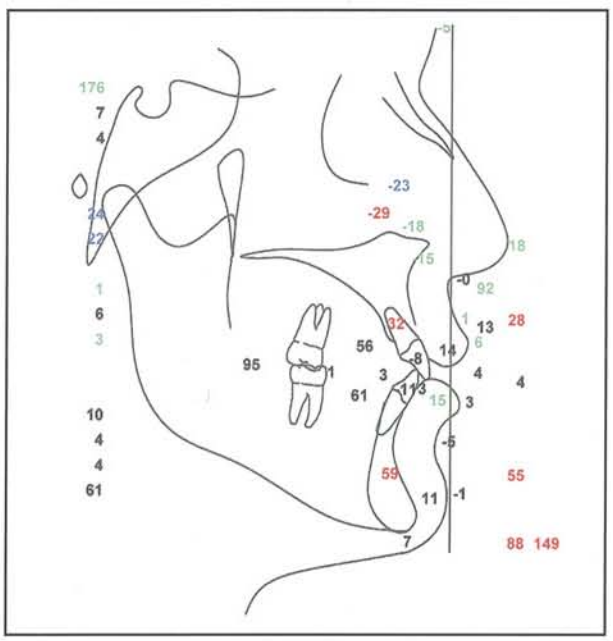


Fig. 1.40 The cephalometric treatment plan (CTP).

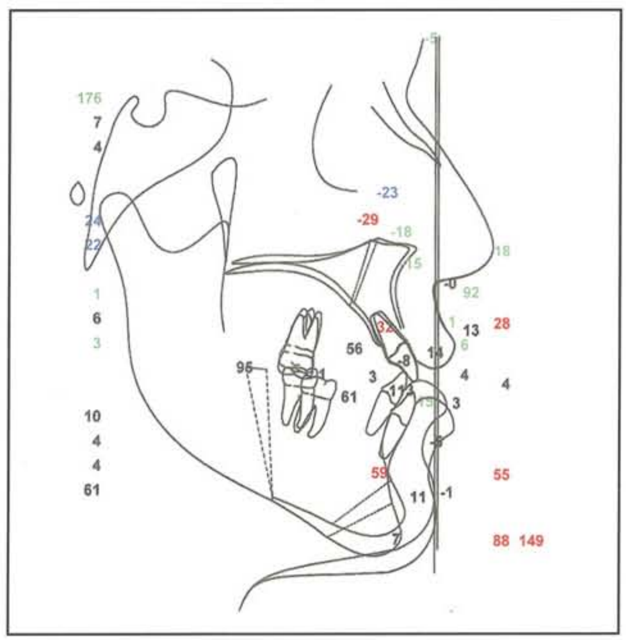


Fig. 1.41 The overlay of the CTP on the STCA. Note the long but proportionate lips.

Figs 1.42 to 1.46 The pre-surgical centric occlusion photographs showing contact on the second molars only. The original arch forms and arch widths were maintained during orthodontic preparation, to prevent orthodontic relapse or gingival recession.

Fig. 1.42

Fig. 1.45

Fig. 1.46

Figs 1.47 and 1.48 The panoral and tomographic radiographs. Note: the long condylar head and neck, which is typical of Class III cases.

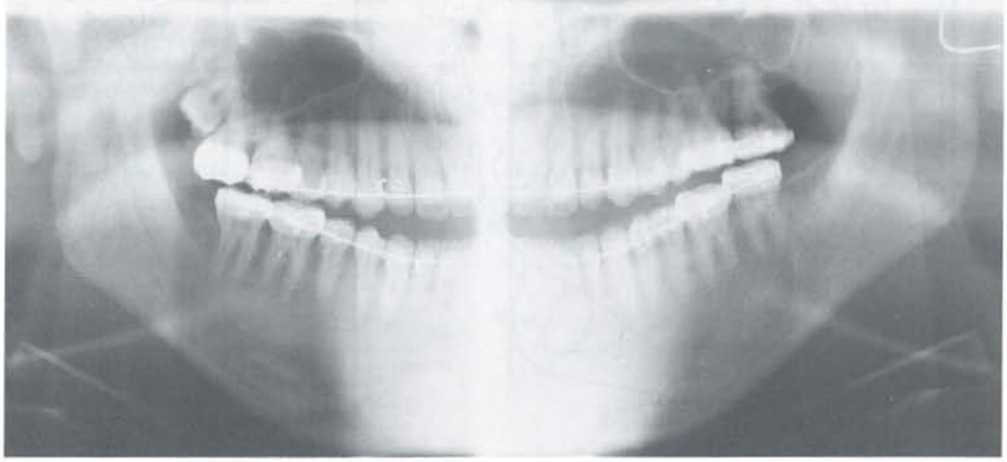


Fig. 1.47


Fig. 1.43


Fig. 1.44


Fig. 1.48

Figs 1.49 and 1.50 The pre-surgical closed lip (attempted) and relaxed lip photographs. Note: the concave nasal base, the lower lip protrusion and the very large inter-labial gap. The patient requested cheekbone augmentations; therefore this was part of the treatment plan.

Figs 1.51 and 1.52 The pre-surgical closed lip and relaxed lip photographs. Note: the excessive lip strain upon attempted closure.

Figs 1.53 and 1.54 The pre-surgical right and left three-quarter relaxed lip facial photographs. Note: the flat cheeckbone contour, the concave nasal base and the large inter-labial gap, which is secondary to the mild vertical maxillary excess and the large open bite.

Fig. 1.55 The pre-surgical (post-orthodontic) soft tissue cephalometric analysis (STCA) shows a flat occlusal plane of 91°, a long lower face height, and an anterior open bite.

Fig. 1.56 The pre-surgical cephalometric treatment plan (CTP) calls for impaction and advancement of the maxilla, steepening the occlusal plane, and a set-back of the mandible at the dental level, but not at the chin, which was maintained. The occlusal plane was set at 97° (green), compared with 91° (blue) in the CTP, to aesthetically position the nasal base and the chin.

Fig. 1.57 The superimpositions.

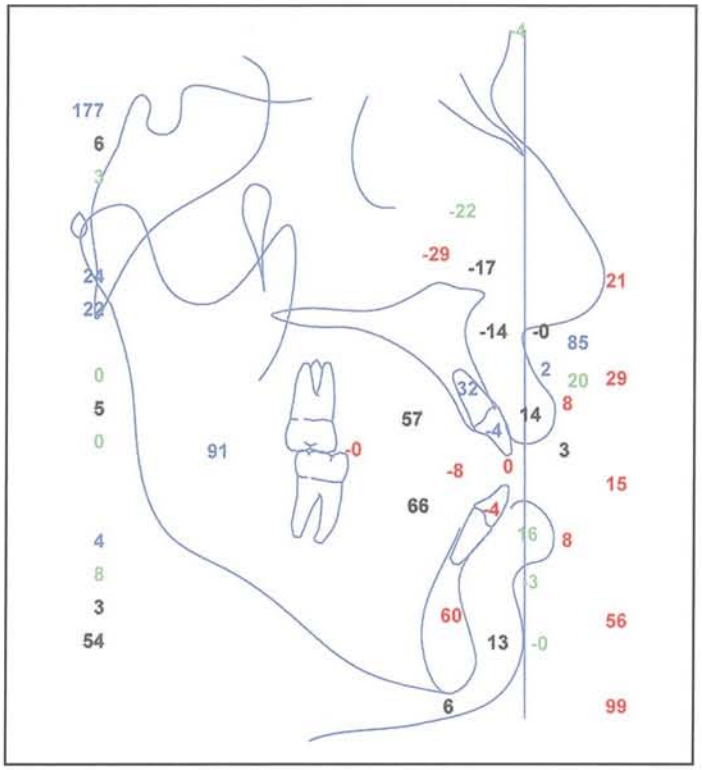


Fig. 1.55 The STCA.

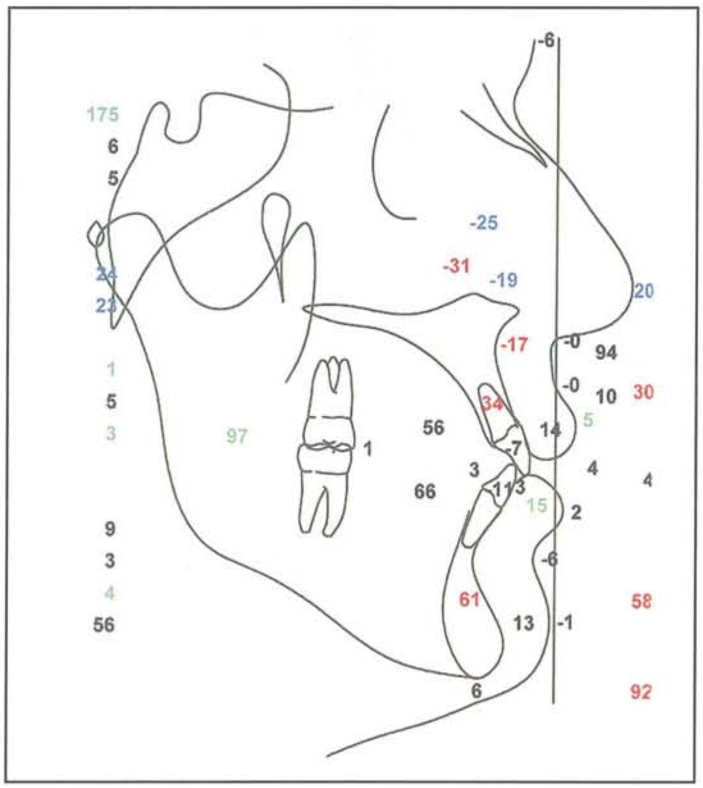


Fig. 1.56 The CTP.

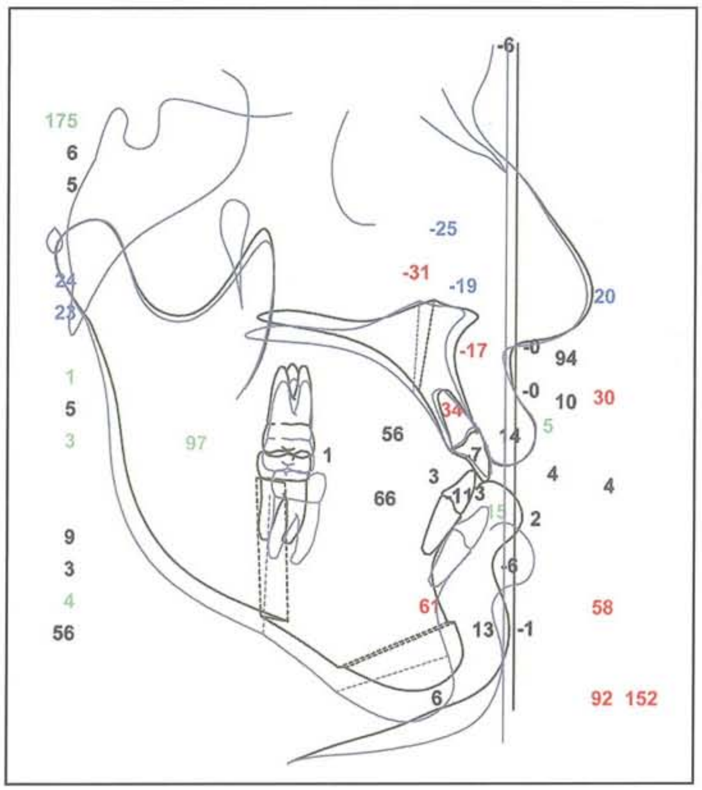


Fig. 1.57 The superimpositions.

Figs 1.58 to 1.62 Post-surgical intra-oral photographs with the appliances removed.

Fig. 1.58

Fig. 1.61

Fig. 1.62

Fig. 1.59

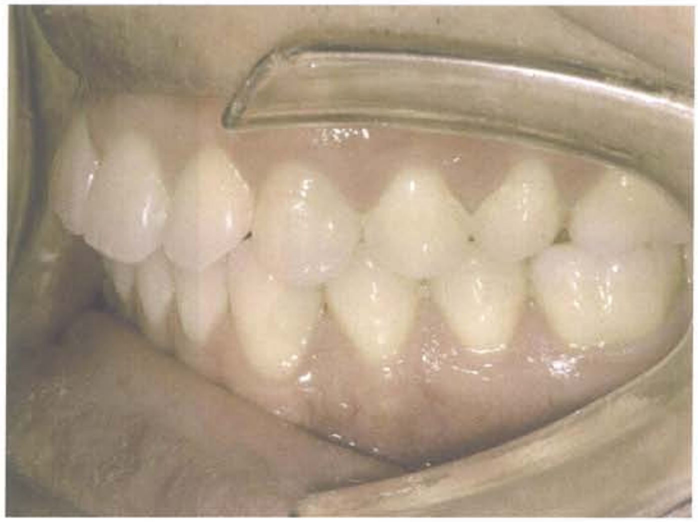


Fig. 1.60

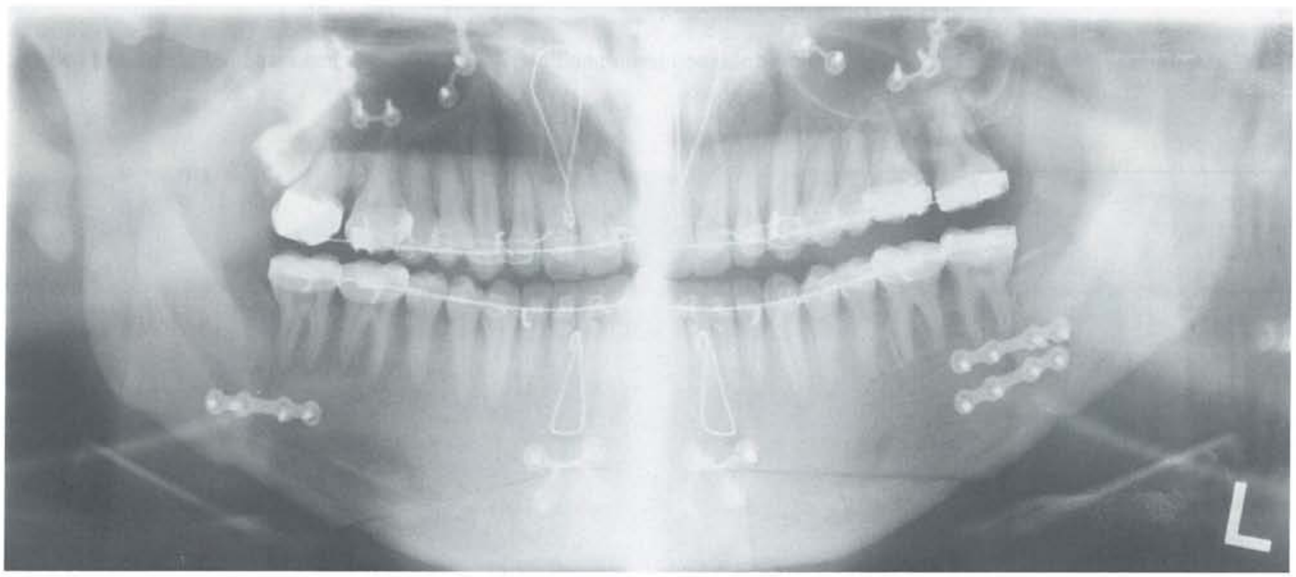


Fig. 1.63 The post-surgical panoramic radiograph, showing the plates for the Le Fort I, the sagittal osteotomy, and the chin reconstruction. The hooks at the anterior nasal spine and 'B' point were constructed from 24 gauge stainless steel wire. The patient was instructed to wear up-and-down elastics between these hooks, full time for eight weeks and then at night only for a further eight weeks. The elastics 'skeletally' hold the bite closed. Intra-oral views of hooks of these type may be seen in Case AC, page 192.


Fig. 1.64


Fig. 1.65


Fig. 1.66

Figs 1.64 to 1.66 Facial profile views with closed lip, relaxed lip, and smile photographs. Note: the normal facial projection and heights.


Fig. 1.70


Fig. 1.71

Figs 1.70 and 1.71 The post-treatment right and left three-quarter facial photographs. Note: the normal projections and contours.

Fig. 1.67

Fig. 1.68

Fig. 1.69

Figs 1.67 to 1.69 The post-treatment frontal facial views with closed lip, relaxed lip, and smile. Note: the normal heights and facial outline.

Fig. 1.72

Fig. 1.73

Figs 1.72 and 1.73 Pre- and post-surgery photographs.

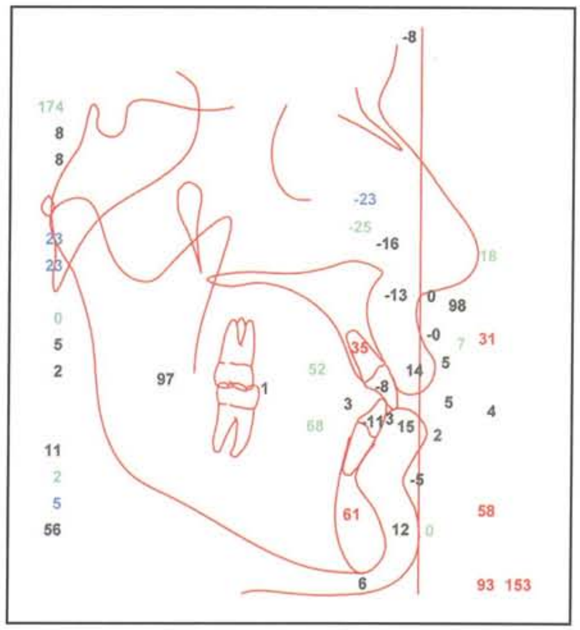


Fig. 1.74 The post-treatment STCA shows normal maxillary and mandibular projections. The vertical dimensions are long, measuring 93 mm (red) and 153 mm (red). However, good proportion exists between the upper lip at 31 mm (red) and the lower lip at 58 mm (red), and this gives good balance and facial esthetics.

2 History taking – a form-based protocol

Taking a patient's history involves the gathering of information in six areas: personal information, chief concerns, medical history, dental and orthodontic history, history of the musculature and the TMJs, and growth. There are many ways to take these histories, and individual clinicians will have their own preferences.

THE USE OF FORMS FOR GATHERING INFORMATION

This chapter contains a form-based system for history taking. The forms are structured to provide a comprehensive and systemized record of the information, but they may easily be modified to meet individual clinicians' requirements.

There is a need for general screening of all patients, using the 'Basic' series. More detailed information will be needed for patients with complex problems, and 'In-depth' questionnaires should be used for those individuals (Fig. 2.1).

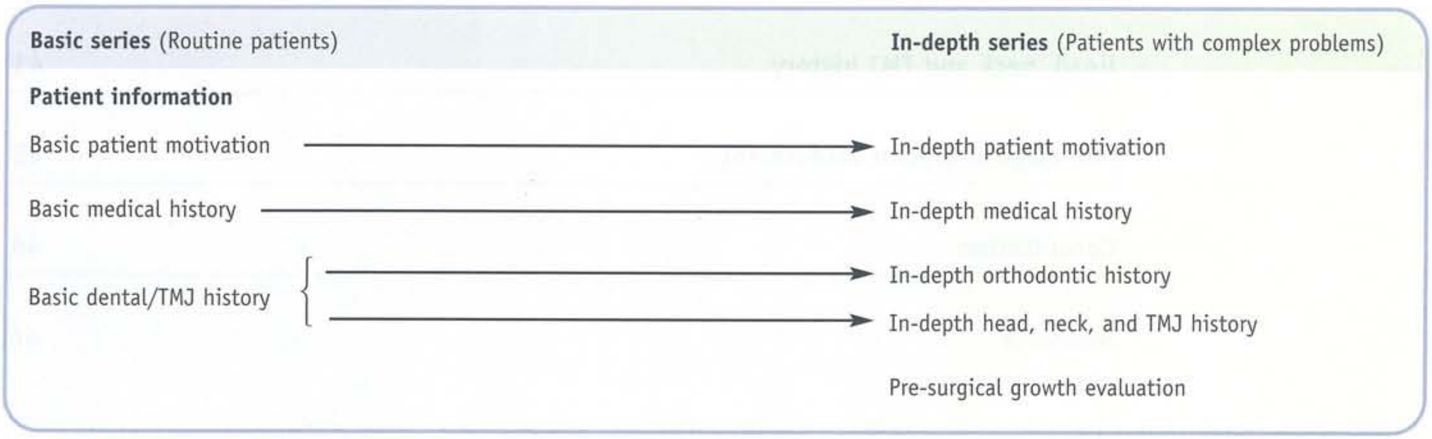


Fig. 2.1

PERSONAL INFORMATION

The process generally begins with a telephone call from the prospective patient (Fig. 2.2). It is helpful to have a protocol for gathering personal and financial information. In this way, many members of office staff can competently deal with this important initial contact. The 'Patient information' form may be used to record this information (Fig. 2.3, p. 32).

After the initial telephone call, a letter can be sent, enclosing helpful information about the practice or department, such as a map and directions for various methods of travel. Relevant forms can be enclosed with this welcoming letter, for completion by the patient at home.

Home completion of forms is usually neater and more accurate than completion in the office, and can save delays at the first appointment. If patients are asked to complete forms in the orthodontic office, it is helpful to provide a convenient and tranquil area for this purpose. Help should be at hand to deal with any questions which are unclear. The patient should be asked to arrive 10 or 15 minutes before the scheduled orthodontist/surgeon appointment, to allow orderly form completion.

Fig. 2.2 It is helpful to establish a protocol for gathering personal and financial information. In this way many members of office staff can competently deal with the important initial telephone contact.

Patient information

Date:

Patient's name: **Social security number:**

Date of birth:

Address:
Street City State Zip

If a minor, parent/guardian's name:

Contact for accounts:

Address:
Street City State Zip

Home phone: **Work phone:** **Mobile phone:**

Fax: **E-mail:**

General dentist:

Physician: **Oral surgeon:**

Reason for consultation:

Whom may we thank for referring you?

Siblings' names and ages:

Fig. 2.3 Patient information form.

MOTIVATION QUESTIONNAIRES – THE PATIENT'S CHIEF COMPLAINTS

It is necessary to identify the patient's reason for seeking treatment and establish what, for him or her, would represent a successful outcome of treatment. These concerns need to be recorded and focused on throughout treatment, to avoid patient disappointment. A common cause of medico-legal problems, after treatment, is failure to resolve the patient's complaints.

Patients who present for consultation to the orthodontist or surgeon will have expectations in one or more of three categories:

- Dental changes
- Facial changes
- Relief of symptoms.

Many orthodontists will feel that it is sufficient to ask initial screening questions about the teeth, facial appearance, and symptoms. However, where appropriate, the 'Patient basic motivation questionnaire' can be used (Fig. 2.4, p. 34). If the answers to the basic form need further investigation, or if the case is clearly complex from the outset, then the 'Patient in-depth motivation questionnaire' is needed.[1] The in-depth form is recommended for all orthognathic surgery cases (Fig. 2.5, p. 35).

At the outset it is important to identify the fastidious patient, who holds unrealistic expectations, or is seeking correction of minute dental or facial problems. Pre-treatment dialogue may not be enough to recognize those individuals who, later on, will be difficult or impossible to please. The in-depth form compels patients to reveal their true expectations. In this way, good communication between clinician and patient leads to shared expectations and mutually defined goals from the start.

Patient basic motivation questionnaire **Name** **Date**

Patients often request changes in their bite or faces and relief from pain or discomfort. Please help us understand your problem by checking the following information. Please be specific (check (✓) the words *backward, less, shorter,* etc.).

Teeth: If your teeth could be changed, how would you like them to change?

☐ Straighten the front teeth	☐ upper	☐ lower
☐ Straighten the back teeth	☐ upper	☐ lower
☐ Move upper teeth	☐ forward	☐ backward
☐ Move lower teeth	☐ forward	☐ backward

☐ Make the line of the upper front teeth more level

☐ Move the midline of the ☐ upper/ ☐ lower teeth to the ☐ left/ ☐ right

☐ Other.............................

Face: If your facial appearance could be changed, what would you change?

☐ Move chin	☐ forward	☐ backward
☐ Move chin to center it	☐ left	☐ right
☐ Move lower lip	☐ forward	☐ backward
☐ Move upper lip	☐ forward	☐ backward

☐ Show ☐ more/ ☐ less of my ☐ teeth/ ☐ gums when I smile

☐ Make my lips ☐ closer together/ ☐ farther apart when my teeth are touching

☐ Make my lips not touch and roll out when my teeth are touching

☐ Other................................

Symptoms: If you want to reduce pain or discomfort, where would it be located? Please be specific about the location; check the right side, left side, or both if they apply.

☐ In front of my ears	☐ right	☐ left
☐ Below my ears	☐ right	☐ left
☐ Above my ears	☐ right	☐ left
☐ In my ears	☐ right	☐ left
☐ Neck	☐ right	☐ left
☐ Shoulders	☐ right	☐ left
☐ Temples	☐ right	☐ left
☐ Eyes	☐ right	☐ left
☐ Teeth		
☐ Sinuses		

☐ Other...............................

Fig. 2.4 Patient basic motivation questionnaire. It may prove difficult to satisfy the treatment expectations for patients who write in many 'other' issues (©Arnett Facial Reconstruction Courses Inc. 2003).

Patient in-depth motivation questionnaire **Name** **Date**

Patients often request changes in their bite or faces and relief from pain or discomfort. Please help us understand your problem by checking the following information. Please be specific (check (✓) the words *backward, less, shorter,* etc.).

Teeth: If your teeth could be changed, how would you like them to change?

☐ Straighten the front teeth	☐ upper	☐ lower
☐ Straighten the back teeth	☐ upper	☐ lower
☐ Make the upper teeth	☐ longer	☐ shorter
☐ Move upper teeth	☐ forward	☐ backward
☐ Move lower teeth	☐ forward	☐ backward

☐ Make the line of the upper front teeth more level
☐ Move the midline of the ☐ upper/ ☐ lower teeth to the ☐ left/ ☐ right
☐ Other..............................

Face: If your facial appearance could be changed, what would you change?

☐ Get rid of sag under lower jaw

☐ Move chin	☐ forward	☐ backward
☐ Move chin to center it	☐ left	☐ right
☐ Move lower lip	☐ forward	☐ backward
☐ Move upper lip	☐ forward	☐ backward
☐ Move the area around my nose	☐ forward	☐ backward
☐ Make the profile of my nose	☐ longer	☐ shorter
☐ Move the area under my eyes	☐ forward	☐ backward
☐ Make my cheekbones	☐ larger	☐ smaller

☐ Show ☐ more/ ☐ less of my ☐ teeth/ ☐ gums when I smile
☐ Make my lips ☐ closer together/ ☐ farther apart when my teeth are touching
☐ Make my lips not touch and roll out when my teeth are touching
☐ Make my face more ☐ narrow/ ☐ wide
☐ Reduce the ☐ width/ ☐ fullness of my lower jaw behind my mouth
☐ Other.................................

Symptoms: If you want to reduce pain or discomfort, where would it be located? Please be specific about the location; check the right side, left side, or both if they apply.

☐ In front of my ears	☐ right	☐ left
☐ Below my ears	☐ right	☐ left
☐ Above my ears	☐ right	☐ left
☐ In my ears	☐ right	☐ left
☐ Neck	☐ right	☐ left
☐ Shoulders	☐ right	☐ left
☐ Temples	☐ right	☐ left
☐ Eyes	☐ right	☐ left

☐ Teeth
☐ Sinuses
☐ Other...............................

Fig. 2.5 Patient in-depth motivation questionnaire. It may prove difficult to satisfy the treatment expectations for patients who write in many 'other' issues (©Arnett Facial Reconstruction Courses Inc. 2003).

MEDICAL HISTORY

A form for basic screening of the medical history is recommended (Fig. 2.6).

Basic medical information **Name** **Date**

Is the patient in good health?	Yes	No
If no, please explain:		
Does the patient have any history of major illness?	Yes	No
If yes, give details:		

If the patient has been treated or diagnosed with any of the following conditions, please check (✓):

Heart complications	Venereal disease
High blood pressure	AIDS
Lower blood pressure	HIV positive
Rheumatic fever	Blood transfusion
Arthritis/rheumatism	Hemophilia/prolonged bleeding
Kidney complications	Neurological disorders
Ulcers	Epilepsy or seizures
Diabetes	Fainting or dizzy spells
Thyroid problems	Nervous/anxious
Emphysema	Psychiatric/psychological care
Tuberculosis	Pneumonia
Asthma	Bone disorders
Latex sensitivity	Herpes/cold sores
Allergies	Anemia
Sinus trouble	Periodontal disease
Cancer	Endocrine problems
Hepatitis A (infectious)	Liver involvement
Hepatitis B (serum)	Hypoglycemia

Does the patient have a tendency to:

Colds?	Yes	No
Sore throats?	Yes	No
Ear infections?	Yes	No

Have tonsils and/or adenoids been removed?	Yes	No
If yes, at what age?		

List any drugs or medications now being taken, and give reasons:

List any allergies or drug sensitivity:

Fig. 2.6

For all surgical cases, and where indicated for other patients, the 'In-depth medical history and symptoms' form should be used (Fig. 2.7).

In-depth medical history and symptoms	**Name**	**Date**	
Are you currently under a doctor's care?		Yes	No
Doctor's name..	Last examination......................		
Have you had heart, blood vessel, lung, kidney or joint replacement surgery?		Yes	No
Have you been hospitalized in the last 2 years?		Yes	No
If yes, state why:			
Have you taken any medication in the last 6 months? (circle): High blood pressure/insulin/heart/tranquillizers/blood thinner/steroids/ aspirin/asthma/Parkinson's/diet medication/anti-depressants/other:			
Do you have any allergies? (circle): Drugs/aspirin/codeine/penicillin/Keflex/other:			
Do you smoke (pipe/cigar/cigarettes)?			
Packs per day:........	For how long have you smoked?		
Have you or any member of your family had a bad experience with a general or local anesthetic?		Yes	No
Women: are you or could you be pregnant?		Yes	No
Months:			
Do you use any recreational drugs?		Yes	No
Have you or anyone in your immediate family ever had tuberculosis?		Yes	No
Do you have a persistent cough lasting more than 2 weeks?		Yes	No
Have you been tested for tuberculosis in the last 3 years?		Yes	No
Have you been vaccinated for tuberculosis?		Yes	No
Have you been tested for HIV?		Yes	No
Have you been diagnosed with HIV or AIDS?		Yes	No
Do you have any of the following? (circle): Unexplained weight loss/weakness/fatigue/malaise/night chills/sweats/fever			
Have you had recent: (circle) Nasal discharge/sore throat/cough/cold		Yes	No
Do you have difficulty carrying out normal activities without shortness of breath or undue fatigue?		Yes	No
Do you rest after climbing one flight of stairs?		Yes	No
Do your ankles swell as the day progresses?		Yes	No
Have you awakened at night short of breath?		Yes	No
Must you remain in a sitting position in order to breathe comfortably?		Yes	No

Fig. 2.7 (©Arnett Facial Reconstruction Courses Inc. 2003).

In-depth medical history and symptoms (continued)

Do you use more than one pillow for comfort while sleeping?	Yes	No
Have you experienced chest pain with physical activity?	Yes	No
When you breathe, can you hear a wheezing sound?	Yes	No
Can you ever feel your heart beat, jump, flutter or seem irregular?	Yes	No
Have you ever taken Fen-Phen™ or Redux™?	Yes	No
Do you wish to speak privately with the doctor about anything?	Yes	No

Have you had any of the following? (please circle to indicate a 'yes' answer)

Alzheimer's	Diabetes	Liver disease
Anemia	Emphysema	Lung disease
Angina pectoris	Excessive bruising	Pneumonia
Arthritis	Glaucoma	Porphyria
Asthma	Glomerulonephritis	Rheumatic fever
Bleeding tendency	Heart attack	Scarlet fever
Blood disorder	Heart murmur	Seizure disorder
Cancer	Heart problem	Sinus problems
Chronic bronchitis	Hepatitis	Smokers' cough
Cold sores/fever blisters	Increased blood pressure	Stroke
Decreased blood pressure	Jaundice	Ulcer
Depressive disorder	Kidney disease	Venereal disease

Other.................................

Fig. 2.7 *Continued*

DENTAL AND ORTHODONTIC HISTORY

For patients presenting to the orthodontic practice for the first time, the 'Basic dental and TMJ history' form is used (Fig. 2.8). Additionally, if the patient is an orthodontic transfer case, the original records and treatment plan will need to be obtained in the normal way.

Basic dental and TMJ history	**Name**	**Date**
Have you ever had any injuries to the face, mouth or teeth?	Yes	No
Other information		
Thumb or finger sucking (past)	Yes	No
Thumb or finger sucking (present)	Yes	No
Mouth breathing	Yes	No
Nail/lip biting (present)	Yes	No
Grinding or clenching of teeth	Yes	No
Have you been informed of any missing or extra permanent teeth?	Yes	No
If yes, please specify:		
Do you have a history of head, neck, or jaw joint problems?	Yes	No
Have you ever been examined by an orthodontist?	Yes	No
If yes, when?		
Have you ever worn braces?	Yes	No
If yes, when?		

Fig. 2.8

When an orthodontic patient presents for surgical evaluation, the surgeon will use the 'In-depth orthodontic history' form (Fig. 2.9, below). Starting records and any progress records will need to be evaluated. Of greatest importance, the surgeon needs to evaluate the original models, to assess the orthodontic changes to arch forms, arch widths, and planes of occlusion. The surgeon will need to know the orthodontic tooth movements which have been carried out before surgical referral, because inappropriate unstable orthodontics can contribute to post-surgical relapse.

There is a need to know the reason for the patient's visit and what surgical procedures the patient is expecting. There are two reasons for this:

- There may be a difference between the surgeon's plan and the patient's expectations. In this situation the surgeon can explain the surgical rationale and thus keep the patient's confidence.
- The patient's expectation is normally derived from consultations and discussions with the orthodontist – again, the surgeon can explain any differences, and retain the patient's trust.

In-depth orthodontic history	Name	Date	
Have you worn braces in the past?		Yes	No
Are you currently wearing braces?		Yes	No
Are you planning to have braces fitted?		Yes	No
(If yes, braces will be placed in approximately ...... months)			
Have you had, or are any of the following planned?			
Extraction of upper teeth		Yes	No
Extraction of lower teeth		Yes	No
Elastics (rubber bands)		Yes	No
Roof of the mouth appliance		Yes	No
Headgear		Yes	No
Functional appliance		Yes	No

What is the reason for your visit?

Bite correction	☐	Facial pain treatment	☐
Facial esthetics	☐	Speech improvement	☐
Dental esthetics	☐	Obstructive sleep apnea	☐
TMJ treatment	☐	Cleft repair	☐
Other:			

What is your impression of the type of surgery needed?

Upper jaw	☐	Joint	☐
Lower jaw	☐	Sleep apnea	☐
Upper/lower jaws	☐	Cleft repair	☐
Cosmetic	☐	Other:	

Fig. 2.9 (©Arnett Facial Reconstruction Courses Inc. 2003).

HEAD, NECK AND TMJ HISTORY

All patients seeking treatment from orthodontists or oral surgeons should be screened for TMJ problems. Thus, the 'Basic dental and TMJ history' form (Fig. 2.8, p. 39) for such patients includes a screening question on head, neck and TMJ pain or dysfunction. For the more complex cases, or where there is a previous history of TMJ problems, the 'In-depth head, neck and TMJ symptoms' form should be used, and this is shown in full in Figure 2.10 below. The form includes questions on obstructive sleep apnea which are relevant to this area. One of the purposes of the TMJ history forms is to reveal local or total condylar remodeling (p. 143) in the 'joint change symptoms' section.

In-depth head, neck and TMJ symptoms	**Name**	**Date**	
Disc symptoms			
Have you heard popping sounds in your ear(s)?		Right	Left
Has the popping stopped?		Right	Left
Has the size of your jaw opening decreased?		Right	Left
Do you hear clicking sounds in your ear(s)?		Right	Left
Do you hear grinding sounds in your ear(s)?		Right	Left
Do you have pain in your ear(s)?		Right	Left
Muscle symptoms			
Is your jaw opening limited?		Yes	No
Is your opening limitation most in the morning?		Yes	No
Do you wake up with facial pain?		Yes	No
Do you have pain below your ear(s)?		Yes	No
Do you have pain in your temple?		Yes	No
Do you clench or grind your teeth?		Yes	No
Do you have lower neck aches or backaches?		Yes	No
Are you in an emotional or stressful period of your life?		Yes	No
Joint change symptoms			
Has your bite changed?		Yes	No
Has your chin moved backwards?		Yes	No
Do your teeth hit unevenly?		Yes	No
Have you had jaw surgery or orthodontic treatment?		Yes	No
Do you clench or grind your teeth?		Yes	No
Have you heard popping sounds in your ear(s)?		Yes	No
Have you had an injury to your face, head, neck or jaw?		Yes	No
Are you female?		Yes	No
Are you between 12 and 17 years old?		Yes	No
Are any of your arms, legs, feet, hands or finger joints painful, swollen or stiff?		Yes	No
Do you have, or have you had, hyperparathyroidism?		Yes	No

Fig. 2.10 (©Arnett Facial Reconstruction Courses Inc. 2003).

In-depth head, neck and TMJ symptoms - continued

Chronology

When did you first notice the above symptoms?	Date	
Have the above symptoms worsened over time?	Yes	No
Do you attribute the symptoms to one incident?	Yes	No

Please explain:

How do you control your head and neck symptoms?

Cold/heat packs	Physical therapy	Diet change
Anti-inflammatory	Pain medication	Limited jaw movement
Injections		
Other:		

Have you had treatment for your head and neck symptoms?

TMJ specialist	Pain clinic	General dentist
Oral surgeon	Orthodontist	Splint
ENT	Neurologist	Jaw surgery
TMJ surgery	Occlusal reconstruction	Equilibration
Physical therapy		
Other:		

Where is your pain?

Please mark on the drawing below the area(s) where you feel pain.

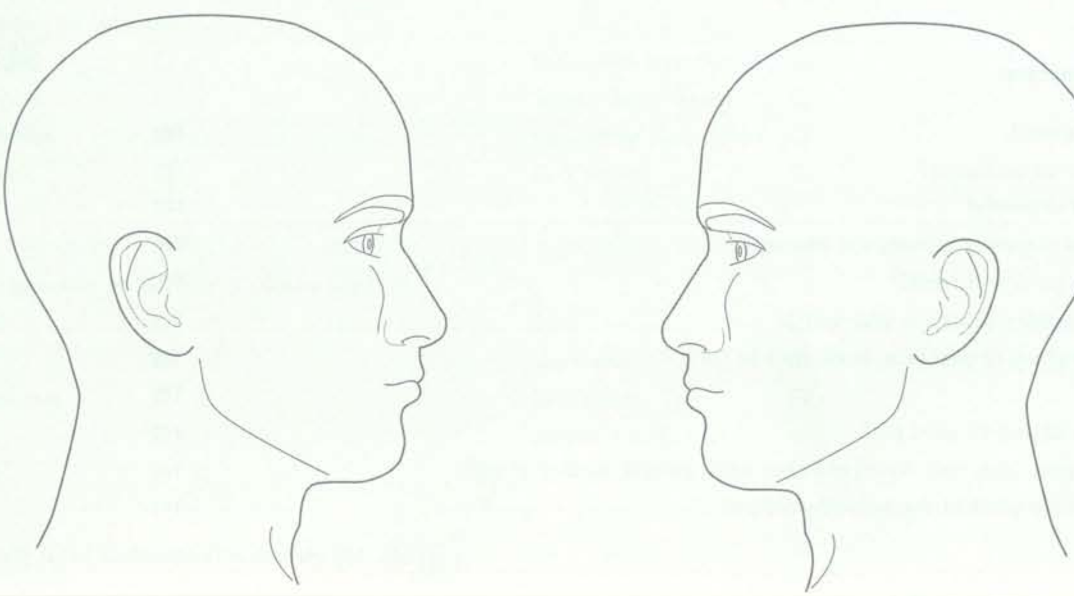


Fig. 2.10 *Continued*

In-depth head, neck and TMJ symptoms - continued

Where is your pain?
Please mark on the drawing below the area(s) where you feel pain.

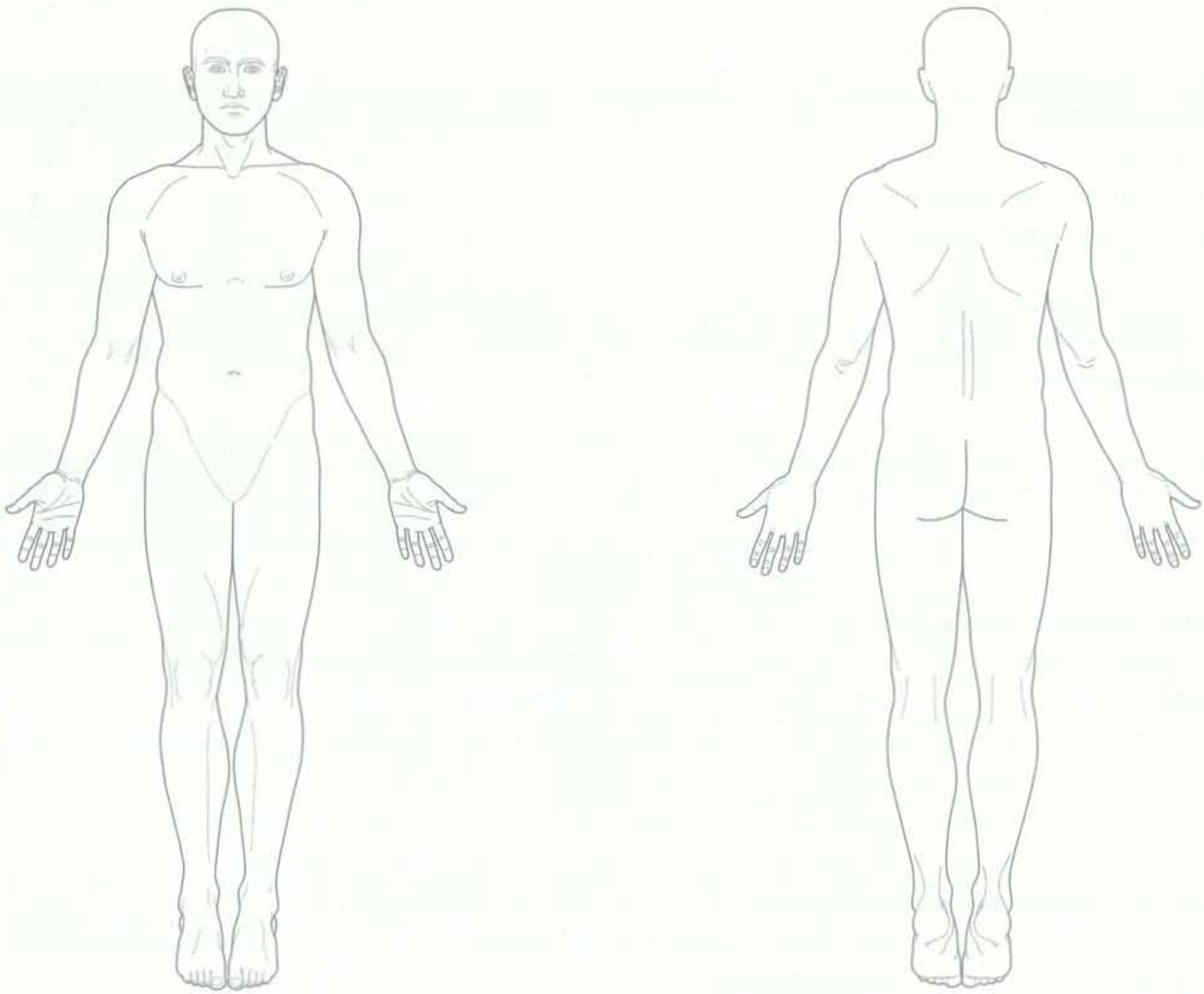


Fig. 2.10 *Continued*

In-depth head, neck and TMJ symptoms - continued

Please complete the following:

Obstructive sleep apnea symptoms

Do you fall asleep during the day?	Yes	No
Have you fallen asleep while driving?	Yes	No
Do you have disrupted sleep?	Yes	No
Do you urinate frequently during the night?	Yes	No
Do you snore heavily at night?	Yes	No
Do you talk in your sleep?	Yes	No
Do you suffer from daytime fatigue?	Yes	No
Do you experience daytime sleepiness?	Yes	No
Have you had a recent weight gain?	Yes	No
Do you have high blood pressure?	Yes	No
Do you take blood pressure medication?	Yes	No
Do you have an irregular heartbeat?	Yes	No
Do you suffer from depression?	Yes	No
Do you have headaches when you wake up?	Yes	No
Does your spouse see you stop breathing during sleep?	Yes	No
Do you drink alcoholic beverages?	Yes	No
Do you take sedative-type medicine?	Yes	No

How do you control your sleep apnea?

Restrict alcoholic beverages		Restrict sedative medication
Sleep upright	Sleep on side	Sleep on back
Sleep with special pillow positions		Other:

Have you had treatment for sleep apnea?

Weight loss	CPAP (continuous positive airway pressure)
Dental appliance	Soft palate surgery
Nasal surgery	Other:

Fig. 2.10 *Continued*

PRE-SURGICAL GROWTH ASSESSMENT

Future growth potential is an important factor in the G2/G3 decision because these groups have malocclusion severity secondary to disproportionate growth. Orthodontic growth assessment normally involves predictions using the patient's age, sex, and skeletal pattern, and can also be derived from measurement of serial cephalometric radiographs.

Careful growth assessment is also needed before surgery, in order to avoid relapse due to post-surgical growth (Case TW, p. 87). This assessment is based on family history and serial cephalometric radiographs, if available (Fig. 2.11).

Growth assessment **Name** **Date**

Family growth history

At what age did members of the patient's family stop growing?

Father .... Mother ...... Brothers ...... Sisters ......

Has the patient's height stopped increasing?	Yes	No
How many inches has the patient grown in the past year?		
Does the patient have relatives with the same facial pattern?	Yes	No

Please circle:	father	mother	brother	sister
	grandfather	grandmother	aunt	uncle

Serial headfilm information (for completion by the orthodontist/surgeon)

Has facial growth occurred in the past 12 months?	Yes	No
Has the occlusal problem worsened in the past 12 months?	Yes	No
Upper incisors relative to lowers?	Yes	No
Skeletal 'A' point relative to 'B' point?	Yes	No
Have orthodontic appliances been worn in the past 12 months?	Yes	No

Fig. 2.11 (©Arnett Facial Reconstruction Courses Inc. 2003).

CONSULTATION

This chapter has recommended the extensive use of forms. These allow a systemized approach to history taking, and ensure that all the important questions are covered.

The orthodontist will mainly use the 'Basic' series of forms to obtain patient information, medical history, and dental/TMJ history. For certain more difficult orthodontic cases, forms from the 'In-depth' group will be needed.

The surgeon's working arena is very different from that of the orthodontist. Almost all the cases presenting to the surgeon will have complex or difficult aspects. Accordingly, the surgeon will rely heavily on the 'In-depth' range of forms.

However, the subsequent personal consultation between the clinician and the patient is all-important. The forms are used to prepare the ground for the patient examination and consultation (Ch. 3), and they indicate areas where there is a need for further information. Used by orthodontists and surgeons, the forms indicate where there will be a need for the clinician to focus energy in managing a particular case, and where the key problems lie.

These key issues can then be discussed with the patient in a calm and unhurried manner (Fig. 2.12). During the consultation the clinician has the opportunity to more fully understand the patient's wishes and treatment needs, and so the professional relationship begins to develop.

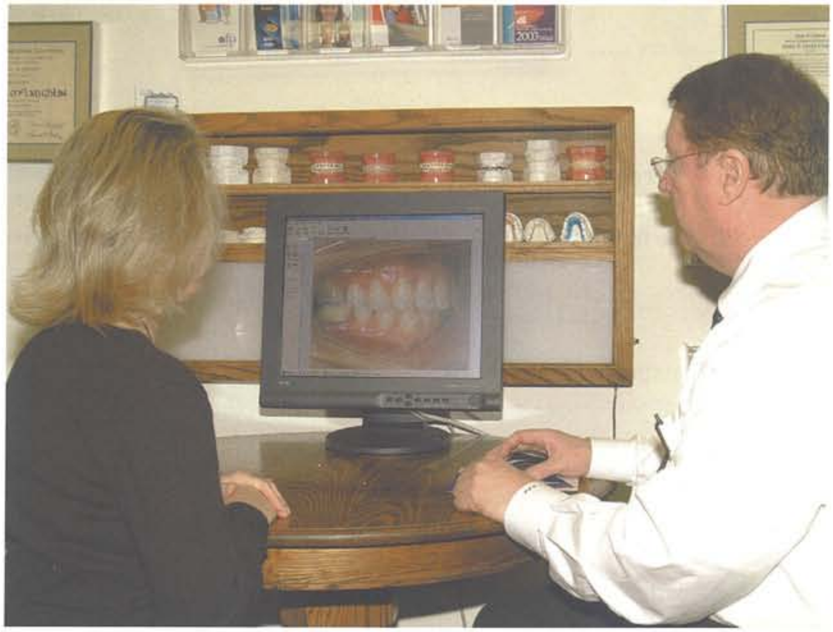


Fig. 2.12 The forms are used to prepare the ground for the patient examination and consultation.

REFERENCE

1 Arnett G W, Macdonald Worley C 1999 The treatment motivation survey: defining patient motivation for treatment. American Journal of Orthodontics and Dentofacial Orthopedics 115:233–238

3 The clinical examination

INTRODUCTION

After reviewing the information provided by the patient (Ch. 2), the clinician will have a good understanding of the patient's concerns and his or her reasons for presenting for evaluation. While keeping this information in mind, the four-part clinical examination can be commenced (Fig. 3.1). Later, the findings will form part of the information needed to analyze the case (Ch. 5). Two views are used during the facial examination[1] – a frontal view and a profile view.

It is helpful for orthodontists and surgeons to adopt a systemized approach to the clinical examination. It can also be an advantage if the orthodontist and surgeon adopt the same system and summary forms. The facial examination method used by the authors (p. 74) has been developed over many years, and it is recommended for all group 2 and group 3 cases. Clinicians will individually decide whether a full facial examination is necessary for group 1 orthodontic cases.

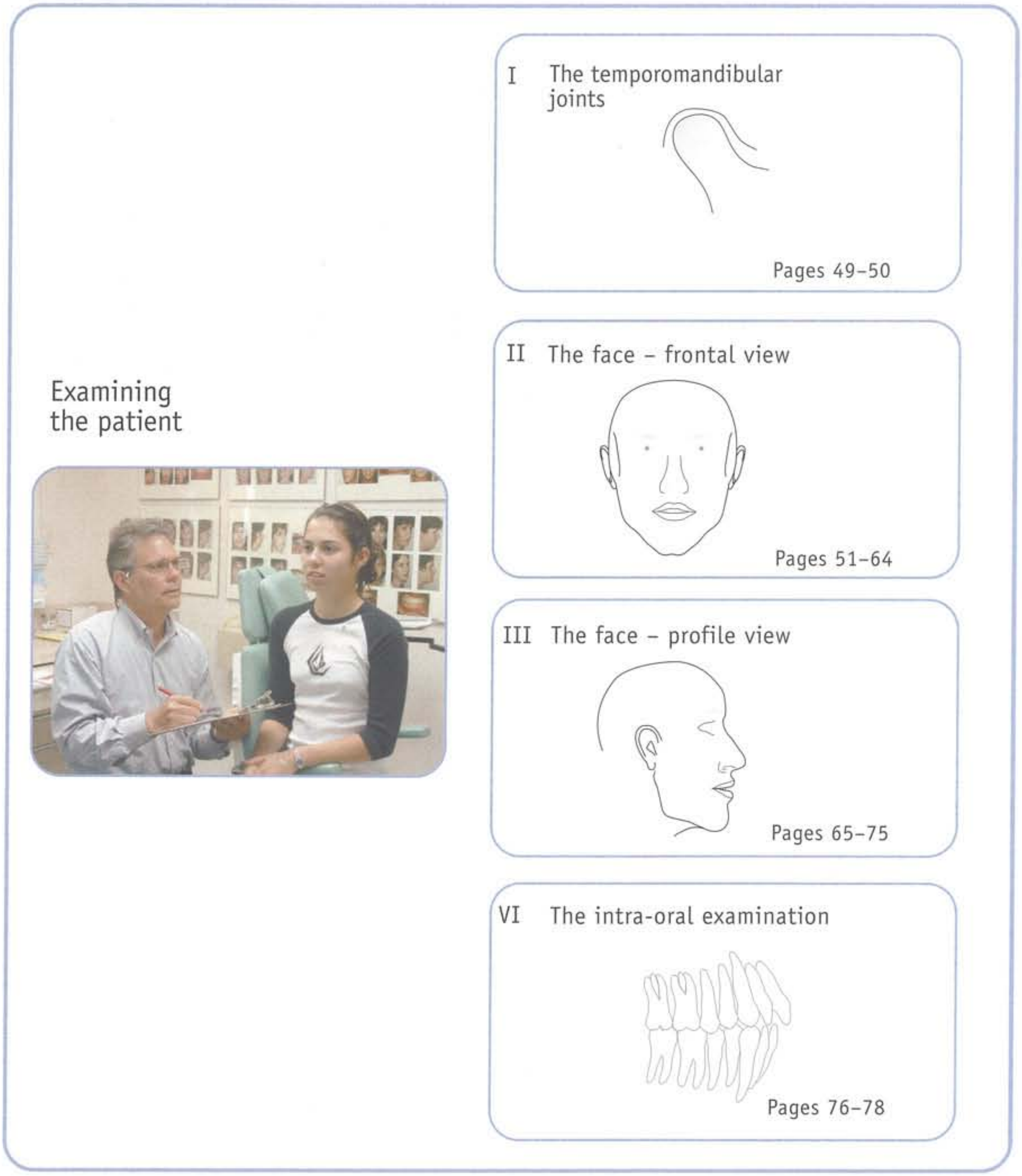


Fig. 3.1 The four aspects of the patient examination.

1. THE TMJ EXAMINATION

It is essential to review the patient's history before the clinical TMJ examination, because the patient can frequently provide valuable insights into problems in this area. A screening TMJ examination is then indicated for all patients, whether they do or do not describe symptoms.

Two palpation positions are used (Figs 3.2 & 3.3) during four mandibular movements, and these provide information concerning the following:

- The range of movement[2]
- Deviation from normal movements
- Any pain during movement
- The joint sounds.

The patient can be taken through opening, left and right lateral, and protrusive movements during bilateral external palpation directly over the joints. This is followed by repetition of these movements and gentle forward palpation in the ear canal with the small fingers.

Fig. 3.2

Fig. 3.3

Figs 3.2 and **3.3** Two palpation positions are used during four mandibular movements. These provide information concerning direction and range of movements, presence of pain during movement, and joint sounds.

Next, muscle palpation is carried out in the head and neck area to reveal the location of any muscle pain. Muscle pain generally indicates the presence of parafunctional habits. Information gathered during these evaluations can be placed in the chart shown in Figure 3.4.

Also, when symptoms exist it is helpful to evaluate general body posture and the range of neck movements. The general body posture can be evaluated by observing the patient frontally and laterally in a standing position. Any body asymmetry can be noted in the frontal plane, and the head posture can be reviewed in the lateral plane. Range of neck movements and specific areas of neck pain can be noted by carefully taking the patient through side bending, rotational, and backward and forward bending movements of the head and neck.

Range of movement, with normals shown in parentheses

Vertical	mm (40–50)	Deviated opening	mm	Right	Left
Right lateral	mm (9–12)	Left lateral	mm (9–12)	Protrusive	mm (9–12)

Left TMJ sound:	☐ pop	☐ click	☐ multiple clicks	☐ crepitation
Left TMJ pain:	☐ opening	☐ palpation	☐ biting	☐ other
Left muscle pain:	☐ masseter	☐ temporalis	☐ medial pterygoid	☐ neck
Right TMJ sound:	☐ pop	☐ click	☐ multiple clicks	☐ crepitation
Right TMJ pain:	☐ opening	☐ palpation	☐ biting	☐ other
Right muscle pain:	☐ masseter	☐ temporalis	☐ medial pterygoid	☐ neck

Fig. 3.4 Clinical examination of the TMJs. Normal ranges in parentheses.

2. THE CLINICAL FACIAL EXAMINATION – FRONTAL VIEW

Natural head position, centric relation, first tooth contact, and relaxed lip position are necessary to accurately assess the face. The patient is therefore examined with a wax bite (pp. 97, 100) in place to meet these requirements.

The frontal view provides information on the vertical dimensions, midlines, facial levels, and outline of the face. Forms can be used for recording the findings (pp. 64, 74), and this information is then used to determine the diagnosis (Ch. 5) and the treatment plan (Ch. 7) for the patient.

It should be noted that this has to be a three-dimensional clinical examination, leading to a thorough three-dimensional diagnosis and treatment plan. Photographs alone are not adequate, due to the variations in mandibular position, head posture, and lip posture which can be produced using only two-dimensional photographs.

General outline form

The general outline form of the face can be described in artistic terms such as 'wide' or 'narrow', 'short' or 'long', or 'round'.

Several key outline landmarks are examined and described as 'wide', 'normal', or 'narrow' – these include the zygomatic arch, mandibular angle, mandibular body, and chin. Each landmark is then examined for equality of the left and right sides – if one side is larger this is noted.

Alternatively, the outline form can be measured. The widest dimension of the face is the zygomatic width. The bigonial width is approximately 30% less than the zygomatic dimension.

Midline assessments – establishing the midline of the face

Midline structures are assessed with the condyles centered in the fossae and at first tooth contact (p. 98). If the condyles are not centered, correct midline assessment is not possible.

The authors establish the midline of the face by using a line through the philtrum of the upper lip and the center of the nasal bridge. The center of the nasal bridge is assessed as half the distance between the inner canthi of the eyes (Fig. 3.5).

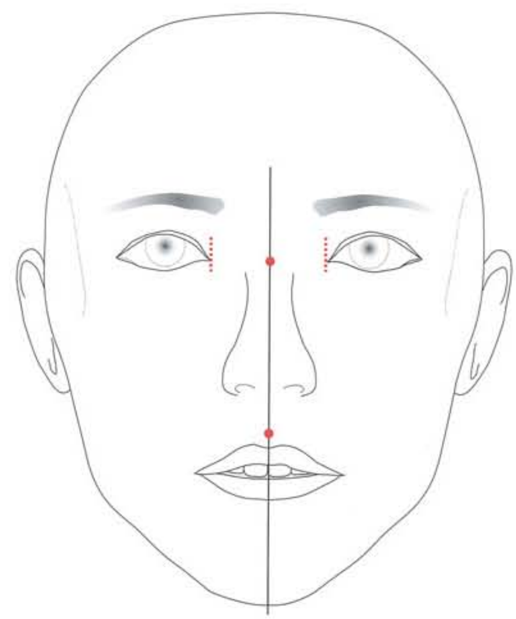


Fig. 3.5 The midline of the face may be determined by using a line through the philtrum of the upper lip and the center of the nasal bridge.

Important soft tissue midline structures, such as nasal tip and chin point, are assessed using the midline of the face. Dentally, upper and lower incisor midlines should also be assessed relative to this line (Fig. 3.6).

It is especially important for orthodontists and surgeons to accurately assess the dental midlines, relative to the philtrum, because most patients use this as a reference point to evaluate their dental midlines after orthodontics and/or surgery. Interestingly, patients often have high awareness levels about dental midlines, and will be quick to point out any discrepancies. Dental midlines cannot be assessed from models alone, and therefore must be evaluated during the clinical facial examination.

The midline of the face – the reliability of the philtrum

The philtrum is usually the most symmetrical of the midline soft tissue points, and is therefore generally used as a starting point for assessment of midline structures. If the nasal tip is severely deviated, the philtrum tends to deviate slightly towards the nasal deviation. If this occurs, an adjustment can be made to create a line which more accurately represents the midline of the face for that individual. This is seldom necessary.

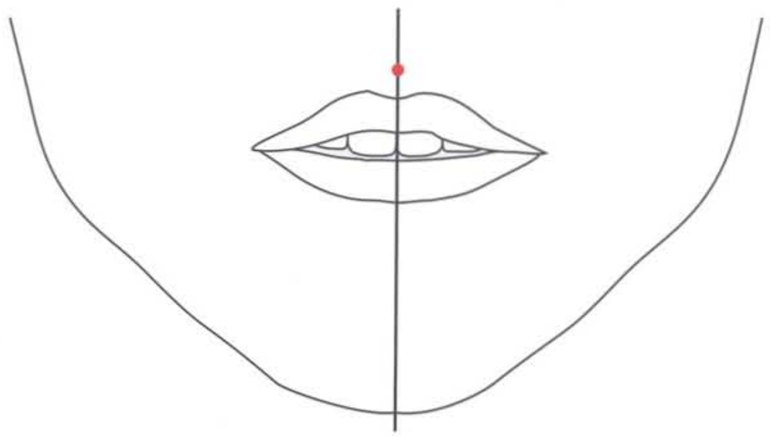


Fig. 3.6 Dentally, upper and lower incisor midlines should also be assessed relative to the midline of the face.

Horizontal reference lines

Horizontal reference lines may be drawn at 90° to the facial midline, and may be used to assess the level of other structures. Upper canines, lower canines, the inferior border of the mandible, and the chin should all be parallel to horizontal reference lines (Fig. 3.7).

The 'upper occlusal level' is assessed using a line formed through the left and right upper canine tips. The 'lower occlusal level' is assessed using a line formed through the left and right lower canine tips. The 'chin–jaw line' is assessed by a line drawn on the under surface of the chin at maximum tissue contact. The lines should be parallel to each other. Lines which are not parallel with the horizontal reference lines are described as 'cants'.

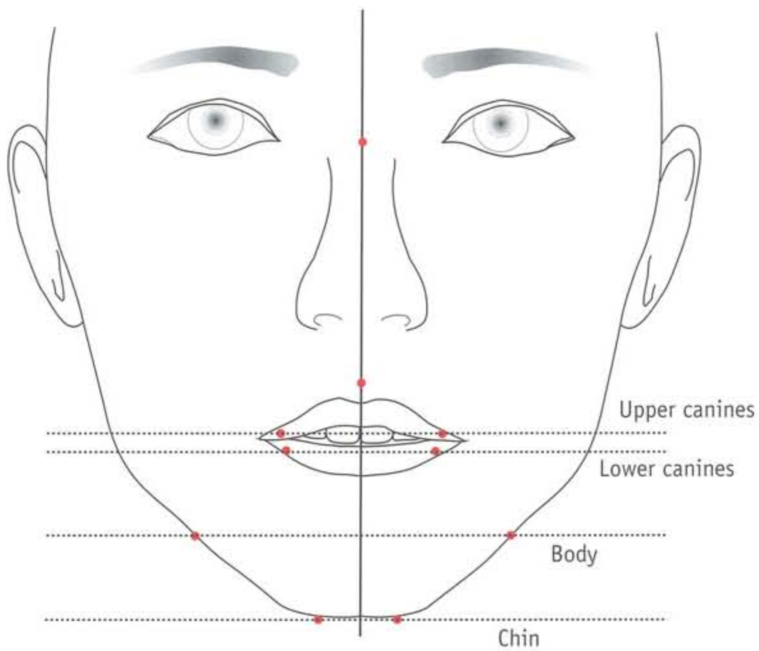


Fig. 3.7 Horizontal reference lines may be used to assess other structures. The 'upper occlusal level' is assessed using a line formed through the left and right upper canine tips. The 'lower occlusal level' is assessed using a line formed through the left and right lower canine tips. The 'chin–jaw line' is assessed by a line drawn on the under surface of the chin at maximum tissue contact. The lines should be parallel to each other. Lines which are not parallel with the horizontal reference line are described as 'cants'.

Mandibular deviations and occlusal cants

Mandibular deviations commonly have upper and lower occlusal cants with an associated chin and jaw line cant (Fig. 3.8). Any cants should be noted, as this information will be required for treatment planning.

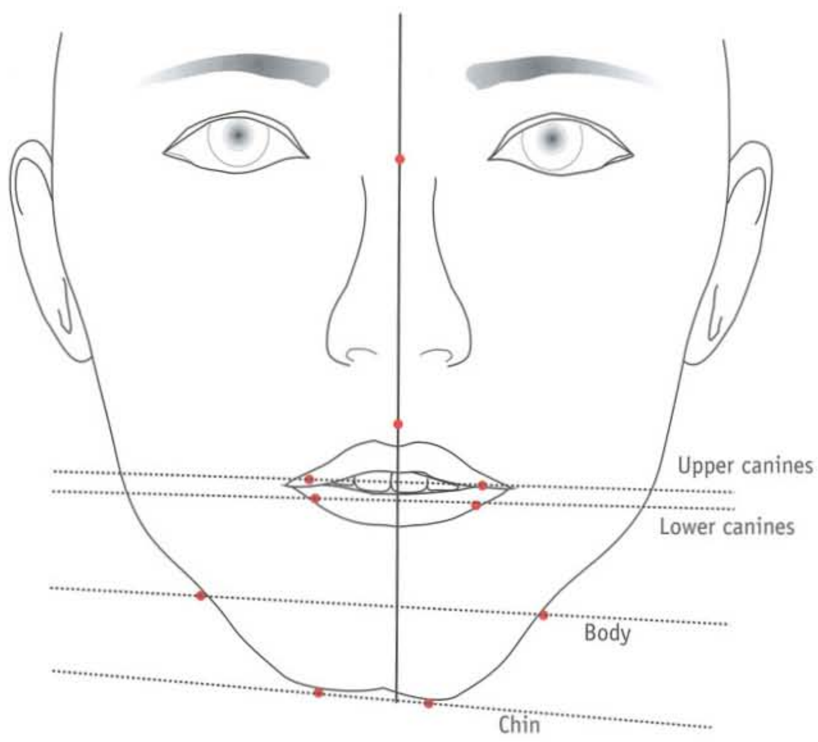


Fig. 3.8 A mandibular deviation to the right, with associated cants of the occlusal planes and the chin–jaw line. Later, if the treatment plan includes two-jaw surgery, the cants are routinely corrected at surgery. If the treatment plan includes only orthodontics or one-jaw surgery, it is normally not possible to achieve correction of cants.

Vertical assessment – the facial thirds

For examination purposes the face is divided into thirds. The middle third is the mid brow to subnasale, and the lower third is subnasale to soft tissue menton (Fig. 3.9). The middle third and the lower third of the face show a range of 62–75 mm. Contrary to popular notion, the middle and lower thirds are rarely equal. The ratio of middle to lower thirds is less important than vertical relationships among structures within the lower third of the face.

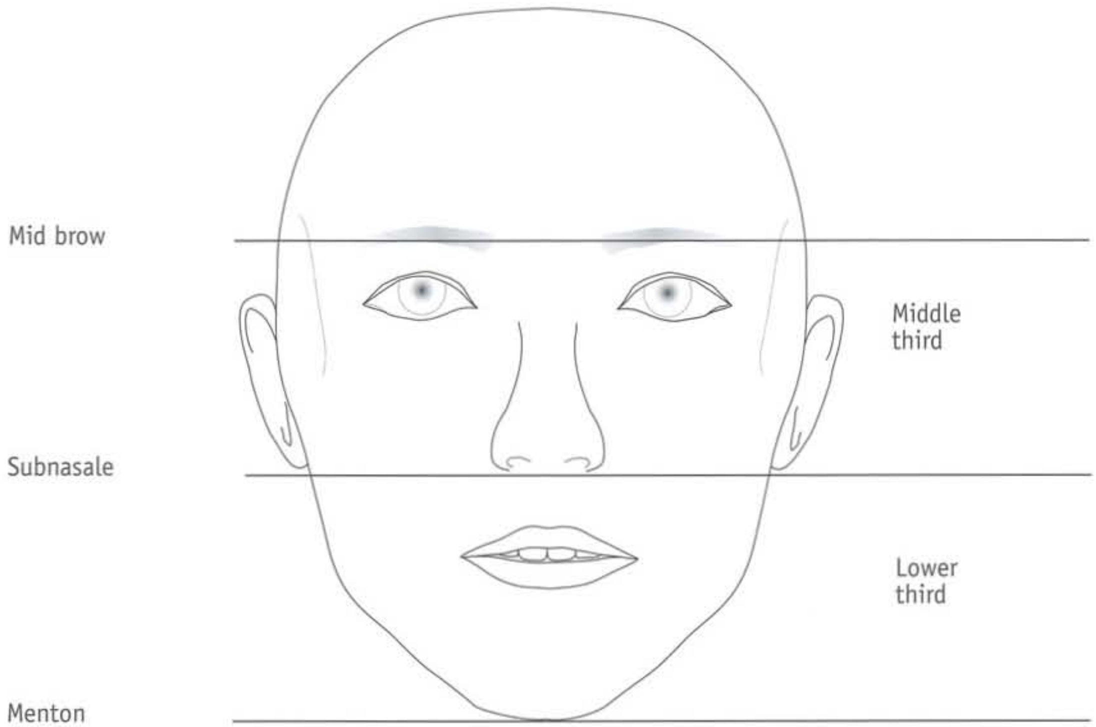


Fig. 3.9 The face may be divided into middle and lower thirds by drawing horizontal lines through the mid brow, subnasale, and soft tissue menton. The middle and lower thirds are rarely equal.

Vertical assessment of the lower third of the face

The lower third of the face is measured from subnasale to soft tissue menton. It is equal to the sum of the upper lip, inter-labial gap, and lower lip (Fig. 3.10).

This area of facial analysis is extremely important in diagnosis and treatment planning of dentofacial deformities. The need for relaxed lips (pp. 94, 106) when making these measurements cannot be overemphasized. The decision between surgical/orthodontic correction, or 'orthodontics only' correction, often depends on the analysis of the lower third of the face.

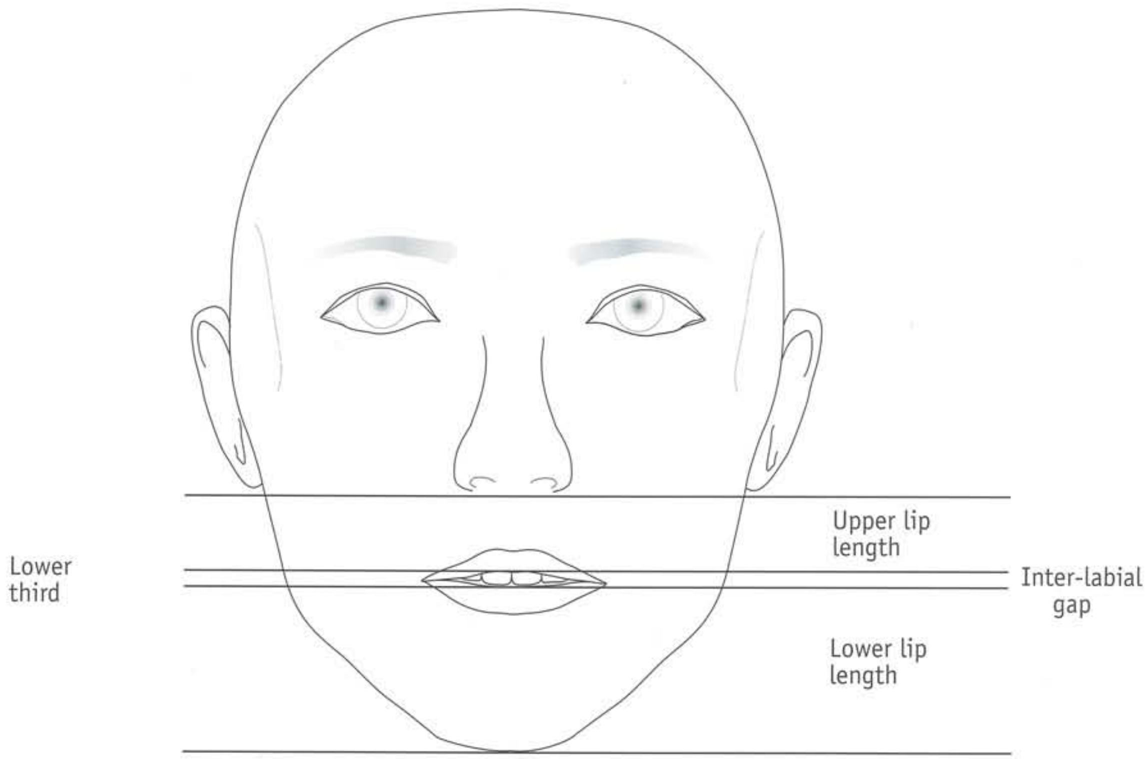


Fig. 3.10 The lower third of the face is equal to the sum of the upper lip length, the inter-labial gap, and the lower lip length.

Upper lip length

The lips are measured independently in a relaxed position (Fig. 3.11). The normal length from subnasale to upper lip inferior is 19–22 mm. Older individuals and males are in the longer end of the range.

Inter-labial gap

With the lips relaxed and teeth in contact, a space of 1–5 mm between upper lip inferior and lower lip superior is normally present (Fig. 3.11). Females show a larger gap within the normal range. The decreased male inter-labial gap is related to longer lips.

Lower lip length

The lower lip (Fig. 3.11) is measured from lower lip superior to soft tissue menton, and normally measures in a range of 42–48 mm. This measurement increases with age as submental fat begins to accumulate. The normal ratio of upper to lower lip is 1:2.2. Proportionate lips harmonize, regardless of length.

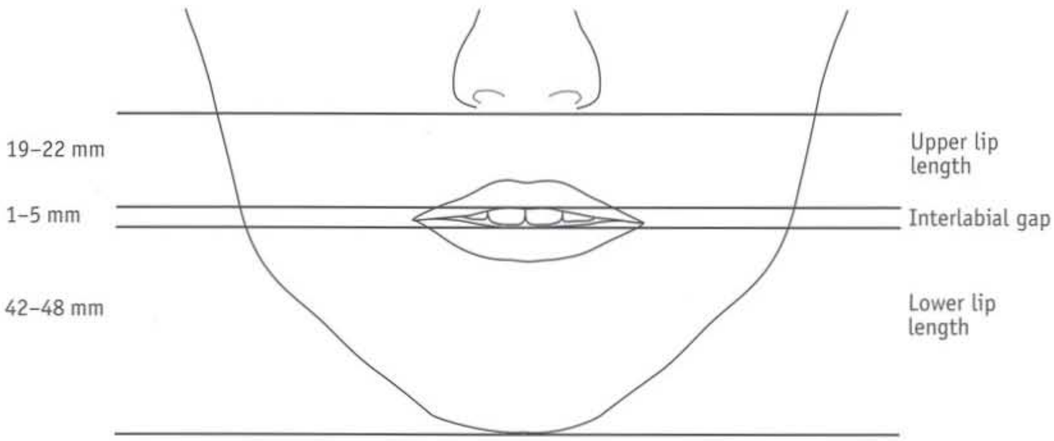


Fig. 3.11 With lips relaxed, the lower third of the face is subdivided by drawing lines through subnasale, upper lip inferior, lower lip superior, and soft tissue menton. The upper lip is normally slightly less than half the length of the lower.

Upper incisor crown length and dental overbite

The normal maxillary central incisor crown length is 9.5–11.5 mm. The amount of vertical overlap (overbite) of the upper incisors relative to the lower incisors is recorded. The normal amount of overbite is 3 mm (Fig. 3.12).

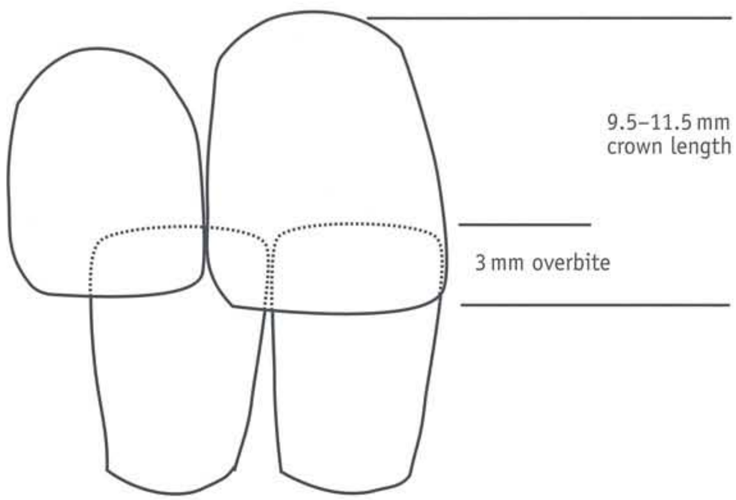
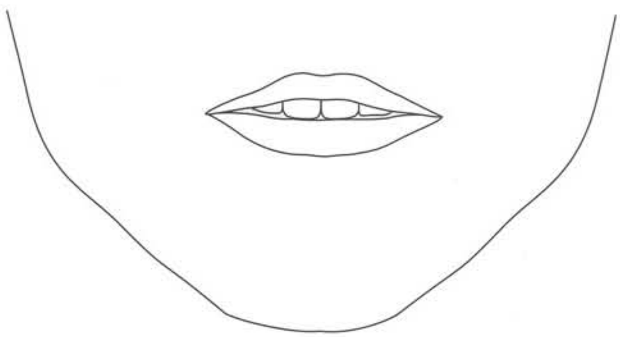


Fig. 3.12 The normal overbite is 3 mm.

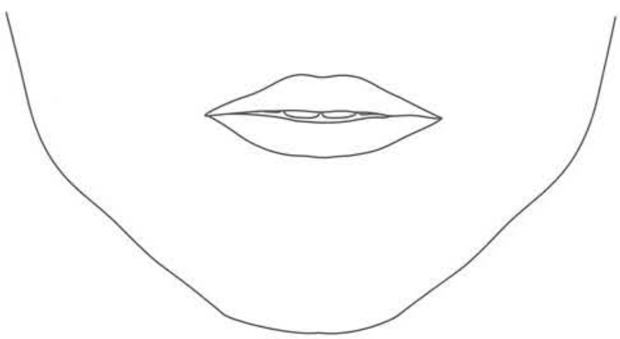
Upper incisor exposure – lips at rest

The vertical distance from upper lip inferior (with the upper lip at rest) to the upper incisor edge is measured to record the 'maxillary incisor exposure' (Fig. 3.13). The normal range is 1–5 mm. Facial rejuvenation is best achieved when there is 3–5 mm of exposure. Males show less incisor exposure than females because of their characteristically longer upper lips.

Upper incisor exposure (with lips relaxed) is the key measurement when planning surgical vertical changes, aiming for a range of 3–5 mm post-surgically. Because of the critical nature of the relaxed lip measurement on vertical planning, this measurement should be taken three times to verify accuracy. Orthodontically, there is less capability to change upper incisor exposure by vertical tooth movement. However, normal values should be considered when deciding surgical versus orthodontic treatment planning.



5 mm upper incisor exposure



1 mm upper incisor exposure

Fig. 3.13 Upper incisor exposure is important. It is measured with lips relaxed, from upper lip inferior to maxillary incisor edge. The normal range is 1–5 mm. Males show less than females on average. Young individuals show more incisor than older individuals – facial rejuvenation places the incisor into the youthful range of 3–5 mm of incisor exposure.

Exposure of upper incisor and gingival tissue when smiling

When examining the smile, different lip elevations are observed in normal and abnormal skeletal patterns. Ideally, when smiling, the exposure should be in the range of three-quarters of the central incisor crown length (about 8 mm) to 2 mm of gingival tissue (Figs 3.14 & 3.15). Males show less incisor exposure than females because of their characteristically longer upper lips.

Because of the critical nature of the smile measurement on vertical planning, this measurement should be taken three times to verify accuracy. Additionally, an attempt should be made to observe the patient's smile when the patient is unaware that the clinician is doing so – a natural, non-requested smile. As important as the smile is, it only adds supplemental information to vertical treatment planning. Achieving 3–5 mm of relaxed lip incisor exposure is the goal. The 'smile' exposure influences the 3–5 mm relaxed exposure but does not alter this range.

Fig. 3.14

Fig. 3.15

Figs 3.14 and **3.15** Ideally, when smiling, the exposure should be in the range of three-quarters of the central incisor crown length (about 8 mm) to 2 mm of gingival tissue.

Closed lip position

As discussed above, an understanding of relaxed lip position is essential. However, knowledge of the closed lip position is also helpful, and can add support to diagnostic decisions. The closed lip position reveals disharmony between skeletal and soft tissue lengths. With balanced lip and skeletal lengths, the lips should ideally close from a relaxed, separated position without lip, mentalis, or alar base strain (Figs 3.16 & 3.17).

Fig. 3.16

Fig. 3.17

Figs 3.16 and **3.17** With balanced lip and skeletal lengths, the lips should ideally close from a relaxed, separated position without lip, mentalis, or alar base strain.

Upper and lower vermilion borders

The normal lengths for the upper and lower vermilion borders of the lips are 6–9 mm for the upper lip and 8–12 mm for the lower lip (Figs 3.18 & 3.19). Normal vermilion balance is achieved when the upper vermilion length is 2–3mm less than the lower vermilion length.

Fig. 3.18

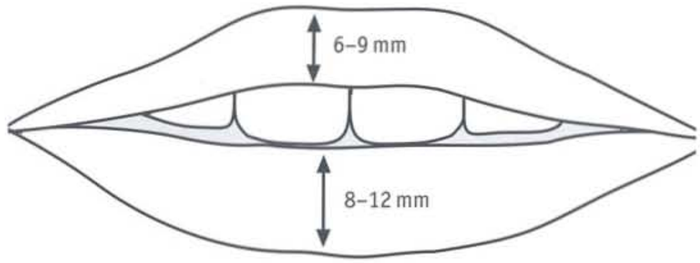


Fig. 3.19

Figs 3.18 and **3.19** Vermilion borders.

Summary charts – the frontal facial examination (Figs 3.20–3.23 – Dr G. William Arnett)

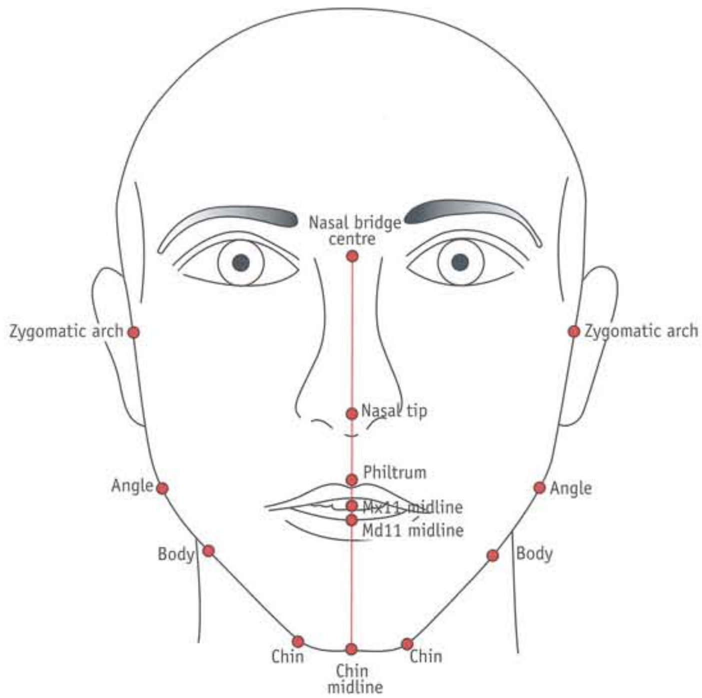


Fig. 3.20

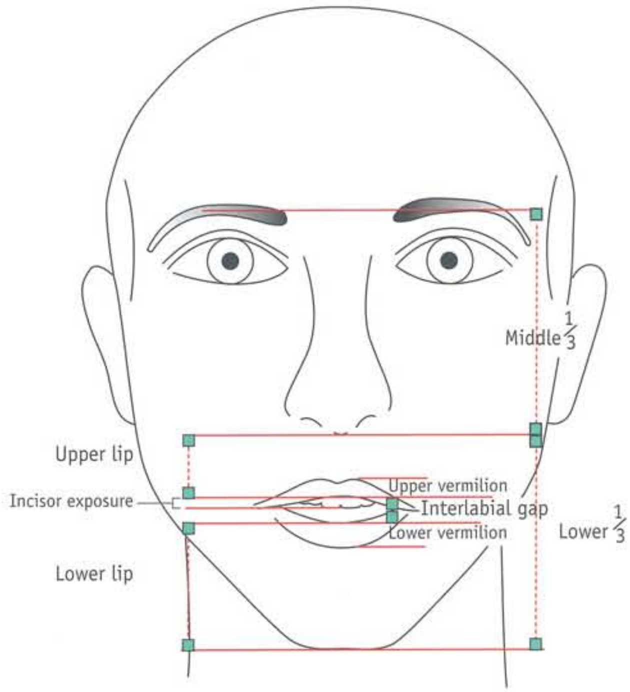


Fig. 3.21

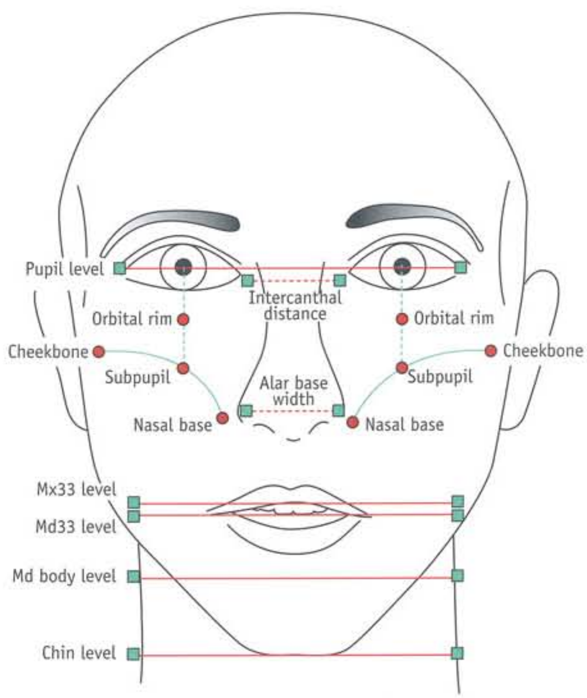


Fig. 3.22

Summary charts – the frontal facial examination (Figs 3.20–3.23 – Dr G. William Arnett)

1. Vertical	Range	Patient
Middle 1/3	62-75mm	
Overbite	3 mm	
Upper lip height (a)	19–22 mm	
Interlabial gap (b)	1–5 mm	
Lower lip height (c)	42–48 mm	
Lower 1/3 height	62–75 mm	a+b+c
Mx incisor exposure (relaxed)	1–5 mm	
Mx incisor exposure (smile)	8 crown to 2 gingiva	
Closed lip	gentle touching without strain	strain redundancy
Mx incisor height	9.5–11.5 mm	
Upper vermilion	6–9 mm	
Lower vermilion	8–12 mm	

Measurements of important factors.

3. Midlines	Patient		
Nasal tip	to right		to left
Philtrum	to right		to left
Mx11	to right		to left
Md11	to right		to left
Chin	to right		to left

4. Facial levels	Patient					
Eyes	R down		L down	Visualize cant	Y	N
Mx canines	R down		L down	Visualize cant	Y	N
Md canines	R down		L down	Visualize cant	Y	N
Md body level	R down		L down	Visualize cant	Y	N
Chin level	R down		L down	Visualize cant	Y	N

5. Outline	Patient									
General	round	wide	narrow	long	short	normal				
Zygomatic	R	larger	wide	*normal*	narrow	narrow	*normal*	wide	larger	L
Md angle	R	larger	wide	*normal*	narrow	narrow	*normal*	wide	larger	L
Md body	R	larger	wide	*normal*	narrow	narrow	*normal*	wide	larger	L
Chin	narrow	wide	waist			flat			angular	
Alar base width	alar base width _____ mm					intercanthal width _____ mm				

Fig. 3.23 Frontal view summary.

3. THE CLINICAL FACIAL EXAMINATION – PROFILE VIEW

The patient's profile should be evaluated clinically in natural head position, centric relation, first tooth contact and with relaxed lips (pp. 94, 104). The patient is examined with a wax bite (p. 97) in place, to meet these requirements. The face can be divided into three parts for the profile examination – the *high midface*, the *maxillary area*, and the *mandibular area* (Fig. 3.24).

Each area will be discussed in detail in the following pages. The normals here and in Chapter 5 apply to Caucasians.[3] Different normals are appropriate for patients of different ethnicity.

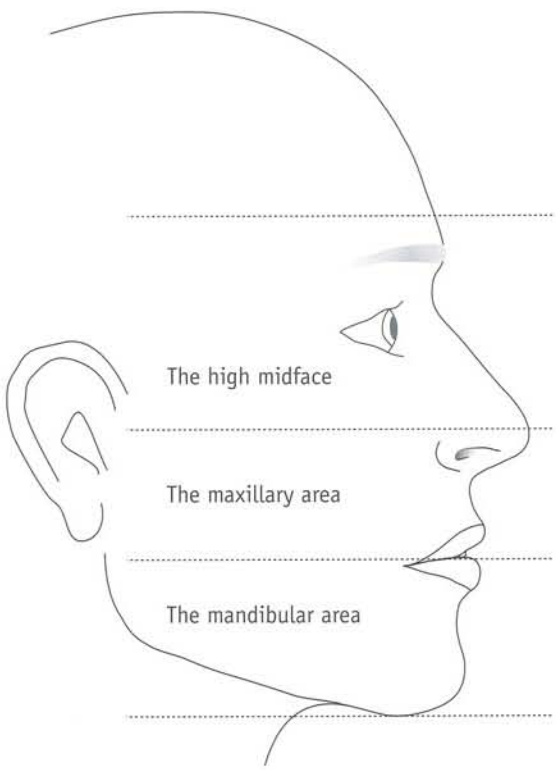


Fig. 3.24 Three areas of the profile may be examined clinically, and each of these will be discussed in detail in the following pages.

Clinical examination of the high midface profile

Four soft tissue areas of the high midface profile can be evaluated (Fig. 3.25). The *glabella*, the *orbital rim*, the *cheekbone contour*, and the *subpupil area* can be graded as 'flat', 'normal' or 'prominent'. When examining the high midface a sheet of paper should be used to hide any structures below the subpupil. This allows examination of the high midface structures without influence from nasal projection and chin projection, which can alter the perception of the high midface structures. The patient is examined from the right side first. After right profile examination the patient should be viewed from the front, to check that the left and right sides of the face are equal in size.

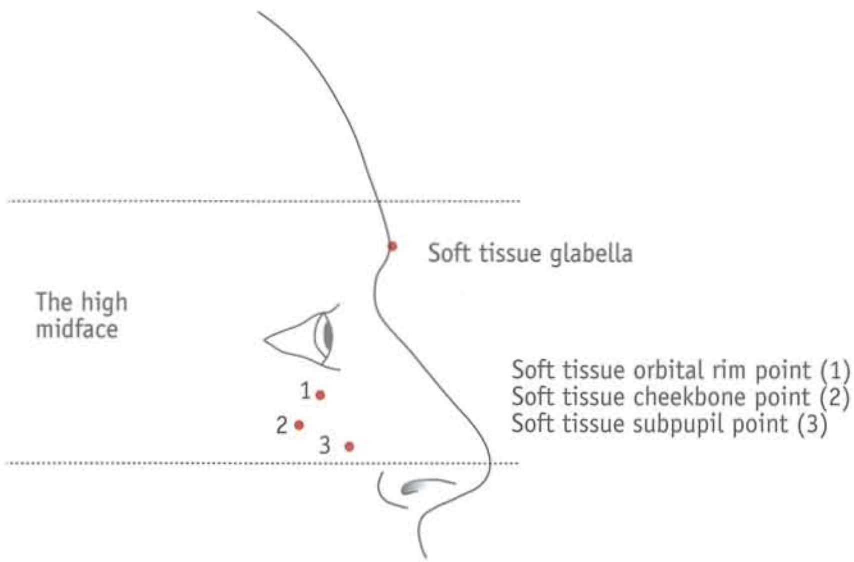


Fig. 3.25 Four soft tissue areas of the high midface profile can be evaluated. These landmarks are described more fully in Chapter 4 (pp. 110–112).

Glabella

Research studies[3] on the soft tissue cephalometric analysis (STCA) show that the prominence of glabella is reasonably consistent in both males and females. Normally, soft tissue glabella lies approximately 2 mm in front of soft tissue nasion (Fig. 3.26).

The orbital rim

The anteriormost aspect of the eye is normally positioned 2–4 mm anterior to the soft tissue orbital rim (Fig. 3.26). This can be described in right profile as 'flat', 'soft', 'normal', or 'prominent'. The face is then viewed from the front to check that left and right orbital rims are equal in size.

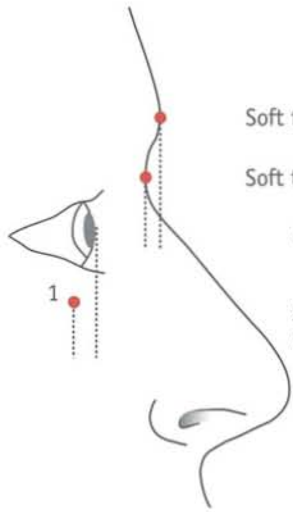


Fig. 3.26 Normally, soft tissue glabella lies approximately 2 mm in front of soft tissue nasion. The orbital rim projection is measured from the anteriormost aspect of the eye to the soft tissue orbital rim. The soft tissue orbital rim may also be described subjectively as 'flat', 'soft', 'normal' or 'prominent'.

The cheekbone

The cheekbone can be described as 'flat', 'soft', 'normal' (convex), or 'prominent'. The cheekbone area has a height of contour. The cheekbone 'height of contour' is located inferior and anterior to the outer canthus of the eye when viewed in profile. When viewed frontally the height of contour is inferior and lateral to the outer canthus of the eye. After assessing the right cheekbone, the patient is viewed from the front to check that right and left cheekbones are equal in size.

The subpupil area

To locate the subpupil position the patient is viewed from the front. The subpupil point is located directly below the pupil of the eye, and midway between the orbital rim and the nasal base points (Fig. 3.27). The nasal base location will be described next in the maxillary profile area. After locating the point, the patient is viewed in profile and the subpupil area can be described as 'flat', 'soft', 'normal' (convex), or 'prominent'. The cheekbone and subpupil areas converge to form a convex line when viewed in profile and frontally. In profile, the curved cheekbone line starts anterior to the ear, travels anteriorly and inferiorly through the cheekbone height of contour and then blends into the subpupil area. The subpupil line when viewed in profile is the continuation of the cheekbone contour and ends at the nasal base. Equality of the left and right sides is checked by viewing the patient from the front.

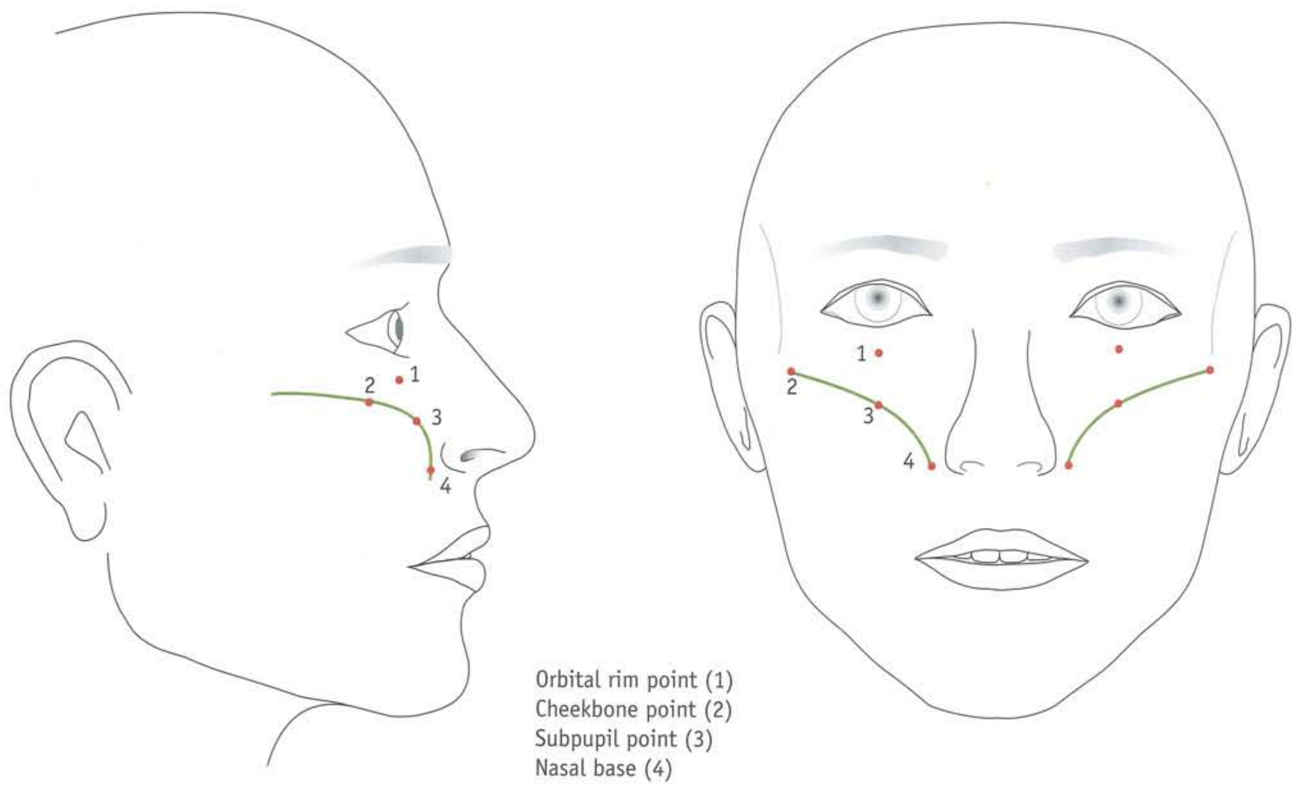


Fig. 3.27 The 'cheekbone and subpupil' contour is a curved line that starts just anterior to the ear, extending forward through the cheekbone height of contour, and the subpupil point, ending at the nasal base of the nose.

In normal skeletal patterns the 'cheekbone and subpupil 'contour is a smoothly curved line. Ideally, when viewed frontally or in profile, this line should be a definite flowing curve, with no interruptions. Interruptions are seen in individuals who have underlying skeletal deformities.

Clinical examination of the maxillary area profile

Four soft tissue areas of the maxilla can be examined – the *nasal base, upper lip prominence, upper lip support,* and *nasal projection* (Fig. 3.28). When examining these areas a sheet of paper is used to hide all structures below the upper lip (Fig. 3.29). This allows assessment of maxillary structures without the relative influence of the position of the mandible which can alter the true perception of the maxillary structures.

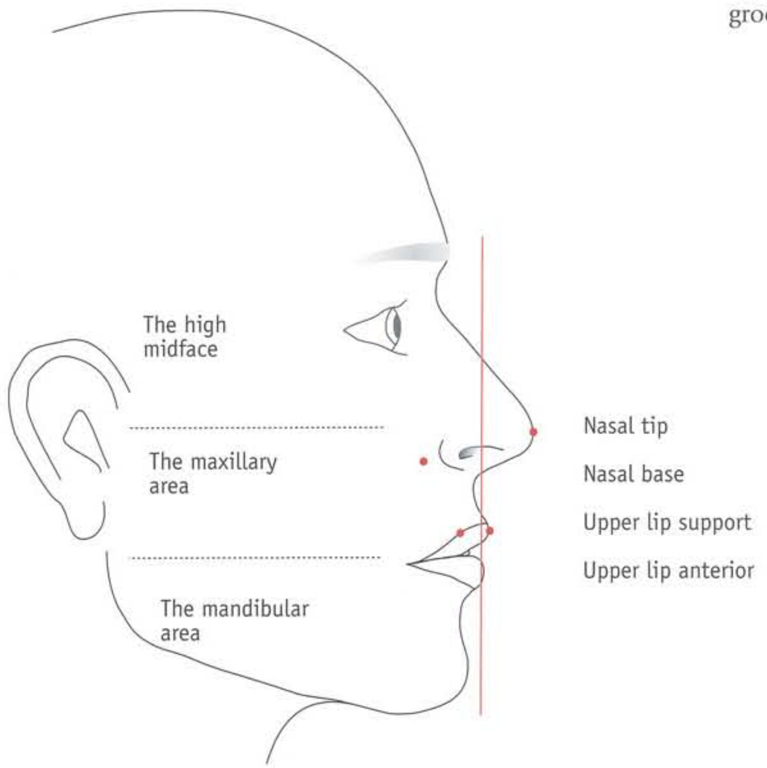


Fig. 3.28 Four soft tissue areas of the maxillary area can be examined – the nasal base, upper lip prominence, upper lip support, and nasal projection.

The nasal base

The nasal base can be described as 'concave', 'flat', 'soft' or 'convex'. 'Convex' is normal, and ideally the nasal base is an anteriorly curved line (convex) just behind the alar base of the nose. Left and right sides should be examined, and if one side is larger than the other, this should be noted. Any planned anterior movement is recorded while examining the patient – this is usually in a range from 2 to 6 mm. Posterior movement of the nasal base area is not indicated for orthognathic surgery patients. If the maxillary base is moved posteriorly during surgery, this creates signs associated with ageing such as upper lip retraction, nasolabial folds, and grooves.

Fig. 3.29 When examining the four soft tissue areas of the maxillary area, a sheet of paper is used to hide all structures below the upper lip.

The upper lip prominence

The upper lip (Fig. 3.30) can be described as 'retruded', 'normal' or 'protruded', and this feature is obviously related to upper incisor position and lip thickness. The maxillary sulcus can be described relative to the prominence of the upper lip. Normally the sulcus is gently curved. Treatment to provide posterior movement of the upper lip is not indicated for orthognathic surgery patients, as this creates an upright and 'prematurely aged' appearance of the upper lip.

The upper lip support

The support of the upper lip can be observed as 'weak', 'normal' or 'strong'. The source of support can be noted as absent (air), teeth or gingival tissues. With eventual treatment in mind, the desired anterior movement of the teeth is recorded while examining the patient – this is usually in a range from 2 to 8 mm.

The nasal projection

The nose can be described as 'long', 'normal' or 'short'. The tip of the nose can be described as 'tipped up' or 'tipped down'. The bridge of the nose can be described as 'humped' or 'saddled'.

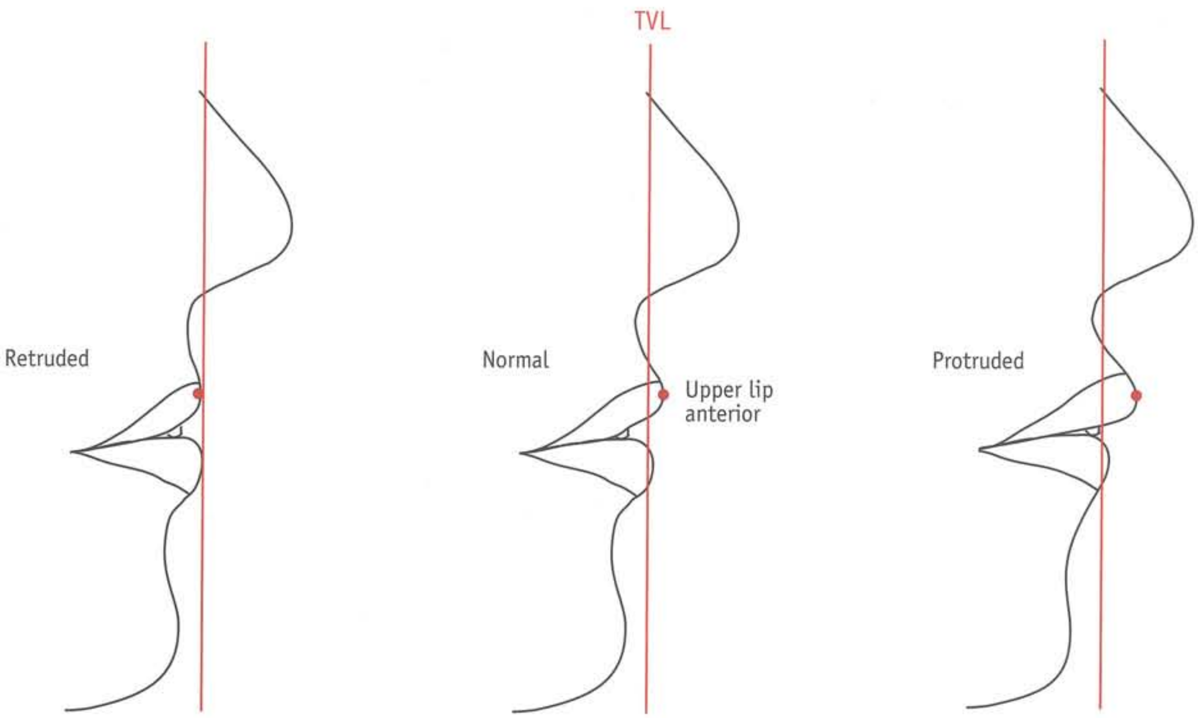


Fig. 3.30 The upper lip can be described as 'retruded', 'normal' or 'protruded'. For females the upper lip is normally 2.5–4.9 mm anterior to the true vertical line (TVL). The normal is 1.6–4.0 mm for males.

Clinical examination of the mandibular area profile

Four soft tissue areas of the mandible can be examined – the *lower lip prominence*, the *soft tissue pogonion prominence*, *throat length and contour*, and *the overjet* (Fig. 3.31). These measurement landmarks are described more fully in Chapter 5.

Lower lip prominence

As with the upper lip (p. 70), the lower lip can be classified as 'retruded', 'normal' or 'protruded'. Relative to TVL the female normals are 0.5 to 3.3 mm, and the male normals are −1.2 to 3.2 mm.

If the position of the lower lip is deflected by the upper incisor, this should be noted. During lower lip examination the labiomental fold is noted as 'accentuated', 'normal', or 'flat'.

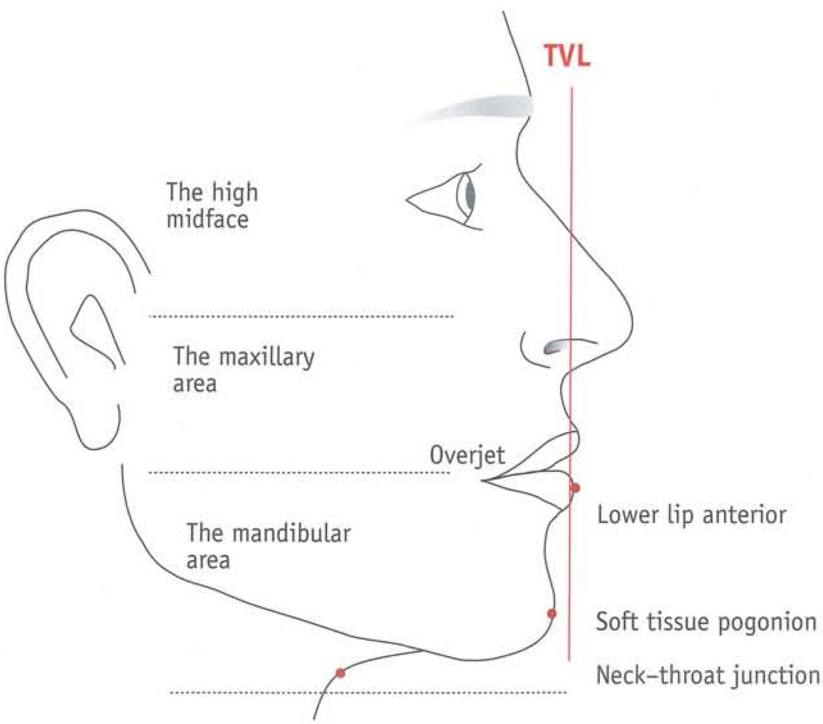


Fig. 3.31 Four soft tissue areas of the mandibular area profile can be examined.

Soft tissue pogonion prominence

Soft tissue pogonion can be described as 'retruded', 'normal' or 'protruded' (Fig. 3.32). Relative to TVL the normals for females are –4.5 to -0.7 mm, and for males –5.3 to -1.7 mm. It is also helpful to assess soft tissue pogonion relative to the lower lip.

Throat length and contour

The distance from the neck–throat junction to the soft tissue menton should be noted (Fig. 3.33). No millimeter measurement is necessary for throat length during facial examination, although it is measured as part of the STCA (pp. 153, 173). This distance is subjectively described as either 'short', 'normal', or 'long', and 'with sag' or 'without sag', and 'with chin line' or 'without chin line'. If the position of the mandible is changed surgically, throat length and contour are affected. Particular care is needed with mandibular set-backs.

The overjet

The overjet is noted as part of the mandibular examination. Overjet describes the relative relationship of the upper and lower incisors but does not clearly reveal the source of the abnormality – the maxillary and mandibular facial examinations reveal the source. The normal overjet is 3 mm and it can be measured during facial examination. It is also measured as part of the intra-oral examination (p. 77) and the cephalometric examination (p. 152).

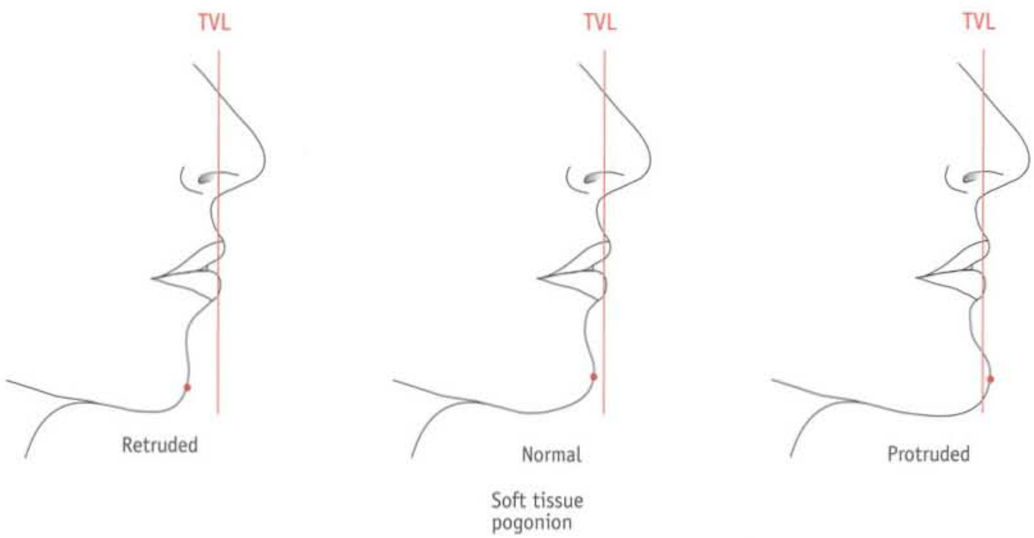


Fig. 3.32 Soft tissue pogonion can be described as retruded, normal or protruded.

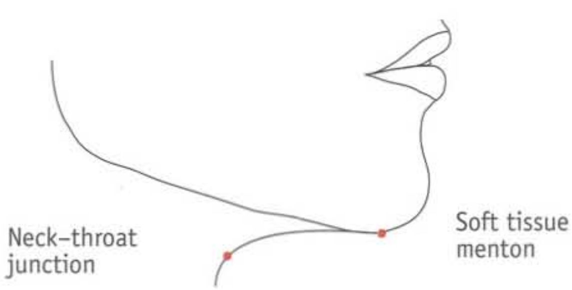


Fig. 3.33 During facial examination the throat length and contour are assessed from neck–throat point to soft tissue menton.

Summary charts – the profile facial examination *(Figs 3.34 & 3.35 – Dr G. William Arnett)*

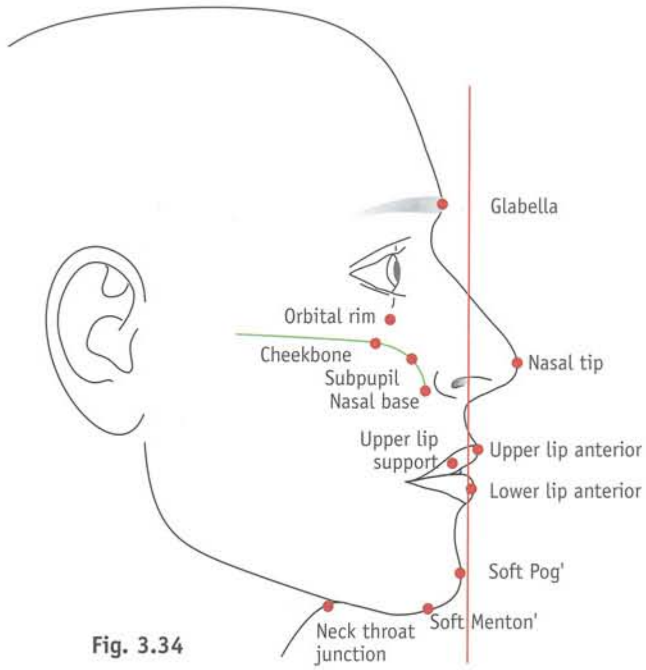


Fig. 3.34

1. High midface projection	**Patient**					
Glabella	retruded		*normal*	prominent	R larger	L larger
Orbital rim	flat	soft	*normal*	prominent	R larger	L larger
Cheekbone	flat	soft	*normal*	prominent	R larger	L larger
Subpupil	flat	soft	*normal*	prominent	R larger	L larger

2. Maxillary projection	**Patient**						
Nasal base	concave	flat	soft	normal convex	prominent	R larger	L larger
ULA to TVL	retruded	*normal*		protruded	straight Mx sulcus	lip: thin thick	
Upper lip support	weak	*normal*		strong	support: air teeth gingiva		
Nasal projection	long	*normal*		short	tip: up down	dorsal: hump saddle	
Orthodontics 1	age	ext		HG	elastics	RPE	FA
Orthodontics 2	age	ext		HG	elastics	RPE	FA

3. Mandibular projection	**Patient**				
LLA to TVL	retruded	*normal*	protruded	11 defection	labiomental fold: accentuated flat
Pog' to TVL	retruded	*normal*	protruded	Pog' relative to lower lip: protrusive retrusive	
Throat length	short	*normal*	long	chin line	sag
Overjet	_________ mm			**does not indicate source of malocclusion**	

Fig. 3.35 The profile view summary.

FACIAL EXAMINATION SUMMARY

Name ______________________________ **Age** ________ **Orthodontist** ______________________

FRONTAL VIEW

1. Vertical	Range	Patient	Possible ways to normalize vertical				
Middle 1/3	*62–75mm*						
Overbite	*3 mm*		LFI	BSSO	Crown length change		Orthodontic crown torque change
Upper lip height (a)	*19–22 mm*		LFI				Lip length surgery
Inter-labial gap (b)	*1–5 mm*			BSSO	Overbite correction	Lip posture change	
Lower lip height (c)	*42–48 mm*						Chin osteotomy–change height
Lower 1/3 height	*62–75 mm*	a+b+c				Submental lipectomy	
Mx incisor exposure (reduced)	*1–5 mm*				Crown length change		Crown torque change
Mx incisor exposure (smile)	*8 crown to 2 gingiva*					Lip length surgery	Gingivectomy
Closed lip	*Strain less touch*	strain redundancy		BSSO	Overbite correction		
Mx incisor height	*9.5–11.5 mm*				Crown length change		Gingivectomy
Upper vermillion	*6–9 mm*				Lip reconstruction procedure		
Lower vermillion	*8–12 mm*						

2. Vertical planning	
Mx 1 plan – relaxed lip:	Current relaxed exposure _____ ± desired change _____ = goal ____ (3–5) (>5 mm advancement anticipated? Yes increase impaction)
Mx 1 plan – smile lip:	Current smile exposure _____ ± desired change _____ = goal ____ (8 crown to 2 gingiva)
Anterior facial plan:	± Mx 1 height change _____ ± overbite change _____ = goal ____ ± chin height change _____ = net _____ OK outline–inter-labial gap

3. Midlines	Patient			Possible ways to normalize facial midlines			
Nasal tip	to right		to left	LFI – shorten septum		Isolated septoplasty	
Philtrum	to right		to left			Dental midlines measured to philtum	
Mx 11	to right		to left	LFI		Orthodontics	Canine cant change
Md 11	to right		to left		BSSO		
Chin	to right		to left			Chin osteotomy	

4. Facial levels	Patient				Possible ways to normalize facial levels	
Eyes	R down		L down	Visualize cant Y N	None	
Mx canines	R down		L down	Visualize cant Y N	LFI–skeletal	Orthodontics–dental
Md canines	R down		L down	Visualize cant Y N	BSSO–skeletal	
Md body level	R down		L down	Visualize cant Y N		Heat treated HA augmentation
Chin level	R down		L down	Visualize cant Y N		Chin osteotomy

5. Outline	Patient		Possible ways to normalize facial outline					
General	Round Wide Narrow Long Short *Normal*		LFI	BSSO	Overbite change	Chin osteotomy–change height	Buccal or submental lipectomy	
Zygomatic arch	R larger wide *normal* narrow	narrow *normal* wide larger L		Heat cured HA augmentation			Reduction osteoplasty	
Md angle	R larger wide *normal* narrow	narrow *normal* wide larger L		BSSO	Midline rotation	Canine cant correction	Cold cure HA graft	Buccal lipectomy
Md body	R larger wide *normal* narrow	narrow *normal* wide larger L						
Chin	Narrow Wide Waist	Flat Angular			Chin osteotomy			
Alar base width	Alar base width ____mm	Intercanthal width ____mm			Alar base cinch		Surgical narrowing	

Fig. 3.36 Facial examination chart (©Arnett Facial Reconstruction Courses Inc. 2003).

FACIAL EXAMINATION SUMMARY (continued)

PROFILE

1. High midface projection	**Patient**						**Ways to normalize high midface projection**	
Glabella	Retruded		*Normal*	Prominent			Osteoplasty	
Orbital rim	Flat	Soft	*Normal*	Prominent	R larger	L larger		Heat cured HA augmentation
Cheekbone	Flat	Soft	*Normal*	Prominent	R larger	L larger	Reduction osteoplasty	
Subpupil	Flat	Soft	*Normal*	Prominent	R larger	L larger	LFI (MSLFI advances more than LFI)	

2. Maxillary projection	**Patient**							**Ways to normalize soft tissue nasal base–upper lip projection**		
Nasal base	Concave	Flat	Soft	*Convex*	Prominent	R larger	L larger	LFI (MSLFI creates more advancement than LFI)		Desired move _______mm
ULA to TVL	Retruded	*Normal*		Prutruded	Straight MX sulcus	Lip: thin thick		LFI	11 torque change	Lip thickness change
Upper lip support	Weak	*Normal*		Strong	Support: air teeth gingiva					Desired move _______mm
Nasal projection	Long	*Normal*		Short	Tip: up down	Dorsal: hump saddle		LFI (MSLFI shortens more than LR)		Rhinoplasty
Orthodontics 1	Age	Ext		HG	Elastics	RPE	FA	LFI advancement		Flatten occlusal plane
Orthodontics 2	Age	Ext		HG	Elastics	RPE	FA			

3. Mandibular projection	**Patient**					**Ways to normalize lip and chin projection**						
LLA to TLV	Retruded	*Normal*	Protruded | 11 deflection	Labiomental fold: accentuated flat		Mx11 torque	LFI	Steepen flatten occlusal plane	Md11 torque	BSSO	Chin	Submental lipectomy
Pog' to TVL	Retruded	*Normal*	Protruded	Pog' relative to lower lip: Protusive Retrusive								
Throat length	Short	*Normal*	Long	Protrusive chin line	Sag							
Overjet	_______mm		Does not indicate source of malocclusion			Ortho		LFI		BSSO		

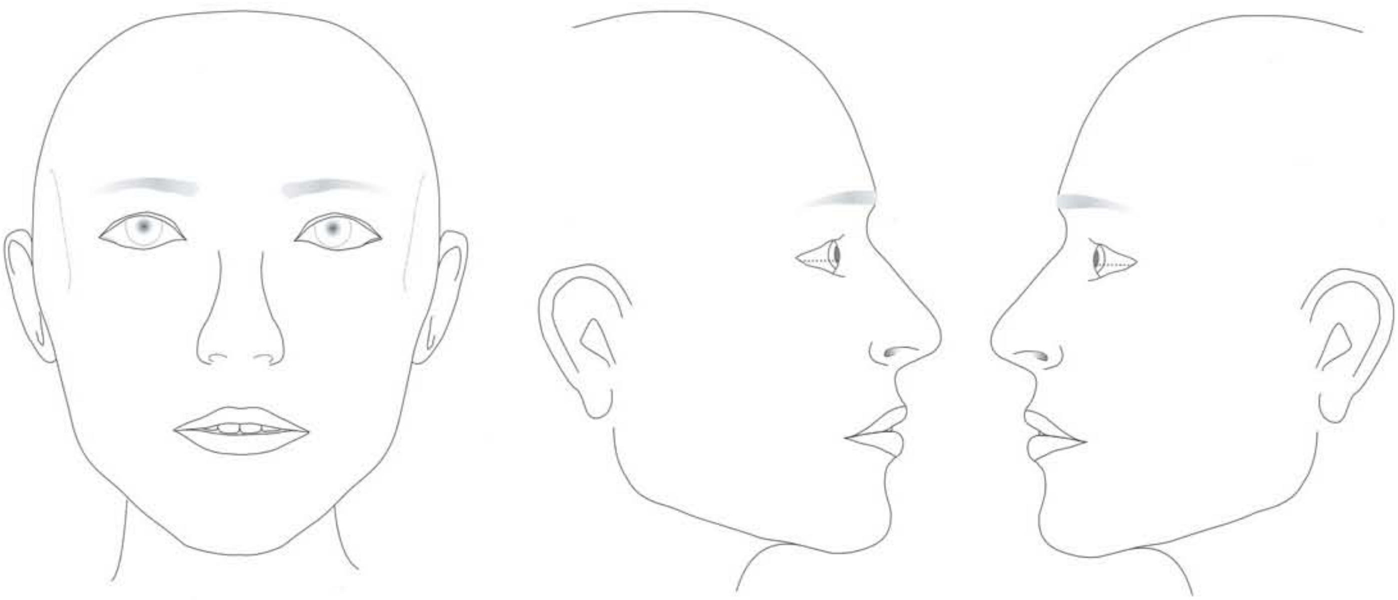


Fig. 3.36 *Continued.* (©Arnett Facial Reconstruction Courses Inc. 2003)

4. THE INTRA-ORAL EXAMINATION

During the intra-oral examination it is necessary to examine the soft tissues and the dento-alveolar structures.

Evaluation of the intra-oral soft tissues

The referring dentist will normally have evaluated the soft tissues of the oral cavity and treated any problems that exist. However, it is wise to carry out a further routine examination for any soft tissue lesions, gingival inflammation or gingival recession, abnormal frenal attachments and other soft tissue anomalies. Appropriate referrals can be made as necessary to manage these conditions, if they are not within the treatment range of the orthodontist or oral surgeon.

Finger or thumb sucking

For the orthodontist it is important to note abnormalities related to finger or thumb sucking. These are of considerable relevance to facial planning and their effects are well documented. Often the upper incisors are proclined and the lowers are retroclined due to the effect of the finger or thumb. Very favorable changes in facial harmony can be obtained in these cases after the child abandons the habit and receives orthodontic correction.

Tongue size, position, and activity

Careful evaluation of the tongue is needed during intra-oral examination.

It is necessary to identify the size and habitual position of the tongue. For example, some Class III cases have a large tongue which is held low in the mouth. Scalloping of the sides of the tongue can be indicative of a clenching habit or excessive size, and needs to be noted, because a tongue of this type can undermine the later stability of occlusal correction.

The activity of the tongue during swallowing needs to be checked. If there is abnormality of the swallowing pattern – the so-called 'infantile swallow' – this needs to be recognized and noted. It is characterized by a habitual forward thrust of the tongue during swallowing, with a tongue-to-lip contact. Such individuals typically present with a Class II/1 anterior open bite type of malocclusion.

Mentalis muscle activity

Over-activity of the mentalis muscle is evident in a small number of individuals and this should be recognized and noted if present. This hyperactivity results in a 'strap-like' effect of the lower lip, and the patient will typically have retroclined lower incisors.

Dental assessment (see also Ch. 8)

The information gathered during the intra-oral examination needs to be confirmed during the study model examination (p. 175). It is important to assess the general condition of the dentition and to note any missing teeth. Also, the presence of large restorations, carious teeth, crowns, bridges, implants, root canal fillings, ankylosed teeth, and other dental anomalies should be recorded.

Molar relationships

The left and right molar relationship should be recorded with the mandible in centric relation. If second premolars are present, it is helpful to observe their relationship, because molar rotations can sometimes be confusing when evaluating dental relationships.

Canine relationships

In centric relation, if the relationship of the canines differs to any great extent from that of the molars, then these positions should also be noted.

Midlines

Midlines were evaluated as part of the facial examination (p. 52) and this information should again be recorded on the intra-oral examination form. Generally, upper midline deviations are of dental origin only. Lower midline discrepancies can be due to three sources – dental factors, skeletal asymmetry, or lateral side shift. During the dental examination it is important to determine the cause of the lower midline deviation.

Overjet and overbite

This information was recorded as part of the facial examination, and it is recorded again here.

Crossbites

Anterior and posterior crossbites should be noted. They can be caused by the same three factors as can cause a lower midline discrepancy – dental factors, skeletal asymmetry, or lateral side shift. An early assessment needs to be made concerning the etiology of crossbites.

Crowding or spacing

Lower arch crowding or spacing needs to be recorded during the dental examination. It is helpful to note this separately for the anterior, premolar and molar areas. This is discussed in Chapter 8 as part of orthodontic treatment planning (pp. 304, 306).

Lower curve of Spee

The depth of the curve of Spee in the lower arch should be estimated and recorded for left and right sides. A more precise measurement is later made on mounted dental models.

Soft tissue		
Habits		
Missing teeth		
Restored or carious teeth		
Molar relationship	Right	Left
Cuspid relationship	Right	Left
Midlines	Right	Left
Overjet		
Overbite		
Crossbites		
Crowding/spacing lower anterior region	Right	Left
Crowding/spacing lower bicuspid region	Right	Left
Crowding/spacing lower molar region	Right	Left
Curve of Spee	Right	Left

Fig. 3.37 Intra-oral examination chart.

After completion of the TMJ examination, the facial examination, and the intra-oral examination, a general discussion can be carried out with the patient. If the approach to treatment is relatively straightforward, then a provisional plan can be discussed with the patient. However, if there is any doubt about the treatment plan, then it is best to delay this discussion until all the information and records have been reviewed, including the cephalometric treatment plan (CTP) (Ch. 7, p. 240).

Cooperation levels

During the examination, the orthodontist and the surgeon will have the opportunity to note any obvious indicators about the likely level of cooperation from the patient.

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2 Helkimo M 1974 Studies of function and dysfunction of the masticatory system. II Index for anamnestic and clinical dysfunction and occlusal state. Swedish Dental Journal 67:101–121

3 Arnett G W, Jelic J S, Kim J et al 1999 Soft tissue cephalometric analysis: diagnosis and treatment planning of dentofacial deformity. American Journal of Orthodontics and Dentofacial Orthopedics 116:239–253

CASE TW

This 14.5-year-old female developed a Class III malocclusion and was seen for consultation for correction of her occlusion. She was referred by her orthodontist who had completed 12 months of pre-orthodontic preparation prior to the referral. Diagnosis and treatment were started with the intention of fulfilling the seven goals of treatment. Her patient motivation form indicated a desire for straightening of her upper and lower front teeth, forward movement of the upper teeth, backward movement of the lower teeth, and left movement of the lower midline. Facially, the patient wanted her lower lip moved back, cheekbones enlarged, lips brought closer together, face widened, and reduce the fullness of the lower jaw behind the mouth. She had no symptomatic complaints. TMJ examination and history, clinical facial examination, soft tissue cephalometric examination, and model examinations were obtained. The problem list and treatments were as follows:

PROBLEM	TREATMENT
1. High midface	
• Flat cheekbones and subpupil area	• Heat treated hydroxyapatite (HA) grafts • Le Fort I (LFI) advancement
2. Maxilla	
Dental	
• Diastema	• Orthodontics
• Excessive incisor lingual crown torque	• Labial crown torque
Skeletal/facial	
• Maxillary retrusion	• Maxillary advancement
• No dental deviation	• No treatment
• Normal incisor exposure	• No treatment
• Wide maxilla in Class I position	• Multi-segment LFI for narrowing
• Level curve of Spee	• Cut archwire to test stability
3. Mandible	
Dental	
• Mild crowding	• Orthodontics
• Excessive incisor lingual crown torque	• Labial crown torque
Skeletal/facial	
• Marked chin, lower lip protrusion	• Bilateral sagittal split osteotomy (BSSO) set-back
• 2 mm right deviation of midline	• 2 mm left rotation
• Short chin height	• Lengthening chin osteotomy
• Level curve of Spee	• No treatment
4. TMJ	
• No signs or symptoms	• No treatment
5. Growth potential	
• 14.5 years old – disproportionate future	• Option 1: deband and postpone surgery
• Class III growth assured	• Option 2: surgery with Class II overcorrection

After the records and diagnosis were completed, the patient was treatment planned antero-posteriorly and vertically using the seven-step cephalometric treatment plan. The midlines, levels, and outline were treatment planned using the frontal clinical examination. The orthodontist was asked to cut the maxillary archwire between the maxillary canines and laterals to allow the curve of Spee to relapse, since an accentuated curve of Spee existed prior to orthodontics. The relapse occurred within 3 months. The multi-segment LFI, and BSSO produced basic facial balance while correcting the occlusion. Facial balance was further improved with heat treated HA cheekbone grafts, sliding chin osteotomy with set-back and lengthening, and lateral HA chin grafting. Lastly, a cold cure HA graft was added to the left mandibular body to correct a slight contour defect.

The patient was too young for surgery. Surgery for female mandibular prognathism should be done after 18 years of age to prevent late Class III mandibular growth. In spite of this, surgery was done on this patient at 15 years of age. Surgery was done at 15 because orthodontic preparation was fully completed, and because of psychosocial reasons. She was surgically overcorrected to a Class II overjet, which allows for late Class III growth.

Three years after surgery, the 18-year-old patient had a strong chin projection in spite of the surgical overcorrection and chin osteotomy set-back. This is a result of the lower incisor lingual crown torque and late mandibular growth.

Fig. 3.41

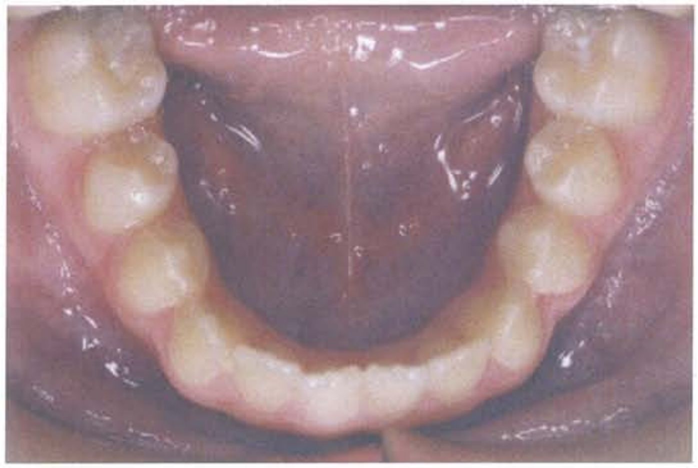


Fig. 3.44

Fig. 3.38

Fig. 3.39

Fig. 3.40

Figs 3.38 to **3.45** Pre-orthodontic facial and bite photographs showing maxillary retrusion, mandibular protrusion, and a Class III malocclusion.

Fig. 3.42

Fig. 3.43

Fig. 3.45

Fig. 3.46 Pre-orthodontic soft tissue cephalometric tracing. Note: lingual compensation of lower incisors, protrusive mandible and deficient maxilla.

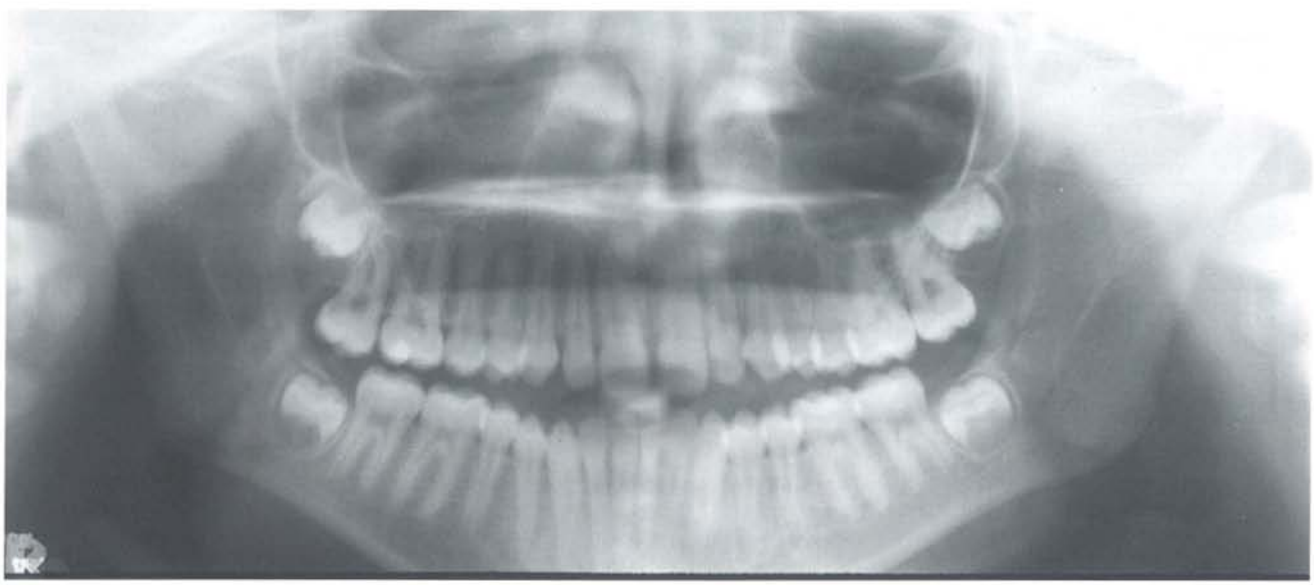


Fig. 3.47 Pre-orthodontic panoral radiograph.

Fig. 3.48

Fig. 3.49

Figs 3.48 to **3.51** Pre-surgical intra-oral photographs of orthodontic preparation, demonstrating the Class III severity. The maxillary archwire has been cut between the canines and laterals to allow any transverse orthodontic expansion to relapse prior to surgery.

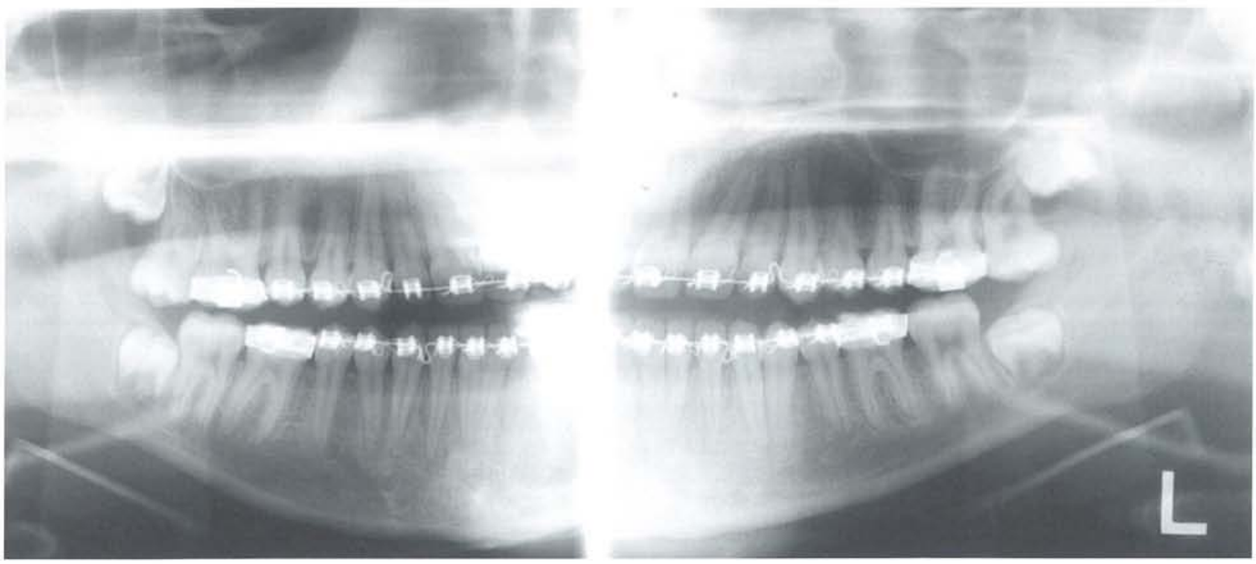


Fig. 3.52 Panoral radiograph pre-surgery.

Fig. 3.50

Fig. 3.51

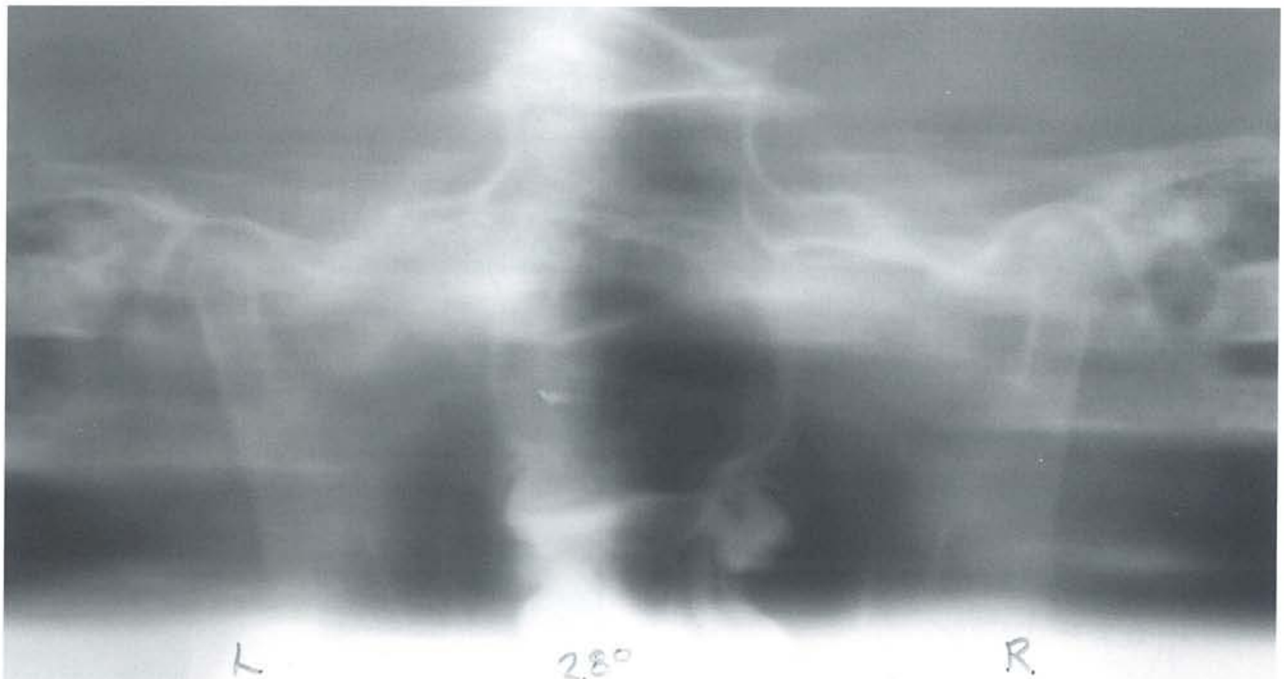


Fig. 3.53 Tomographic radiograph. Note: condyles with long condylar heads and necks which are characteristic of mandibular protrusion. The left condyle appears posterior in the fossa but is totally asymptomatic and is therefore in a physiologic position.

Fig. 3.54

Fig. 3.55

Figs 3.54 and **3.55** Closed lip and relaxed lip photographs. Note: deficient cheekbones, maxillary retrusion, mandibular protrusion, and mild lip strain.

Fig. 3.56

Fig. 3.57

Fig. 3.58

Figs 3.56 to **3.58** Closed lip, relaxed lip, and smile photographs. Note: mild lip strain and right deviation of the mandible.

Fig. 3.59

Fig. 3.60

Figs 3.59 and **3.60** Right and left three-quarter facial photographs. Note: deficiency of cheekbones, subpupil areas, and nasal base areas; mandibular protrusion.

Figs 3.61 to **3.63** STCA demonstrates cheekbone (–24, green), subpupil (–18, green), nasal base (–14, green), and upper lip retrusion (2, green) with chin protrusion (2, blue). Treatment consisted of maxillary advancement, mandibular set-back, cheekbone augmentations, and chin osteotomy with setback and lengthening. The treatment CTP shows normal projections and lengths of the face. The cheekbone, subpupil, and nasal base areas were corrected with heat treated hydroxyapatite grafts and a maxillary advancement. The overjet was planned at 4 mm to allow space for labial mandibular crown torque and late mandibular growth.

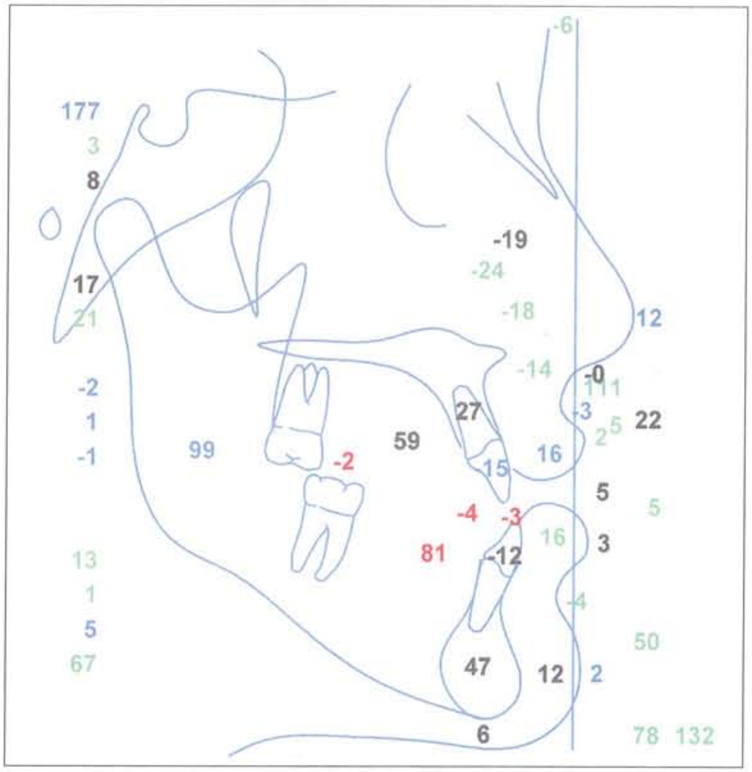


Fig. 3.61 STCA

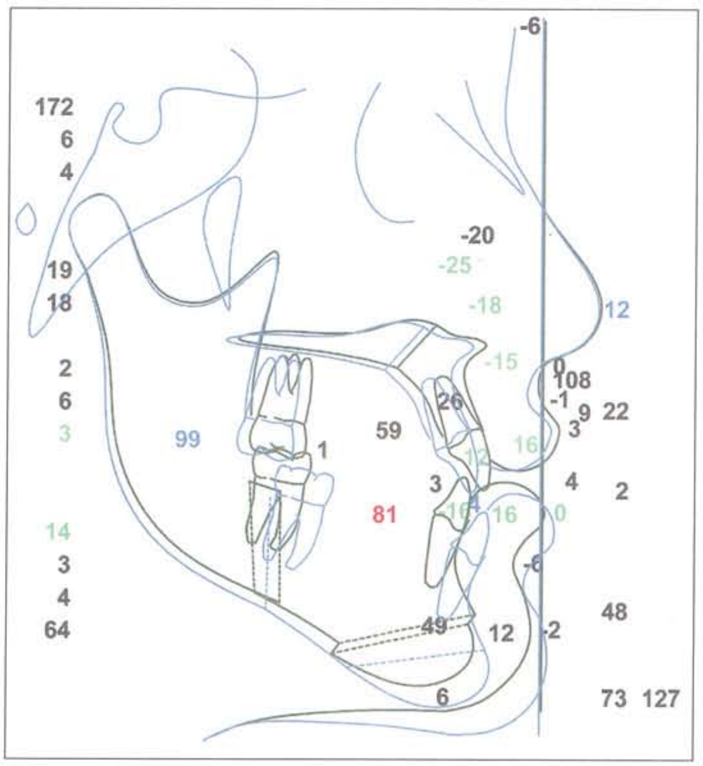


Fig. 3.62 Cephalometric treatment plan overlay (blue–orthodontic preparation; green–cephalometric treatment plan, CTP). The occlusal plane was maintained at 99° to position the base of the nose and chin esthetically.

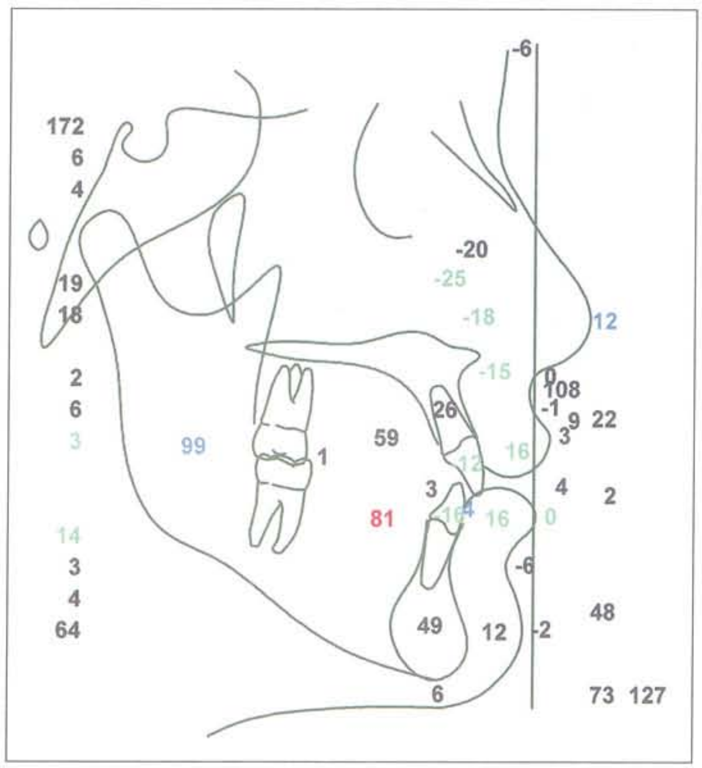


Fig. 3.63 Cephalometric treatment plan (CTP).

Fig. 3.64

Fig. 3.65

Figs 3.64 to **3.67** Post-surgical intra-oral photographs. The patient was offered bonding for the upper incisor diastema but declined treatment.

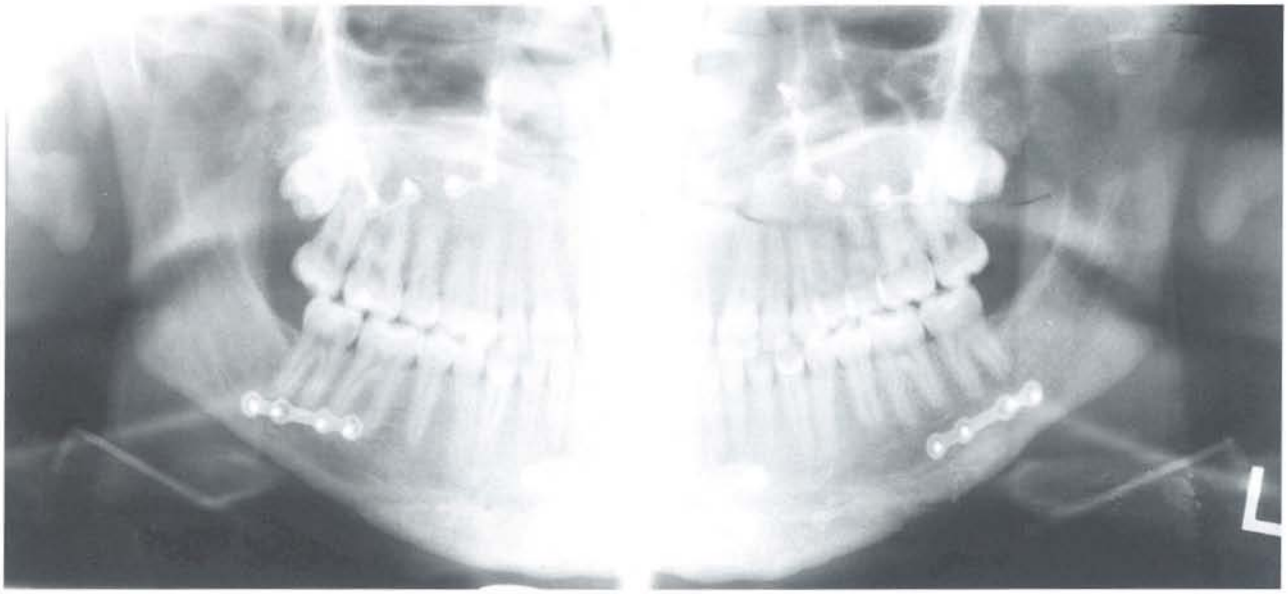


Fig. 3.68

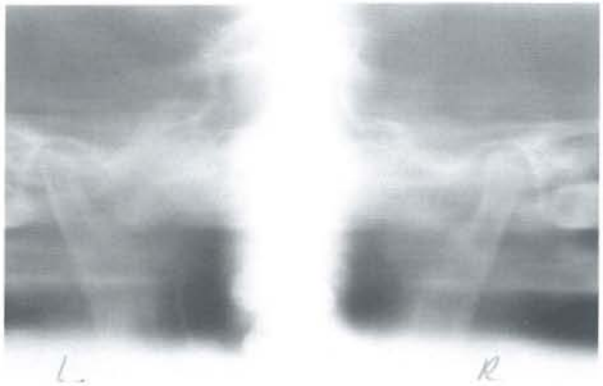


Fig. 3.69

Figs 3.68 and **3.69** Post-surgical panoral radiograph and right and left tomograms. Note in panoral radiograph: one plate per sagittal osteotomy set-back. Note in tomograms: the right condyle was unchanged from the pre-op position. The left condyle was posterior, as in the pre-operative tomogram, with new focal remodeling of the anterosuperior condyle head. This was asymptomatic.

Fig. 3.66

Fig. 3.67

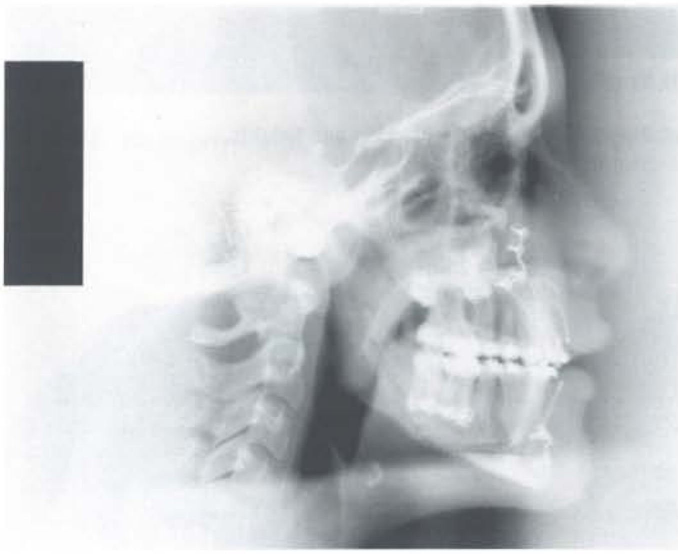


Fig. 3.70 2 weeks post-surgical headfilm. Note: Class II overjet to allow for mandibular incisor labial crown torque and future mandibular growth.

Fig. 3.71 2.5 years post-surgical headfilm. Note: the overcorrection is gone, secondary to late mandibular growth.

Fig. 3.72 Relaxed lip

Fig. 3.73 Closed lip

Figs 3.72 and **3.73** Relaxed lip and closed lip photographs. Note: normal facial projection and heights.

Fig. 3.74 Closed

Fig. 3.75 Relaxed

Fig. 3.76 Smile

Figs 3.74 to **3.76** Closed lip, relaxed lip, and smile photographs. Note: Normal heights and facial outline.

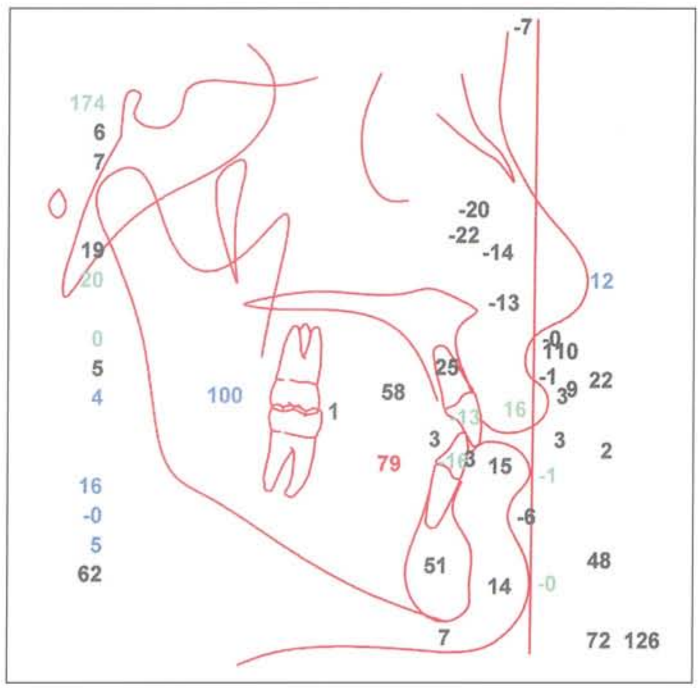
Fig. 3.77 Pre-surgery

Fig. 3.78

Fig. 3.79

Figs 3.78 and **3.79** Right and left three-quarter facial photographs. Note: normal projections and contours.

Fig. 3.80 Post-treatment



3.81 STCA showing excessive lingual crown torque and a tendency towards mandibular protrusion secondary to late mandibular growth after surgery. Note the STCA intramandibular disharmony (16, -0, 5, blue) which has occurred secondary to late mandibular growth. Close clinical inspection of the profile (Figs 3.72, 3.73) confirms the SCTA disharmony findings.

The orthodontic treatment for this patient was provided by Dr Leo Logsdon. The authors gratefully acknowledge his assistance in treating this patient.

4 Record taking – a basis for treatment success

INTRODUCTION

Good treatment is based on good diagnosis and treatment planning, which in turn depend on accurate records. Orthodontists and surgeons therefore give a high priority to obtaining the best possible records for their patients. Correct head orientation, condyle position, and lip posture are needed, and it is a challenge to achieve high quality and consistency. Many aspects of record taking are delegated, and the quality of the documentation rests in the hands of well-trained staff or commercial laboratories, who need to be continually monitored and re-motivated.

CONVENTIONAL VERSUS DIGITAL RECORDS

There is a need for easy retrieval, analysis, storage, transfer, and eventually archiving of patient records. These requirements are generally better met by electronic methods of documentation, which have clear advantages. The technology of digital record taking is rapidly improving at the time of writing, and digital records are becoming the normal for radiographs and photographs. Digital imaging is also available for measurement and archiving of models. Despite this, most surgeons and orthodontists prefer to have actual mounted plaster models for treatment planning and presentation to the patient, rather than images of models (Fig. 4.1). Plaster models are also needed for surgical cases for accurate treatment planning.

DOCUMENTATION

This chapter describes a systemized approach for obtaining in-depth and comprehensive records, suitable for treatment planning of the most difficult group 2 and 3 cases. Full documentation is required for all surgical cases, but less is needed for many orthodontic cases, and a case-by-case decision needs to be made by clinicians. However, the authors recommend that there should be a minimum level of documentation for all orthodontic patients, to include:

- An accurate wax bite
- Facial and dental photographs
- A lateral cephalometric radiograph
- A panoramic radiograph and bite-wing radiographs
- Mounted plaster models.

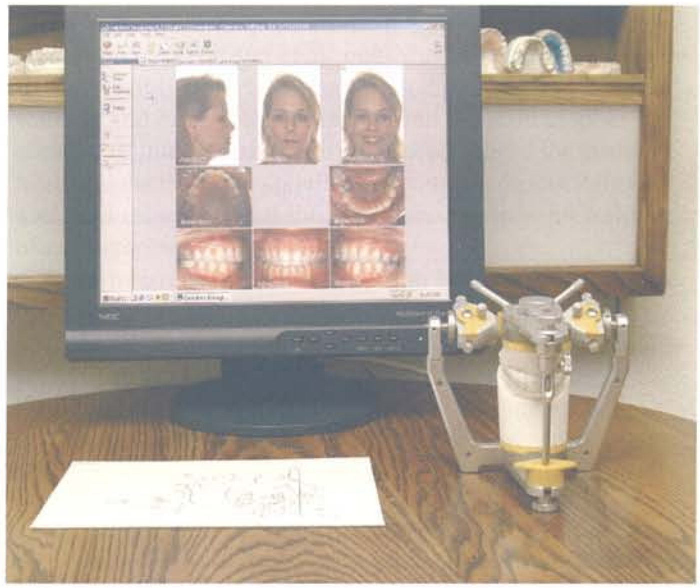


Fig. 4.1 High quality records allow better treatment planning, and support successful surgical and orthodontic practice. Electronic methods of documentation have clear advantages for radiographs and photographs. However, most surgeons and orthodontists prefer to have actual mounted plaster models for treatment planning and presentation to the patient, rather than images of models.

QUALITY, ACCURACY, AND CONSISTENCY OF RECORDS

High quality records allow better treatment planning, and support successful surgical and orthodontic practice. A systemized approach is required, with every effort being made to achieve accurate records. High quality records can also be suitable for research purposes. If a patient transfers from the practice, or sees a colleague for a second opinion, accurate records can be sent with the patient, which enhance the ability of the second opinion to make a correct diagnosis and treatment plan.

Standardization is also important, because the various aspects of record taking are interdependent (Fig. 4.2). For example, a seated condyle position, natural head position and relaxed lip posture are required for the lateral facial photograph and the lateral cephalogram, because these need to be superimposed as part of computerized facial planning.

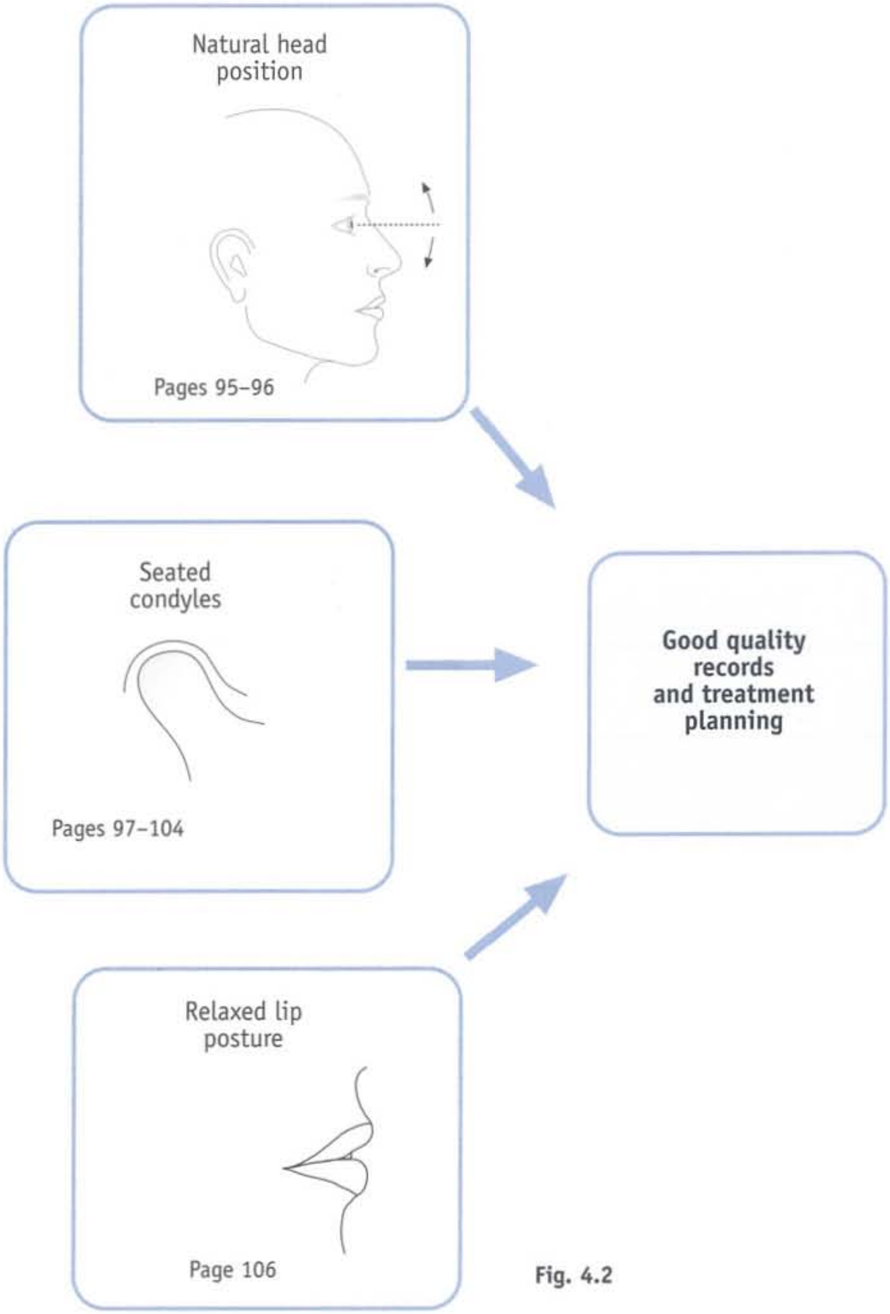


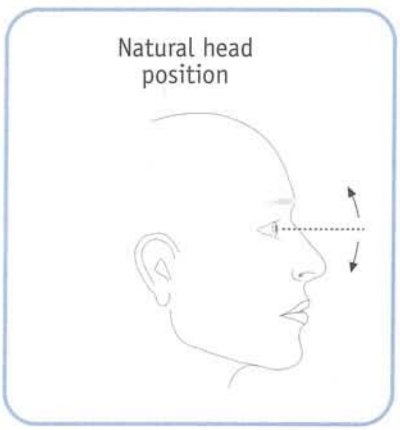
Fig. 4.2

NATURAL HEAD POSITION (NHP)

The concept of natural head position (NHP) was introduced to orthodontics in the 1950s in papers by Moorees & Kean,[1] Mølhave[2] and others. Subsequently, as discussed below, studies have shown it to be valid and reproducible for cephalometric diagnosis.

In 1988, Cooke and Wei reported on 217 randomly selected 12-year-old Chinese children in Hong Kong.[3] They measured natural head position on repeated radiographs, and found reproducibility close to 2°. The reproducibility was better (1.9°) with patients looking at a mirror, than without a mirror (2.7°). They also investigated the effect of using ear posts, and commented that 'No significant difference in reproducibility was found between NHP recordings taken with and without ear posts. However, without ear posts the radiographs tended to be of poor quality.' They stated that 'NHP has been found in this study to be remarkably reproducible in 12-year-old children'.

In a landmark paper in 1992, Lundström and Lundström[4] reported on a group of 27 boys and 25 girls aged 10–14 years. For each subject, NHP was recorded photographically and then transferred to the cephalometric radiograph. They found that reproducibility of NHP was close to 2° (compared with sella–nasion, basion–nasion and porion–orbitale, which showed standard deviations of between 4.5° and 5.6°). Lundström and Lundström observed that NHP represents a realistic appearance of patients. This, combined with their research findings, 'supported the use of NHP for cephalometric analysis of dentofacial anomalies'.



There is evidence of constancy of NHP over the age range 12–45 years. For example, in a 1985 study Chow, Clarke and Cooke[5] used identical protocols to compare adult Chinese males (mean age 25 years, range 16–45 years) with a group of Chinese boys. They measured Frankfort horizontal to a true vertical line, derived from NHP, and remarkably found means of 86.6° (adults) compared with 86.4° (boys).

A technique for establishing NHP was developed by Solow and Tallgren.[6,7] They recommended that the patient should firstly walk around and relax. The standing patient should then perform decreasing forward and backward head oscillations, before allowing the head to settle into a 'self-balance' position. Patients are then asked to look into the reflection of their eyes in a mirror at a 200-cm distance. Male subjects typically look up more when asked to view the mirror.[3] Care is needed with the ear post insertion to ensure there is no head movement away from the NHP, and to avoid any change in condyle position within the fossae, as suggested by Eliasson.[8] Cooke and Wei[3] also advised that patients sway less when standing in the cephalometer if their feet are in a defined position 'a comfortable distance apart and slightly diverging'.

More recently, Bister et al[9] published a review of reproducibility of NHP. In part of their study they omitted the walking and head-tilting exercises, and the radiographer was allowed to interfere and repeat the procedure if the patient's head was clearly not in NHP. They found reproducibility of 1.4°, and recommended the use of photographs for training of radiographers.

In summary, natural head position has been shown to be the most accurate and reproducible head position. Using NHP, facial planning can be based directly on the face and is not influenced by cranial base variability. NHP (not Frankfort) is the head position which most patients use habitually. True mandibular position can be recorded if the cephalometric radiograph is taken at NHP with a centric relation (pp. 100–103) wax bite in place.

MODIFIED NHP

A few patients consistently assume a modified NHP,[10] often in an attempt to mask a Class II or Class III facial pattern. For example, an individual with Class II mandibular retrognathism may habitually tilt the head backward to mask the Class II appearance (Fig. 4.3).

It is necessary for the clinician to identify these individuals, and to adjust their head position towards NHP for record taking (Fig. 4.4). This head orientation is 'clinician determined' and provides a more reliable basis for cephalometric analysis for these individuals.[10]

Fig. 4.3 Individuals with Class II mandibular retrognathism may habitually tilt the head backward (left) to mask the Class II appearance (see Case RS, p. 248, Fig. 7.40). Natural head position reveals the retrognathic profile (right).

Fig. 4.4 It has been shown that for some patients it is necessary to adjust the head position towards NHP for accurate record taking.

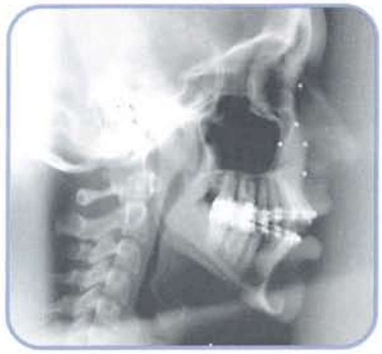
THE IMPORTANCE OF THE WAX BITE

The wax bite is the cornerstone of good record taking. Properly constructed, it correctly relates the mandible to the maxilla during facial examination, facial photography, cephalometry, and tomography. Later it is used to ensure accurate model articulation.

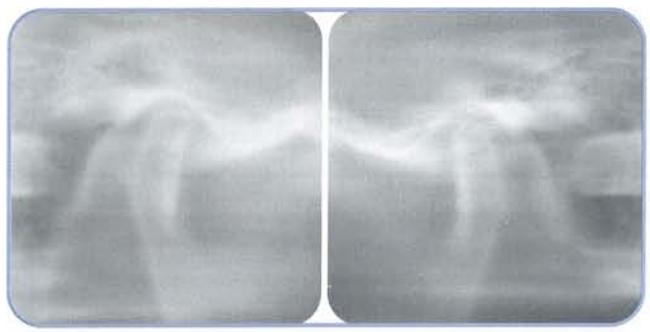
The wax bite

Facial examination

Facial photography



Cephalometry



Tomography

Accurate model articulation

Fig. 4.5 The wax bite is the cornerstone of good record taking.

FIRST TOOTH CONTACT – THEORETICAL AND CLINICAL CONSIDERATIONS

A high percentage of individuals show a 'slide' or 'displacement' from first tooth contact during final closure of the mandible. Consequently, centric occlusion (CO) and centric relation (CR) do not coincide. For example, in some Class III cases there is often a forward slide of the mandible from an incisor first tooth contact. A mandibular slide may be defined as:

A lateral or A/P displacement of the mandible from centric relation to centric occlusion from a premature tooth contact.

The accuracy of the wax bite is all-important, because the position of the mandible needs to be recorded without any displacement (Figs 4.6 & 4.7). It is traditionally described as

Fig. 4.6 A patient's teeth at maximum intercuspation (CO).

Fig. 4.7 The same patient at first tooth contact (CR) showing the mandibular slide. Note the midline change and the bicuspid positional change.

being taken at first tooth contact during closure, with no mandibular slide. Patients with a mandibular slide show a difference in overbite between:

- the patient at first tooth contact (CR), and
- the patient at maximum intercuspation (CO).

The overbite difference can be visualized and noted on mounted study models, and then transferred to the cephalometric radiograph for treatment planning. Three factors can open the bite during the above process:

1. Incomplete closure into the wax bite
2. Posterior interferences at centric relation (CR)
3. Skeletal abnormalities.

Mounted models are valuable for identifying the source of the bite opening. If the models indicate (1) or (2) above as the source, the difference can be measured on the models. The cephalometric radiograph can then be 'closed down' by the measured amount, hinging on CR. Alternatively, if the bite opening is caused by skeletal factors (3) above, the cephalometric film should not be 'closed down' – it should be left at an unchanged vertical dimension.

In some Class II/1 cases, the mandible may be anteriorly displaced from first tooth contact, disguising the true extent of the underlying Class II discrepancy (Fig. 4.8). Some adults may have a long-established slide of this type. For these individuals, a full time acrylic splint may need to be worn for 3–6 months before record taking (pp. 104, 200).

Individuals with a narrow maxilla, relative to the mandible, frequently show a lateral slide from first tooth contact, producing an anterior midline discrepancy at CO.

Great care is needed to eliminate these displacements when taking records. Every effort is made to ensure that wax bites record true mandibular position, at first tooth contact and with no slides. Most clinicians have a preferred method of taking a correct wax bite without mandibular displacement, and with the condyles centered in the fossae. The technique described below has proved useful to the authors, and may be helpful.

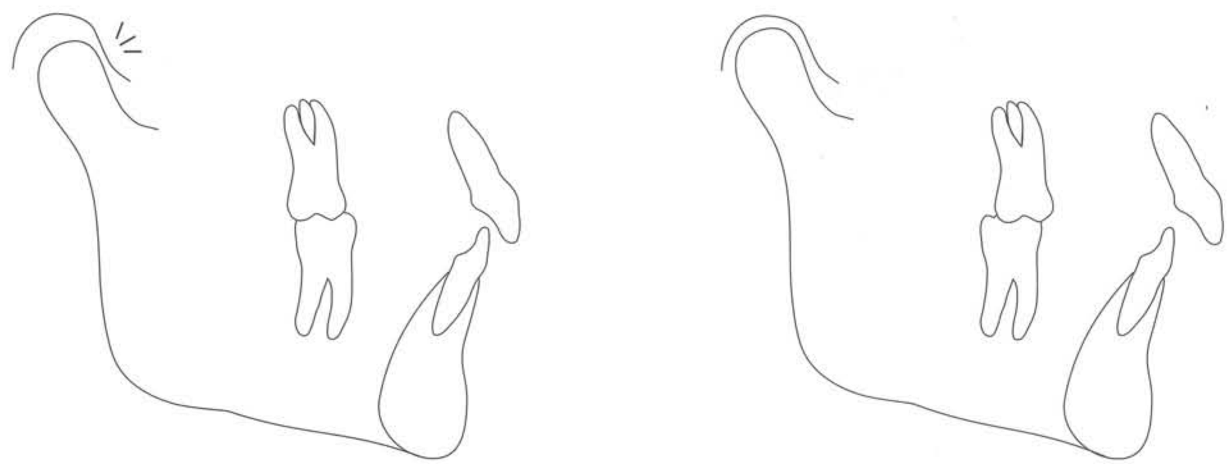


Fig. 4.8 In some Class II/1 cases, there may be anterior displacement of the mandible at CO. This disguises the true extent of the underlying Class II discrepancy.

WAX BITE CONSTRUCTION

The following technique has proved to be reliable for wax bite construction at first tooth contact (without slides). A warmed piece of wax[11] is folded in half and then a 1-cm anterior portion is folded again (Fig. 4.9A). This creates a two wax layer of thickness in the posterior region and four wax layer of thickness in the incisor region. This thicker anterior area acts as a gentle fulcrum to seat the joints during bite registration, as it does not soften as much as the wax in the molar area. The wax is trimmed to the appropriate shape of the patient's arch before being placed in the mouth. It needs to be 'seated' three times for accurate bite registration.

Fig. 4.9A A warmed piece of wax[11] is folded in half and then a 1-cm anterior portion is folded again.

The first wax bite closure

The patient should be sitting at 45° and in a calm and relaxed working environment. Mild upward pressure is applied to guide the mandible during closure to first tooth contact (Fig. 4.9B), thereby assisting the condyles into the uppermost centric position. It is necessary to look carefully for slides (Fig. 4.10A).

Fig. 4.9B Mild pressure is applied to guide the mandible during closure to first tooth contact, thereby assisting the condyles into the uppermost centric position.

Fig. 4.10A It is necessary to gently assist the condyles into the uppermost centric position and to look carefully for slides.

Trimming of the wax bite

After the first closure, the wax is carefully removed and accurately trimmed to the edges of the maxillary teeth (Fig. 4.10B & C), using a sharp pair of scissors. Later, when the wax bite is used during facial photography, this trimming will avoid soft tissue deflection (Figs 6.19–6.22, p. 215). It is helpful to examine the impression which the lower incisors make in the wax. This should be clean and clear.

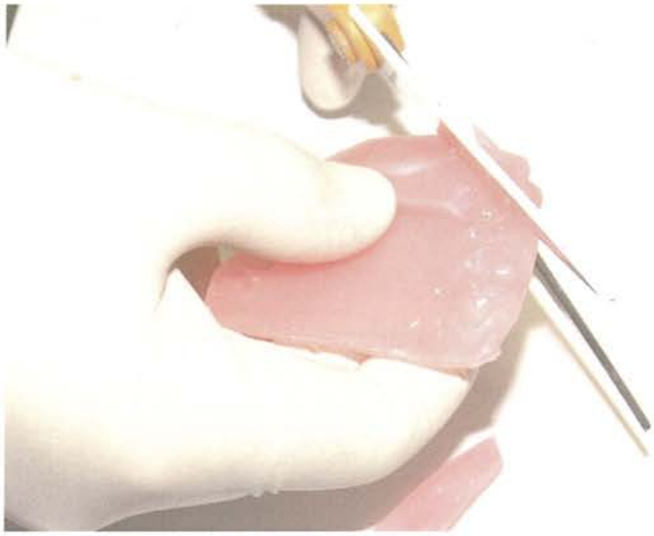
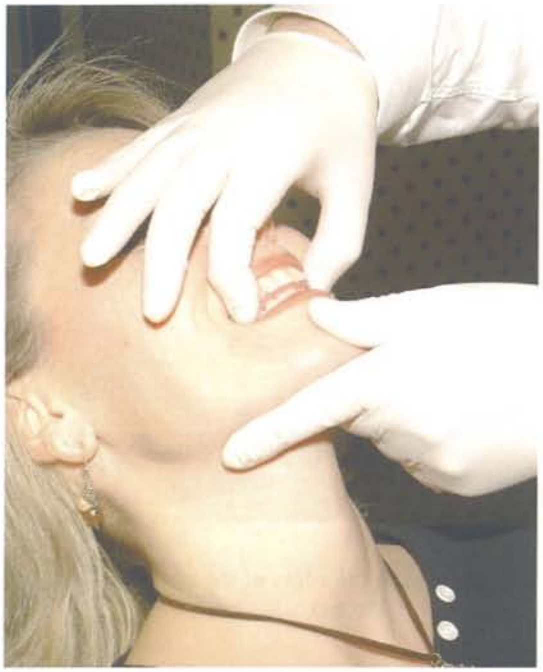
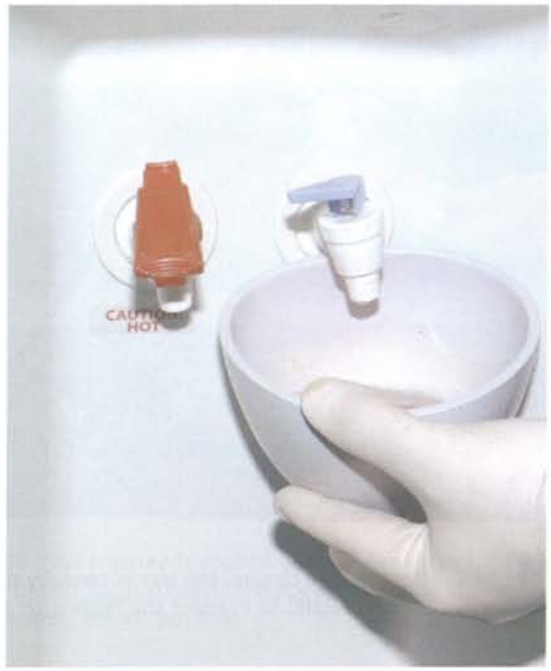


Fig. 4.10B and **C** After the first closure, the wax is carefully removed and accurately trimmed to the edges of the maxillary teeth, using a sharp pair of scissors. It is helpful to examine the impression which the lower incisors make in the wax.

The second wax bite closure

At the second try-in the patient is again gently guided to first tooth contact. It is important to ensure that the lower incisors seat into the original wax impression (Fig. 4.11A). If the lower incisors fail to coincide with the wax indentations at this stage, then the wax bite should be discarded and the process begun again. The wax is then cooled in cold water (Fig. 4.11B) before the third try-in.





Figs 4.11A and **B** At the second try-in the patient is again gently guided to first tooth contact. It is important to ensure that the lower incisors seat into the original wax impression. The wax is then cooled in cold water before the third try-in.

The third wax bite closure

At the third try-in the patient is again guided to first tooth contact for the final time. This is the final verification (Fig. 4.12A). Lower incisor seating into the wax is then checked for repeatability at this third try-in. It should be possible to gently and repeatedly position the relaxed mandible into the wax bite, at the hinge axis. This has an unmistakable clinical 'feel', and provides enough clinical verification for most orthodontic patients, where there is no evidence of TMJ complications. As with the second try-in, if the lower incisors fail to coincide with the wax indentations at this stage, then the wax bite should be discarded and the process begun again. This simple wax bite construction technique records a centric position three times, and is therefore reliable for recording proper mandibular position (Fig. 4.12B).

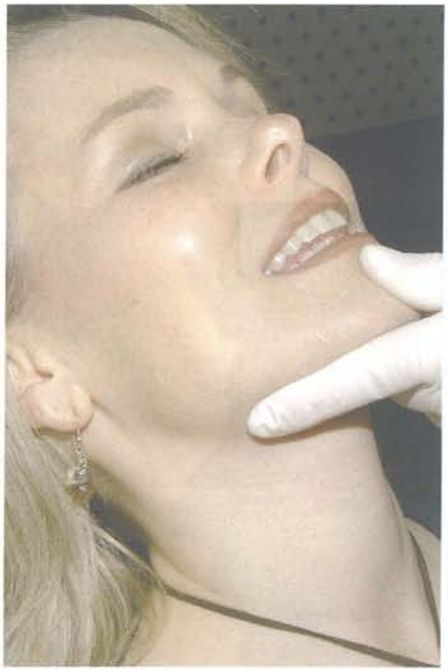


Fig. 4.12A At the third try-in the patient is again guided to first tooth contact for the final verification.

Fig. 4.12B The completed wax bite. This simple technique records a centric position three times, and has proved reliable for recording proper mandibular position.

THE NEED FOR DIAGNOSTIC ACRYLIC SPLINTS

For some patients it is not possible to obtain a repeatable wax bite. If a good quality wax bite cannot be obtained after two or three attempts, a diagnostic acrylic splint is indicated. This should be worn full time for 3–6 months. Also, if at the clinical examination stage it becomes clear that the patient has TMJ symptoms, a TMJ splint is also indicated (p. 200). This will assist in de-programming of the musculature and general healing of the muscles and joints. This process normally takes 3–6 months. After this, a further attempt at taking an accurate wax bite is normally successful.

'BITE-OPEN' WAX BITES

A special 'bite-open' wax bite is helpful for some cases, where the skeletal or dental discrepancy causes compression of the upper lip with the teeth in occlusion. This upper lip compression is seen in cases with vertical deficiency of the maxilla. A bite-open wax bite allows the lips to adopt a non-compressed position (Fig. 4.13). During record taking, this non-compressed lip position can provide more accurate relaxed lip and incisor measurements (Case RS, p. 247).

Construction of the bite-open wax bite involves at least a four-layer thickness of wax, and the bite is registered several millimeters before first tooth contact, depending on the needs of the case. This wax bite registration should be repeated three times, as for normal wax bites, and is used for photography, cephalometry, tomography, and for mounting surgical models.

Fig. 4.13 Profile views of patient RS (p. 247) without (left) and with (right) a bite-open wax bite. The upper lip adopts a non-compressed position, allowing more accurate treatment planning.

ACCURACY DURING FACEBOW AND WAX BITE TRANSFERS

Good laboratory protocol needs to be observed, so that facebow[5] and wax bite errors do not occur during transfer (Fig. 4.14). If such errors occur, it is the equivalent of unintended surgical jaw movement.

Some additional trimming may be needed for the wax bite, and the wax on the facebow, to avoid any soft tissue contact (Case E O'K, p. 129). Commonly, soft tissue contact can occur at the anterior soft palate area (Fig. 4.76). It may also be seen in the tuberosity and retromolar regions. The plaster models also need to be carefully checked to ensure there are no bubbles of plaster which will prevent full seating of the plaster model into the wax.

Fig. 4.14

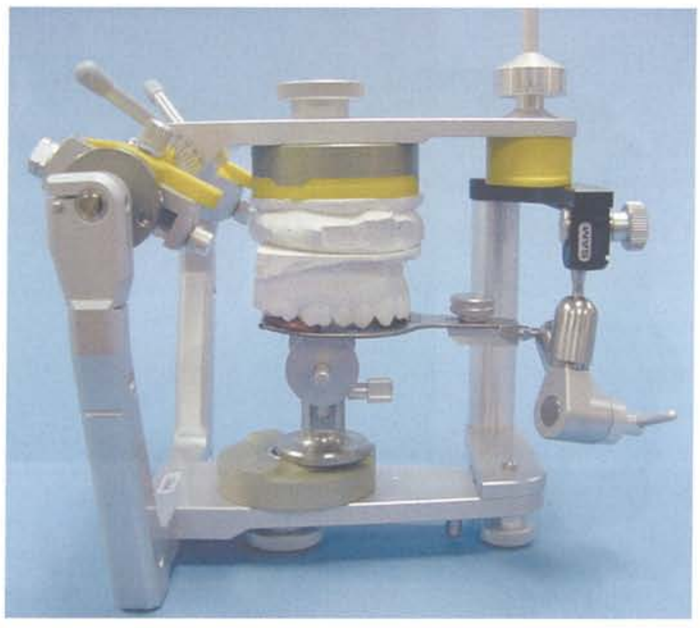


Fig. 4.15

Figs 4.14 and **4.15** Good laboratory protocol needs to be observed, so that facebow and wax bite errors do not occur during transfer. Absolute accuracy is needed when mounting the lower model to the upper model. Some additional trimming of the wax bite, may be needed. This will avoid any soft tissue contact in the anterior soft palate area and tissues posterior to the distalmost molars.

FACIAL PHOTOGRAPHS

The lateral and frontal facial photographs are taken with the head in natural head position, the lips at rest, and with the wax bite in place, to ensure that the condyles are centered in the fossae. If these requirements are not followed, errors will be introduced. Photographs are an important tool in documenting change, and a standardized approach is recommended.[12]

The following technique[13,14] is recommended to obtain relaxed lips during facial photography and for taking lateral cephalometric radiographs.

The patient is asked to relax. The lips are stroked gently, and repeatedly assessed at short intervals. The patient can be observed while being unaware of the observer. In this way it is possible to ensure soft tissue diagnostic accuracy.

If the patient has a vertical deficiency of the maxilla, causing compression of the upper lip, it is helpful to use the 'bite-open' wax bite (p. 104) to take additional photographs, thereby recording the true resting lip position. For these patients, photographs should also be taken without the open bite wax bite in place, to demonstrate the lip distortion.

Fig. 4.16

Routine facial photographs

Three facial photographs are normally taken for all patients (Figs 4.17–4.19). It is helpful to also take a close-up front smile view (Fig. 4.18).

In-depth facial photographs

Seven or more facial photographs can be taken for complex cases, and these photographs (Case TW, p. 84) may sometimes reveal a major discrepancy.

Fig. 4.17 Three facial photos are normally taken for all patients.

Fig. 4.18 A close-up front smile view is helpful

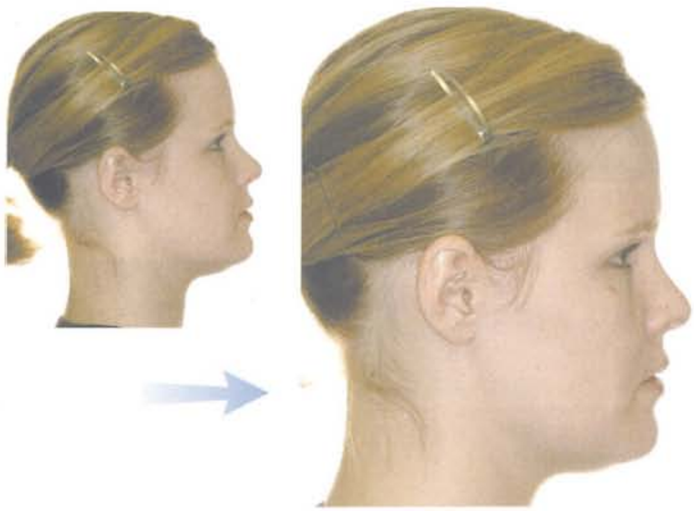


Fig. 4.19 Cropping, re-sizing and re-arrangement of the images is easily achieved digitally.[15]

INTRA-ORAL PHOTOGRAPHS AT CO

Fig. 4.20

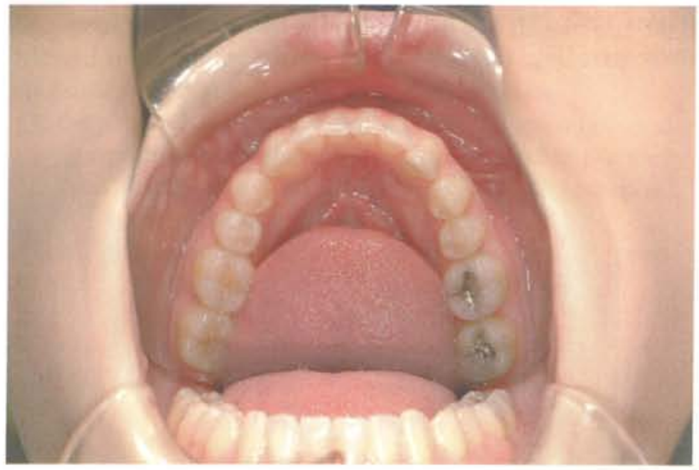


Fig. 4.21

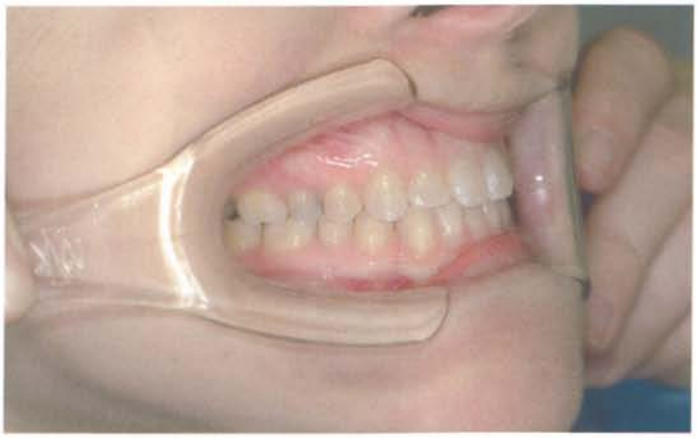


Fig. 4.22

Fig. 4.23

Fig. 4.24

Figs 4.20 to **4.24** These images were taken with a digital camera at deliberately incorrect tilts. Note the images are less 'close up' than with conventional Kodachrome.

INTRA-ORAL PHOTOGRAPHS AT CO (continued)

Fig. 4.25

Fig. 4.26

Fig. 4.27

Fig. 4.28

Fig. 4.29

Figs 4.25 to **4.29** The images on this page were created from the images on page 108 opposite, using the Dolphin™ digital imaging program.[15]

METALLIC MIDFACE MARKERS

Group 2 and group 3 patients requiring in-depth analysis benefit from the application of five metallic markers.[14,16] These are placed on the right side of the face (Fig. 4.30) to mark the following soft tissue structures in preparation for the cephalometric radiograph (Fig. 4.31):

- cheekbone
- soft tissue orbital rim
- nasal base
- subpupil
- neck–throat junction.

Fig. 4.30 In preparation for the cephalometric radiograph five metallic markers are placed on the right side of the face.

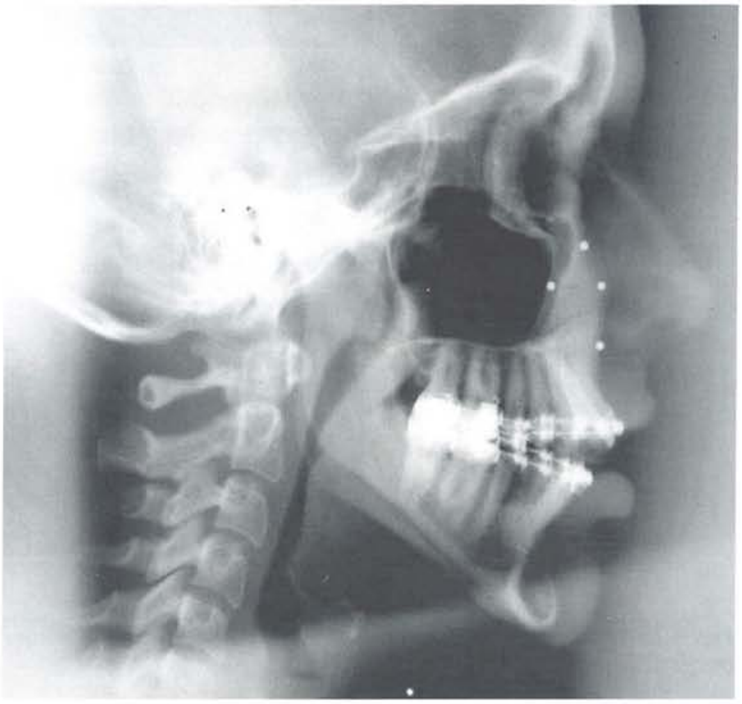


Fig. 4.31 A cephalometric radiograph, taken before surgery, showing the images of the metallic markers.

PLACEMENT OF METALLIC MIDFACE MARKERS

Cheekbone

It is necessary to look across the right cheekbone from the opposite side to see the cheekbone maximum contour, and make a horizontal pen line at that level. Then, in front view, a vertical line through the outer canthus is drawn.

The intersection of these two lines locates the cheekbone point (Fig. 4.32).

Orbital rim

In straight ahead gaze the osseous infra-orbital rim is palpated. The orbital rim point is the intersection of a vertical line through the pupil in straight gaze and the infra-orbital rim (Fig. 4.33).

Fig. 4.32 Cheekbone point

Fig. 4.33 Orbital rim point

Nasal base

The nasal base point is the point of greatest depth adjacent to the alar base of the nose (Fig. 4.34).

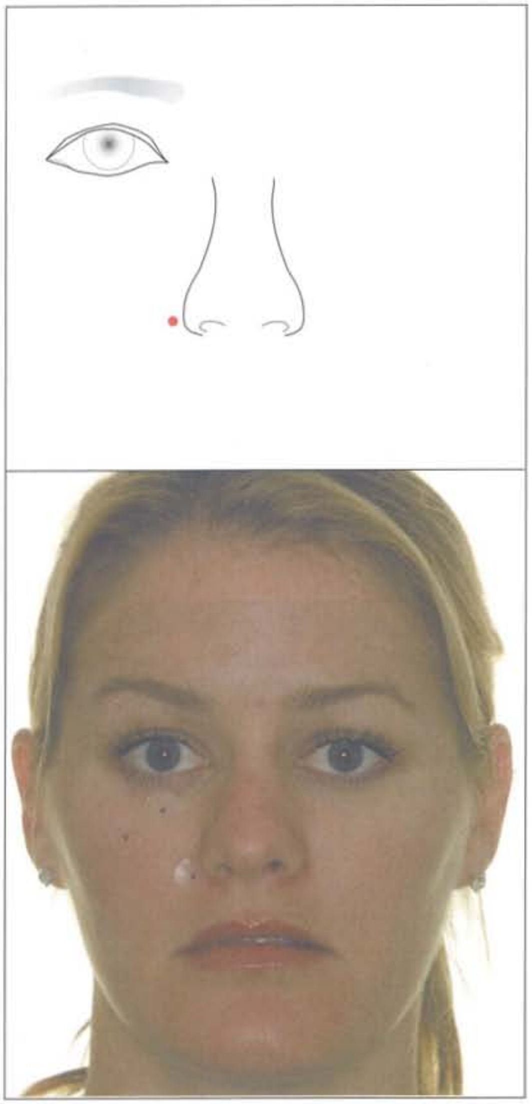


Fig. 4.34 The nasal base point is the point of greatest depth adjacent to the alar base of the nose. It is shown here with cheekbone, orbital rim, and subpupil points.

Subpupil

In straight ahead gaze, the subpupil point is on a vertical line through the pupil, one-half of the distance between the orbital rim point and the nasal base point (Fig. 4.35).

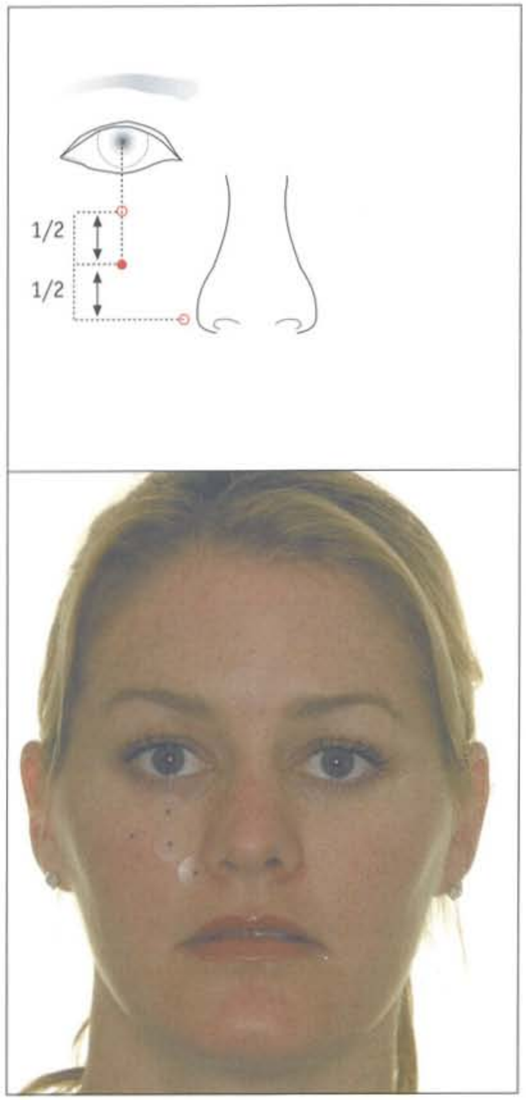


Fig. 4.35 Subpupil point.

Neck–throat point

This records the midline junction of neck to throat (Fig. 4.36), which is extremely difficult to see on standard cephalometric films. It defines throat length, which is neck–throat point to soft issue pogonion, measured horizontal to TVL (pp. 158, 173).

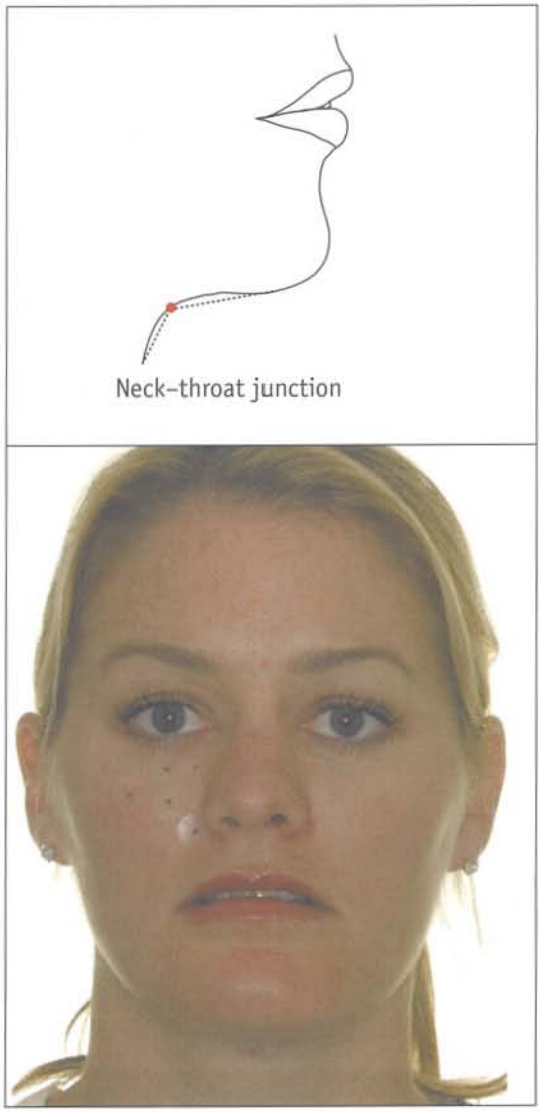


Fig. 4.36 Neck-throat point records the midline junction of neck and throat. The 'Spee-D-Mark' Facial Markers (Catalogue number SDM-FASEM) are manufactured by The St John™ Companies, PO Box 800460, Santa Clarita, CA 97380. 1-800-435-4242.

LATERAL CEPHALOMETRY

The lateral cephalogram is taken with the head in natural head position (pp. 95–96), the condyles seated in the fossae with the wax bite in place, and the lips at rest. If these requirements are not followed errors will be introduced.

Additionally, if the patient has a vertical deficiency of the maxilla, which distorts the level of the upper incisors to the relaxed upper lip, it may be helpful to take the radiograph with a bite-open wax bite (p. 104) in place, thereby allowing a record of the true resting upper lip profile to be made. For later analysis of cases amenable to orthodontic treatment, the mandible needs to be rotated to the correct overbite and vertical dimension, using the centers of the condyles as rotation points. This compensates for the slightly open mandible. However, if the case is surgical, then the position is maintained for the CTP.

PANORAMIC RADIOGRAPHS

Panoramic radiographs (Fig. 4.37) are used[17] by surgeons and orthodontists to exclude the possibility of major abnormality or systemic disease. Additionally, they give a visual indication of the size, shape and cortication (pp. 124, 274) of the condyles. A good quality panoramic radiograph provides a large amount of information for the surgeon or orthodontist. The radiograph is taken with the mandible postured forwards (not in habitual occlusion) to give an improved image of the condyles, avoiding superimposition with the bone of the fossa area. Using digital equipment, the radiation dose can be reduced by more than 40%, with no loss of image quality.[18,19]

The panoramic radiograph reveals major changes in the condyle area and helps to screen the patient for conditions such as syndromes, hyperplasias, and hypoplasias, including many other primary conditions such as osteomyelitis, cysts and tumors. For many orthodontic and orthognathic surgery patients the panoramic view may be the only required radiograph[20] in addition to the cephalometric radiograph.

There is approximately 20% vertical magnification in a panoramic radiograph.[21] Careful positioning of the patient's head is required to avoid producing a distorted image with areas of different magnification, although slight variations in head position have only a minor effect on vertical magnification.[22] Asymmetry indexes have been proposed for use with panoramic radiographs, but findings from these are not reliable.[23]

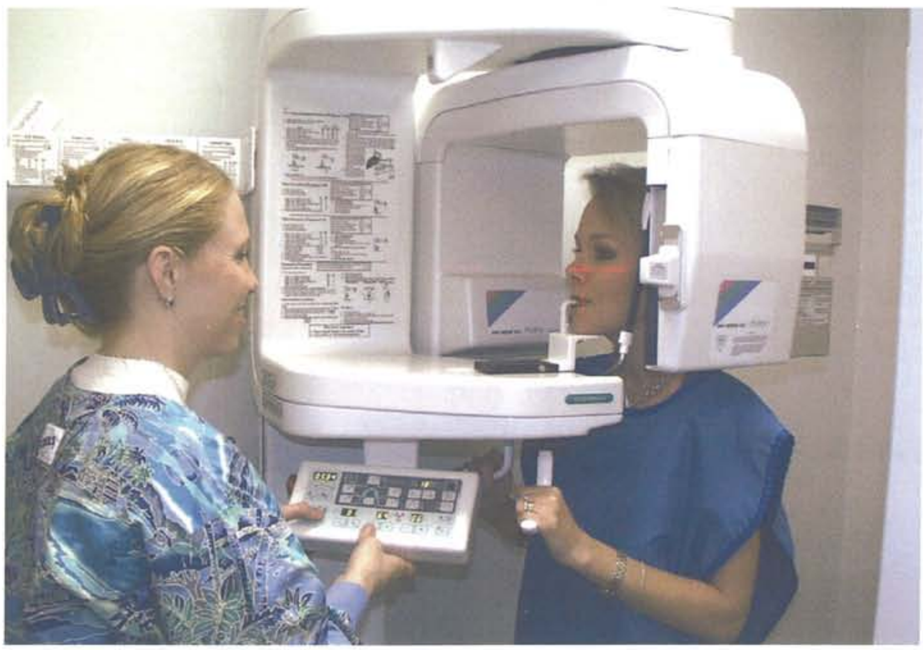


Fig. 4.37

INTRA-ORAL RADIOGRAPHS

The panoramic view is not reliable for initial caries detection, and bitewings are required for this. These are normally available from the referring dentist. In accordance with normal dental and orthodontic procedures, intra-oral radiographs are also required to assist in diagnosis of other dental anomalies such as ectopic canines and impacted or supernumary teeth.

THE USE OF TOMOGRAMS

There are differing opinions about the diagnostic use and relevance of tomograms, because of the high level of electromagnetic radiation involved. They have been shown to be more effective than panoramic views in showing degenerative changes in the joint[24] and they give reliable information about bony changes in the condyle and the fossa. If pathology of the condyles is detected from the panoramic radiograph, this is an indication for taking a tomogram (Fig. 4.38). However, while tomography is very helpful in detecting moderate to severe condylar displacements, it is not accurate in detecting minimal displacements.

For difficult group 2 cases, and for all surgical cases, tomograms (taken with the wax bite in place) are indicated to evaluate bony structures. MRI images can be taken to assess soft tissue structures. The tomogram will be used to evaluate the cortication, size, and shape of the condyles, but will also provide another 'check' for condyle positions in the fossae. Although tomographic assessment of condyle position[25] is not reliable for minimal displacements, it is a helpful supplement to the CR mounting on the articulator.

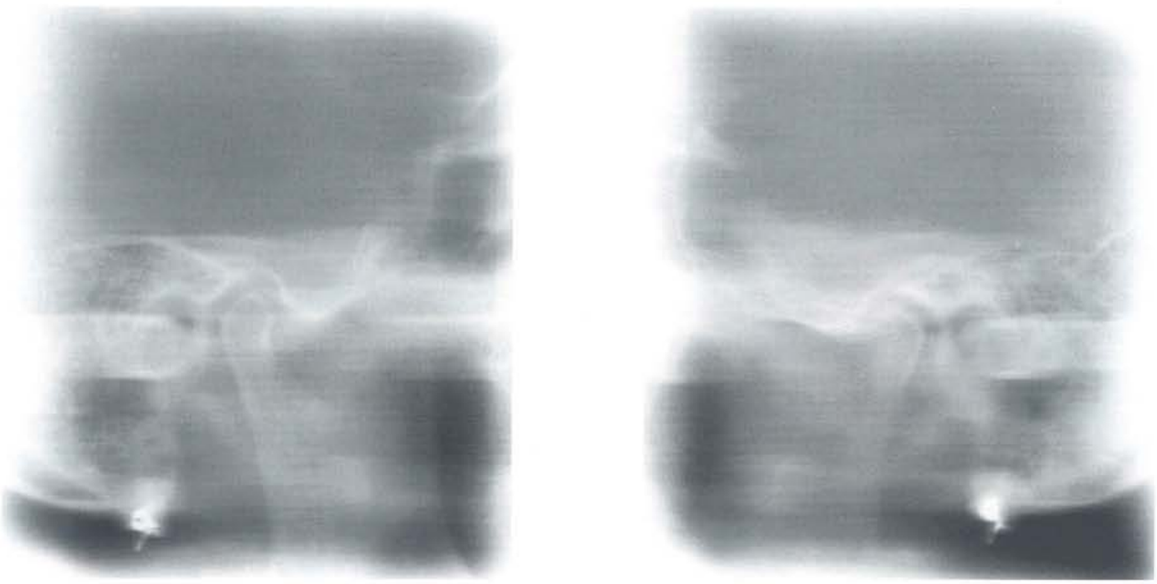


Fig. 4.38 Tomograms involve high levels of electromagnetic radiation, but they have been shown to be more effective than panoramic views in revealing degenerative changes in the temporomandibular joint. If pathology of the condyles is detected from a panoramic radiograph, this is therefore an indication for taking tomograms.

MAGNETIC RESONANCE IMAGING (MRI)

First described in 1946, this form of imaging has seen major developments in the last 20 years. It has the advantage that soft tissue detail is well reproduced, and there is no radiation exposure for the patient. It is therefore the method of choice for patients with disc displacement. In the future, as imaging techniques improve,[26] magnetic resonance imaging (MRI) is likely to see greater use for assessment of bone structures of the joint. There is increasing use of MRI to assess the non-bony aspects of diseased joints, revealing information on changes to the articular surfaces and the disc itself. The use of tomograms is indicated for other structures.

IMPRESSION TAKING AND MODEL MOUNTING

It is essential to follow good chairside and laboratory practice to create high quality dental models. There should be no contact between the metal of the impression tray and tooth substance during impression taking, and the impression should not be removed too soon from the mouth (Fig. 4.39). After removal, it is necessary to check that the impression material has not separated from the tray.

A careful technique should be followed when pouring the models, with adequate time for plaster set, and a visual check for distortion of the teeth or arch form on the completed models.

The authors favor the SAM III articulator (Fig. 4.40A) and the Great Lake Company Model Block (Fig. 4.40B) which both have a convenient design for surgical cases. The manufacturer's recommended mounting method[27] should be followed – extreme care and attention to detail are needed to avoid errors at the model mounting stage.

Fig. 4.39 High quality impressions are needed, free from distortion. There should be no contact between the metal of the impression tray and tooth substance during impression taking, and the impression should not be removed too soon from the mouth.

Fig. 4.40A The SAM III articulator.

Fig. 4.40B Great Lakes Model Block. Model surgery can be accomplished in three planes of space within a hundredth of a millimeter with the Model Block.

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CASE E O'K

This 28.5-year-old female with a Class II malocclusion was seen for consultation. She was referred for surgery even though her malocclusion was probably amenable to orthodontic correction, but without desired facial changes. Diagnosis and treatment were started with the intention of fulfilling the seven goals of treatment. Her patient motivation form indicated that no dental changes were desired. Facially, the patient wanted to get rid of the sag under the lower jaw, move the chin forward, enlarge the cheekbones, show less gingiva when smiling, make the face look more narrow, and reduce the fullness behind the lips. She had a history of intermittent joint noises and some discomfort which she hoped occlusal correction would alleviate. TMJ examination and history, clinical facial examination, soft tissue cephalometric examination, and model examination were obtained. The problem list and treatments were as shown on page 119.

Pre-surgical orthodontics was completed in 12 months. Six months of TMJ stabilization was then accomplished using a splint and medications. After TMJ stabilization, a new antero-posterior diagnosis and treatment plan were accomplished utilizing the seven-step CTP. The frontal midlines, levels, and outline were treatment planned using the frontal clinical examination. A one-piece LFI and BSSO advancement were necessary to correct the occlusion and produce basic facial balance. The occlusal plane was flattened to produce chin projection without advancing the nasal base. To flatten the occlusal plane the posterior maxilla was moved inferiorly. The posterior lengthening of the LFI was stabilized with OsteoMed rigid plates, platelet rich plasma, bone harvested from the anterior nasal floor with the OsteoMed bone harvester, Interpore 200 blocks, and amitriptyline at bedtime to prevent clenching. Improved facial balance was achieved with a 2 mm chin advancement and small Interpore 200 Avitene heat treated cheekbone augmentations. Additionally, the upper lip was reconstructed, increasing the antero-posterior thickness and vermilion height. The patient was maintained on joint medication (minus feldene) for 12 months after the surgery to stabilize the TMJs.

PROBLEM	TREATMENT
1. High midface	
• Normal	• No treatment • Patient requests cheekbone augmentation
2. Maxilla	
Dental	
• Lingual crown torque	• Labial crown torque
Skeletal/facial	
• Upright upper lip	• Maxillary advancement and labial crown torque
• 6 mm relaxed incisor exposure	• Le Fort I (LFI) impaction
• Steep occlusal plane	• Flatten occlusal plane
• Maxillary and mandibular width match in a Class I position	• One-piece LFI
• Deficient upper vermilion height	• Upper lip reconstruction
3. Mandible	
Dental	
• Labial crown torque	• Lingual crown torque • Stripping
Skeletal/facial	
• Chin, and lower lip retrusion	• Maxillary advancement • Bilateral sagittal split osteotomy (BSSO) advancement • Chin augmentation • Flatten occlusal plane to increase chin • Plan with CTP to produce desired nasal base + chin projections
• 2 mm right deviation	• 2 mm left rotation midline
• Throat length–short, sag	• Mandible advancement • Chin augmentation • Flatten occlusal plane
• Right lower third of the face larger	• 2 mm left rotation of the midline
4. TMJ	
• Internal derangement history • Decreased cortex in right TMJ • Small condyles bilaterally	• Splint + medications after orthodontic preparation for 6 months
5. Growth potential	
• 28.5 years old	• Non-factor

Fig. 4.41

Fig. 4.42

Fig. 4.43

Fig. 4.44

Figs 4.41 to **4.44** Pre-orthodontic facial photographs taken in centric occlusion indicate chin retrusion. This was the patient's chief complaint as indicated on the patient motivation questionnaire (p. 33).

Fig. 4.45

Fig. 4.46

Fig. Fig. 4.47

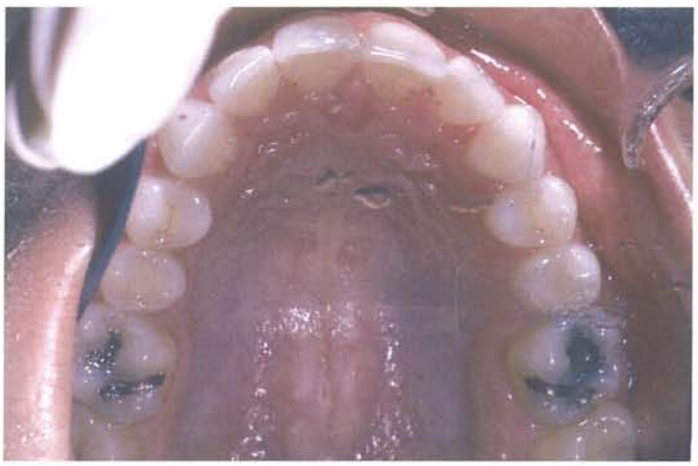


Fig. 4.48

Fig. 4.49

Figs 4.45 to **4.49** Pre-orthodontic intra-oral photograhs taken in centric occlusion indicate a Class I occlusion. The Class II malocclusion is not revealed because the joints are not seated in centric relation.

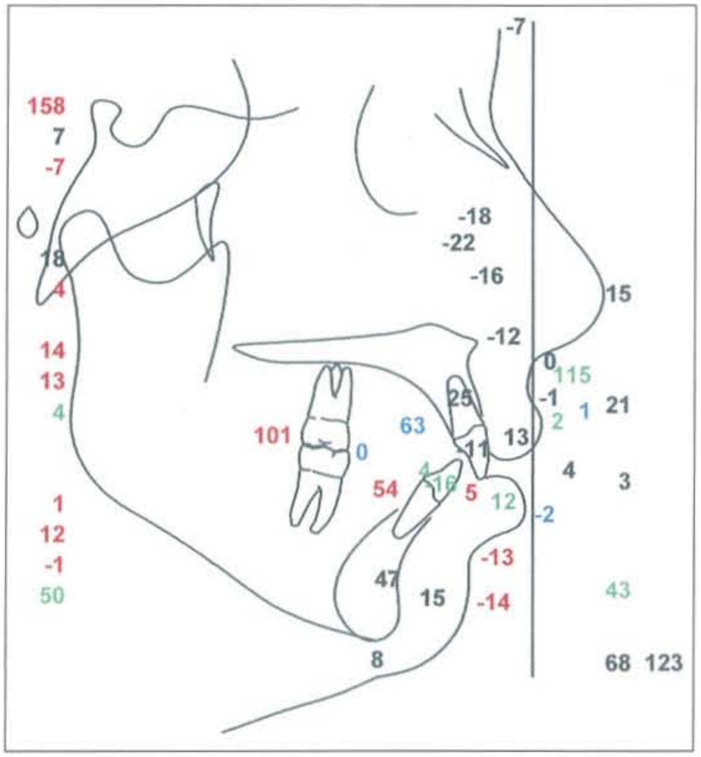


Fig. 4.50 Pre-orthodontic STCA tracing demonstrates upper lip retrusion (115, green; 1, blue; 2, green), mandibular retrusion (−14, red; −16, green), 5 mm of overjet (red), steep occlusal plane (101, red), and upper (63, blue) and lower (54, red) dental compensations for the Class II skeletal pattern.

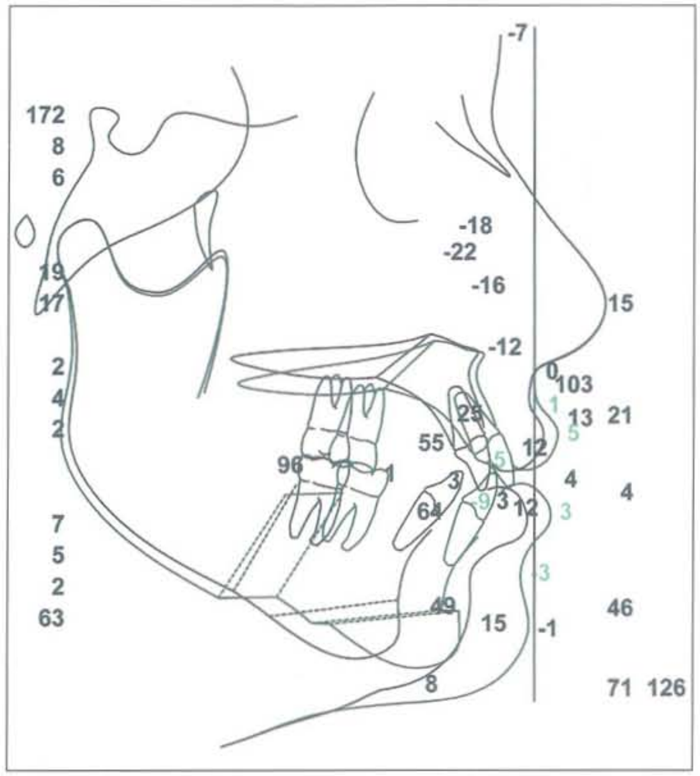


Fig. 4.51 Superimposition of STCA and CTP for case E O'K.

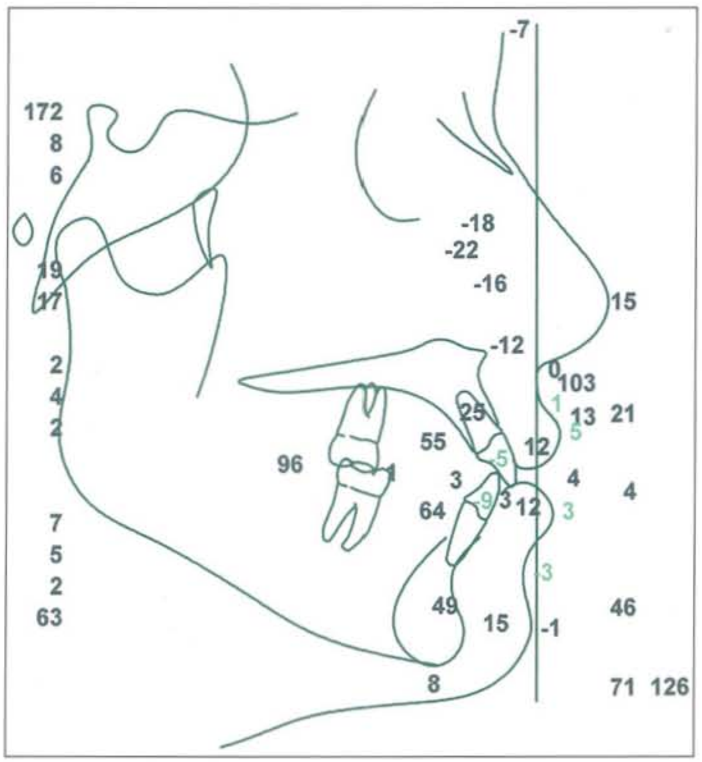


Fig. 4.52 CTP for Case E O'K. The dental compensations and steep occlusal plane have been corrected. The profile is normalized (black or green) and harmony is achieved (black number column on left).

Fig. 4.53 Pre-treatment profile.

Fig. 4.54 Dolphin[15] Imaging™ – facial treatment prediction for comparison with Figure 4.53.

Fig. 4.55

Fig. 4.56

Fig. 4.5

Fig. 4.58

Figs 4.55 to **4.58** Pre-surgical occlusion reveals Class II on the right, near Class I on the left, and lower midline deviation to the right. The patient was positioned in CR prior to photographs.

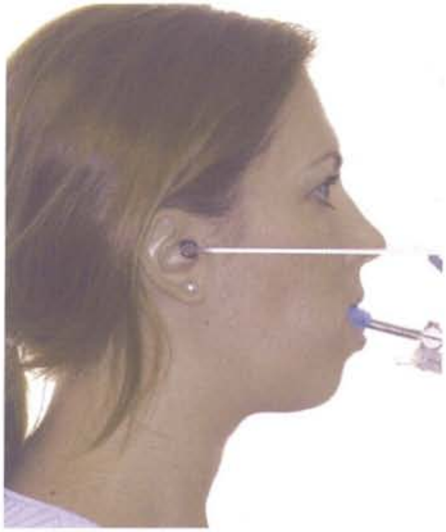


Fig. 4.59 Pre-surgical facebow taken for mounting of study models. Note that the nasal regulator is not used, to allow more accurate natural head posture and to allow the facebow to be taken parallel to postural horizontal. This matches the X and Y axis of the model mount with the head film. This is necessary for accurate model movements.

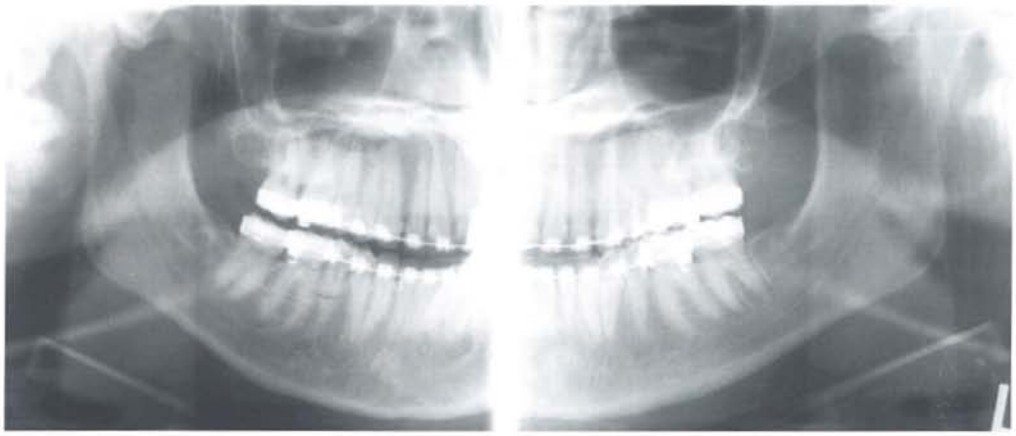


Fig. 4.60 Pre-surgical panoral radiograph with brackets and wires in place.

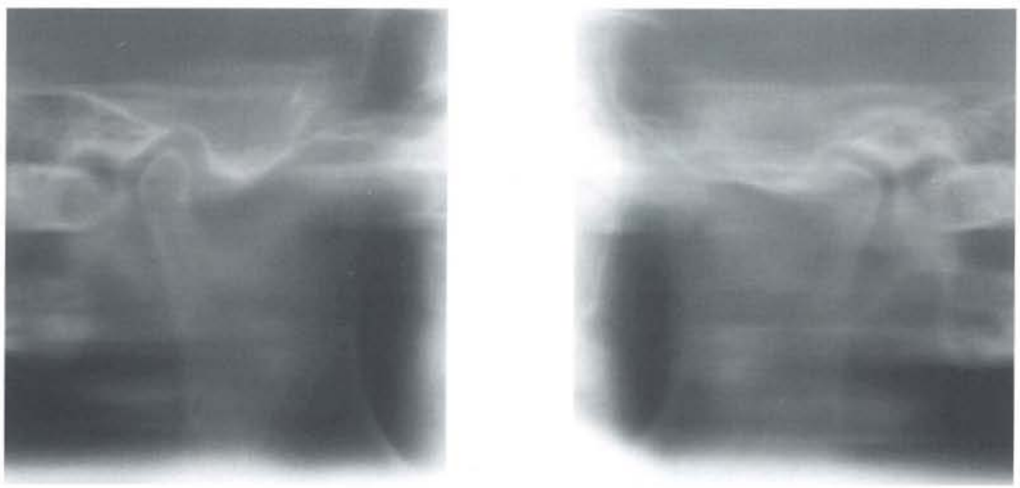


Fig. 4.61 Tomographic radiographs showing condyles of medium size, bilateral antero-superior flattening, normal cortication and position in the fossae. The patient was treated with the splint and medication protocol after orthodontic preparation and before surgery.

Fig. 4.62

Fig. 4.63

Figs 4.62 and **4.63** Pre-surgical profile facial views in closed lip and relaxed lip positions. Note: normal high midface, upper lip upright, normal nasal base, moderate chin retrusion, and lip strain. The patient requested cheekbone augmentations; therefore this was part of the treatment plan. The wax bite is in place.

Fig. 4.64

Fig. 4.65

Fig. 4.66

Figs 4.64 to **4.66** Pre-surgical closed lip, relaxed lip, and smile frontal photographs. Note: excessive relaxed lip incisor exposure, excess gingival smile, large inter-labial gap, and lip strain. The wax bite is in place.

Fig. 4.67

Fig. 4.68

Figs 4.67 and **4.68** Pre-surgical right and left three-quarter facial photographs. Note: the normal cheekbone contours and the retruded mandible. The patient had requested cheekbone augmentation on the patient motivation form. The wax bite is in place.

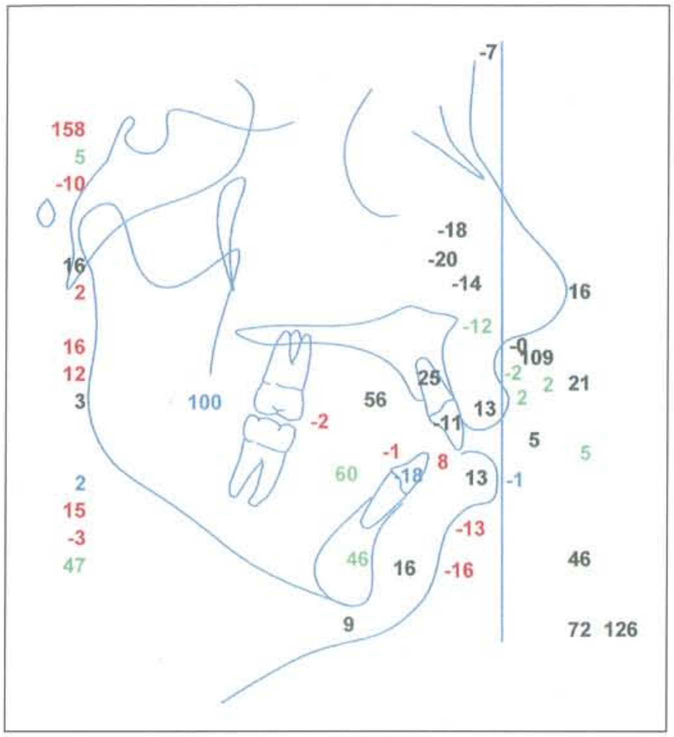


Fig. 4.69 Pre-surgical STCA showing mild upper lip retrusion (–2, green; 2, green), severe mandibular retrusion (–18, blue; –16, red), short chin height (46, green), and steep occlusal plane (100, blue).

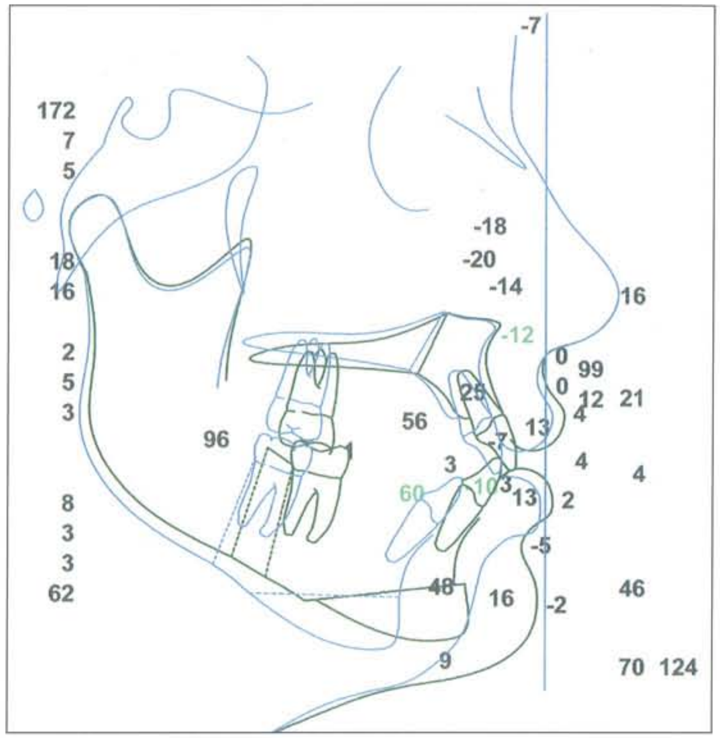


Fig. 4.70 Superimposition demonstrating changes between STCA and CTP. The dental and skeletal changes were planned to produce facial balance.

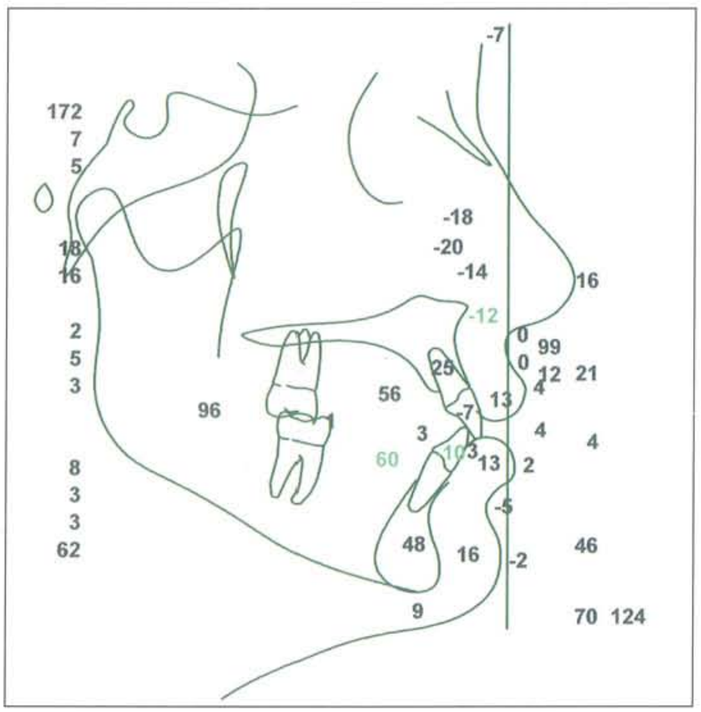


Fig. 4.71 The CTP showing maxillary dental advancement (–7, black), and mandibular advancement (–10, green). The occlusal plane was flattened (96, black) to produce nasal base (–12, green) and chin (–2, black) esthetics.

Fig. 4.72

Fig. 4.73

Fig. 4.74

Figs 4.72 to **4.74** Three views of centric relation mounted models – SAM III articulator.

Fig. 4.75 and **Fig. 4.76** Wax bite (mandibular side – Fig. 4.75 (left); maxillary side – Fig. 4.76 (right)) used to mount the models. The most common mounting error is pink wax bite contact with the anterior soft palate or soft tissues posterior to the molars. These wax bite to soft tissue model contacts produce incorrect mountings which are the equivalent of unintended surgical movements.

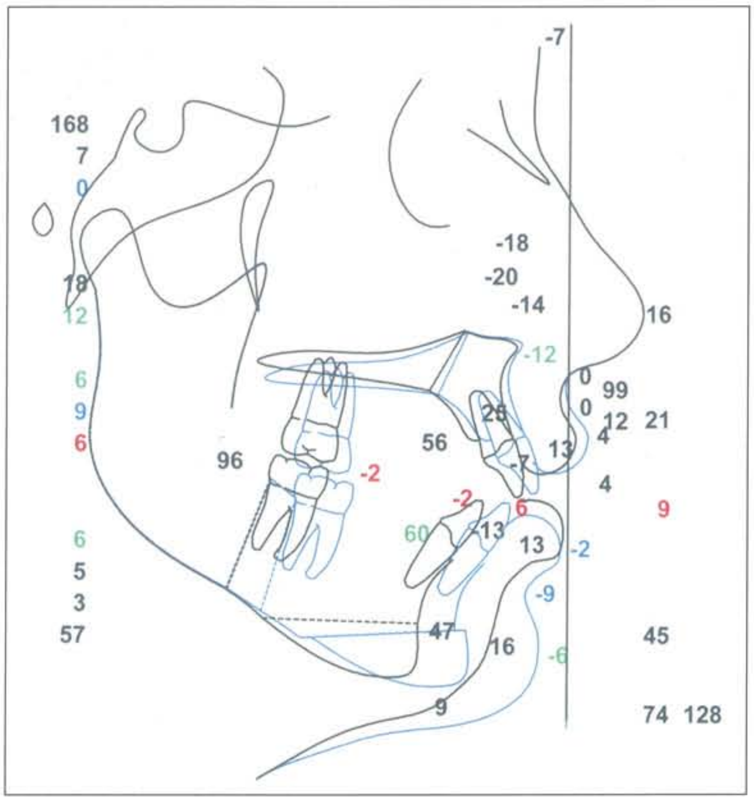


Fig. 4.77 This is the CTP from Fig. 4.70 with the mandible auto-rotated on the hinge to an open bite (–2, red; incisor open bite). When we perform two jaw surgery, as with this patient, the mandible is done first on the articulator model surgery and at the actual surgery. This improves the accuracy of the surgical movements for several reasons. To facilitate accuracy with the model surgery the mandibular position on the finalized CTP is auto-rotated open. The measurements from the new auto-rotated mandibular position are then used to guide the movements of the mandible for the articulator model surgery. This rotational opening of the mandible on the patient's accurate radiograph hinge axis allows the mandibular model to be advanced unimpeded by the maxillary teeth. If contact were to be made between the model's mandibular and maxillary dentitions, the articulator pin would open. This would produce model surgery inaccuracy as the articulator's arc of rotation is different than the patient's actual opening arc of rotation (hinge axis).

Fig. 4.78

Fig. 4.79

Fig. 4.80

Fig. 4.81

Figs 4.78 to **4.81** Post-treatment intra-oral photographs.

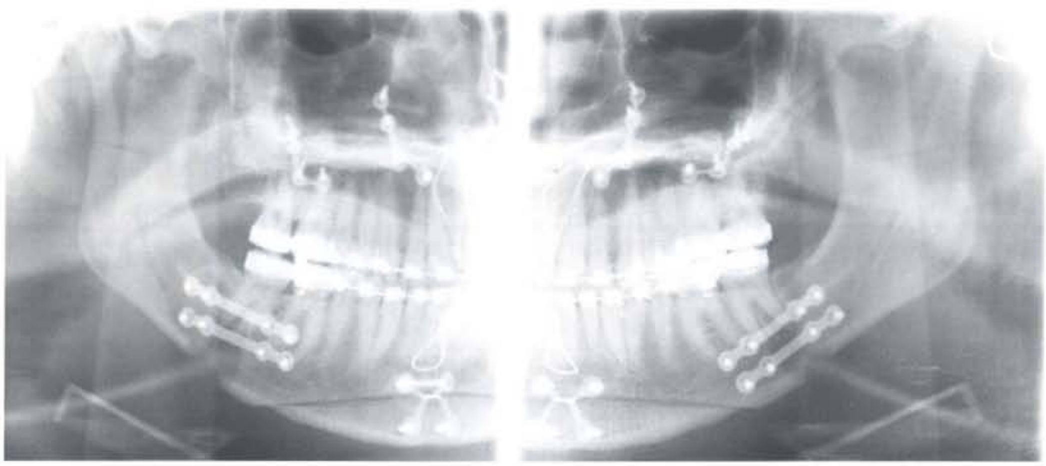


Fig. 4.82 Post-surgical panoral radiograph. Note: two plates per sagittal osteotomy advancement site. Two plates are used with large advancements or when the lower jaw is operated first. These plates are designed by OsteoMed Corporation specifically for this purpose.

Fig. 4.83

Fig. 4.84

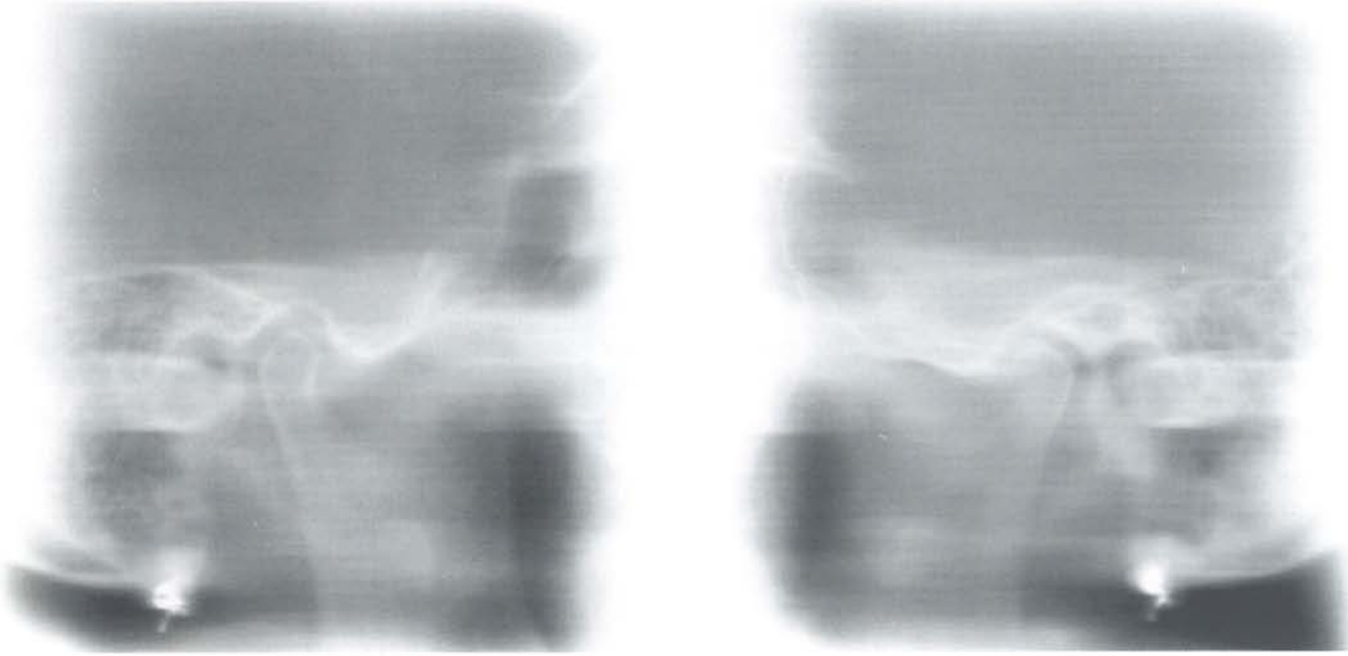
Figs 4.83 and **4.84** Final closed lip and relaxed lip photographs. Note: normal facial projection and heights.

Fig. 4.85

Fig. 4.86

Fig. 4.87

Figs 4.85 to **4.87** Final closed lip, relaxed lip and smile photographs. Note: normal height and facial outline.



Figs 4.88 Post-surgical right and left tomograms. Note: condyles centered in the fossae and showing local remodeling consistent with presurgical tomograms.

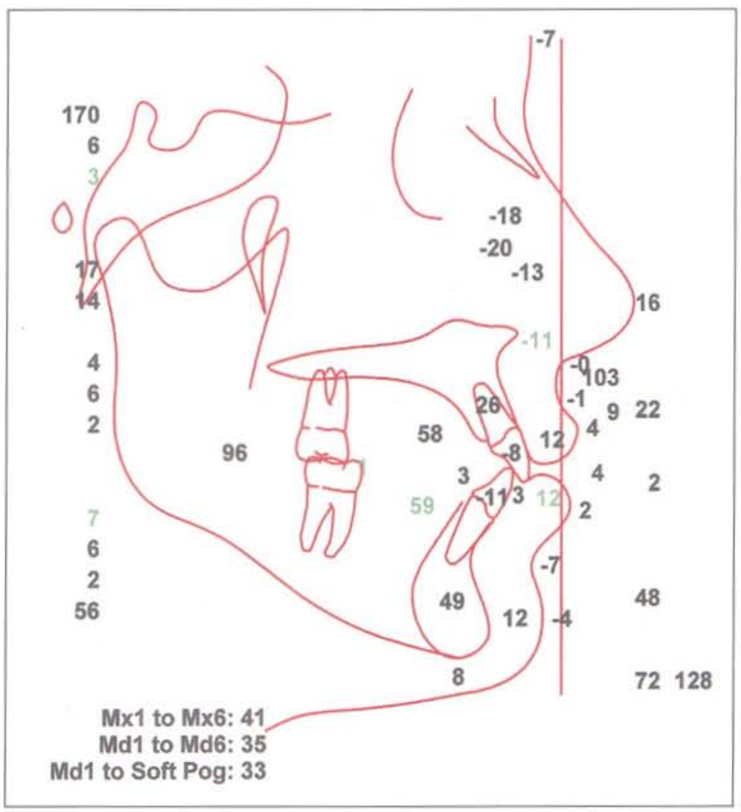


Fig. 4.89 Final STCA showing normal projections and heights. The occlusal plane was flattened (96, blue) to produce esthetic projections of the nasal base and chin.

Fig. 4.90

Fig. 4.91

Figs 4.90 and **4.91** Right and left three-quarter facial photographs. Note: normal projections and contours.

Fig. 4.92

Fig. 4.93

Figs 4.92 and **4.93** Pre- and post-surgery photographs.

The orthodontic treatment for this chapter was provided by Dr Gregory W. Evrigenis. The authors gratefully acknowledge his assistance in treating this patient.

5

Diagnosing the case

INTRODUCTION

It is important to review all the information obtained from the patient history, the clinical examination, and the patient records (Fig. 5.1). From this it is possible to diagnose the case in three areas:

1. The musculature and TMJs
2. The face
3. The dentition

It is essential to list the problems in these categories, before moving on to treatment planning and asking the question 'How do I solve the problems?' If this sequence is not followed, it is possible to make errors in treatment planning that may lead to less-than-ideal results.

During the diagnostic work-up, the orthodontist and orthognathic surgeon will identify the true nature of the case. They will recognize what should be corrected, and they will decide where to focus their energy and treatment skills for the patient.

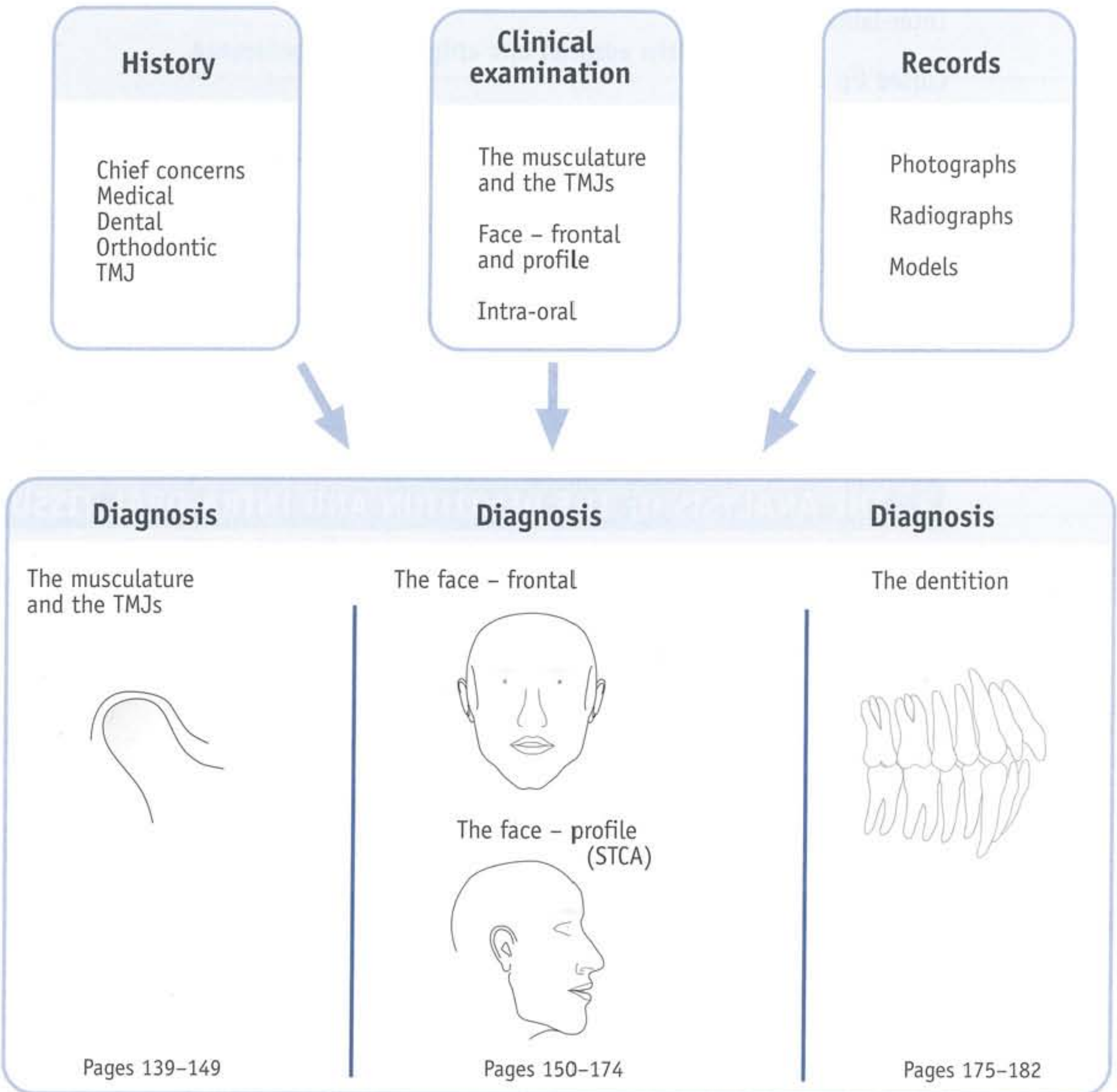


Fig. 5.1 It is important to review all the information obtained from the patient history, the clinical examination, and the patient records, before proceeding to diagnose the case.

1. THE MUSCULATURE AND THE TMJs

GENERAL OVERVIEW

Before considering facial planning, it is important to decide if the patient has any kind of problem with head, neck and TMJ pain and/or dysfunction. The patient's history, clinical examination and records provide information in this area. If so, it is necessary to make a differential diagnosis, to decide if the problem should be managed by the orthodontist, the oral surgeon or another specialist.

Various classifications of head, neck, and TMJ pain and dysfunction have been presented over the years. In 1996, the American Academy of Orofacial Pain[1] established a classification, which is shown in Figure 5.2. This list is included in order to assist in making a differential diagnosis. However, it is beyond the scope of this text (which is focused on dental and facial planning) to discuss all the conditions named in this classification. If required, additional information should be sought from other sources.

All the conditions on the list should be referred to other specialists for management, with the exception of temporomandibular disorders.

Head, neck and TMJ pain and dysfunction (Classification published in 1996 by the American Academy of Orofacial Pain)

Intracranial pain disorders
- Neoplasm, aneurysm, abscess, hemorrhage, hematoma, edema

Primary headache disorders (neurovascular disorders)
- Migraine, migraine variants, cluster headache, paroxysmal hemicrania, cranial arteritis, carotidynia, tension-type headache

Neurogenic pain disorders
- Paroxysmal neuralgias
  - Trigeminal, glossopharyngeal, nervus intermedius, superior laryngeal neuralgias
- Continuous pain disorders
  - Deafferentation pain syndromes (peripheral neuritis, post-herpetic neuralgia, post-traumatic and post-surgical neuralgia)
- Sympathetically maintained pain

Intra-oral pain disorders
- Dental pulp, periodontium, mucogingival tissues, and tongue

Temporomandibular disorders
- Masticatory muscles, temporomandibular joint, associated structures

All the conditions listed should be referred to other specialists for management, with the exception of temporomandibular disorders

Associated structure pain
- Ears, eyes, nose, paranasal sinuses, throat, lymph nodes, salivary glands, and neck

Axis II, mental disorders
- Somatoform disorders

Pain syndromes of psychogenic origin

Fig. 5.2

TEMPOROMANDIBULAR DISORDERS (TMDs)

These are disorders of the muscles and joints. They can be managed by the orthodontist and oral surgeon (with the exception of some neoplasias). Their primary cause has been stated to be trauma and/or parafunctional habits, but there are other factors which should be considered, and these are discussed below.

The American Academy of Orofacial Pain classified temporomandibular disorders (TMDs) into two categories (Fig. 5.3):

- Muscle problems – known as 'masticatory muscle disorders'
- Joint problems – known as 'temporomandibular joint articular disorders'.

If a TMD exists it is important to determine if the problem is related to the musculature, the TMJs, or a combination of the two. If the joints are involved, then the type and degree of joint dysfunction must be decided.

Masticatory muscle disorders

Myofascial pain
Myositis
Myospasm
Local myalgia-unclassified
Myofibrotic contracture
Neoplasia

Muscle problems

Temporomandibular joint articular disorders

Congenital or developmental disorders
  Aplasia
  Hypoplasia
  Hyperplasia
  Neoplasia
Disc derangement disorders
  Disc displacement with reduction
  Disc displacement without reduction
Temporomandibular joint dislocation
Inflammatory disorders
  Capsulitis/synovitis
  Polyarthritides
Osteoarthritis (non-inflammatory disorders)
  Osteoarthritis: primary
  Osteoarthritis: secondary
Ankylosis
Fracture (condylar process)

Joint problems

Fig. 5.3 The American Academy of Orofacial Pain classification of temporomandibular disorders.

CONDYLAR REMODELING – A KEY ISSUE FOR ORTHODONTISTS AND ORTHOGNATHIC SURGEONS IN FACIAL PLANNING

The details of each area of the classification of temporomandibular disorders (p. 140) will not be discussed because they are beyond the scope of this text. However, this chapter will deal with the important topic of joint remodeling.

The significance of remodeling

As stated in the opening chapter, the TMJs are the foundation on which occlusal correction is built, and there is a need for awareness concerning the etiology, diagnosis, and treatment of condylar remodeling. The effect of this remodeling on occlusal and facial treatment stability needs to be understood. It has significance for the orthodontist and orthognathic surgeon during facial planning.

The majority of young orthodontic patients present with healthy joints. Subsequent treatment proceeds uneventfully, and they continue to be free of problems during and after orthodontic treatment. However, a small percentage of orthodontic patients present with evidence of condylar remodeling, or have apparently healthy joints pre-treatment, but develop condylar remodeling during or after treatment. This can have a disastrous effect on the treatment outcome.

Recognizing condylar remodeling and its effects

Against this background, orthodontists and orthognathic surgeons need to recognize joint remodeling. They need to be able to identify patients with an increased risk of future remodeling, and inform them of this possibility. Also, they need to avoid treatment procedures which compress the joints and can lead to an increased risk of joint remodeling.

The orthognathic surgeon has a much higher involvement with temporomandibular disorders than the orthodontist. This reflects a very different referral group, including more difficult cases, normally with a high percentage of female patients in the 15- to 35-year-old age group. Within this group are those who have had deficient condylar growth and have developed large overjets. In females problems often begin in the 12–17 year range. If late relapse occurs, after occlusal correction, condylar remodeling is a predominant cause. In some cases, after achieving a pleasing Class I result, the occlusion slowly relapses into a Class II overjet (Figs 5.4–5.6). This type of relapse is seen in orthodontic practice and in orthognathic surgery cases. It may be more common than is realized and it will be discussed in detail in this chapter.

Fig. 5.4

Fig. 5.5

Figs 5.4 and **5.5** Condylar remodeling is a predominant cause of late relapse, following orthodontic or surgical correction, as seen in this surgical case. After achieving a pleasing Class I result, the case slowly relapses into a Class II outcome. Note: no mandibular advancement was done, and yet, the mandible relapsed.

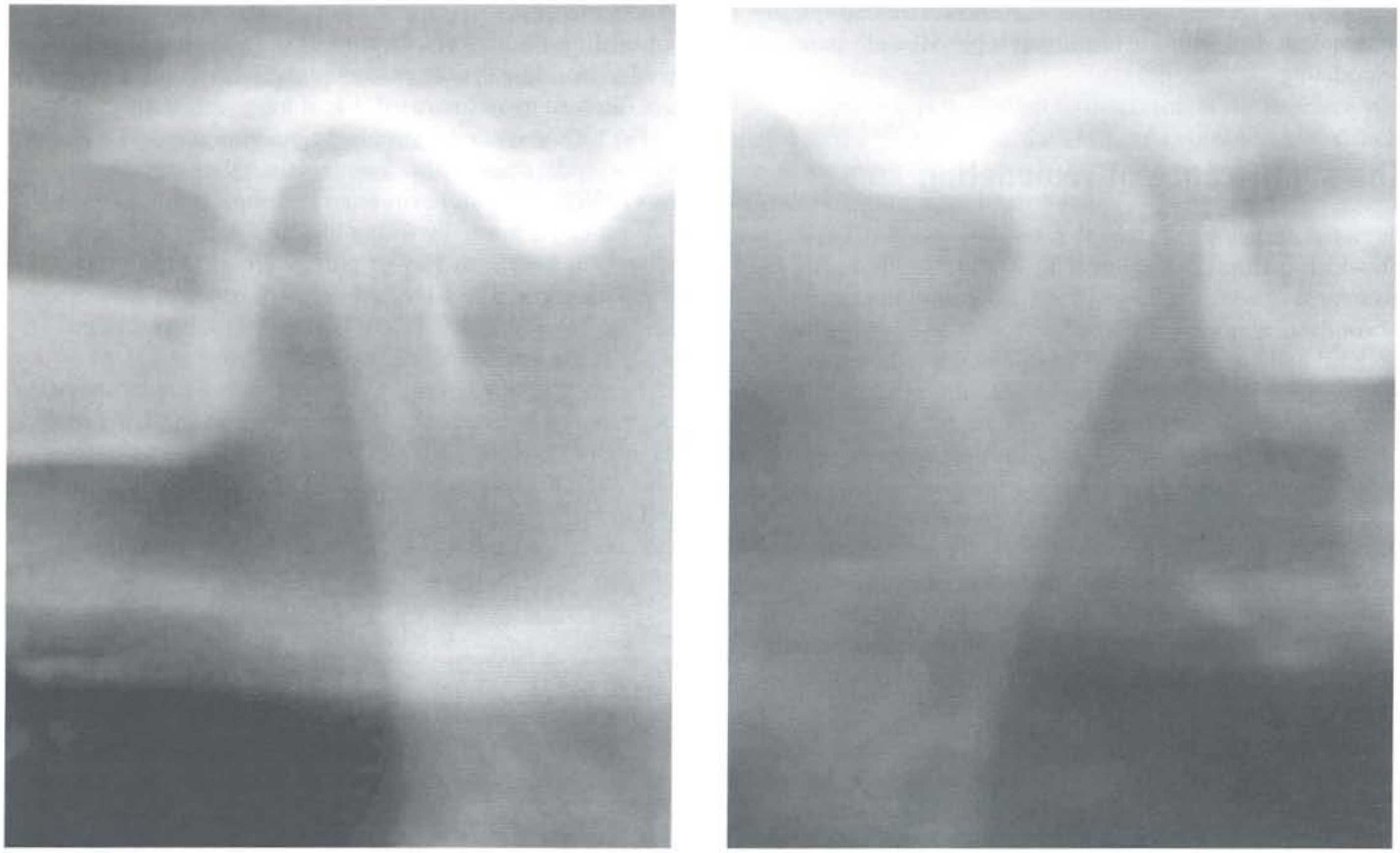


Fig. 5.6 Tomograms to show the appearance of remodeled condyles on a non-surgical case. Note: the loss of condylar head volume, flattening, and loss of the condylar head to neck angle. These condyles may remodel during orthodontic treatment increasing the Class II overjet and open bite.

TYPES OF CONDYLAR REMODELING – LOCAL AND TOTAL

Local condylar remodeling

This is characterized by limited morphologic changes, stable ramus height, stable occlusion, and normal growth.

Local remodeling involves:

- only a portion of the head of the condyle
- no decrease in ramus height
- no mandibular retrusion and bite changes in adults
- no impaired growth in growing patients.

Total condylar remodeling

This involves significant morphologic change. This reduces ramus height, creates progressive mandibular retrusion, and diminishes the growth rate when present. The significance of total remodeling is that the occlusion undergoes a slow change towards Class II overjet after occlusal treatment, as the condyles change size and shape (Figs 5.7 & 5.8).

Total remodeling involves:

- the entire head of the condyle
- decreased ramus height
- mandibular retrusion and bite changes in adults
- impaired growth in growing patients.

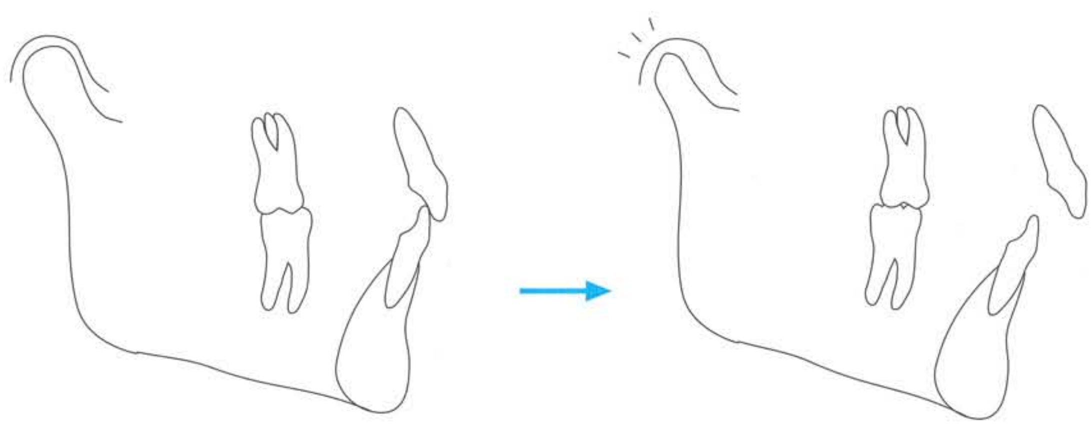


Fig. 5.7 **Fig. 5.8**

Figs 5.7 and **5.8** During total remodeling the occlusion undergoes a gradual change towards Class II, with or without an open bite as the condyles change size and shape.

ETIOLOGY OF TOTAL CONDYLAR REMODELING – INSTABILITY FACTORS

If joint instability factors are present, total condylar remodeling can occur,[2,3] and this produces 'B' point relapse. Three recognized instability factors are:

- The adaptive capacity of the patient
- Joint compression
- Joint anatomy which is prone to remodeling.

The adaptive capacity of the patient

Age and gender,[4] hormone levels,[4,5] and systemic diseases[6] have been associated with diminished host adaptive capacity. Total remodeling has been linked to teenage females, hyperparathyroidism, corticosteroid excess and autoimmune diseases.[2,3] Most important to dental treatment is the relatively high incidence of young females with uncontrolled, total remodeling. This is related to different TMJ estrogen receptor numbers, estrogen levels, and possibly prolactin levels which are associated with female TMJs. Imbalances in patient adaptive capacity can initiate joint remodeling in isolation, but they are particularly damaging when combined with joint compression.[5] This compression can be associated with occlusal treatment which displaces the condyle from its physiological uppermost position.

Joint compression

Many animal studies have shown that joint compression leads to soft tissue and hard tissue changes within the TMJs.[7-11] It can be argued that similar changes can be produced if the TMJ is compressed due to orthognathic surgery, orthodontics or restorative dentistry.

Several sources of joint compression have been identified in the literature. These include orthognathic surgery,[5,12] orthodontics,[4,13] general dentistry,[14] internal derangement,[15-17] parafunction,[18] unstable occlusion,[7-11,19] and trauma.[4]

When any type of occlusal treatment displaces condylar position, the condyle and fossa alter shape and form. With tomograms, Peltola[13] and Mongini[14] discovered that equilibration and orthodontic treatment created local condyle changes.

Arnett et al[12] demonstrated that orthognathic surgery which torqued the condyles or moved them posteriorly could cause local or total remodeling. They further demonstrated that condylar displacement at the time of surgery led consistently to late condylar remodeling and 'B' point relapse. Parafunction and internal derangement may produce condylar remodeling in isolation, but can be particularly destructive when combined with dental treatment which displaces the condyles.

In animal studies, where unstable occlusions have been created with a centric occlusion/centric relation (CO/CR) discrepancy, consistent histologic and morphologic changes have been demonstrated in the TMJs.[7-9,11,19] These changes are secondary to compression which occurs when a CO/CR disparity exists. If occlusal treatment leads to compression of the TMJ when the teeth are in occlusion, this will be unstable, and the joints will undergo morphologic changes as seen in animal and human studies.

Finally, mandibular trauma can be a source of joint compression. One traumatic blow to the mandible has been reported to produce TMJ change and, subsequently, slow development of a Class II overjet.[4,5,12,20]

Condylar anatomy – stable, unstable and immature types

Stable condylar anatomy

This is characterized by full cortication, an angle change between the condyle neck and condyle head, normal condylar size, and a clear appearance on tomography (Fig. 5.9). Stable condylar anatomy is less prone to total remodeling when dental treatments produce compression.

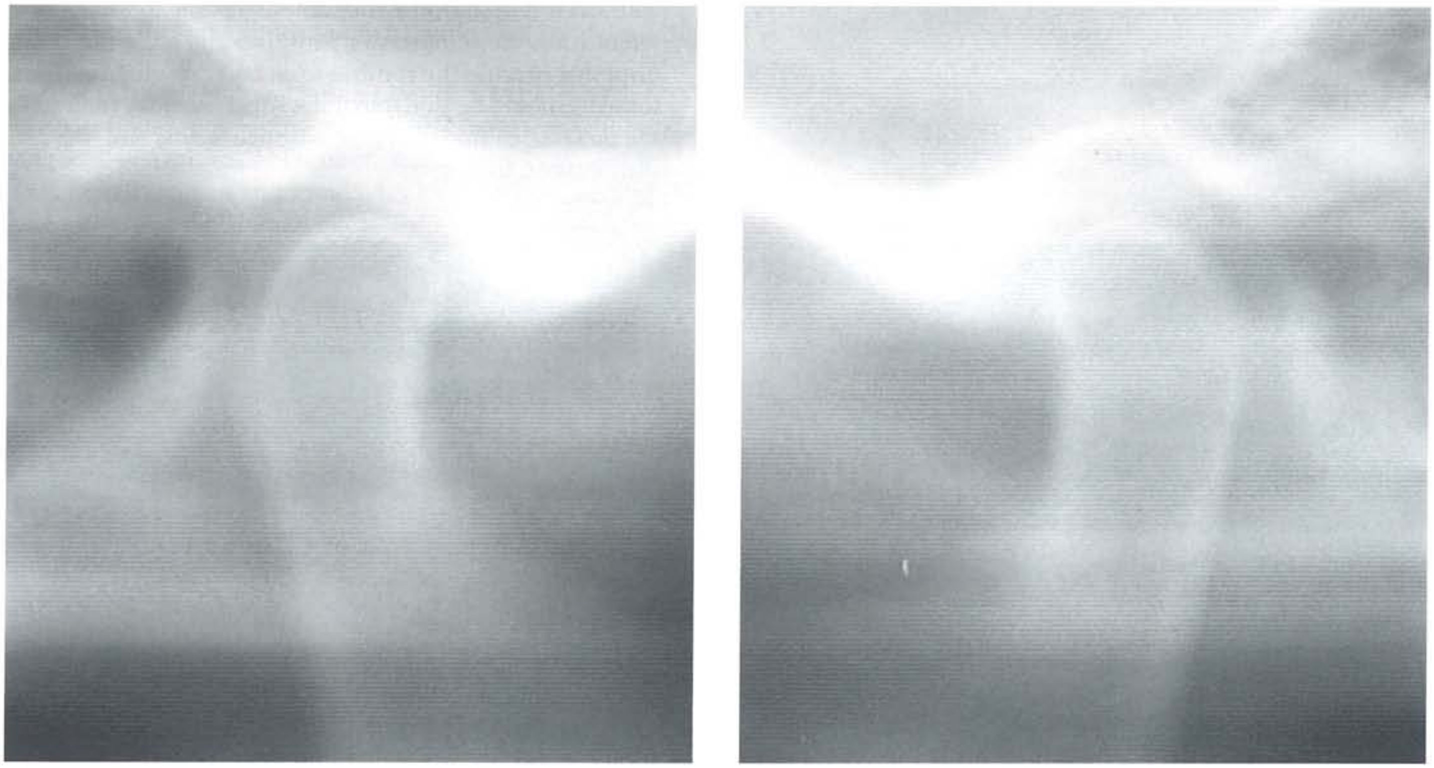


Fig. 5.9 Tomograms showing the features of stable condylar anatomy. Well-formed condyles of this type are less prone to total remodeling.

Unstable condylar anatomy

This is identified by decreased cortication and straight alignment of the neck and head of the condyle (Fig. 5.10A). The condyles show small size, with a fuzzy tomographic image, and are prone to total remodeling if displaced during treatment (Fig. 5.10B)

Immature condyles

These are defined as not having cortication (cortication occurs at 15–16 years of age). They show decreased head/neck angle, normal size, distinct tomographic image, and are prone to remodeling during treatment because of lack of cortication.

Condyle size

This is regarded as the single most important factor influencing the stability of condyles when displaced by treatment.

- Large condyles (larger surface areas) provide stable support for occlusal changes. For example, they are associated with many Class III malocclusions and some Class II malocclusions. They are generally not susceptible to total remodeling, and are less sensitive to compression. They are considered to be more resistant to displacement because of the tight fit of the fossa, condyle and capsule.
- Small condyles (small surface area) provide unreliable support for occlusal changes, and are frequently associated with Class II occlusions. They are susceptible to total remodeling, are compression sensitive, and are easily displaced because the condyle fossa and capsule fit is loose. It should be noted that the small size may indicate the presence of impaired host adaptive factors and compression factors.

Fig. 5.10A Intermediate stage total condylar remodeling. Note the loss of the head-neck angle, anterior beak, small size, and flat antero-superior surface. The occlusion has changed by this time. When total remodeling reaches advanced stages, it is difficult to see the condyle clearly with tomography.

Fig. 5.10B Early stage changes of total remodeling. Often, the left and right joints changes at different times. This condyle shows early changes, indicated by anterior beaking and mild antero-superior flattening. The occlusion may be unchanged at this stage.

DIAGNOSING CONDYLAR REMODELING

The history form and the patient examination

A diagnosis of TMJ remodeling is based on answers to specific questions and on examinations intended to expose the unstable joint. The completed TMJ history (p. 41) form will indicate if remodeling is present (Fig. 5.11A). The questions are designed to reveal if the bite is undergoing change, if compression factors are present, and if patient adaptive capacity problems may be present. In other words, the TMJ history form reveals information on condylar resorption. Importantly, it indicates if the bite is changing, the teeth are occluding unevenly, or the chin is moving backwards. Positive answers to these questions imply ongoing total condylar remodeling.

The TMJ patient examination form (p. 149) is used to uncover the most common clinical sign associated with total remodeling, which is multiple clicks. The facial examination may reveal a convex and sometimes long facial appearance, if there is an associated open bite.

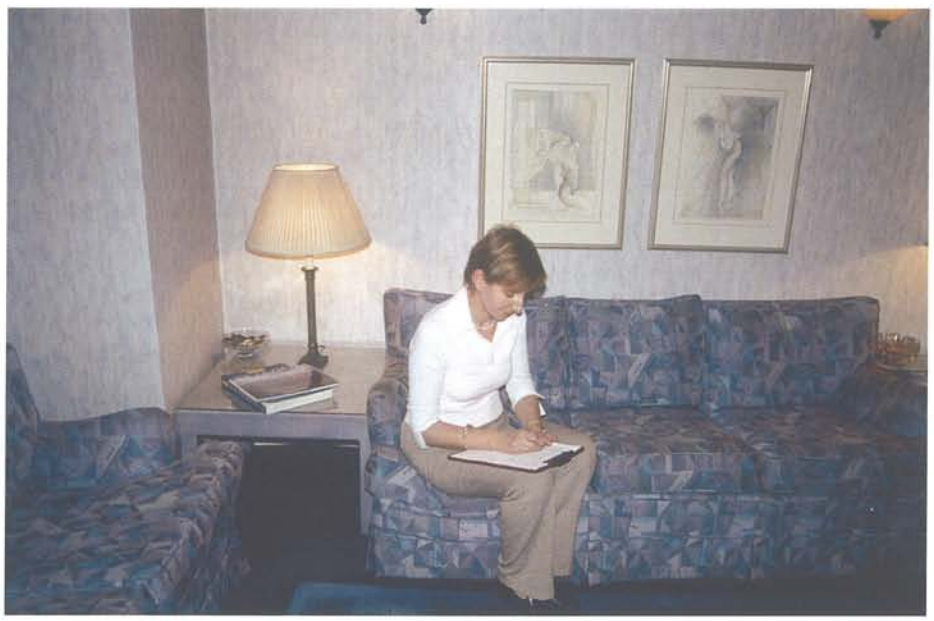


Fig. 5.11A The questions in the TMJ history form (p. 41) are designed to reveal if the bite is undergoing change, due to condylar remodeling.

Radiographic images

The panoramic radiograph serves as an excellent screening tool for total remodeling, and can indicate if a more in-depth evaluation is needed. The truest image of the size and shape of the condyles is obtained from tomography (Fig. 5.11B). Tomography is an excellent diagnostic tool for revealing total remodeling — small, finger-shaped condyles without clarity indicate the presence of remodeling. Other radiographs, such as panoramic or transcranial views, or other imaging methods, such as MRI, give less information. The lateral cephalogram usually reveals a Class II incisor relationship, often (but not always) with an anterior open bite, which increases on serial headfilms.

LISTING THE PATIENT'S TMJ PROBLEMS

If the patient has problems of any kind with head, neck and TMJ pain and/or dysfunction it is helpful to list these in order of importance. A note should be made of the patient's main TMJ complaints, and what the patient is expecting from treatment. The Temporomandibular Joint Examination form may be used for this (Fig. 5.12). The guidelines for treatment planning of TMDs are presented in Chapter 6.

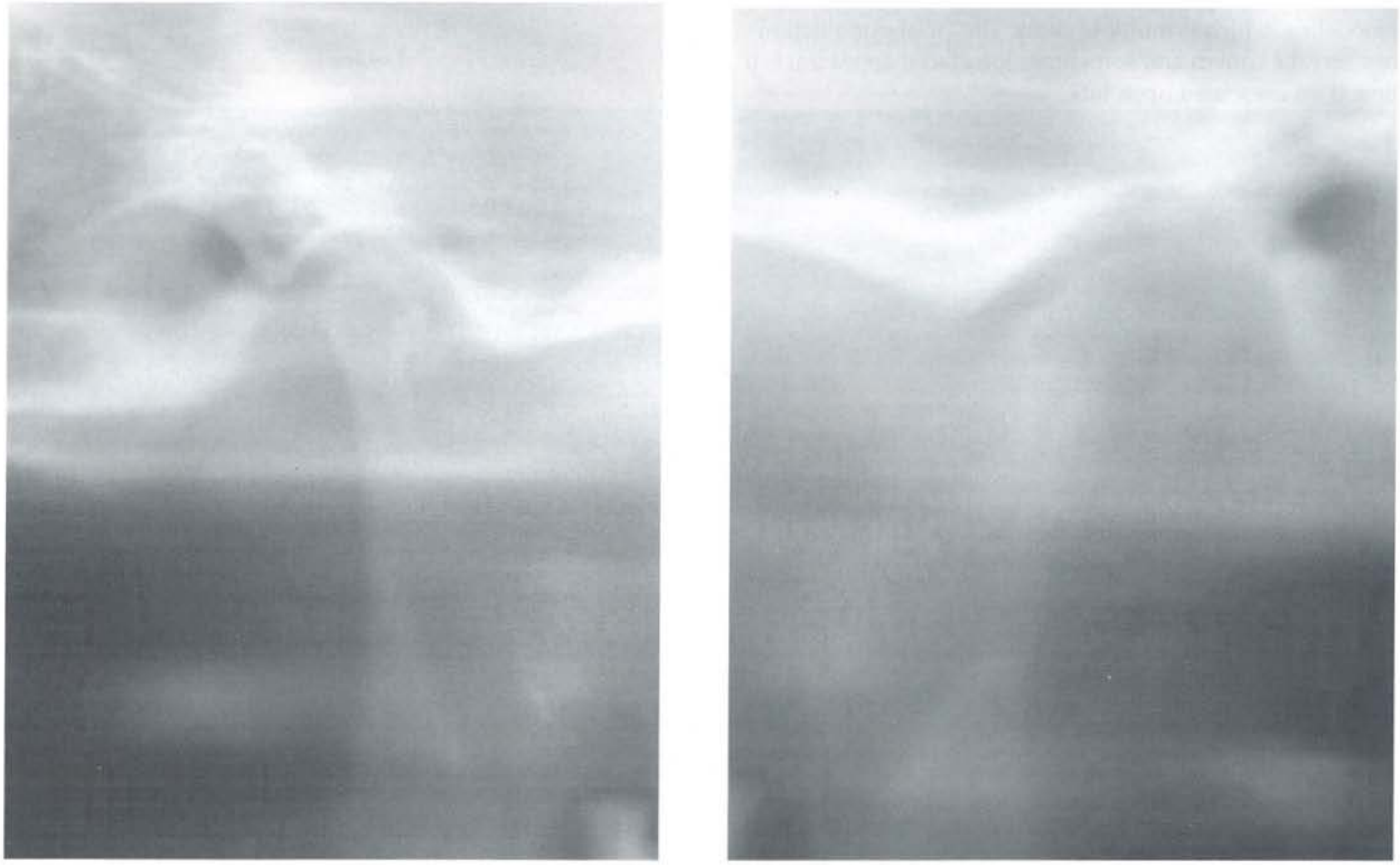


Fig. 5.11B Tomography is an excellent diagnostic tool for revealing total remodeling. Left Side: Total remodeling with loss of head-neck angle, antero-superior flattening, anterior beak, decreased head volume, and the start of an increase in joint space. Right side: Same as left side, plus grossly enlarged joint space and very blurred or 'fuzzy' image. Advanced remodeling does not show clearly with tomography.

Temporomandibular Joint Examination

Patient______________________ Age________ Orthodontist____________________

Findings										Treatment
Motion (normal in parenthesis)	Vertical_____ (40-60)	Deviation_____ R lateral (1-2)		R lateral_____ (9-12)		L lateral_____ (9-12)		Protrusive_____ (9-12)		Splint[3] and/or medical protocol[1]
Right clinical examination					Left clinical examination					
TMJ sound	Pop	Click	Multiple clicks	Crepitation	TMJ sound	Pop	Click	Multiple clicks	Crepitation	Splint[3] and/or medical protocol[1]
TMJ pain	Opening	Palpation	Biting	Yawning	TMJ pain	Opening	Palpation	Biting	Yawning	Splint[3] and/or medical protocol[1]
Muscle pain	Masseter	Temporalis	M. pterygoid	Neck	Muscle pain	Masseter	Temporalis	M. pterygoid	Neck	Splint[3] + amitriptyline + anti-inflammatory
Right tomogram					Left tomogram					
Condyle position	Central	Anterior	Posterior	Inferior	Condyle position	Central	Anterior	Posterior	Inferior	Diagnostic splint[2]
Condyle shape	Head bulge	Finger	Flat surface	Indistinct	Condyle shape	Head bulge	Finger	Flat surface	Indistinct	Splint[3] and/or medical protocol[1]
Condyle cortex	Corticated	Decorticated	Hypercorticated	Beak	Condyle cortex	Corticated	Decorticated	Hypercorticated	Beak	Splint[3] and/or medical protocol[1]
Eminence	Normal	Steep	Shallow	Flat surface	Eminence	Normal	Steep	Shallow	Flat surface	Splint[3] and/or medical protocol[1]

1 feldene 50–100mg q.d. or voixx 25–50mg q.d. or celebrex 50–100mg q.d. (anti-inflammatory), amitriptyline 5–10mg h.s. (antibruxism, skeletal muscle relaxant), vitamin C 500mg and E 400_u q.d. (antioxidants), doxycycline 50–100mg q.d. (stabilize connective tissue and bone)
2 splint designed to seat condyle in centric relationship (uppermost), must not be designed to overseat and compress joint
3 full coverage, acrylic, centric relationship, excursive guidance, usually on maxilla, on mandible with large openbites, designed to heal joints by decreasing the intra-articular pressure

pathognomic for total condyle remodeling
pathognomic for osteoarthritis
normal

Fig. 5.12 Clinical and tomographic examination form. Treatments are listed on the far right (green column).

2. THE FACE

THE TWO COMPONENTS OF FACIAL ASSESSMENT

Information obtained from the patient's history, clinical examination and records are used to assess the face (Fig. 5.13). If the patient has facial imbalance this will be revealed during the *clinical examination* (p. 74) and from the *soft tissue cephalometric analysis* (STCA) described below.

The clinical examination is extremely important, and it provides information in both the profile and frontal views. However, it is subjective. The advantage of the STCA is that it provides the ability to make objective measurements of important structures and relationships. It is a method of quantifying facial disharmony and identifying the underlying causes.

The clinical examination is in three planes and is most useful for revealing shapes and contours. The two-plane STCA, which assesses the profile view, excels at measuring vertical and anteroposterior positions and relationships of facial parts. The clinical and cephalometric examination findings are then used together to define the needed facial changes.

This part of the chapter discusses facial imbalances and the associated etiologic factors. It shows the value of the STCA in recording facial imbalance, and how it is indispensable in identifying the sources of any problems. This is important, because as a rule, better facial esthetics can be achieved if the underlying problems are identified and then treated at the source.

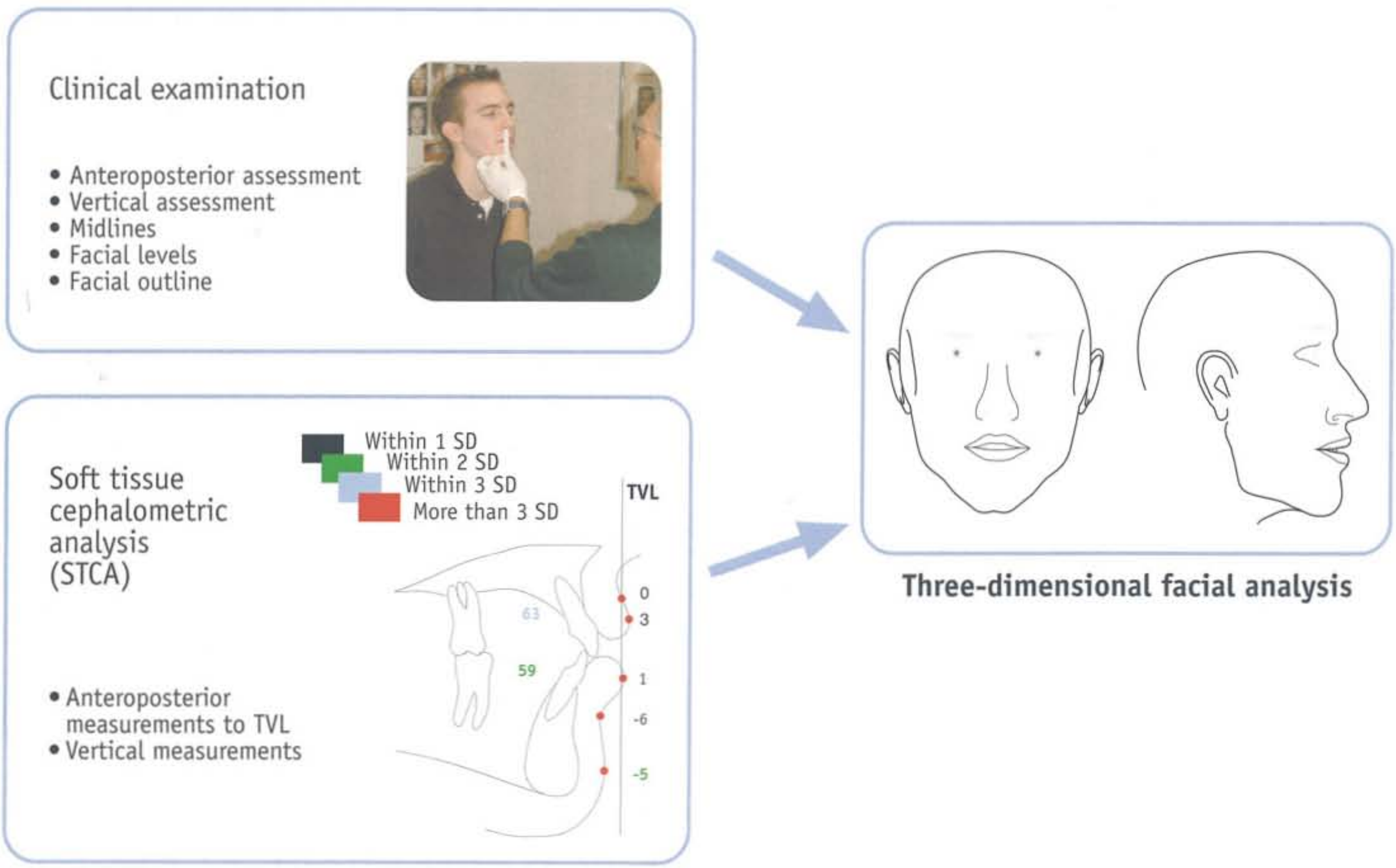


Fig. 5.13 There are two components of facial assessment – the clinical examination and the soft tissue cephalometric analysis.

THE DEVELOPMENT OF THE SOFT TISSUE CEPHALOMETRIC ANALYSIS (STCA)

A 1999 paper published by Arnett et al[21] described a new way of evaluating lateral cephalometric radiographs. It was called the soft tissue cephalometric analysis (STCA), and it is appropriate here to discuss the contents of that paper, because it is an essential part of the facial diagnosis and treatment planning method described in this text.

The cephalometric database for the analysis comprised 46 adult Caucasian patients (20 male, 26 female). The cephalograms were digitized and mean values, standard deviations, and probability values were calculated. All the patients had untreated Class I occlusions and were viewed as reasonably facially balanced. A distinction was made during selection between *quality* of facial parts (hair, eyes, skin, etc.) and *position* of facial parts. Patients were chosen for inclusion only on the basis of balance of facial parts, and qualities of parts, such as beautiful eyes, were disregarded.

To initiate the STCA, the patients were first assessed clinically[21] in natural head position, seated condyles, and with lips at rest. Correct positioning during clinical examination was imperative, to ensure the reliability of the STCA that followed. The STCA was not used without clinical input; it required clinical facial assessment to augment and elucidate cephalometric findings. Clinical facial examination (Ch. 3, pp. 51–71) was used as described by Arnett and Bergman[22] with particular emphasis on midface structures that do not show on standard cephalometric analysis (Ch. 3). In particular, orbital rim, subpupil, and alar base contours were noted to indicate A/P position of the maxilla.

Before taking the cephalometric radiograph, metallic markers were placed on the right side of the face to mark key midface structures (p. 110). These essential midface structures, although normally lost on traditional cephalograms, were metallically marked on each cephalogram and became the cornerstone to the cephalometric midface diagnosis and treatment planning. The neck–throat point was then localized, and a metal marker was placed in that position.

With the midface structures marked, a cephalogram was obtained with the patient positioned in natural head position (pp. 95–96), seated condyles, and with lips at rest. Lundström and Lundström[23] noted that despite careful natural head position instructions, some patients assume an 'unnatural head position'. Accordingly, these individuals needed adjustment to natural 'head orientation' by experienced clinicians. As noted by Lundström and Lundström, some patients in this study also assumed head positions that were obviously not a natural head position. These headfilms, as per Lundström and Lundström, were leveled to natural head orientations.

The true vertical line (TVL) was then established (p. 159). This line was placed through subnasale and was perpendicular to the natural head position. Soft tissue landmarks were then marked on the cephalogram. The midface metallic landmarks were also identified as new landmarks on the headfilm. Important hard tissue landmarks were then identified on the cephalogram. The cephalometric hard and soft tissue landmarks were measured on the 46 facially balanced patients. The vertical or horizontal position of soft tissue and hard tissue landmarks were recorded relative to the patient's natural head position or TVL. Female and male values and standard deviations were established in the following areas:

1. Dental and skeletal factors
2. Soft tissue components
3. Vertical facial heights or lengths
4. TVL projections
5. Facial harmony.

In Table 5.1 and in the following discussion the order of the 46 measurements has been changed slightly from the original published study,[21] for reasons of clarity, but the values remain the same. Also, several measurements appear more than once. This is because they are useful in the assessment of more than one category.

Mean female and male values for STCA

Table 5.1 Means, standard deviations, and probability values for the 26 female and 20 male individuals in the sample

	Mean ± SD females	Mean ± SD males	Female to male difference significant when less than 0.05
1. Dentoskeletal factors			
a. projections			
Mx1 projection to TVL	-9.2 ± 2.2	-12.1 ±1.8	1.064E-05
Mx1 inclination (Mx1 - Mx OP)	56.8 ± 2.5	57.8 ± 3.0	0.2585
Overjet	3.2 ± 0.4	3.0 ± 0.6	0.6371
Md1 projection to TVL	-12.4 ± 2.2	-15.4 ± 1.9	1.312E-05
Md1 inclination (Md1 - Md OP)	64.3 ± 3.2	64.0 ± 4.0	0.7764
b. heights or lengths			
Mx1 exposure relaxed lip	4.7 ± 1.6	3.9 ± 1.2	0.0417
Overbite	3.2 ± 0.7	3.2 ± 0.7	0.7481
Md anterior height (Md1 tip-Me')	48.6 ± 2.4	56.0 ± 3.0	8.573E-11
posterior height (Mx OP -TVL angle)	95.6 ± 1.8	95.0 ± 1.4	0.1789
2. Soft tissue thicknesses			
upper lip (UL inside - ULA)	12.6 ± 1.8	14.8 ± 1.4	3.388E-05
lower lip (LL inside - LLA)	13.6 ± 1.4	15.1 ± 1.2	0.0004
pogonion - chin (Pog - Pog')	11.8 ± 1.5	13.5 ± 2.3	0.0086
menton (Me to Me')	7.4 ± 1.6	8.8 ± 1.3	0.0019
3. Facial heights or lengths			
a. soft tissue			
upper lip length (Sn - ULI)	21.0 ± 1.9	24.4 ± 2.5	1.024E-05
interlabial gap (ULI - LLS)	3.3 ± 1.3	2.4 ± 1.1	0.0214
upper incisor exposure relaxed lip	4.7 ± 1.6	3.9 ± 1.2	0.0417
lower lip length (LLS - Me')	46.9 ± 2.3	54.3 ± 2.4	2.158E-13
lower 1/3 height (Sn - Me')	71.1 ± 3.5	81.1 ± 4.7	3.170E-09
total facial height (Na' - Me')	124.6 ± 4.7	137.7 ± 6.5	8.916E-09
b. hard tissue			
maxillary height (Sn - Mx1 tip)	25.7 ± 2.1	28.4 ± 3.2	0.0026
overbite	3.2 ± 0.7	3.2 ± 0.7	0.7481
mandibular height (Md1 tip to Me')	48.6 ± 2.4	56.0 ± 3.0	8.573E-11
posterior height (Mx OP - TVL angle)	95.6 ± 1.8	95.0 ± 1.4	0.1789
4. True Vertical Line Projections			
a. high midface projections			
glabella (Gb' - TVL)	-8.5 ± 2.4	-8.0 ± 2.5	0.5246
soft tissue orbital rim (Or' - TVL)	-18.7 ± 2.0	-22.4 ± 2.7	1.060E-05
cheekbone (CB - TVL)	-20.6 ± 2.4	-25.2 ± 4.0	7.405E-05
subpupil (SP - TVL)	-14.8 ± 2.1	-18.4 ± 1.9	2.666E-07
b. maxillary projections			
nasal projection (NT - TVL)	16.0 ± 1.4	17.4 ± 1.7	0.0052
nasal base (NB - TVL)	-12.9 ± 1.1	-15.0 ± 1.7	6.054E-05
soft tissue A point (A' - TVL)	-0.1 ± 1.0	-0.3 ± 1.0	0.6629
upper incisor tip (Mx1 - TVL)	-9.2 ± 2.2	-12.0 ± 1.8	1.064E-05
upper lip anterior (ULA - TVL)	3.7 ± 1.2	3.3 ± 1.7	0.3836
upper lip angle (Mx1 - TVL)	12.1 ± 5.1	8.3 ± 5.4	0.0197
nasolabial angle (Columella-Sn-ULA)	103.5 ± 6.8	106.4 ± 7.7	0.1937

Mean female and male values for STCA

Table 5.1 Means, standard deviations, and probability values for the 26 female and 20 male individuals in the sample (continued)

	Mean ± SD females	Mean ± SD males	Female to male difference significant when less than 0.05
c. mandibular projection			
lower incisor tip (Md1 – TVL)	12.4 ± 2.2	−15.4 ± 1.9	1.312E-05
lower lip anterior (LLA – TVL)	1.9 ± 1.4	1.0 ± 2.2	0.1065
soft tissue B point (B′ – TVL)	−5.3 ± 1.5	−7.1 ± 1.6	0.0004
soft tissue Pogonion (Pog′ – TVL)	−2.6 ± 1.9	−3.5 ± 1.8	0.1294
throat length (NTP – Pog′)	58.2 ± 5.9	61.4 ± 7.4	0.1213
5. Harmony values			
a. total facial harmony			
facial angle (Gb′ – Sn – Pog′)	169.3 ± 3.4	169.4 ± 3.2	0.9609
forehead to maxilla (Gb′ – A′)	8.4 ± 2.7	7.8 ± 2.8	0.4609
forehead to mandible (Gb′ – Pog′)	5.9 ± 2.3	4.6 ± 2.2	0.0511
b. soft tissue inferior orbital rim to jaw harmony			
maxilla (Or′ – A′)	18.5 ± 2.3	22.1 ± 3	8.645E-05
mandible (Or′ – Pog′)	16.0 ± 2.6	18.9 ± 2.8	0.0009
c. maxilla to mandible harmony			
nasal base to chin (Sn – Pog′)	3.2 ± 1.9	4.0 ± 1.7	0.1191
Mx base – Md base (A′ – B′)	5.2 ± 1.6	6.8 ± 1.5	0.0010
lip to lip (ULA – LLA)	1.8 ± 1.0	2.3 ± 1.2	0.1236
d. intramandibular harmony			
incisor tip to chin (Md1 tip – Pog′)	9.8 ± 2.6	11.9 ± 2.8	0.0076
lower lip anterior to chin (LLA – Pog′)	4.5 ± 2.1	4.4 ± 2.5	0.8915
chin contour (B′ – Pog′)	2.7 ± 1.1	3.6 ± 1.3	0.0192

Glossary for table 5.1

Mx1 – Maxillary central incisor tip
TVL – true vertical line
Mx OP – maxillary occlusal plane
Md1 – mandibular incisor tip
Md OP – mandibular occlusal plane
Me′ – soft tissue menton
UL – upper lip
ULA – upper lip anterior
LL – lower lip
LLA – lower lip anterior
Pog – hard tissue pogonion
Pog′ – soft tissue pogonion
Me – hard tissue menton
Me′ – soft tissue menton

Sn – subnasale
ULI – upper lip inferior
LLS – lower lip superior
Na′ – soft tissue nasion
Gb′ – soft tissue glabella
Or′ – soft tissue orbital rim
CB – soft tissue cheekbone
SP – soft tissue subpupil
NT – nasal tip
NB – nasal base
A′ – soft tissue A point
NTP – neck throat point
B′ – soft tissue B point

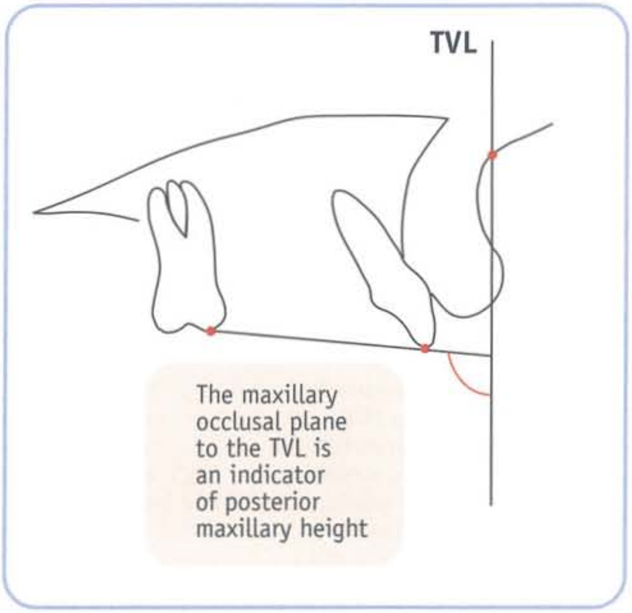
Note – E values denote digits to the left of the decimal point, i.e. 1.312E-05 = 0.00001312.

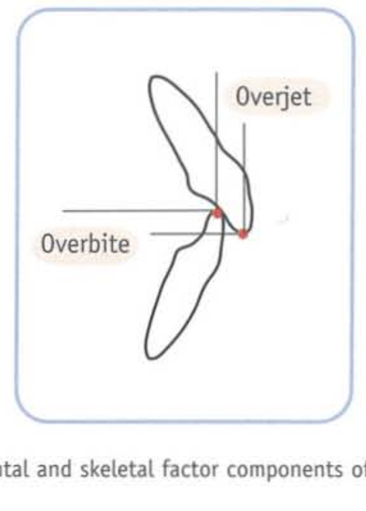
ASSESSING DENTAL AND SKELETAL FACTORS WITH THE STCA

Dental and skeletal factors have a large influence on the facial profile (Fig. 5.14A and B). When these factors are in the normal range they will usually produce a balanced and harmonious nasal base, lip, chin relationship, and soft tissue A' point and B' point. The profile at the end of treatment is greatly influenced by how accurately the orthodontist and surgeon manage the dentoskeletal components. The nine factors are shown in Figure 5.14 and may be listed as follows:

- Dentoskeletal factors
  - projections
    - Mx1 projection to TVL
    - Mx1 inclination (Mx1 - Mx OP)
    - Overjet
    - Md1 projection to TVL
    - Md1 inclination (Md1 - Md OP)
  - heights or lengths
    - Mx1 exposure relaxed lip
    - Overbite
    - Md anterior height (Md1 tip–Me')
    - posterior height (Mx OP –TVL angle)

Occasionally, the occlusal plane, and the upper and lower incisor to the TVL will be blue to produce adequate projections of the soft tissue profile. The upper and lower incisors are forward of normal position in these situations to produce necessary lip protrusion.





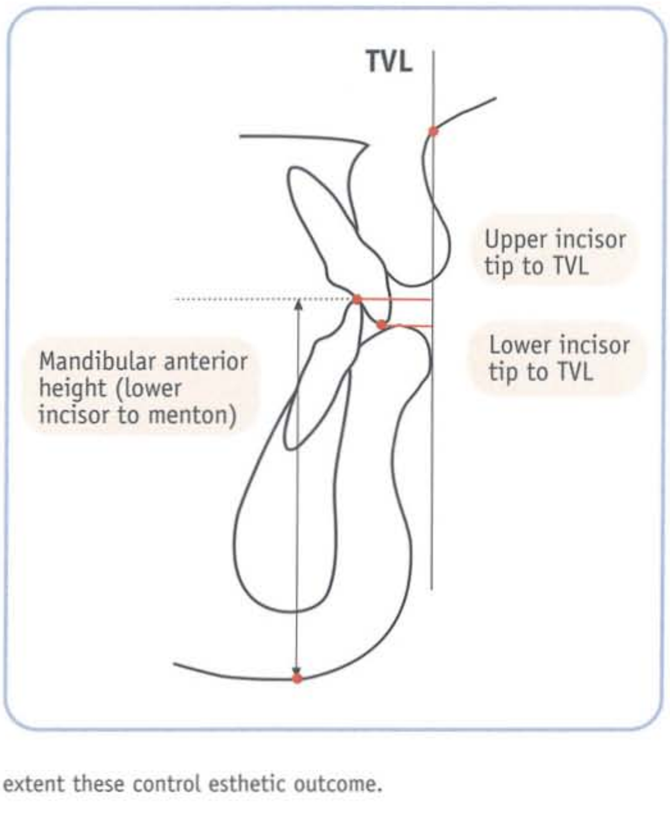


Fig. 5.14A Dental and skeletal factor components of the STCA. To a large extent these control esthetic outcome.

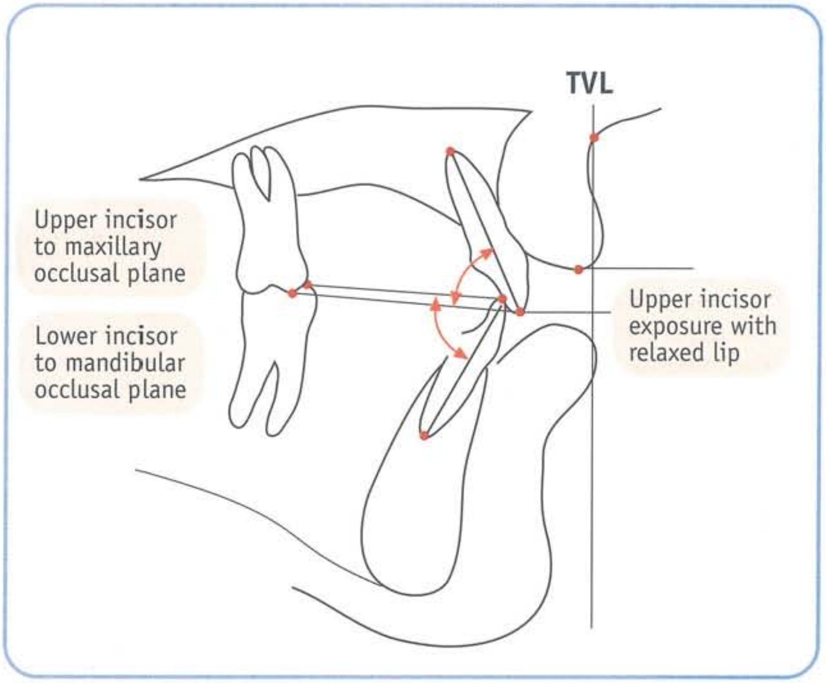


Fig. 5.14B Dental and skeletal factor components of the STCA.

ASSESSING SOFT TISSUE THICKNESS WITH THE STCA

Four soft tissue thickness are important to facial esthetics (Fig. 5.15). They are listed as follows:

- Thickness of the upper lip
- Thickness of the lower lip
- Thickness of the soft tissue pogonion
- Thickness of the soft tissue menton

The soft tissue thicknesses and the nine dental and skeletal factors (pp. 152, 154) largely control the esthetic balance of the lower third of the face.

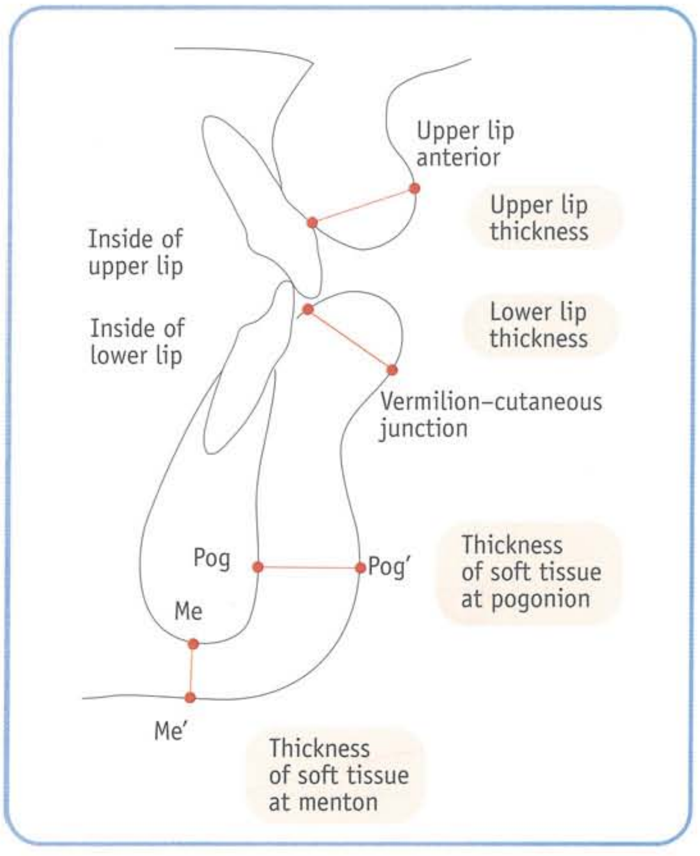


Fig. 5.15 Soft tissue thicknesses. The profile is determined by these and the dental and skeletal factors.

ASSESSING FACIAL HEIGHTS AND LENGTHS WITH THE STCA

The facial heights and lengths (Fig. 5.16A and B) include a total of 10 soft tissue and hard tissue measurements. Vertical abnormalities are assessed using these 10 factors:

- Soft tissue heights and lengths
  - The upper lip length
  - The inter-labial gap
  - The upper incisor exposure, with a relaxed upper lip
  - The lower lip length
  - The height/length of the lower third of the face
  - The total facial height/length
- Hard tissue
  - The height/length of the maxilla
  - The overbite
  - The height of the mandible – the 'chin height'
  - The angle of the maxillary occlusal plane to TVL – this is a measure of the posterior height of the maxilla.

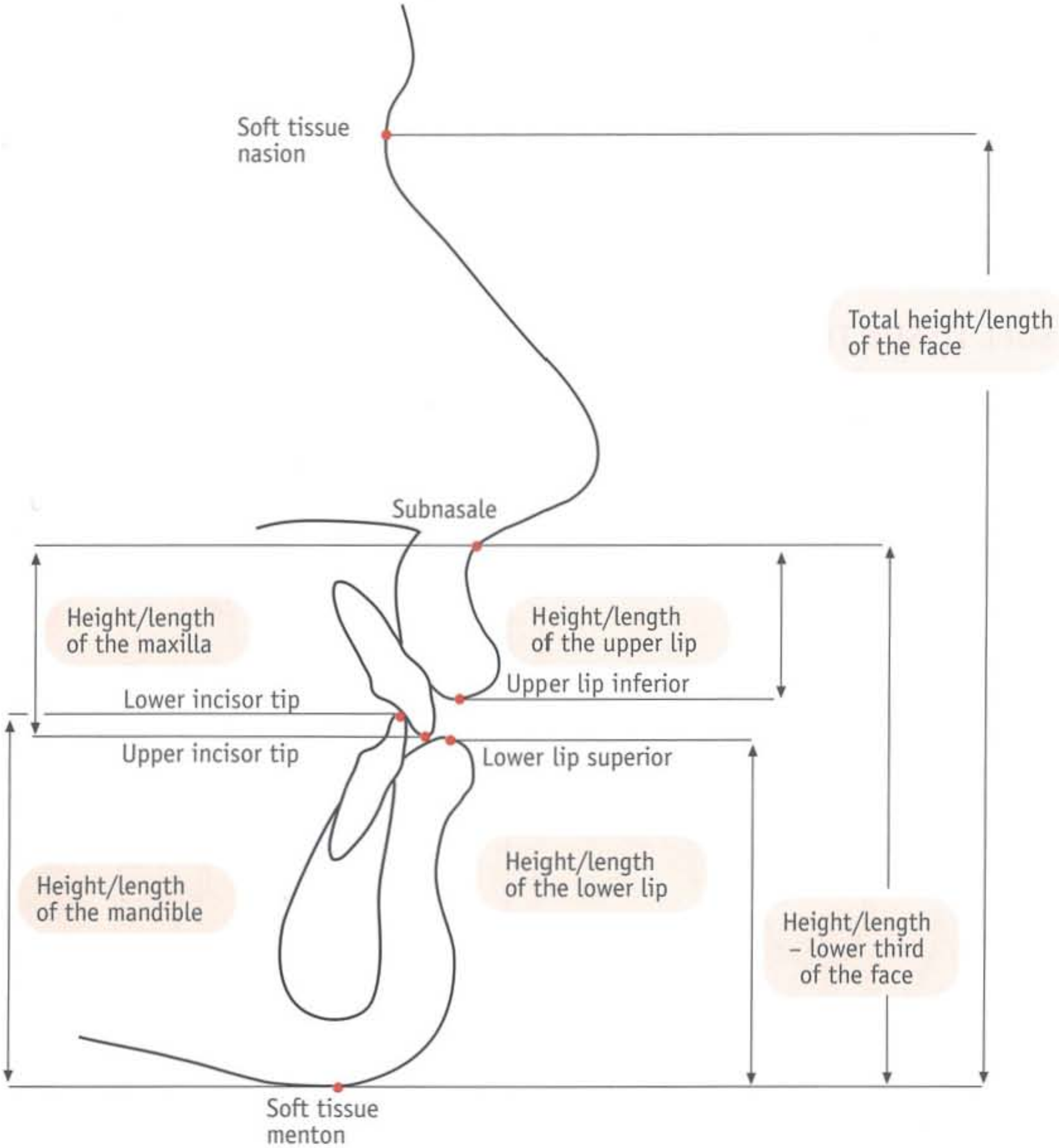
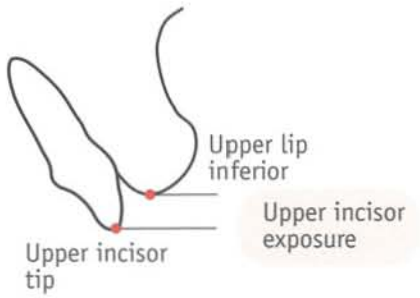
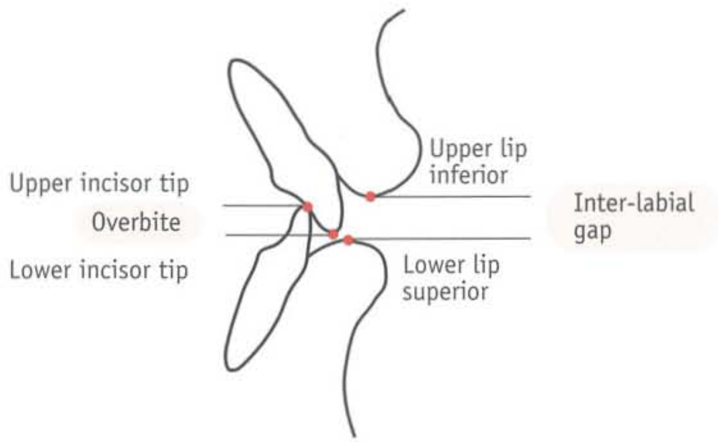


Fig. 5.16A The 10 facial heights and lengths measurements. The only hard tissue to hard tissue measurement is the overbite.





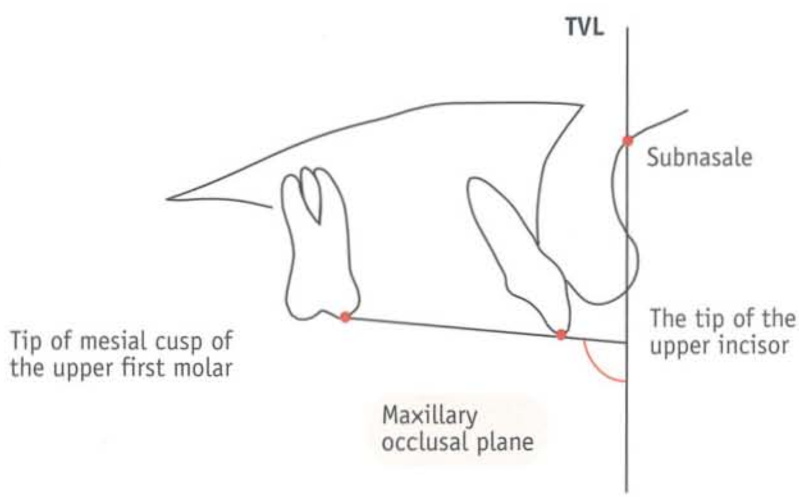


Fig. 5.16B The 10 facial heights and length measurements.

ASSESSING PROJECTIONS TO TVL WITH THE STCA

The TVL measurements are A/P measurements of mainly soft tissue structures. They represent the sum of the dental or skeletal position plus the thickness of the overlying soft tissue (Fig. 5.17). TVL components fall into three groups – the high midface, the maxilla, and the mandible. They may be listed as follows:

- The high midface to the TVL
  - Glabella
  - Soft tissue orbital rim
  - Cheekbone
  - Subpupil
- The maxilla to the TVL
  - The nasal projection
  - The nasal base
  - Subnasale
  - Soft tissue A′ point
  - The upper lip anterior
  - The upper lip angle
  - The nasiolabial angle
- The mandible
  - The lower incisor to TVL
  - The lower lip anterior
  - Soft tissue B′ point
  - Soft tissue pogonion
  - The throat length (NTA – Pog′).

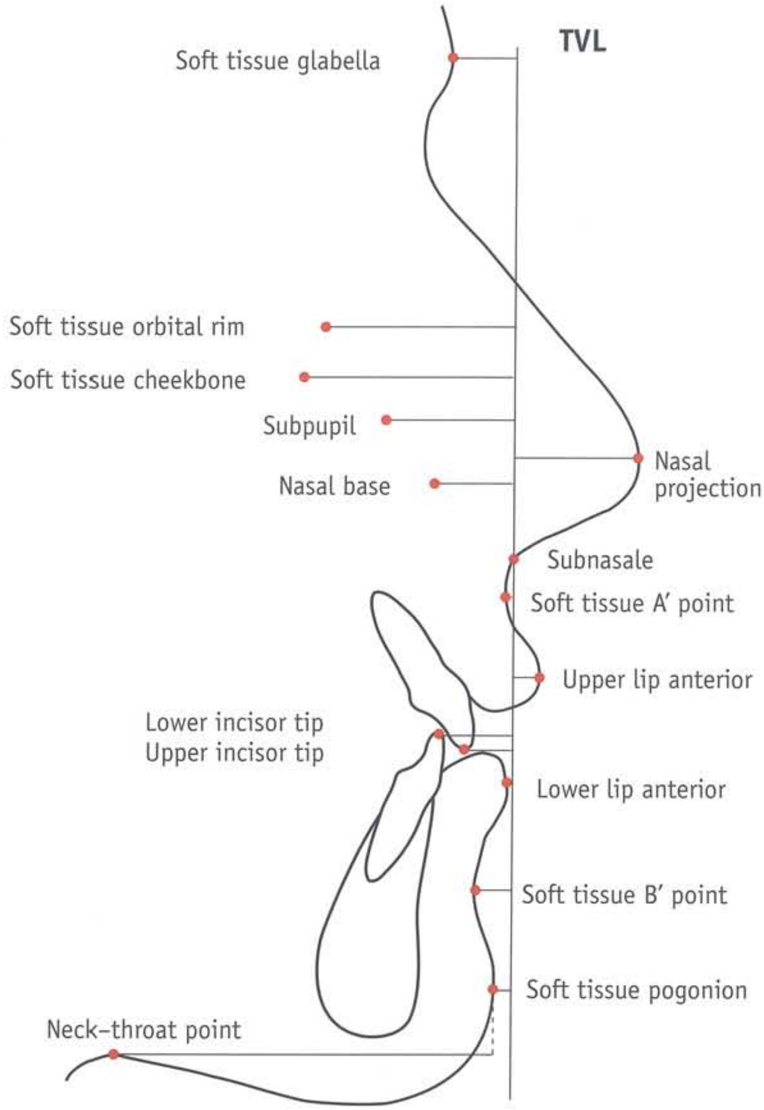


Fig. 5.17 The measurements to TVL represent the sum of the dental or skeletal position plus the thickness of the overlying soft tissue.

The A/P positioning of the TVL will frequently be through subnasale (Fig. 5.18a). However, the TVL must be moved forward 1–3 mm in cases of maxillary retrusion (Fig. 5.18b). Midface retrusion is defined by an apparently long nose, and depressed or flat orbital rims (Case TW, p. 79), cheekbones, subpupils, and alar bases. Additional features of midface retrusion may include poor incisor support for the upper lip, an upright upper lip, a thick upper lip, and retruded upper incisors. Clinical and STCA examinations of the patient are necessary to verify maxillary retrusion.

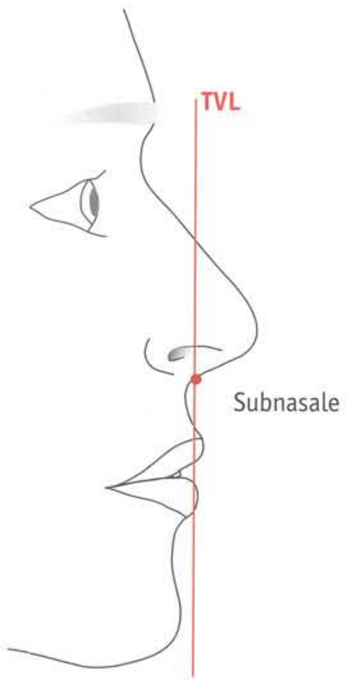


Fig. 5.18a The A/P position of the TVL will frequently be through subnasale.

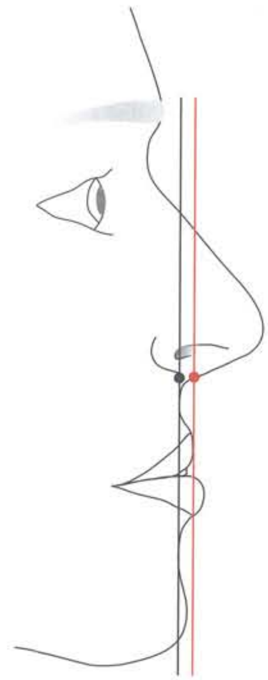


Fig. 5.18b The TVL must be moved forward 1–3 mm in cases of maxillary retrusion.

ASSESSING HARMONY VALUES WITH THE STCA

Harmony values were created to measure the balance and harmony between the facial structures. Harmony or balance between different facial landmarks is an important component of beauty. The facial balance is determined by the position of each landmark relative to other landmarks. Harmony values (Fig. 5.19) are the horizontal distances between two landmarks, measured perpendicular to the true vertical line. The 11 measurements are divided into four groups.

Harmony values, as the name implies, provide information on the balance between parts of the face. They are sensitive indicators of imbalance. They are so sensitive that they can identify imbalance between two landmarks which are, nonetheless, within their individual normal ranges. For instance, if soft tissue pogonion is a *strong* normal, and soft tissue B′ point is a *weak* normal, a disharmony between these two points can be detected. This occurs frequently after large chin augmentations. If disharmony of parts exists, the vertically closer the parts, the more obvious the disharmony. For example, subnasale to soft tissue pogonion disharmony is less evident than upper to lower lip disharmony.

Harmony values
- Total facial harmony
  - facial angle
  - forehead to maxilla (Gb′ – A′)
  - forehead to mandible (Gb′ – Pog′)
- Soft tissue inferior orbital rim to jaw harmony
  - maxilla (Or′ – A′)
  - mandible (Or′ – Pog′)
- Maxilla to mandible harmony
  - nasal base to chin (Sn – Pog′)
  - Mx base – Md base (A′ – B′)
  - lip to lip (ULA – LLA)
- Intramandibular harmony
  - incisor tip to chin (Md1 tip – Pog′)
  - lower lip anterior to chin (LLA – Pog′)
  - chin contour (B′ – Pog′)

Fig. 5.19

Total facial harmony

This is the first of the four harmony examinations (Fig. 5.20). The upper face, midface, and chin are related via the facial angle (Gb′–Sn–Pog′). The facial angle, by itself, does not identify the source of disharmony but does measure the product of all other factors. Then the forehead is compared to two specific points, the upper jaw (Gb′–A′) and chin (Gb′–Pog′). These three measurements give the broad picture of facial balance. If there is an abnormal A/P position (projection) of a jaw or jaws, this is often revealed by an abnormal relationship to the forehead.

Soft tissue inferior orbital rim to jaw harmony

This evaluates the position of the soft tissue inferior orbital rim relative to the upper jaw (as measured by soft tissue A′ point) and lower jaw (as measured by soft tissue pogonion) (Fig. 5.20). Measurements between these areas record the balance between the soft tissue orbital rim and the jaws. The *clinical examination* and *STCA* orbital rim number are used to establish that the orbital rim projection is correct. If it is correct, it can then be used to reveal if the jaws are in disharmony relative to the normal orbital rim. The jaw or jaws which are in abnormal A/P relationship (projection) are often revealed by an abnormal balance with the soft tissue orbital rim.

Maxilla to mandible harmony

The relationship between the maxilla and the mandible reveals the esthetics of the lower one-third of the face (Fig. 5.20). This is the area which is most changed by treatment. Dental and skeletal factors (the upper incisor angulation and A/P position, the lower incisor angulation and A/P position, and the maxillary occlusal plane) are the main factors, but soft tissue thickness is also a factor. Values indicate the relationship between the base of the maxilla (measured at subnasale) and the chin (measured at soft tissue pogonion), soft tissue B′ point and soft tissue A′ point, and the upper lip (upper lip anterior) and the lower lip (lower lip anterior). If disharmony exists between the maxilla and the mandible, it may be clear which is the offending jaw. If the source of disharmony between the maxilla and mandible is not clear, the upper and lower jaw harmony to the forehead and orbital rim may reveal the jaw or jaws which are out of balance.

Mandibular harmony

These values assess chin protrusion (measured as soft tissue pogonion) relative to the lower incisor, the lower lip, and the soft tissue B′ point (Fig. 5.20). Analysis of these structures indicates the chin position relative to other mandibular structures. The analysis indicates which structure, if any, is abnormally placed. For example, decreased distance from the mandibular incisor tip to the chin (soft tissue pogonion) may indicate flared lower incisors, a small hard tissue pogonion, thin soft tissue in the chin region, or a steep occlusal plane. The relationship of soft tissue B′ point to soft tissue pogonion is one indication of chin contour. Normalizing these relationships is important, because chin projection is a main consideration for facial balance.

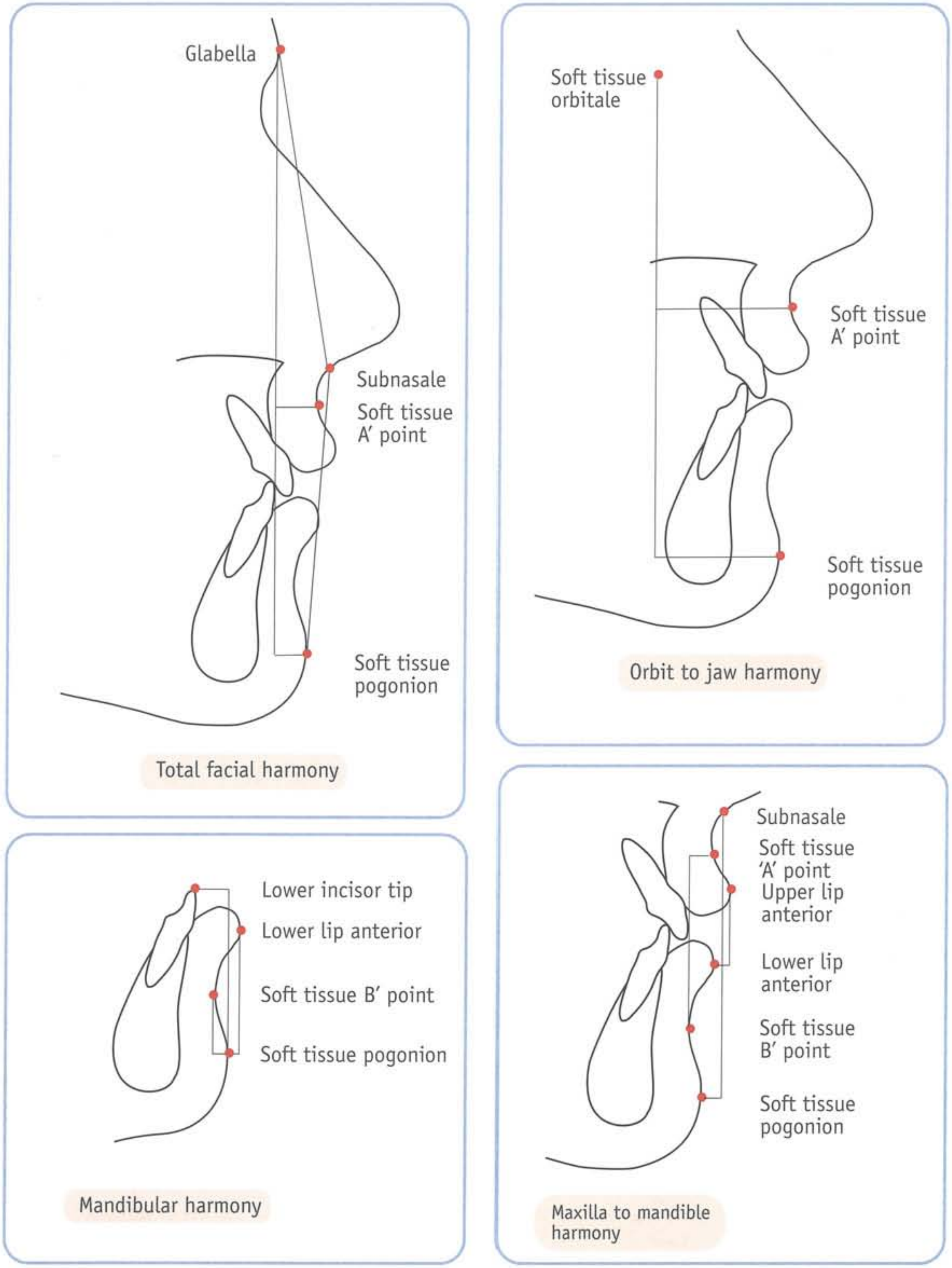


Fig. 5.20 Harmony values. The 11 harmony values are the horizontal distances between two landmarks, measured horizontally. They are divided into four groups. The facial balance or harmony is determined by the position of each landmark relative to other landmarks.

FEMALE/MALE DIFFERENCES

The female STCA and male STCA values (Figs 5.21 and 5.22) demonstrate the need for separate male and female values. If male values are applied to an ideal female face, multiple differences are evident at the two and three standard deviation level.

STCA female soft tissue cephalometric analysis

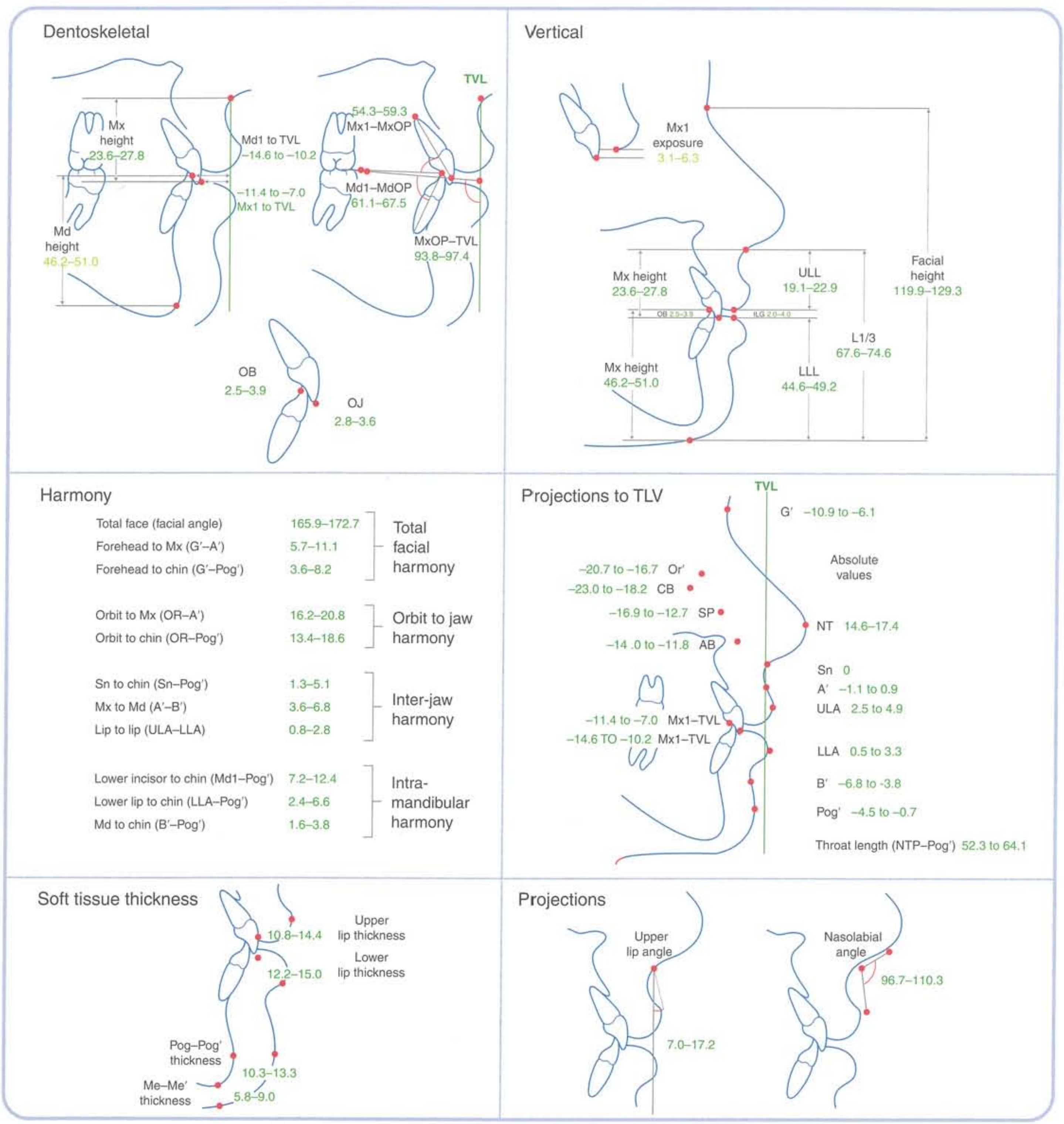


Fig. 5.21 Female STCA normal ranges (©Arnett Facial Reconstruction Courses Inc. 2003).

Females and males are facially similar in some measurements but different in others. All male soft tissue thicknesses are statistically greater than the female values. Female faces are shorter in all dimensions except incisor exposure and inter-labial gap.

STCA male soft tissue cephalometric analysis

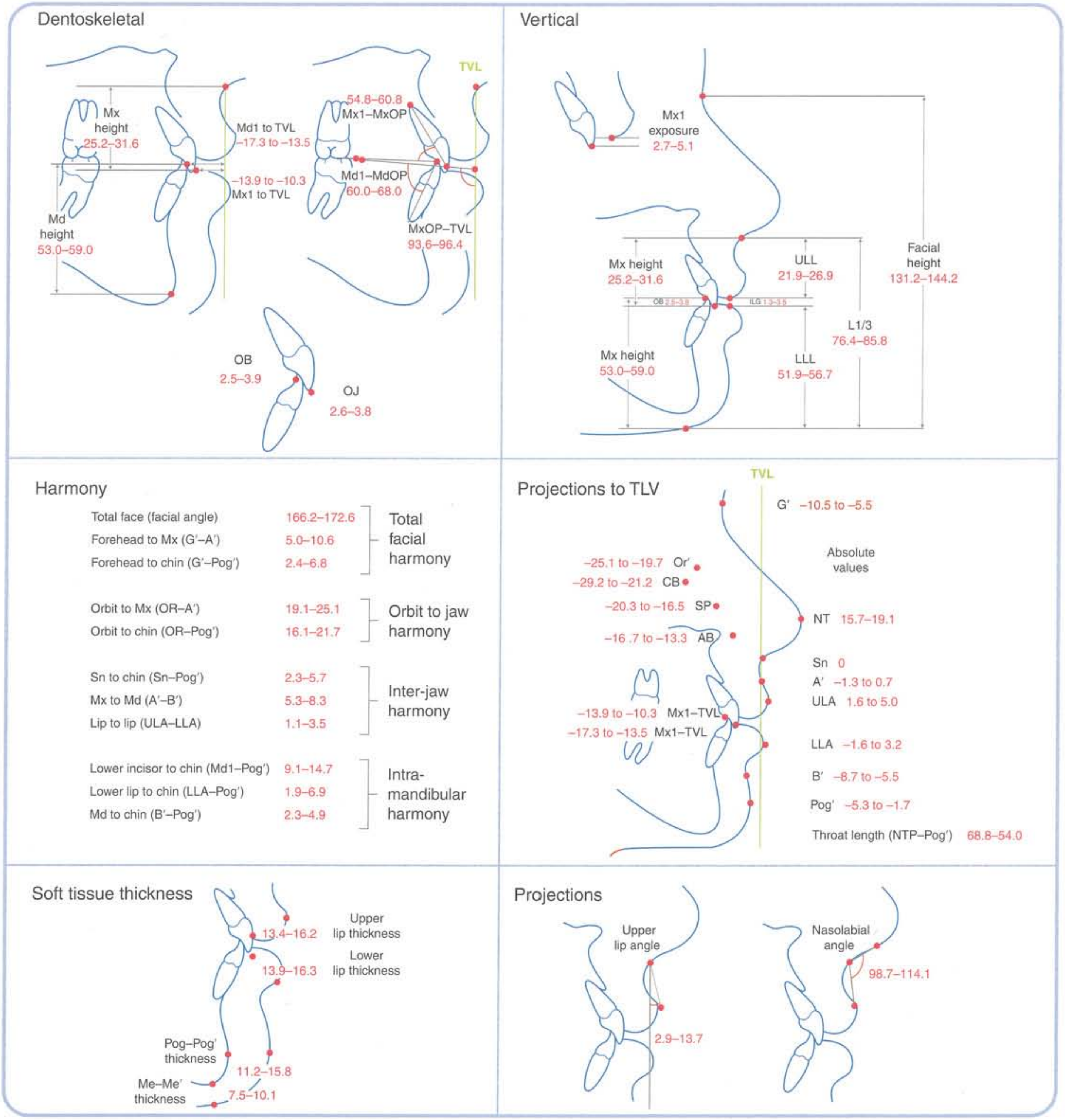


Fig. 5.22 Male STCA normal ranges (©Arnett Facial Reconstruction Courses Inc. 2003).

Female and male A/P measurements to TVL (projections) are similar, except the male midface, incisor, and soft tissue B' point projections are larger. Harmony values between the sexes are quite similar.

In the original research the female sample showed more upper lip protrusion (12.1° female, 8.3° males), as measured by the upper lip angle. Female faces were statistically shorter than male faces, and females had more incisor exposure (4.7 mm) than males (3.9 mm).

For treatment planning purposes, the important difference between females and males is the large vertical difference between the two groups.

LISTING THE PATIENT'S FACIAL PROBLEMS

At this stage many clinicians will choose to make a list of the patient's facial problems. These will be listed in order of importance, and will be derived from the subjective findings during the clinical examination (Fig. 3.36, p. 74) and the more objective STCA (Table 5.1, p. 152). A note should be made of the patient's main complaints, and what the patient is expecting from treatment. The treatment planning can then be based on this key information, as described in Chapter 7.

COMMENTARY ON THE MIDDLE THIRD OF THE FACE

The following comments give further insight into the significance of some of the clinical and STCA findings. They are made to assist the reader in the interpretation of abnormal facial findings. Comments in the following sections apply to both clinical and STCA measurements but are described in terms of the normal values for the STCA which are approximately 8–10% larger that the identical clinical measurements as a result of cephalometric magnification. The STCA measures can be found in Tables 5.21 and 5.22. The clinical values may be found in Chapter 3.

The orbital rim

Osseous structures are often deficient as groups. Therefore, an individual with a retruded maxilla may have deficient orbital rims. Orbital rim protrusion is rare. During surgery, heat cured hydroxyapatite can be used to correct deficient orbital rim contours.

The cheekbone

There is a high correlation between flat or soft cheekbones and maxillary retrusion. If the cheekbones appear flat or soft, a cheekbone augmentation is indicated. Heat cured hydroxyapatite can be used to correct deficient cheekbone size and contour.

The subpupil area

If the subpupil area is flat or soft, the maxilla is often retrusive. Le Fort I (LFI) advancement corrects subpupil deficiency. The maxilla is rarely, if ever, moved posteriorly, because this produces concavity of the nasal base area. This leads to nasolabial folds, which are associated with aging.

The nasal base

The nasal base is supported by the maxilla. Therefore, maxillary retrusion presents as nasal base concavity, flatness, or softness. Le Fort I advancement is used to correct nasal base retrusion. Rarely, if ever, is the maxilla moved posteriorly.

The nasal projection

The projection of the nose can be an indicator of the A/P position of the maxilla, but not always (Fig. 5.23). A long nose in conjunction with normal maxillary projection is treated with rhinoplasty.

The nasal projection is important when considering surgical anterior movement of the maxilla. If there is decreased nasal projection, this limits the amount of maxillary advancement which will be possible.

Conversely, if a patient has a Class III malocclusion and a short nose, a mandibular set-back may be indicated.

Midface retrusion is defined by a nose that appears long, a depressed or flat alar base, poor incisor support for the upper lip, upright upper lip, thick upper lip and retruded upper incisor.

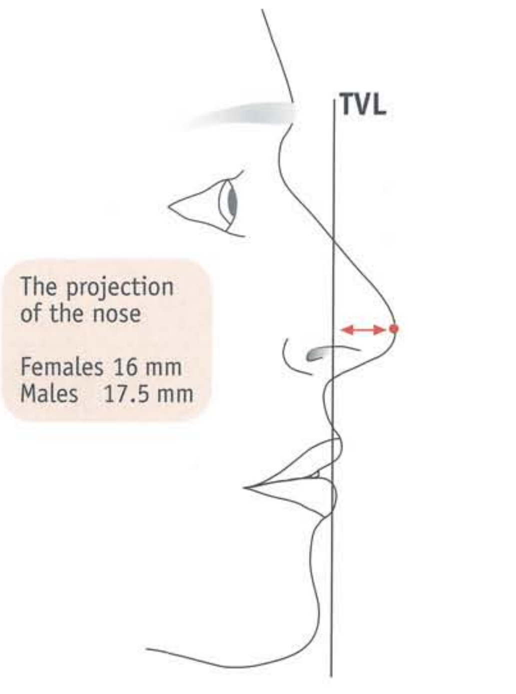


Fig. 5.23 The projection of the nose can be an indicator of the A/P position of the maxilla, but may merely reflect the size of the nose.

COMMENTARY ON THE LOWER THIRD OF THE FACE USING THE CLINICAL AND STCA EXAMINATIONS

The following comments are made to assist the reader in the clinical interpretation of abnormal findings. They give further insight into the clinical significance of some of the lower third STCA findings. Once again, the values shown from the STCA are 8–10% larger than their clinical counter parts secondary to cephalometric magnification.

Length of the lower third of the face

Predictably, increased length of the lower third of the face is frequently found in cases with vertical maxillary excess (Fig. 5.24). It is also found in some Class III malocclusions, where lack of interdigitation increases the vertical length.

Decreased length of the lower third of the face is associated with vertical maxillary deficiency and with mandibular retrusion deep bite cases.

The appearance of landmarks within the lower third of the face, specifically the relaxed incisor exposure and inter-labial gap, are very significant in guiding vertical treatment planning. They are more important in assessing facial balance than is the ratio of the middle and the lower thirds of the face. Equality of the middle and the lower thirds should not be used as the deciding factor.

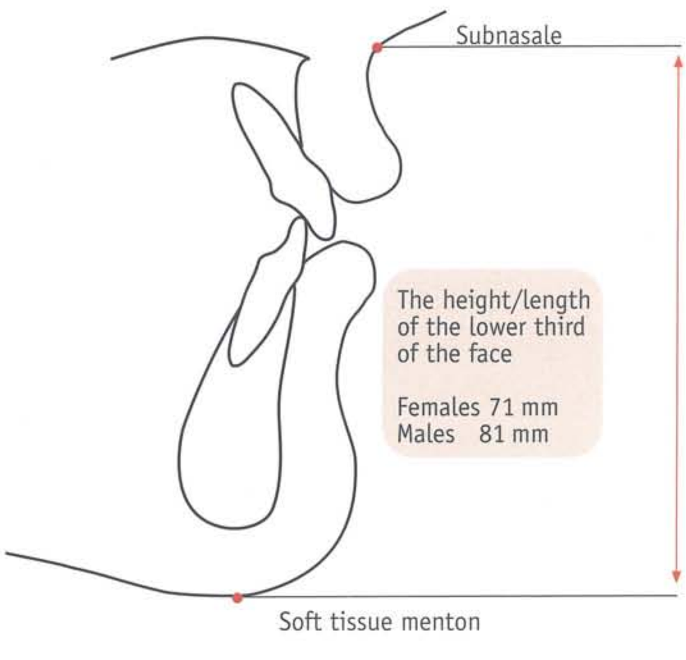
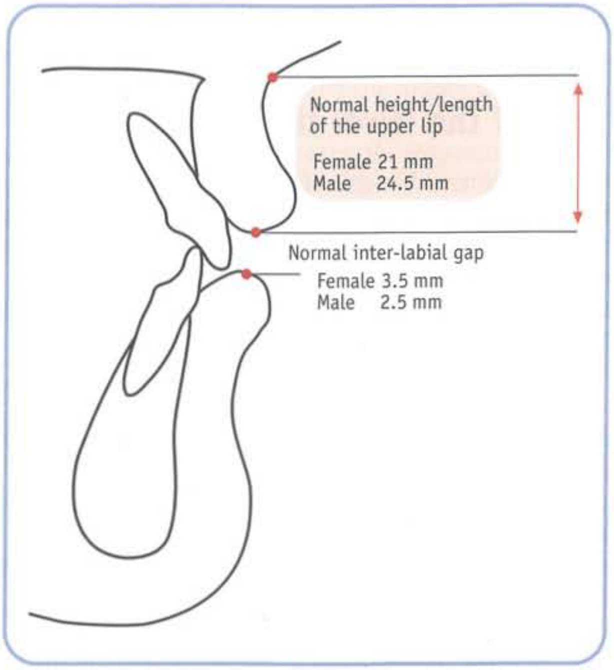


Fig. 5.24 The average height/length of the lower third of the face is 71 mm for females and 81 mm for males.

The short upper lip

If a patient has a normal lower face height/length, but the upper lip is anatomically short, an increased inter-labial gap and incisor exposure is seen compared with the normal (Fig. 5.25).

This should not be confused with vertical maxillary excess, which causes increased lower one-third facial length, increased inter-labial gap, and increased upper incisor exposure (Fig. 5.26).



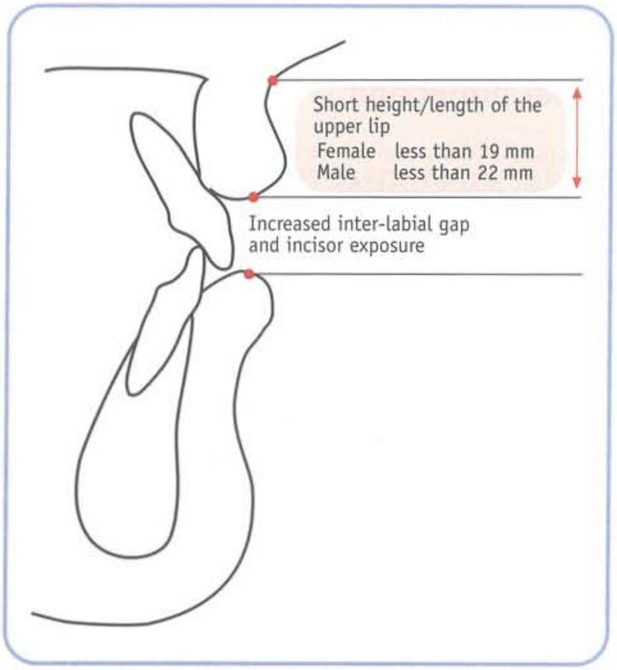


Fig. 5.25 If the upper lip is anatomically short, an increased inter-labial gap and incisor exposure may be observed.

Fig. 5.26A Relaxed lip. Patient with vertical maxillary excess. Note excess incisor exposure and interlabial gap.

Fig. 5.26B Smile. Patient with vertical maxillary excess. Smiling reveals greater than 2 mm of gingiva

Fig. 5.26C Closed lip. Patient with vertical maxillary excess. Closing the lip produces alar base narrowing, lip flattening, and chin dimpling.

The short lower lip

An anatomically short lower lip is sometimes associated with Class II malocclusions. This is verified by cephalometric measurement of the lower anterior dental length (lower incisor tip to soft tissue menton). The average values are for females 45–49 mm, and for males 52–57 mm.[21] An anatomically short lower lip should not be confused with a lower lip which appears short, due to Class II deep bite upper incisor interferences. An anatomically short lower lip can be lengthened with a lengthening genioplasty.

The long lower lip in Class III cases

An anatomically long lower lip is not common. It can be associated with Class III malocclusions. Care is needed to carefully examine patients with a Class III malocclusion. A closed lip position will produce the appearance of a long lower lip, as the lip elongates to close over the Class III incisor relationship. The closed lip length is misleading and should not be used for treatment planning. Also, in Class III cases the relaxed lip appearance is deceiving due to hypertonicity of the lower lip – this causes elevation and apparent lengthening. The lower lip length should be verified with the cephalometric anterior dental length measurement (lower incisor tip to soft tissue menton) which is not influenced by posture (Figs. 5.21, 5.22).

The lip proportions

The normal ratio of upper to lower lip is 1 : 2.2 (Fig. 5.27). Proportionate lips harmonize regardless of length; disproportionate lips may need surgical length modification to appear in balance.

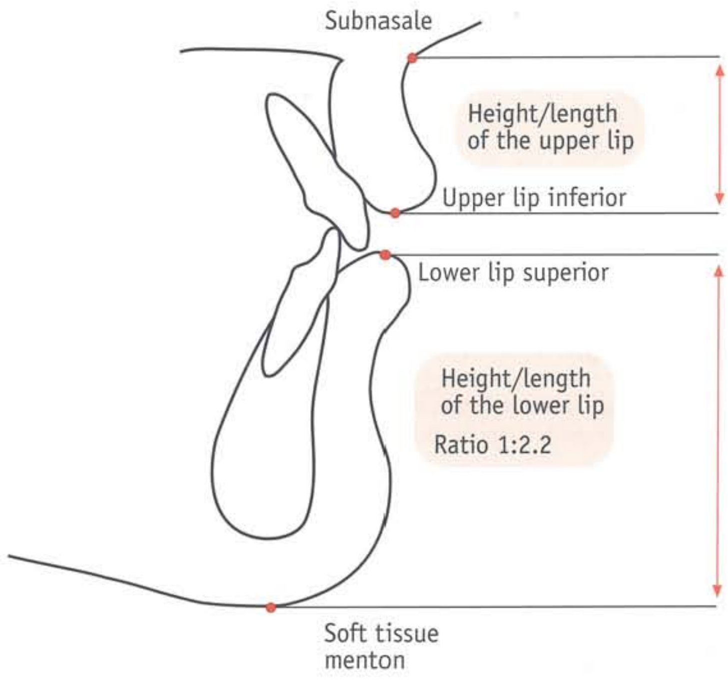


Fig. 5.27 The normal ratio of upper to lower lip is 1 : 2.2.

Lip redundancy

Lip redundancy is seen with vertical maxillary deficiency. In older patients, it may be due to long lip lengths. To accurately assess lip lengths when redundant lip is present, the patient's bite must be opened until the lips separate. This is best accomplished with a wax bite, used to open the bite on centric relation (p. 104). The face is examined in that position.

If the lip redundancy is caused by vertical maxillary deficiency, surgical correction normally involves a vertical skeletal increase. If the redundancy is due to a long upper lip, the lip can be shortened.

The upper lip prominence

Upper lip prominence (Fig. 5.28) is related to the A/P position of the maxilla, upper incisor torque, and upper lip thickness. If the maxilla is retruded, this is associated with upper lip retrusion and a straight maxillary sulcus curve. Upper lip retrusion is treated with labial crown torque, Le Fort 1 advancement, or by increasing upper lip thickness. For optimal esthetic outcome, the source of the retrusion should be identified and treated – for example, thickening of a thin lip.

The upper lip support

Upper lip support is lacking when maxillary retrusion exists. A special note should be made if the upper lip is unsupported by the teeth, and is effectively supported only by air. An unsupported upper lip of this type is a pendulous drape and usually has a deep maxillary sulcus curve. The maxilla should be advanced in this situation to bring the incisors into lip contact and to provide support from the teeth. An orthodontic history is important when evaluating upper lip support. If this reveals that retraction mechanics were used, maxillary advancement is normally indicated. If the support for the upper lip is deficient, this is treated with labial crown torque and/or maxillary advancement.

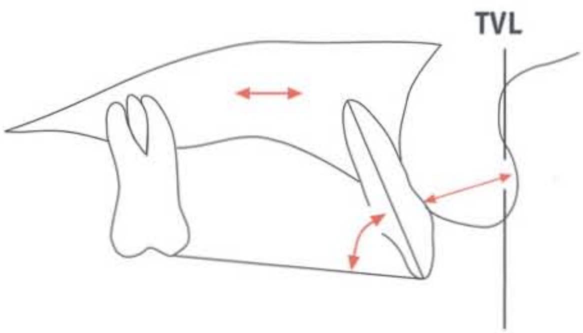


Fig. 5.28 Upper lip prominence is related to the A/P position of the maxilla, upper incisor torque, and upper lip thickness.

The nasolabial angle and the upper lip angle

Closely related to upper lip projection are the nasolabial angle (Fig. 5.29) and the upper lip angle (Fig. 5.30). These reflect the position of the upper incisor teeth and the thickness of the soft tissue overlying these teeth. These angles are extremely important in assessing the upper lip. The soft tissue structures are altered by movement of the incisor teeth. These angles should be studied before orthodontic overjet correction, to assess the potential for unfavorable retrusion and flattening of the upper lip.

The lower lip projection to TVL

Lower lip projection is influenced by the inclinations of upper and lower incisors, the projection of the maxilla and mandible, the overbite, and the thickness of the lower lip. Anterior deflection of the lower lip with accentuation of the labiomental angle occurs with deep bite Class II and vertical maxillary deficiency (Case RS, p. 247). Class III malocclusions are associated with a protruded lower lip and straight labiomental angle. Abnormalities of the lower lip are treated by correcting the A/P and vertical occlusal disharmonies.

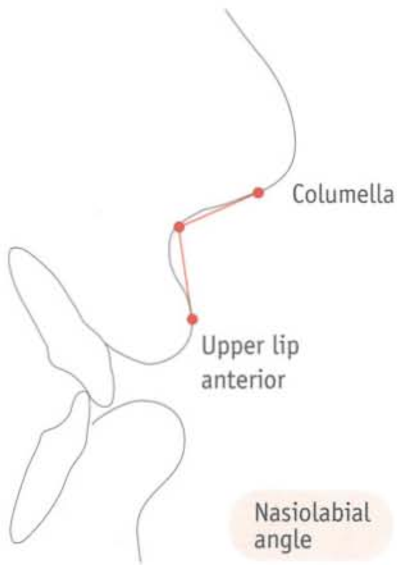


Fig. 5.29

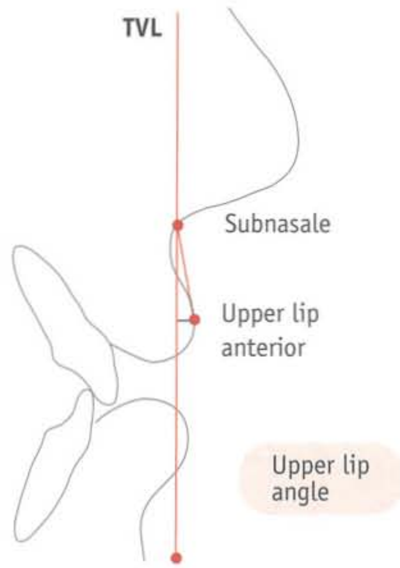


Fig. 5.30

Figs 5.29 and **5.30** The nasolabial angle and the upper lip angle reflect the position of the upper incisor teeth and the thickness of the soft tissue overlying them. These angles should be studied prior to orthodontic extraction and retraction – if they alter to unesthetic values extractions and retraction shoud be avoided.

Upper incisor exposure–lips at rest disharmony

During clinical frontal examination and STCA of the lips it is necessary to establish the cause of any disharmony that is observed. Disharmony of upper incisor exposure (Fig. 5.31) can be produced by the following:

- Increased or decreased length of the upper lip (Fig. 5.32).
- Increased or decreased skeletal length of the maxilla (Figs 5.26 and 5.33).
- Increased or decreased length of the upper incisor crowns (Fig. 5.34).
- Lip thickness - increased lip thickness reveals less tooth exposure. This is determined by the distance from the facial surface of the upper lip to the upper incisor edge (Fig. 5.15).

Fig. 5.31 The mean value for upper incisor exposure in females, with lips at rest, is 4.7 mm. The mean for males is 3.9 mm.

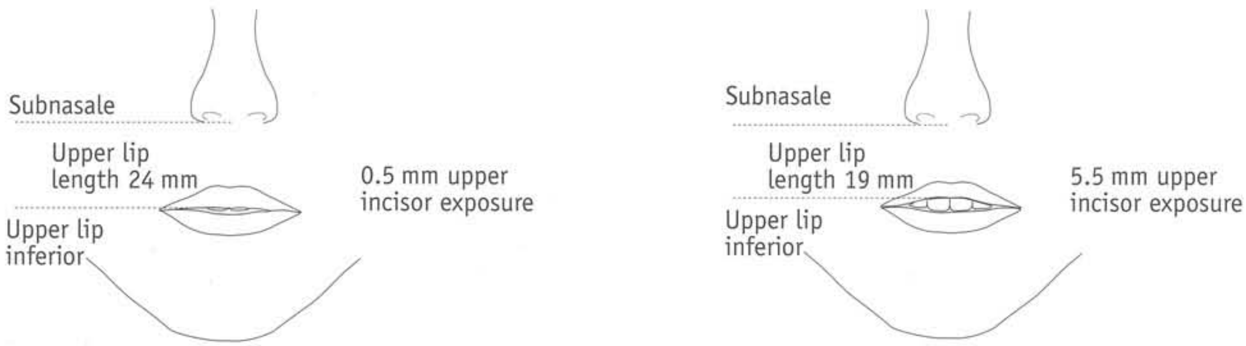


Fig. 5.32 Female depiction, a differences in upper lip length - just one of four possible causes of differences in upper incisor exposure with lips at rest. Predictably, it is also a factor when smiling (p. 60).

Exposure of upper incisor and gingival tissue when smiling

Variability in gingival exposure is related to:

- The length of the upper lip (Fig. 5.32)
- The vertical length of the maxilla (Fig. 5.33)
- The crown lengths of the upper incisors (Fig. 5.34)
- The presence of gingival hypertrophy
- The magnitude of lip elevation when smiling (Fig. 5.35).

Excessive gingival exposure when smiling may therefore be caused by a short upper lip, vertical maxillary excess, short crowns, gingival hypertrophy, and/or large upper lip elevation when smiling.

Historically, the subject of excessive gingival exposure and 'gummy smiles' has been much discussed in orthodontics. It

Fig. 5.35 It is acceptable to show up to 2 mm of gingival tissue at the smile, as seen here. Excessive gingival exposure when smiling may be caused by a short upper lip, vertical maxillary excess, short incisor crowns, gingival hypertrophy, and/or a large elevation of the upper lip when smiling. Interestingly, none of these can be influenced by orthodontic treatment.

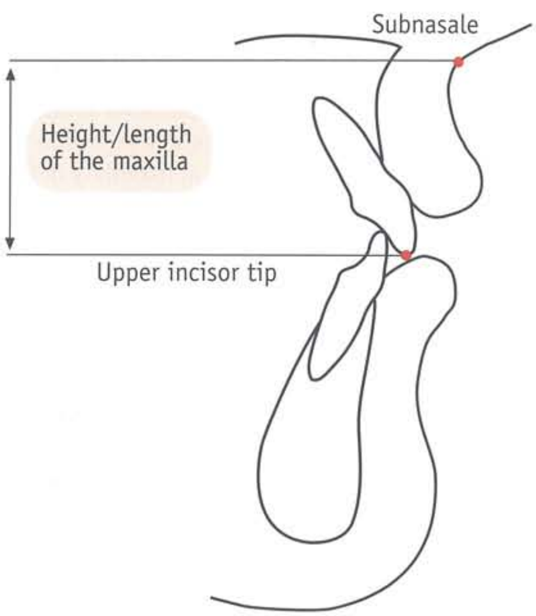


Fig. 5.33 Gingival exposure varies with the vertical length of the maxilla.

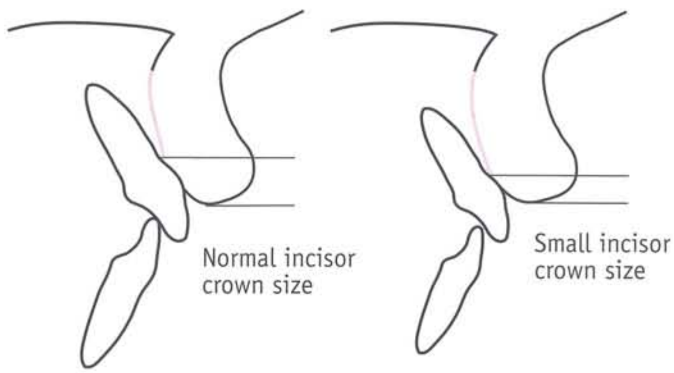


Fig. 5.34 Gingival exposure varies with the length of the upper incisors. All other factors being equal, if the crown height is short more gingiva is exposed when smiling.

is interesting to note that the causes of a gummy smile are not treatable orthodontically. By orthodontic methods it is not normally possible to change the causative factors, such as vertical maxillary excess or short incisor crowns.

If there is decreased incisor display when smiling, this can be caused by maxillary vertical deficiency, short crown lengths, or decreased elevation of the upper lip during smiling.

Short incisors are commonly associated with functional and parafunctional abrasion. Before surgery the teeth should be lengthened to normal anatomical dimensions. In this way, normal incisor to lip dimensions can be planned.

Inter-labial gap

The inter-labial gap measurement varies with lip lengths and vertical skeletal height or length. An *increased inter-labial gap* (Case HH, p. 18; Case AC, p. 185; Case AD, p. 218) is seen in patients with a short upper lip, vertical maxillary excess, or mandibular protrusion with an open bite. A *reduced inter-labial gap* is found in patients with vertical maxillary deficiency (Case RS, p. 252), and an anatomically long upper lip (this is a natural aging change, especially in males). Abnormalities of inter-labial gap measurement should be considered when planning any skeletal changes. For example, a short upper lip should be recognized as a soft tissue problem. It should not be treated by excessive surgical vertical shortening of the maxilla. This error can lead to a short, round facial outline.

Closed lip strain

In cases with closed lip strain, mentalis contraction (mentalis strain), lip strain, and alar base narrowing are observed at the closed lip position (Fig. 5.26, p. 166). This may be related to vertical skeletal excess, a short upper lip, or in some cases, mandibular protrusion with an open bite.

Upper and lower vermilion heights

Many procedures exist which can alter the vermilion heights and A/P thickness of this lip area. When applicable, these soft tissue procedures should be used to create normal lip anatomy and thus enhance facial beauty (Fig. 5.31, p. 170).

Prominence of soft tissue pogonion

The prominence of soft tissue pogonion (Fig. 5.36) is influenced by the torque of upper and lower incisors, the A/P position (projection) of the maxilla, the A/P position of the mandible, the overjet, the angle of the occlusal plane, and the soft tissue thickness of pogonion.

Disharmony, due to a *retrusive soft tissue pogonion*, is seen in cases with vertical maxillary excess, mandibular retrusion, and steep occlusal planes. Disharmony, due to a *protrusive soft tissue pogonion*, is associated with vertical maxillary deficiency, mandibular protrusion, and a flat occlusal plane.

Pogonion harmony is produced by identifying and treating the source of the disharmony. For these cases, surgery often includes a double jaw surgery to flatten the occlusal plane and/or a chin augmentation of 2–4 mm. Chin augmentations in excess of 4 mm are compensations for poor planning (steep occlusal planes, upright upper incisors and/or flared lower incisors).

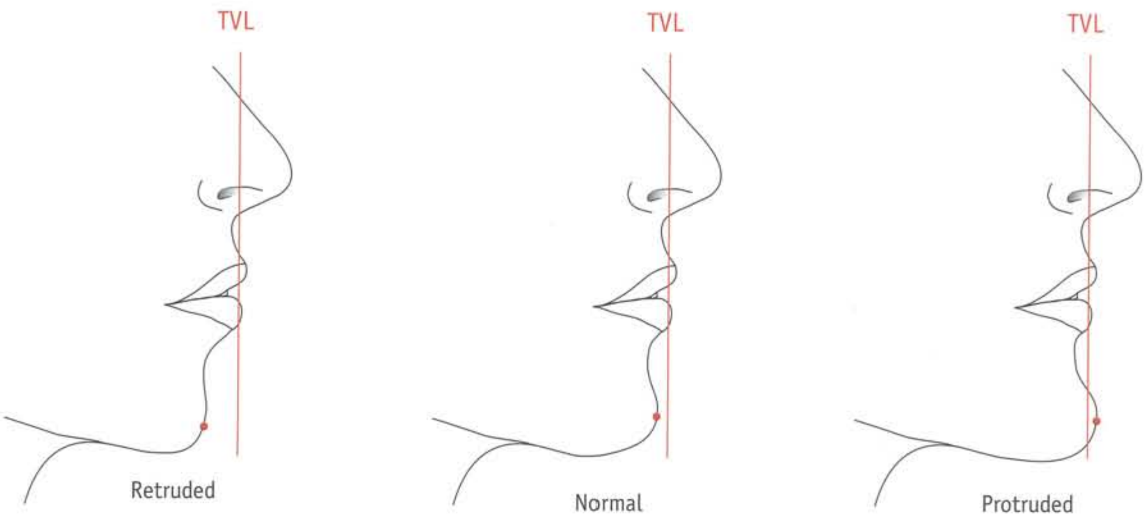


Fig. 5.36 The prominence of soft tissue pogonion.

Throat length and contour

The throat length (Fig. 5.37) and contour are influenced by the torque of the upper and lower incisors, the A/P position of the maxilla and mandible, the angle of the occlusal plane, and the soft tissue thickness of pogonion, and presence of submental fat. Surgical set-back of the mandible will change throat length. The esthetic result, after surgery, should produce a throat with adequate length, without sagging, and adequate airway.

Consequently, a patient with a long, straight throat length can be considered for a mandibular set-back. Conversely, a patient with a short, sagging throat length is not a good candidate for a mandibular set-back, but should have a mandibular advancement and possibly a submental lipectomy.

Balancing the dental, skeletal, and soft tissue relationships to TVL

As stated earlier, if dental and skeletal factors are within a normal range, they will usually produce balance and harmony of the profile. The nasal base, the lips, the chin relationship, and the soft tissue A′ point and B′ point will be balanced and harmonious. The profile at the end of treatment is greatly influenced by how accurately the orthodontist and surgeon manage the dental and skeletal components.

As a goal, the dental and skeletal values should be within two standard deviations to achieve a balanced profile. However, in a few cases the occlusal plane, and the upper and lower incisor values to the TVL will need to be in the three standard deviation range, in order to produce adequate projections of the soft tissue profile. The upper and lower incisors will be forward of normal positions in these situations to produce the necessary lip protrusion and chin projection.

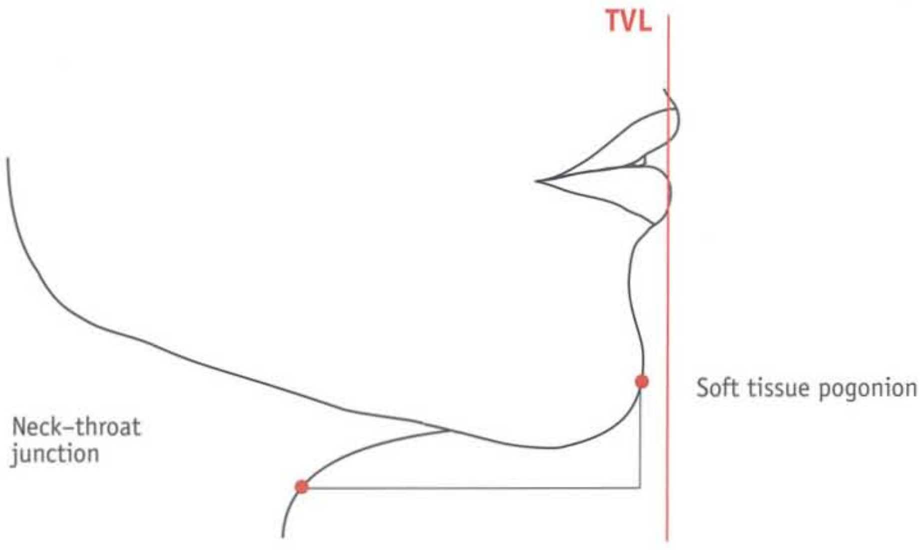


Fig. 5.37 The throat length. Surgical set-back of the mandible changes the throat length.

A clinical commentary on facial growth, facial imbalances, and the need for bimaxillary surgery

Volumes have been written on the 'mechanisms' involved in facial growth. In clinical practice, certain patterns of facial growth repeatedly present themselves. These eventually begin to influence clinical diagnosis and treatment planning. The following clinical observations are worthy of consideration. The mandible appears to drive the growth of both jaws – A/P (anteroposterior) and vertically. For example, if mandibular A/P hypoplasia occurs, maxillary A/P hypoplasia also occurs, but to a lesser extent than in the mandible. The maxilla appears to lag back for want of the push provided by normal A/P mandible growth. Following this logic, the clinician will feel that many Class II malocclusions should (for facial reasons) be treated by a small advancement of the maxilla and a larger advancement of the mandible. If treatment is based on facial examination and not only on the Class II overjet, this is a frequent finding; the most common facial operation in the orthognathic surgery practice is bimaxillary advancement. The same logic (mandibular growth driving maxillary growth) can be seen in Class III (mandibular prognathism) cases. The maxilla is often retruded (maxillary retrusion) when mandibular prognathism exists. It appears that the mandible 'jumps past' the maxilla. Consequently, the maxilla seems to 'lag back' for want of the push provided by normal A/P mandibular growth. As a consequence, when treatment is directed by facial examination and not by the overjet, a mandibular set-back and a maxillary advancement are frequently required to produce facial balance. Vertically, the mandible also seems to control the growth of both jaws. Normal vertical ramus growth seems to allow normal posterior maxillary height to develop. If vertical ramus growth is deficient, posterior vertical growth of the maxilla is frequently also diminished. If this occurs it is occlusally expressed as a Class II steep occlusal plane, and facially expressed as deficiency of the chin. By looking beyond the Class II overjet, facial examination requires a treatment plan which will 'flatten' the occlusal planes of both jaws. This will provide normal chin projection. Consequently, if treatment planning is directed by facial examination (and not the overjet), the occlusal plane of both jaws must be flattened during treatment, and the mandible advanced, to produce facial balance.

A recent study seems to provide support for the above clinical observations. Gidarakou et al[24] studied the effects of degenerative joint disease on skeletal and dental patterns. They found the following morphology:

1. Maxillary retrusion
2. Mandibular retrusion
3. Clockwise mandibular rotation
4. Upper and lower denture base retrusion
5. Overjet increase.

These findings are identical to the clinical experience stated above (bimaxillary retrusion with a steep occlusal plane). Gidarakou felt that the DJD possibly affected growth, leading to the altered facial pattern. It might be true that any decrease in condylar growth, for any reason, will result in this growth pattern and require bimaxillary advancement with counter-clockwise occlusal plane change.

It can also be observed that the mandible appears to drive the growth of both jaws (that the maxilla follows the developmental pattern of the mandible) in asymmetrical cases. Asymmetries are most often an expression of asymmetrical condylar growth. Excess condylar growth pushes the midline to the opposite side while canting down the maxilla and mandible on the affected side. Unilateral condylar hypoplasia has the opposite affect. The midline deviates to the small condyle and the maxilla and mandible cant up on the affected side.

3. THE ANALYSIS OF THE DENTITION AND INTRA-ORAL TISSUES

THE PRE-ORTHODONTIC ANALYSIS

Information is gathered about the teeth and intra-oral tissues using the patient history, the patient examination, the mounted dental models, and the panoramic and bite-wing radiographs. It is necessary to analyze the teeth and supporting periodontal tissues, the intra-oral soft tissues (in particular tongue size and posture) and the alveolar bone. A note should be made concerning oral hygiene and predicted levels of cooperation, as these become increasingly important as orthodontic correction proceeds.

As with any patient analysis, it is essential to identify any soft or hard tissue anomalies or pathology. Where necessary this needs to be referred to a dentist, periodontist, surgeon or other appropriate specialist.

The mounted dental models are used to identify and quantify any mandibular slides. The mounted models need to be carefully compared with the intra-oral findings during the clinical examination.

After this, the dentition becomes the main focus of the analysis. It is assessed and recorded in three categories:

- Vertical
- Horizontal
- Transverse.

Vertical analysis of the dentition

This includes the overbite, the plane of occlusion, and the curve of Spee. If there is a dual plane of occlusion in the maxilla (Fig. 5.38), this should be noted. Ankylosed teeth can cause local vertical difficulties, and these need assessment.

Any cants should be noted and correction included in the overall treatment plan if possible. If bimaxillary surgery is contemplated, occlusal cants will be corrected routinely at surgery (Figs 5.39–5.56). If the treatment plan involves one-jaw surgery, the occlusal cant will have to be accepted, unless there is an esthetic problem. If there is a clear esthetic problem, either orthodontic tooth movement or bimaxillary surgery must be used to correct the cant. It is difficult to correct a cant orthodontically.

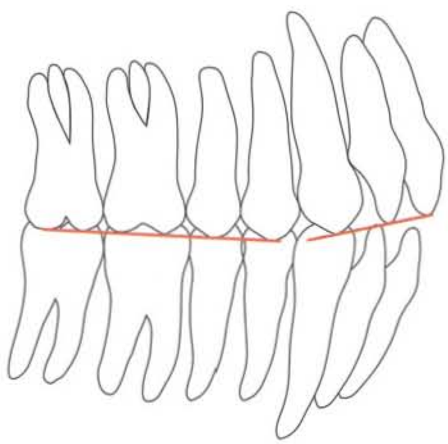


Fig. 5.38 If there is a dual plane of occlusion in the maxilla, this should be noted. Orthodontal flattening of the dual plane occlusion has a high rate of relapse.

CASE MV

This female patient (Figs 5.39 to 5.49) presented with facial asymmetry and a small cant of the dentition (down on the left). This was due to less condylar growth on the right side than on the left side. There had been previous extraction of upper first premolars.

The lower midline discrepancy was not of dental origin, but was assessed as being due to a mandibular asymmetry and a mandibular slide.

Fig. 5.42 Pre-orthodontic photographs in centric occlusion (these photos do not reflect the severity of the malocclusion)

Fig. 5.39

Fig. 5.40

Fig. 5.41

Figs 5.39 to **5.41** Pre-orthodontic facial photographs taken in centric occlusion (with no CR wax-bite). The frontal photographs show the facial asymmetry, however, the profile photograph does not show the severity of the facial imbalance.

Fig. 5.43

Fig. 5.44

Fig. 5.45

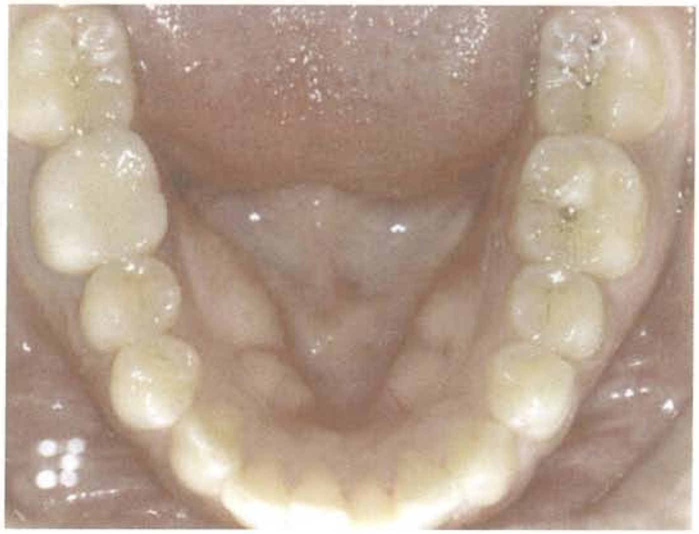


Fig. 5.46

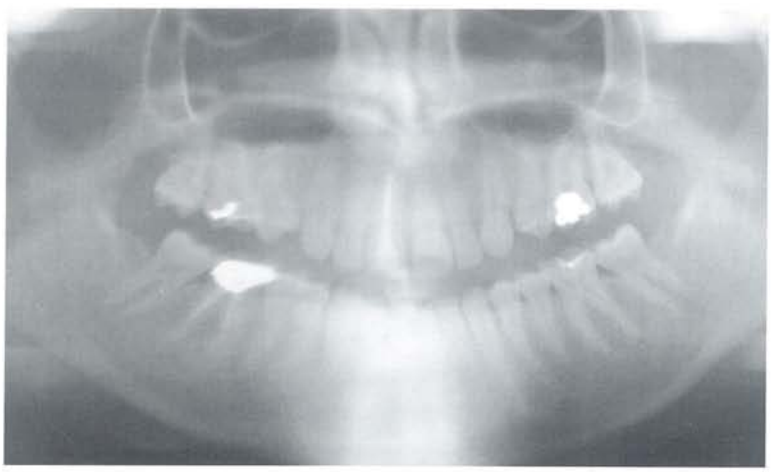


Fig. 5.47

Fig. 5.48 Post-orthodontic preparation profile with waxbite.

Fig. 5.49 Post-orthodontic preparation frontal with waxbite

The overall treatment plan included bimaxillary surgery, to level the occlusal cant and center the mandible. If the treatment plan had involved only one-jaw surgery, the occlusal cant must be accepted.

The occlusal cant and the mandibular asymmetry were corrected at surgery. Dentally, the upper arch was prepared for implants (Figs 5.50 to 5.58).

Fig. 5.53 Post-treatment intra-oral photograph. Implants will be placed in upper first bicuspid areas.

Fig. 5.50

Fig. 5.51

Fig. 5.52

Figs 5.50 to **5.58** Post-treatment facial photographs, showing excellent facial balance.

Fig. 5.54

Fig. 5.55

Fig. 5.56

Fig. 5.57

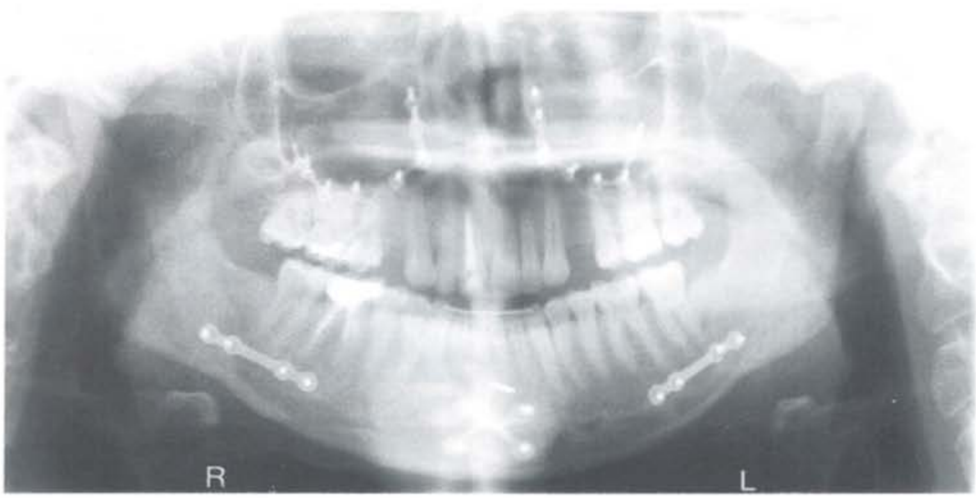
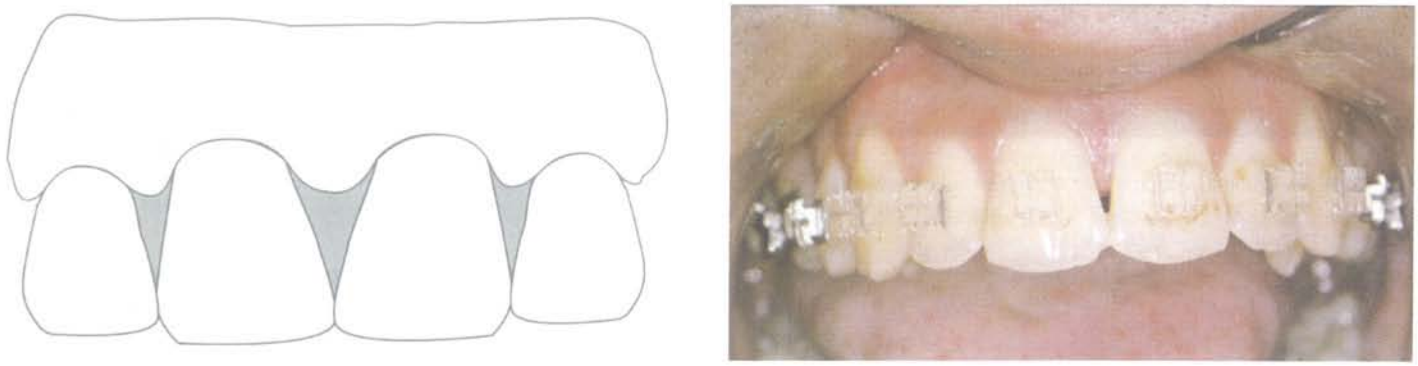


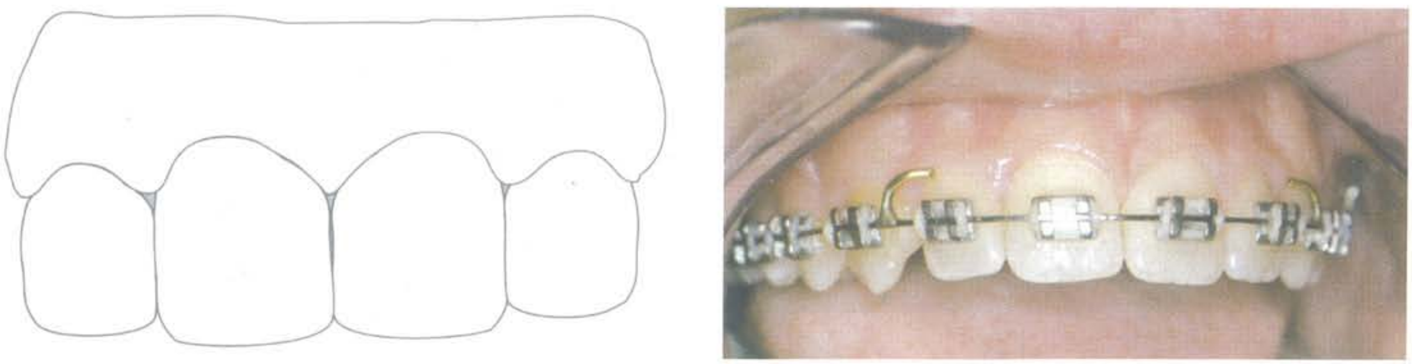
Fig. 5.58 Post-surgery panorex.

Horizontal analysis of the dentition

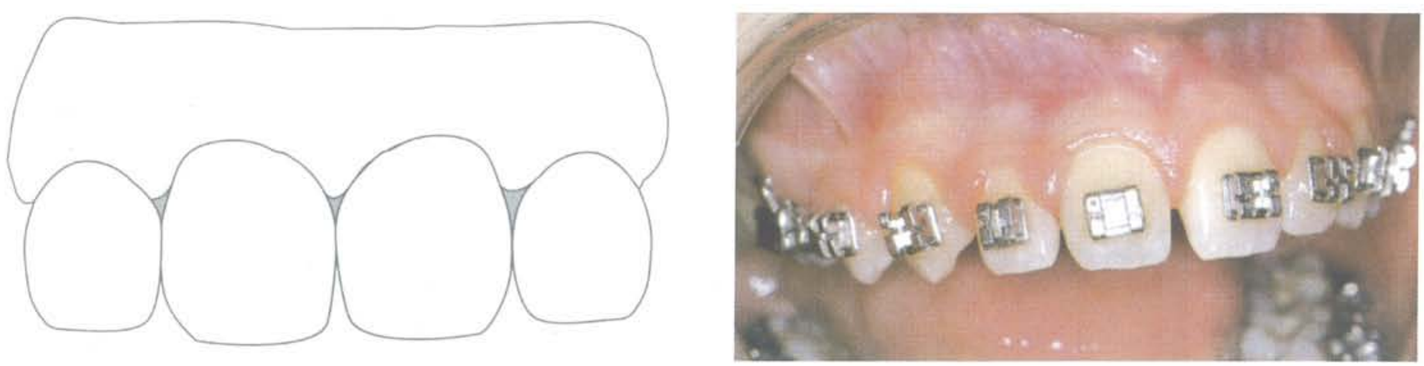
This will include a note of any crowding or spacing, and a tooth size analysis (for example the Bolton analysis). Overjet is recorded in this horizontal category, as well as the molar and canine relationships. The general anatomical form of the teeth (Fig. 5.59) needs to be noted (rectangular, triangular or barrel shaped). Missing teeth and small teeth (Fig. 5.60) such as peg-shaped lateral incisors should be recorded, together with any severe rotations.[25]



Triangular shaped crowns.



Rectangular shaped crowns.



Barrel shaped crowns.

Fig. 5.59 The general anatomical form of the teeth needs to be noted. They may be rectangular, triangular or barrel shaped.

Fig. 5.60 Missing teeth and small teeth should be recorded, together with any severe rotations.

Transverse analysis of the dentition

Upper and lower arch forms are noted, together with arch coordination. Crossbites are recorded and analyzed to determine whether they are of dental, skeletal, or functional origin. If the maxilla is narrow skeletally this important fact should be noted, because surgical correction will be needed in a non-growing individual. Rapid maxillary expansion can achieve an increase in maxillary skeletal width for younger patients (Fig. 5.61). However, Wertz and Dreskin noted that 'older patients often lose much of the width increase that is achieved through palatal expansion'.[26] Linder-Aronson and Lindgren investigated rapid maxillary expansion cases 5 years post-retention.[27] They found that only 45% of molar expansion, and 23% of inter-canine expansion was maintained.

Upper and lower midline discrepancies are noted. When analyzing the midlines, the philtrum represents the soft tissue midline of the face (p. 52). Midlines are assessed relative to this. As previously stated, upper deviations are normally of dental origin. A lower midline discrepancy may be of dental origin, but may be due to a mandibular slide or mandibular asymmetry (Figs 5.41–5.58). This needs to be analyzed.

A mandibular shift is characterized by dental and chin shifting. Skeletal asymmetry of the mandible is caused by differential condylar growth or unilateral condylar resorption.

During later treatment, midline corrections will be achieved by correcting the cause. During analysis of the dentition it is therefore necessary to diagnose the underlying source of any midline discrepancy.

Fig. 5.61 Rapid maxillary expansion can achieve an increase in maxillary skeletal width for younger patients, but careful retention is needed. Surgical correction will be required for stable maxillary expansion in a non-growing individual. When rapid palatal expansion is achieved presurgically, the archwire should be cut to allow any expansion instability to relapse prior to surgery. Note in the center photograph that the central incisors have separated. This indicates the desired skeletal expansion has occured.

Listing the patient's dental problems

The patient's dental and any other intra-oral problems are listed, with information about what the patient is expecting from treatment. The guidelines for dental treatment planning are presented in Chapter 8.

For potential surgical cases, the initial records and the findings need to be sent to the surgeon for review and input from the surgical aspect. It is important to involve the surgeon at this early stage, to allow a full exchange of information, and to assist the patient in preparing for possible surgery. This preparation can be a lengthy process, involving emotional, intellectual, and financial planning. The patient needs to be fully comfortable with the final treatment plan, and well prepared from all aspects.

THE PRE-SURGICAL ANALYSIS OF THE DENTITION AND INTRA-ORAL TISSUES

For surgical cases further models should be taken as orthodontics proceeds and the pre-surgical set-up gets closer. There should be more than one set, to evaluate the progress. Both the surgeon and the orthodontist should be checking these progress models. This ongoing analysis makes sure that the dentition is properly set up orthodontically, in preparation for surgery.

The surgeon will require detailed information about the orthodontic tooth movements which have been carried out. The pre-orthodontic records can be compared with the latest models and radiographs to note 'orthodontic changes' on the appropriate form (Fig. 5.62)

MODEL EXAMINATION

1. Orthodontic extraction decision (periodontal health and stability)			**Solution**			
upper	_____mm crowding	accentuated C of spee	extraction	44	55	
			labial crown torque			
			reapproximation			
lower	_____mm crowding	accentuated C of spee	extraction	44	55	1
			labial crown torque			
			reapproximation			

2. Orthodontic preparation stability (compare pre-ortho to presurgical models)				**Solution**
upper arch width/form	no change	expanded	contracted	cut arch wire to allow relapse
lower arch width/form	no change	expanded	contracted	bend archwire to match original arch width and form
upper occlusal plane	no change	leveled		cut arch wire to allow 2 plane relapse

3. Surgery decisions (1 piece versus multisegment)					**Solution**
CI bicuspid test	class I overjet	class II overjet	class III overjet		place upper distal lateral spaces
					upper crown torque change
					lower reapproximation
					lower crown torque change
class I arch width	match	mismatch	edge to edge	crossbite	multisegment LFI
					midline osteotomy Md
upper occlusal plane	one plane	two plane	accentuated	reverse	multisegment LFI

Patient name ______________________________ **Referring doctor** ______________________

Fig. 5.62 Three areas of model analysis are accomplished; orthodontic extraction decision, orthodontic stability, and surgical decisions. Findings are listed on the left while treatment is shown on the right. Areas examined and treatments are based on stability and periodontal health of orthodontic changes. (©Arnett Facial Reconstruction Courses Inc. 2003)

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CASE AC

This 15.2-year-old female presented for consultation with a severe Class II malocclusion. She was referred by her orthodontist. Diagnosis and treatment were started with the intention of fulfilling the seven goals of treatment. Her patient motivation form indicated a desire for straightening of her upper and lower front and back teeth, forward movement of the lower teeth, and correction of the midline. Facially, the patient wanted the sag removed from under her lower jaw and her face to look proportional. She had clicking in her jaw but no pain. TMJ examination and history, clinical facial examination, soft tissue cephalometric examination, and model examination were obtained. The problem list and treatments were as follows:

PROBLEM	TREATMENT
1. High midface	
• Deficient cheekbone contour	• Heat treated hydroxyapatite augmentations
2. Maxilla	
Dental	
• Upper incisor lingual crown torque	• Upper incisor labial crown torque
• Orthodontic preparation stability (assess models)	• Stable
Skeletal/facial	
• Upper lip retrusion	• Maxillary advancement
• Long nasal projection	• Maxillary advancement, possible future rhinoplasty?
• No dental deviation	• No treatment
• Normal incisor exposure	• No treatment
• Class I hand held model – narrow maxilla	• Multi-segment LFI expansion or orthodontic expansion?
• Curve of Spee – level	• No treatment
3. Mandible	
Dental	
• Mild crowding	• Orthodontics anterior stripping
• Lingual crown torque	• Labial crown torque
• Orthodontic preparation stability (assess models)	• Stable
Skeletal/facial	
• Marked chin and lower lip retrusion	• Bilateral sagittal split osteotomy (BSSO) advancement, flatten occlusal plane
• 2 mm left deviation	• 2 mm right rotation
• Short chin height	• Lengthen chin with osteotomy
• Class I hand held models – wide mandible	• Midline osteotomy of mandible?
• Curve of Spee – accentuated	• Level orthodontically
4. TMJ	
• Clicking	• Splint + medications after orthodontic preparation for 6 months
• Condyles with flat surfaces, thick cortex	• Splint + medications after orthodontic preparation for 6 months
5. Growth potential	
• 15-year-old female, unstable condyles at this age (p. 146)	• Orthodontics at age 16 • Medications + splints at age 17.5 • Surgery at age 18

Secondary to suspected joint instability, orthodontics was to start at age 16, splint and medications at age 17.5, and surgery at age 18. After diagnosis, the patient was treatment planned antero-posteriorly and vertically using the seven-step cephalometric treatment plan. The frontal midlines, levels, and outline were treatment planned using the frontal clinical examination. Two possible treatment plans were proposed, which would correct the Class II malocclusion and arch width mismatch. These included multi-segment LFI + BSSO or BSSO with a midline osteotomy. Using orthodontics to correct the arch width mismatch was eliminated because of potential relapse and periodontal decline. After orthodontic preparation, the orthodontist was asked to cut the maxillary archwire between the canines and laterals, and a moderate transverse mismatch developed. This relapse occurred within 3 months. Based on this, a multi-segment LFI was chosen to correct the transverse discrepancy. The multi-segment LFI and BSSO produced basic facial balance while correcting the occlusion. Additional improvement of facial balance was achieved with heat treated hydroxyapatite cheekbone grafts and a sliding chin osteotomy with advancement and lengthening. Platelet rich plasma was used, and local bone was grafted to the LFI osteotomy and the large BSSO vertical gaps. A supra-hyoid myotomy was done through the chin osteotomy to reduce posterior tension on this 20.4 mm pogonion advancement. To stabilize the joints post-surgically, the patient was maintained on doxycycline, amitriptyline, and vitamins C and E. Feldene was not used postoperatively, to avoid the decreased bone healing associated with anti-inflammatory medication.

Fig. 5.66

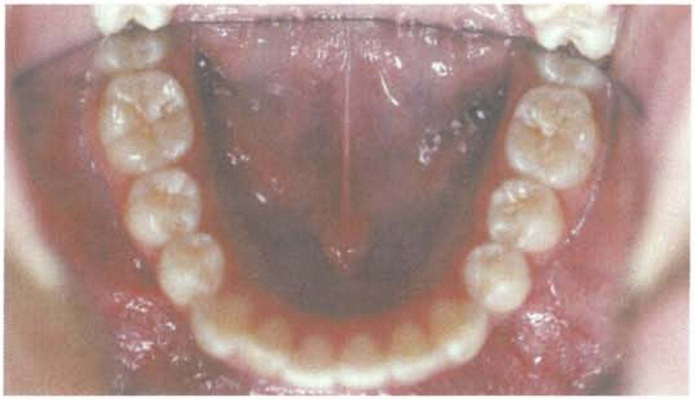


Fig. 5.69

Fig. 5.63

Fig. 5.64

Fig. 5.65

Figs 5.63 to **5.70** Pre-orthodontic facial and intra-oral photographs reveal a severe Class II skeletal pattern and minimal Class II dental pattern in centric occlusion. These records were obtained in a dental lab. They demonstrate the typical problem of lab records; the patient's joints are not seated and all records are thus inaccurate. Diagnostic records must reveal the true mandibular position relative to the maxilla – only with this information can an accurate diagnosis and treatment plan be developed.

Fig. 5.67

Fig. 5.68

Fig. 5.70

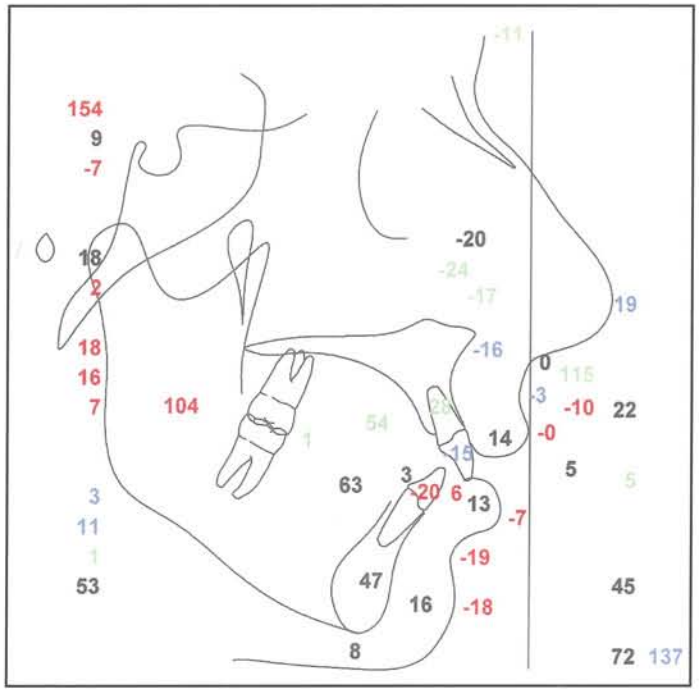


Fig. 5.71 Pre-orthodontic STCA tracing reveals a large nose (19, blue), a flat upper lip (-0, red and -10, red), a steep occlusal plane (104, red), and a very retrusive mandible (-20, red and -18, red). This headfilm radiograph is accurate. A first tooth contact waxbite was utilized to insure CR condylar position. Further, tomograms were utilized to examine condyle positions utilizing the same waxbite used for the headfilm.

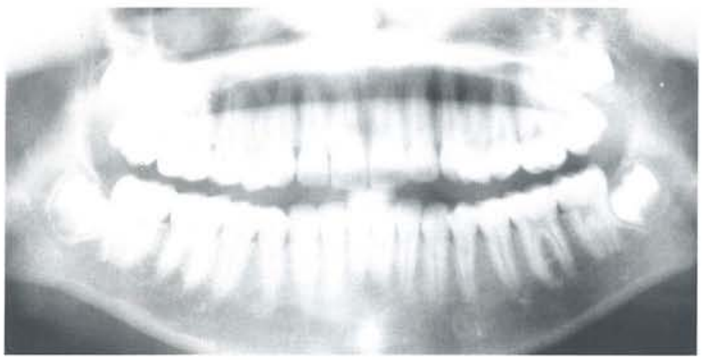
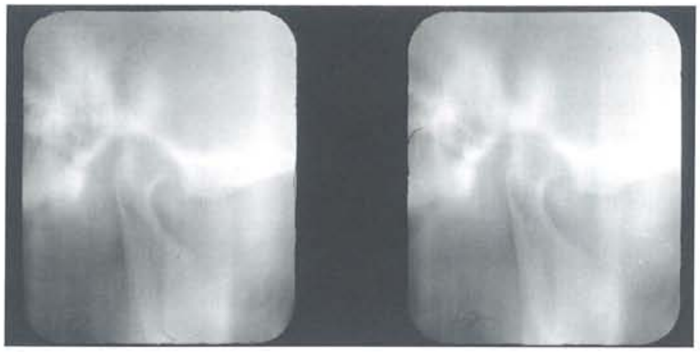


Fig. 5.72 Pre-orthodontic panoral radiograph shows a healthy, caries and restoration free dentition. Third molars were present.



Figs 5.73

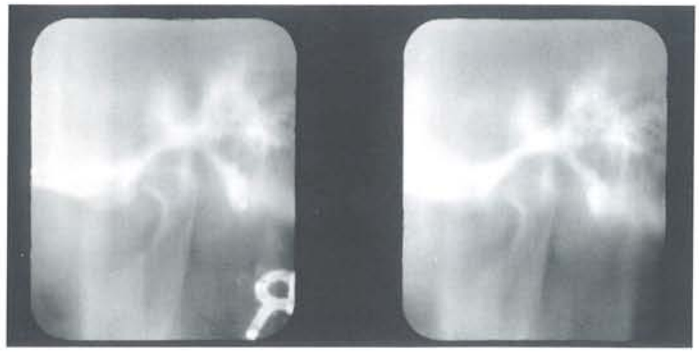


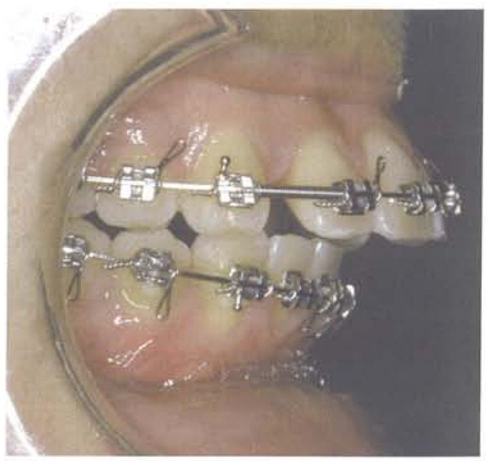
Fig. 5.74

Figs 5.73 and **5.74** Pre-orthodontic tomographic radiographs. Note: the flat antero-posterior surface and anterior beaking. These joints must be stabilized after orthodontic preparation, prior to surgery, with splints and medications.

Figs 5.76 to **5.78** The pre-surgical orthodontic preparation, carried out on a non-extraction basis. The distal lateral spaces were developed to allow a Class III overcorrection of the mandible at surgery.

Fig. 5.76

Fig. 5.79 A severe overjet was present pre-surgically. The mandible was carefully positioned in CR for the photograph.



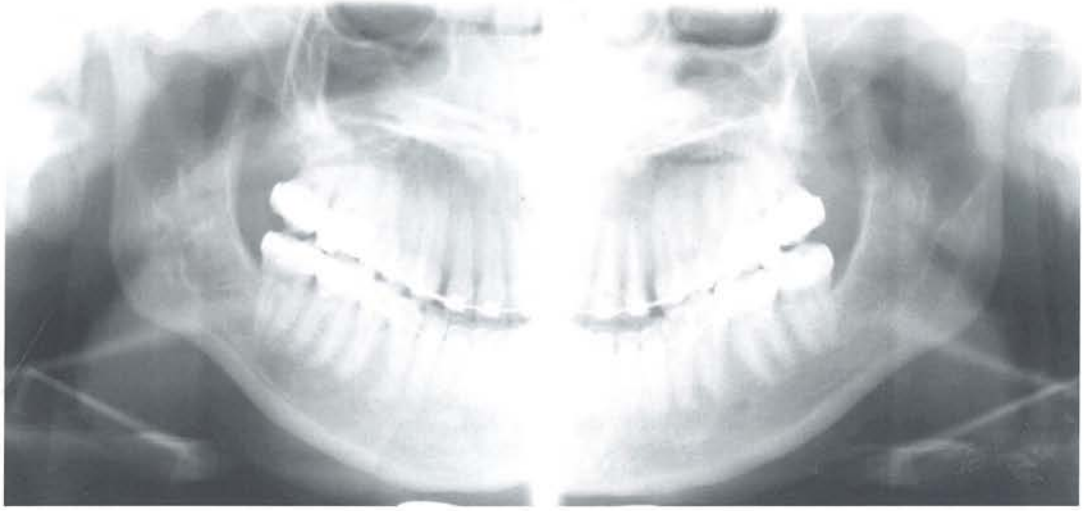


Fig. 5.75 The pre-surgical panoral radiographs showed that third molars had been removed.

Fig. 5.77

Fig. 5.78

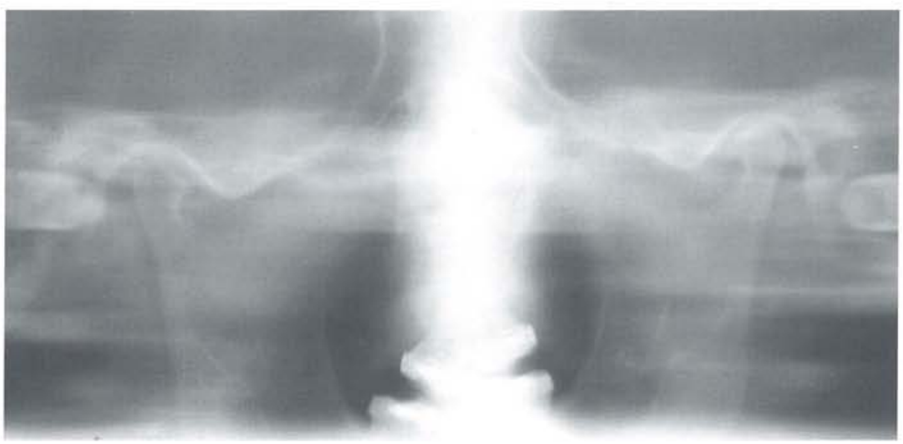


Fig. 5.80 The pre-surgical tomographic radiographs continued to show flat antero-superior surfaces of condyles and anterior breaking. Medications and splint (Ch. 6) were started 6 months prior to surgery. The condyles are recorticated and centered in the fossa. A waxbite was in place for the tomograms and headfilm.

Figs 5.81 and 5.82 Pre-surgical profile photographs. Note: chin retrusion and lip strain. A waxbite was in place for the photographs. This provides centric relation positioning between the maxilla and mandible.

Fig. 5.81

Fig. 5.82

Figs 5.83 to 5.85 Pre-surgical frontal photographs. Note: gingival smile, excess incisor exposure and mentalis strain.

Fig. 5.83

Fig. 5.84

Fig. 5.85

Figs 5.86 and 5.87 Pre-surgical right and left three-quarter photographs. Note: chin recession and deficient cheekbone contour.

Fig. 5.86

Fig. 5.87

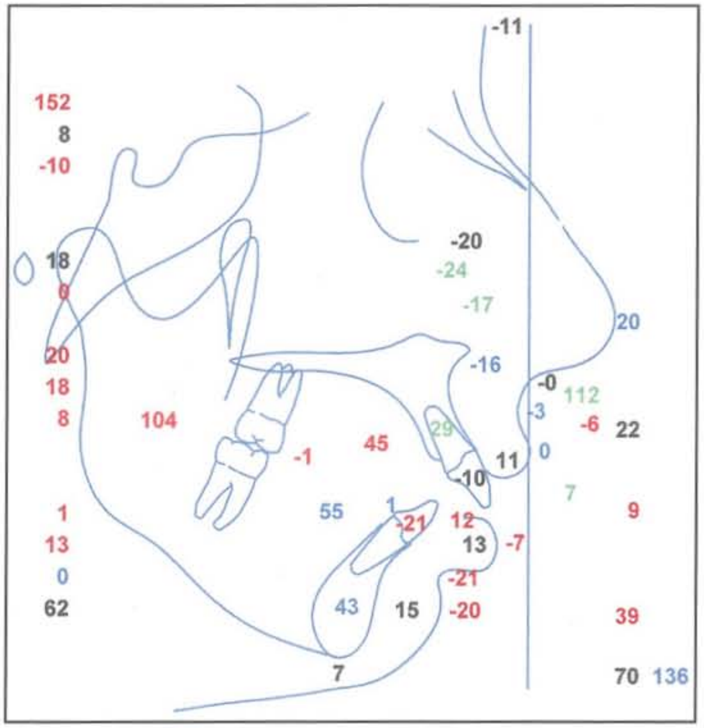


Fig. 5.88 STCA

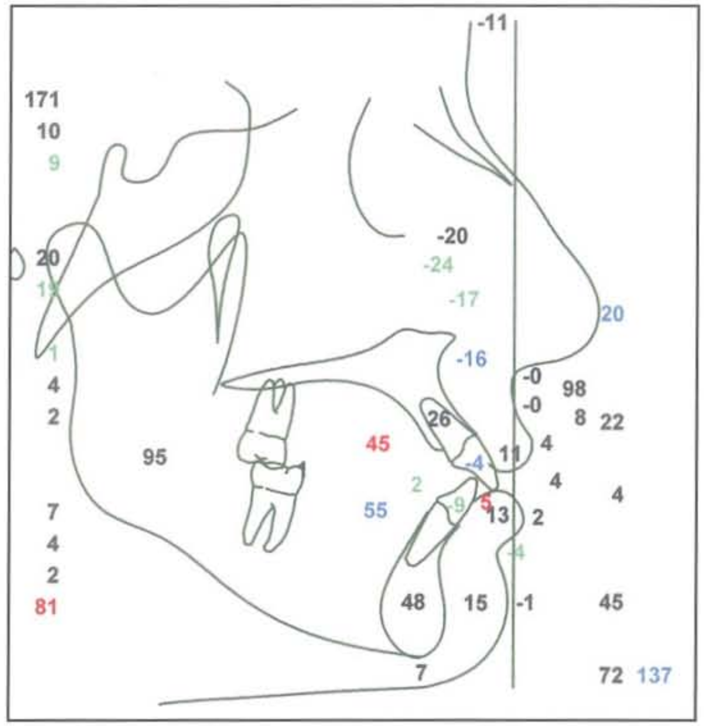


Fig. 5.89 CTP

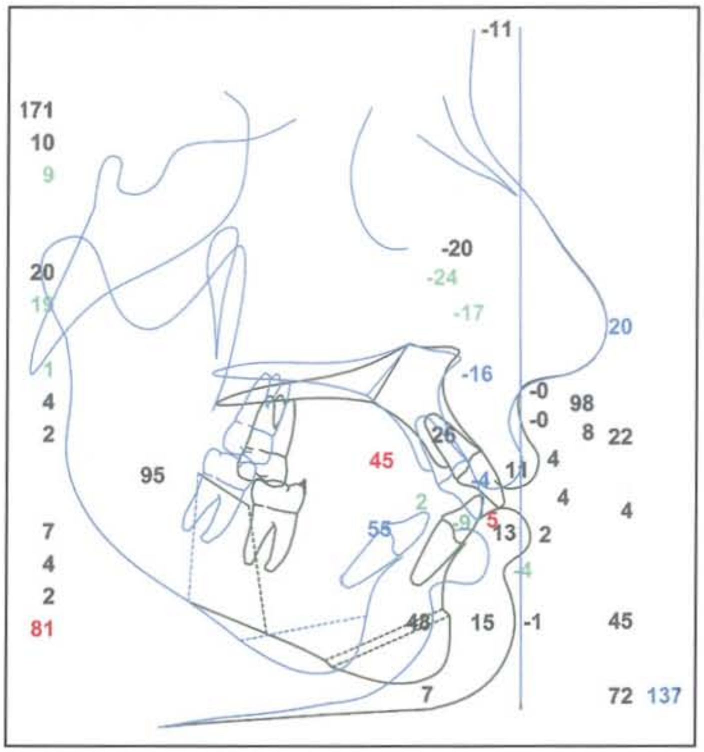


Fig. 5.90 Superimposition

Figs 5.88 to **5.90** STCA (upper left) showed excess incisor exposure (7, green), steep occlusal plane (104, red), and severe chin retrusion (-20, red). CTP (upper right) and superimposition (lower center). Note: the overjet was set at 5 mm due to excessive incisor flaring. The flaring was planned to allow for Class III overcorrection advancement of the mandible. Chin projection was achieved with upper incisor flare, maxillary advancement, mandibular advancement, flattening of the occlusal plane (104, red to 95, black), and chin augmentation. The posterior maxilla must be lengthened to produce chin projection.

Fig. 5.91

Fig. 5.92

Fig. 5.93

Figs 5.91 to **5.93** Intra-oral photographs post-surgically. Note: acrylic placed across the segmental surgical site (on brackets and archwire) in maxillary cuspid and lateral incisor area. The acrylic is utilized to stabilize the multisegment maxillary surgery. Also note anterior skeletal hooks for anterior stabilizing elastics. Elastics are worn between the hooks to 'skeletally' maximize the overbite for 8 weeks after surgery.

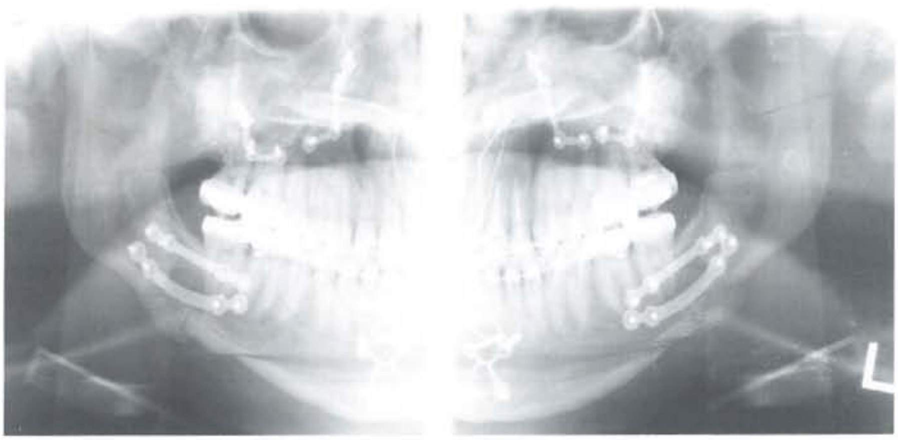


Fig. 5.94 Post-surgical panoral radiograph shows surgical hardware for maxillary and mandibular surgery, as well as chin reconstruction. The plates are specially designed by OsteoMed Corportion for large mandibular advancements and lengthening of the posterior maxilla.

Fig. 5.95

Fig. 5.96

Fig. 5.97

Figs 5.95 to 5.97 Final intra-oral photographs reveal a Class I occlusion. Distal lateral spaces have been closed orthodontically.

Fig. 5.98 Retainers in place. All types of retention must allow the teeth to contact on surgical cases. Contact maintains arch form and width stability.

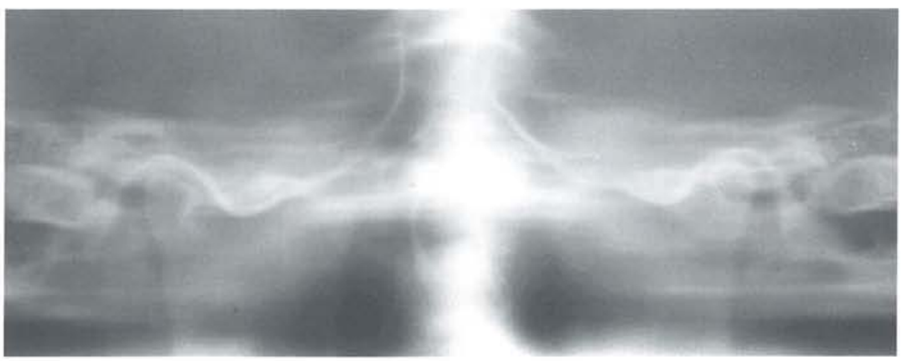


Fig. 5.99 Final tomographic radiographs of the TMJs show seated and concentric condyles. 12 months of post-surgical medications were used for joint stabilization.

Fig. 5.100

Fig. 5.101

Fig. 5.102

Fig. 5.103

Fig. 5.104

Fig. 5.105

Fig. 5.106

Fig. 5.107

Figs 5.100 to **5.107** Final photographs which include profile and frontal views with lips together, at rest, and smiling. Also final photographs of three-quarter views. These show a well-balanced face.

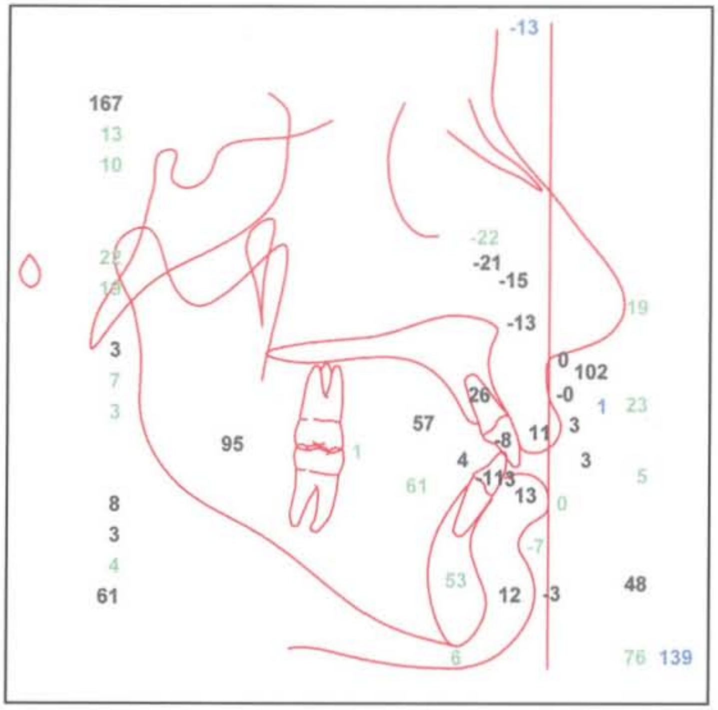


Fig. 5.108 Final STCA tracing, confirming the presence of facial balance. Note improved post surgical incisor inclinations.

Fig. 5.109

Fig. 5.110

Figs 5.109 and **5.110** Pre- and post-surgical photographs.
The key to chin projection is occlusal plane control. By flattening the occlusal plane (104, red to 95, black) the chin is advanced, importantly, in a natural looking fashion.

The orthodontic treatment for this patient was provided by Dr Paul F. Hannah. The authors gratefully acknowledge his assistance in treating this patient.

6 Treatment planning for the TMJs and musculature

INTRODUCTION

In this chapter general guidelines and comments are offered on treatment planning for the TMJs, sufficient for facial planning purposes. Specialist books exist on TMJ treatment, and the reader is referred to these for more in-depth information.

The presence of any form of head, neck or TMJ pain and dysfunction requires decisions concerning the appropriate direction of treatment. Information in this area is gathered from three main sources, the patient history, the clinical examination and the patient records. These records include the panoramic and any tomographic radiographs, MRIs if indicated, and the mounted study casts. After this information has been reviewed, a treatment plan can be established (Fig. 6.1).

All orofacial pains (p. 140), other than temporomandibular disorders (TMDs), should be referred to the appropriate specialist for treatment. TMDs need to be treated by the orthodontist and oral surgeon. In this category, it must be determined if the problem is related to the musculature, the TMJs, or a combination of the two.

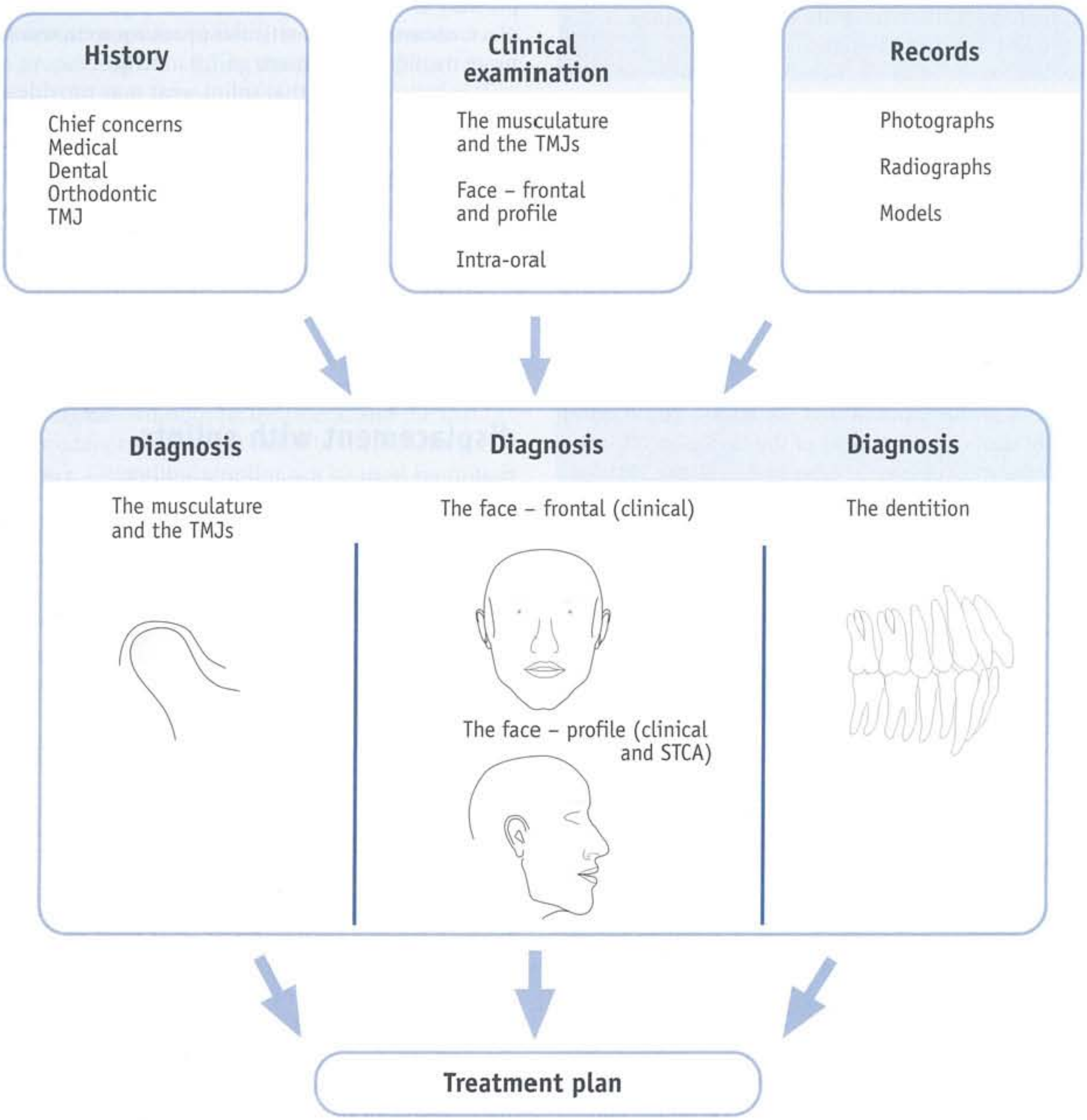


Fig. 6.1 Utilizing the history, clinical examination and records, a problem list is generated. The problem list (diagnosis) then generates the needed TMJ, facial, and occlusal treatment plan.

THE CONSERVATIVE PHASE OF TREATMENT

After the source of the TMJ problem has been established, a conservative phase of treatment can be initiated. Whether the problem involves only the musculature, or the musculature and total joint remodeling, this conservative phase consists of up to four parts:

- Splint therapy
- Physical therapy
- Stress management
- Appropriate medications.

If the patient is to undergo orthognathic surgery after orthodontic alignment, then the splint and medications should be repeated or initiated prior to surgery.

SPLINT THERAPY

The purpose of splints

Patients tend to position their mandibles where the teeth fit best – in maximum intercuspation or centric occlusion (CO). This may occur at the expense of the musculature and the TMJs, in the form of soft tissue changes and remodeling changes. In other words, a disharmony may exist between where the teeth fit best, and where the musculature is relaxed with the condyles properly positioned. An inter-occlusal splint can temporarily eliminate the effects of the occlusion. This in turn can allow the musculature to relax and heal, the TMJs to heal, and the condyles to seat in an uncompressed position within the glenoid fossae. From this corrected mandibular position, a diagnosis and treatment plan for the face and dentition can be established. It has also been determined[1] that splints may reduce parafunctional activities such as clenching and grinding in a number of patients, or at least protect the teeth and the joints from the damaging effects of these activities.

Reducing the effects of bruxism with splints

Bruxism has been defined as 'the grinding or clenching of teeth at other times than for mastication'.

Nitzan[1] investigated a group of patients diagnosed with displaced articular discs. She measured hydrostatic pressures within the superior joint space of symptomatic TMJs, and observed positive hydrostatic pressures with clenching in these patients. In over 40% of these patients these pressures were of sufficient magnitude to possibly influence regional blood flow (i.e. hydrostatic pressure exceeded expected end-capillary perfusion pressure). This latter point is speculative since direct measurements of blood flow to discreet regions of the TMJ are currently not possible. However, the data do not refute models, such as the hypoxia–reperfusion model proposed by Milam and Schmitz,[2] that implicate excessive mechanical loading in the development of degenerative TMJ disease. These models are:

1. Direct mechanical injury
2. Hypoxia–reperfusion injury
3. Neurogenic inflammation.

Nitzan[1] demonstrated that splint therapy reduces intra-articular pressure. During clenching, without the splint, pressure averaged 68.8 mmHg. However, with the splint in place, measured intra-articular pressures were reduced by more than 80% to a mean of 7.9 mmHg.

It is hypothesized that splint wear may provide an effective therapy for reducing potentially damaging mechanical loads in some patients. Splint therapy could prevent or minimize tissue breakdown by reducing excessive mechanical loads to levels that are tolerated by susceptible TMJs. In other words, splint therapy could provide a mechanism for the stabilization of some unstable joints that would otherwise undergo extensive breakdown, perhaps leading to a progressive retrognathia and apertognathia.

Reducing the effects of condyle displacement with splints

Positional changes between the condyle, and the articular disc or the glenoid fossa can be caused during some treatments. In a patient with pre-existing TMJ disease, the joints may be very intolerant of these changes. Pain, restricted jaw movements, and even condylar resorption can be produced in these intolerant patients. Even subtle condylar position changes produced during treatment can produce a change (p. 144; Peltola, Mongini). In these patients, the use of splints and medications (p. 209) prior to surgery or orthodontics may 'heal' the joints and lessen the impact of changes in condyle position produced with treatment.

Types of splints

Soft versus hard splints

While soft splints may serve as short-term devices for pain management, they are not satisfactory for the purpose of stabilizing mandibular position. They are easy to construct for emergency purposes, but are difficult to properly adjust and for eventual recording of mandibular position. Hard splints, on the other hand, can be accurately adjusted to simulate an ideal occlusion in a condyle seated position. They can also be used to aid in establishing correct lateral and protrusive movements.

Maxillary versus mandibular splints

Factors to be considered relative to maxillary versus mandibular splints are function, esthetics, comfort, retention and effects on the occlusion. While mandibular splints may be comfortable, esthetic and easy to retain (and hence popular with patients!) they are often unsuitable relative to function and effects on the occlusion. Since the majority of patients needing splint therapy present with Class I or Class II malocclusions, it is a routine procedure to obtain proper function during lateral and protrusive movements with full coverage upper splints (Fig. 6.2), and impossible to do so with lower splints. While not all patients require canine and anterior guidance during a short phase of stabilization (as long as solid centric stops are present), many patients do benefit from proper function during the phase of splint therapy.

It is most important that tooth movements be eliminated or at least minimized during the phase of splint therapy. When *mandibular splints* are used on Class I and Class II patients, there is no way to stabilize the upper incisors and prevent their potential eruption. In the past, many orthodontic and surgical problems have been created by improperly designed splints. In contrast, Class III cases often benefit from mandibular splints (Fig. 6.3), since all teeth in the upper and lower arches can be stabilized, and their movement prevented. With patients who have committed to orthodontic or surgical-orthodontic treatment, and the first orthodontic procedure to be carried out is in the maxilla (i.e. palatal expansion), a mandibular splint can be used for initial stabilization. This will avoid the need for placement of a second mandibular splint when the expansion is initiated.

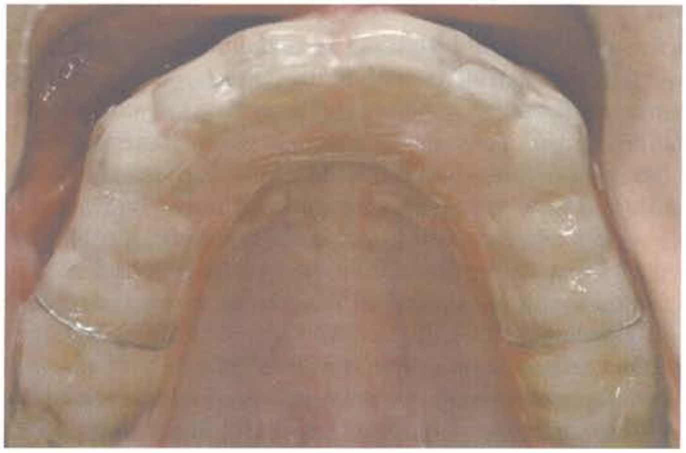


Fig. 6.2 The majority of patients present with a Class I or Class II malocclusion. Full coverage upper splints can be used routinely to obtain proper function during lateral and protrusive movements. This is not possible with lower splints.

Fig. 6.3 Class III cases often benefit from wearing a mandibular splint.

Condyle positioning – the historical perspective

Before discussing the technique for mandibular positioning with TMJ patients, it is helpful to briefly review the concept of centric relation (CR).

The condyles have taken a rather circuitous route around the glenoid fossae over the years in dentistry. In the late 1800s and early 1900s, it was suggested that the condyles be placed in a relaxed and seated position within the glenoid fossae. Sears was the first to coin the term 'centric relation' in reference to this position, and defined it as 'the most retruded unstrained position in the glenoid fossa from which lateral movements can be made'.[3] In the late 1920s, the gnathologists suggested that the condyles should be placed as far up and back in the fossae as possible, in the rearmost, uppermost and midmost 'RUM' position. This seemed to meet the needs of the fully adjustable articulator, but not necessarily the patient. There were criticisms of this position by such individuals as Posselt,[4] who observed that there was a small slide between CO and CR in most healthy patients, Ricketts,[5,6] who observed radiographically that most healthy patients showed a concentric condyle position (Fig. 6.4), and Pankey and Mann,[7] who restoratively supported the concept of 'long centric', or a small slide between CO and CR.

Despite these criticisms, the standard definition and treatment position for centric relation remained the RUM position for approximately 50 years. In the 1970s, when the problems with the RUM position finally became more than the profession could bear, the recommended condyle position was changed to an upward and forward position; however, techniques for condyle positioning remained largely the same.

As with many changes, initially there was an over-reaction to the RUM concept by many, with the condyles being placed forwards on the eminence. This over-reaction was also supported by the concept of 'recapturing' the disc.[8,9] When it was determined by MRI studies that discs were not actually being recaptured in the manner described,[10] there was a return to the concept of allowing the condyles to seat into the originally defined position within the fossae, determined primarily by the musculature and joint anatomy.

In Chapter 5 (p. 144), the etiology of joint remodeling was discussed. Three contributing factors were described – deficient host adaptive capacity, joint compression, and joint anatomy which is prone to remodeling. These factors have been well documented. Therefore, during splint therapy it is important to establish a seated and uncompressed condyle position to avoid the damaging effects of condyle compression.

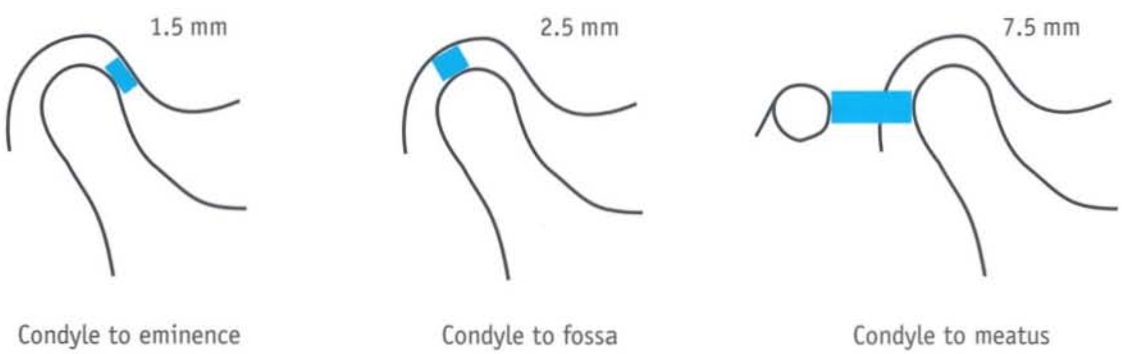


Fig. 6.4 Ricketts observed radiographically that most healthy patients showed a concentric condyle position. The average condyle position was 1.5 mm from the eminence, 2.5 mm from the superior aspect of the fossa, and 7.5 mm from the middle of the bony meatus.

Positioning the mandible for splint construction

Taking of the wax bite for splint construction is best accomplished using a gentle condyle seating technique to first tooth contact (p. 100). If this proves to be difficult, the patient can be placed in postural rest position and asked to close to just short of first tooth contact from that position. The splint wax bite is taken just short of first tooth contact, leaving the splint with approximately 2 mm of thickness. While this position may not be centric relation, it will normally be a tolerable position for the patient at that time. As the joints heal and the musculature relaxes, the condyles will settle into the fossae with little difficulty on the part of the patient and clinician. If needed, the position can be confirmed with a mandibular position indicator (MPI) recording. The splint can then be modified to match the new centric relation position of the teeth on the splint.

Splint construction

To assure greater accuracy, and to minimize adjustment time at placement, it is helpful to construct splints on study casts mounted on an articulator. The authors have found that the SAM III articulator is excellent for this purpose (Fig. 6.5). This instrument requires a minimal amount of re-calibration, and the magnetic mounting plates allow for quick and convenient removal and placement of the upper and lower models.

Splints should be constructed of hard acrylic that is allowed to cure under pressure. Ball clasps can be used on each side for retention. Most importantly, splints should be generally kept to a minimal thickness to avoid encroachment on the freeway space, and to minimize the difficulty of later returning patients to their normal vertical dimension as treatment proceeds.

It should be noted that improperly constructed splints, which displace the condyle from the uppermost position, will eventually produce an increase in overjet due to condyle, condylar fossa and disc changes.

Initially, splints should be relatively flat, with only minor indentations for centric stops, and with no attempt to establish lateral and protrusive guidance. This will allow the mandible to move into a stable position in which the condyle is seated and not compressed. After this position has been established, acrylic can be added anteriorly to create lateral disclusion and anterior guidance. Acrylic can be added or removed as needed to produce consistency between splint concentric occlusion and joint centric relation. Tomograms are suggested to verify condyle position produced by the splint occlusion.

Fig. 6.5 The SAM III articulator.

PHYSICAL THERAPY

Thomas M. Eggleton DPT, MS

Physical therapy for the management of craniomandibular disorders is a specialty in the field of orthopedic manual physical therapy. The physical therapist must have a thorough understanding of the dental diagnosis, and work in conjunction with the orthodontist, the maxillofacial surgeon, and other specialists.

In the treatment of craniomandibular disorders, the physical therapy diagnosis can be classified into two categories: hypomobility and hypermobility. This creates the best diagnostic classification, based on the 'movement system', to develop a proper treatment plan. With the TMJ, two joints are acting simultaneously as one. Each side may present with a unilateral hypermobility and hypomobility, or a combination of hypo/hypo-, hyper/hyper- or hyper/hypomobility (Fig. 6.6A).

These conditions alter normal translation and rotation in joint arthrokinematics of the TMJ. This results in dysfunction, pathology, and loss of function. The altering of normal arthrokinematics also leads to repetitive motion disorders, which include:

- Bruxism, leading to myalgia or trigger points
- Tissue breakdown and inflammation, leading to tendonitis, synovitis, and ligamentous laxity
- Altered histology, leading to adhesion formation or ankylosis (histological changes from fibrocartilage to hyalinization)
- Eventual bony remodeling changes (osteoarthritis or osteophyte formation).

In addition to the categories of hypomobility and hypermobility, a differential diagnosis must be made between cervical dysfunction or spondylosis, fibromyalgia and true dysfunction of the TMJ (Fig. 6.6B).

The resulting functional limitations and disabilities may include limited opening, joint instability, and difficulty with mastication, speech or other oral motor functions. Other effects may include abnormal posture, leading to altered condyle position.[11–13]

If the patient is given a splint, the physical therapist must work with the orthodontist. The splint should properly correct the condyle position, leading to stabilization of the condyle–fossa relationship. This stability is in joint rest position only and does not affect the dynamics.

Physical therapy is designed to:

1. Normalize joint function during movement
2. Alter muscle function and length
3. Increase joint stability.

The end result should be normal joint function which results in decreased muscle trismus, reduced myalgia, and an increased range of motion.

Combining physical therapy with splint therapy reduces the number of adjustments that need to be made to the splint, and decreases the length of the time the appliance needs to be worn. This in turn reduces the risk of unwanted tooth movements due to prolonged splint wear.

Physical therapy should not be limited to warm moist heat, ultrasound and electrical stimulation. Used alone, these do little to normalize joint function. Physical therapy should therefore include joint mobilization, therapeutic exercise and ergonomic assessment, in order to decrease postural influences on the condyle–fossa relationship.

Hypomobility	Hypermobility
Internal joint derangement	Global hypermobility
Anterior displaced disc	Rheumatoid arthritis
Adhesions	Trauma, e.g. third molar extraction
Osteoarthritis	Secondary to hypomobility on the contralateral side

Fig. 6.6A Types of hypomobility and hypermobility of the TMJ.

	Fibromyalgia	Cervical dysfunction	TMD hypomobility
History	Insidious onset Varied generalized pain from day to day Widespread (back, neck, and shoulders) Worse at the end of the day	Insidious onset Pain in neck Referred into shoulder/arm Stiffness Pain in a.m. upon waking	Insidious onset or sudden onset Facial pain Retro-occular pain, suboccipital pain Limited opening, difficulty chewing
Observation	No joint swelling Tenderness in muscle Sleep difficulties Experience headaches Easily fatigued	Crepitation Muscle spasm	Trismus Clicking, popping or crepitation Guarding Capsular pattern with deviation to restricted side
Passive motion	Soft end feel Pain at end of range of motion (ROM) (end range of opening) Muscle spasm, trigger points, tender points Referred pain patterns	Hard end feel Restricted ROM Segmental restrictions cervical spine Crepitations may be palpated	Hard end feel inferior glide, protrusive glide, and medial glide (into restriction) Limited ROM opening, protrusion and laterotrusion
Active motion	Guarded, limited by muscle tightness	Limited AROM (active range of motion)	Limited motion and laterotrusion on opposite side and limited protrusion on same side
Special tests	None	Cervical radiograph Distraction test may be positive Spurring test may be positive	Tomograms, MRI

Fig. 6.6B Differential diagnosis must be made between cervical dysfunction or spondylosis, fibromyalgia and true dysfunction of the TMJ.

STRESS MANAGEMENT – BIOFEEDBACK

Richard Gevirtz PhD

Stress management in the form of biofeedback has long been accepted as a component in the treatment of temporomandibular disorders (TMDs). A number of controlled trials and many case reports support the use of biofeedback as an adjunct to splint therapy and other modalities. This is logical, because many cases of TMD have muscle pain rather than joint pain. The muscular component of TMDs is significant. Trigger points in the muscles of mastication (Figs 6.7A and 6.7B), especially the pterygoids, can produce pain and referred pain in the joint or jaw areas.[14]

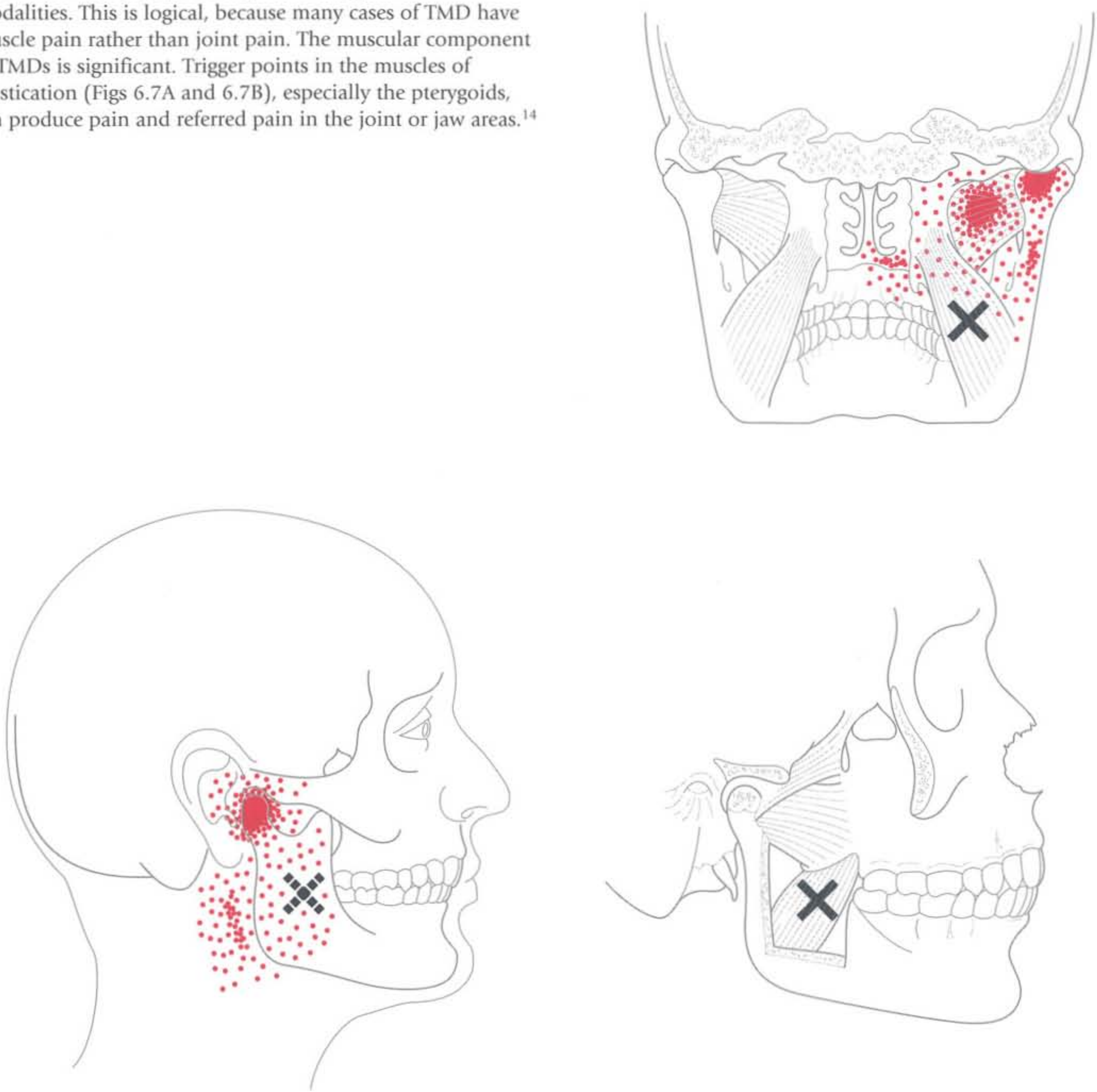


Fig. 6.7A The medical pterygoid muscles. Trigger points in the muscles of mastication, especially the medial and the lateral pterygoids, can produce pain and referred pain in the joint or jaw areas. (After Travel & Simons 1983.)

Changing the focus to muscle relaxation can help the patient in the following ways:

1. Lowering patient concern of a major structural defect
2. Relaxing specific muscles
3. Producing overall relaxation and indirectly affecting the jaw trigger points
4. Giving the patient an active coping technique so as to reduce feelings of helplessness and depression.

The biofeedback clinician will typically assess the patient in three areas, and each will be considered in turn:

- Psycho-physiological
- Cognitive
- Behavioral.

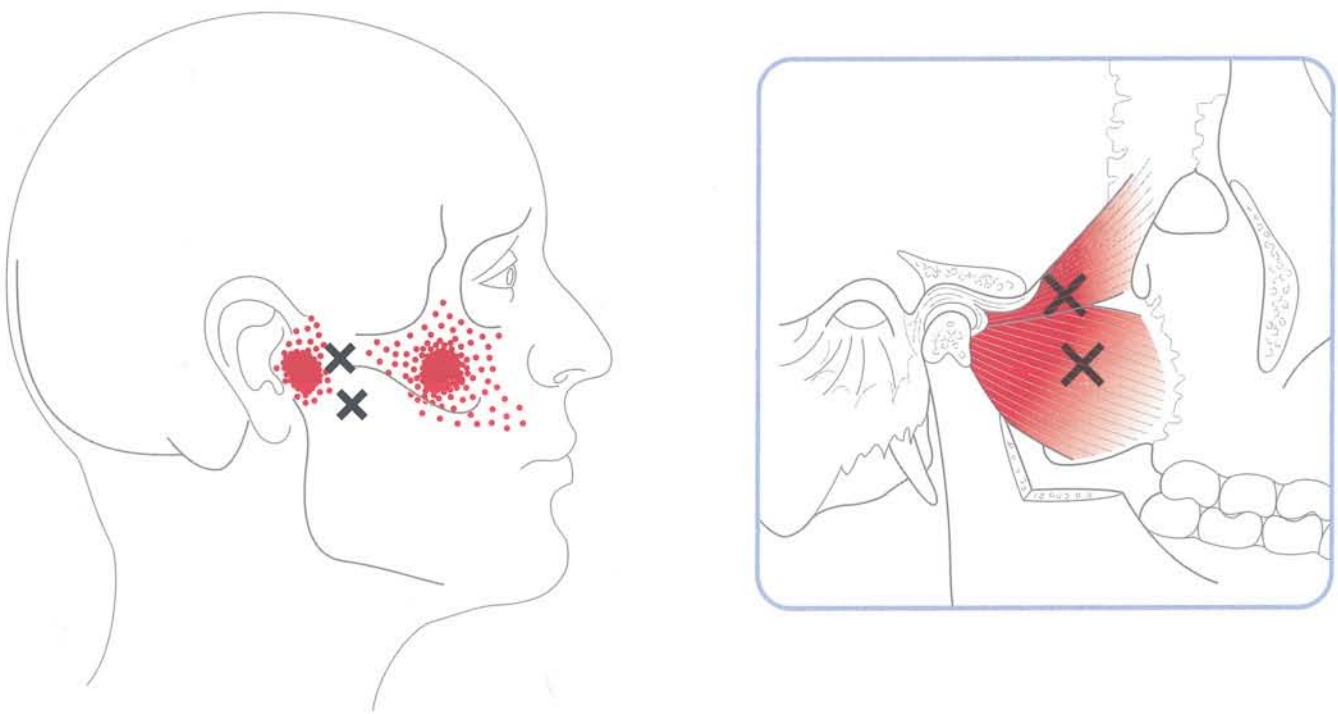


Fig. 6.7B The lateral pterygoid muscles can produce trigger points leading to referred pain in the adjacent joints. (After Travel & Simons 1983.)

Psycho-physiological assessment

Psycho-physiological assessment involves measuring various physiological parameters while the patient is at rest, under stress, and recovering from stress. Commonly used measures include: electromyography (EMG) for muscle activity, heart rate, skin conductance (palm sweatiness), finger temperature, and respiration. In addition, there are various subtle rhythms in heart rate that indicate how various parts of the autonomic nervous system are working. Muscle activity, especially the jaw and facial muscles, are monitored.

There is a need for balance between the two branches of the autonomic nervous system – the sympathetic or 'fight/flight' system and the parasympathetic or 'rest/digest' system. The balance between these systems determines how well one can manage stress and where it will affect the body, if not well managed.

Cognitive assessment

The clinician is looking for maladaptive thinking patterns that may be contributing to overall stress or tension levels. For example, many TMD patients are perfectionistic and tough on themselves. This style of thinking can be productive, but is often damaging to the muscles because they are in a clenched position for much of the day and night.

Behavioral assessment

Finally, many behaviors can contribute to worsening of TMD symptoms. These can include jaw clenching or grinding, gum chewing or other parafunctional activities, self-defeating behaviors, and excessive drinking or smoking. The clinician should assess these behaviors and also assess the readiness for change.

Psycho-physiological model

After the full assessment is complete, the clinician constructs a 'psycho-physiological model' with the patient. This serves as a treatment model for the collaborative work of biofeedback treatment.

Treatment planning for relaxation and stress management

Treatment planning consists of considering a number of possible components. *Relaxation techniques* can be learned by observing changes in physiological measures available on a computer screen for the patient. These would usually entail muscle relaxation, breathing techniques, guided imagery, hypnosis, or one of many other feedback modalities.

Integrated into this part of the treatment can be *stress management techniques* that target dysfunctional thinking, and behavioral techniques that target dysfunctional habits. Home practice can occur on an inexpensive home trainer or with tapes made by the practitioner.

Relaxation and stress management can be learned by the patient from computerized information.

MEDICATIONS

Stephen B. Milam, DDS, PhD

Medication may have an increasing role in the stabilization of TMJs. Some clinicians are evaluating this approach pre- and post-surgically, often for extended periods. Normal blood study precautions are followed. Some of the medications currently of interest include:

- Doxycycline
- Buspirone
- Amitriptyline

Doxycycline

Matrix metalloproteinases (MMPs) are enzymes that degrade molecules of the extracellular matrices of articular tissues of the TMJ. An emerging body of evidence indicates that these enzymes play important roles in tissue destruction in arthritic joints. MMPs require zinc as a co-factor for activity. Recent studies have shown that tetracyclines (doxycycline for example) can inhibit MMPs by chelation of zinc. In animal models of degenerative joint disease, tetracyclines administered systematically inhibit MMPs and substantially reduce progression of cartilage and bone destruction.[15] This effect is independent of the anti-microbial activity of the tetracycline. The effect is solely related to the agent's ability to inhibit MMPs by effectively removing the co-factor zinc by chelation.

Tetracycline administration (e.g. doxycycline) may therefore offer an effective intervention strategy for stabilization of degenerating TMJs. From these preliminary observations, it is likely that tetracyclines will minimize pathologic response of articular tissues to mechanical loads (i.e. prevent degradation of bone and cartilage by MMPs). If so, these agents could stabilize joint structure, providing stability to the projection and function of the mandible. Further research is needed to clearly document positive benefits in humans and to define the dosing parameters needed for the desired effect.

Buspirone

'Selective seratonin re-uptake inhibitors' are commonly referred to as SSRIs. The SSRI group of drugs (i.e. fluoxetine, sertraline and paroxetine) have a reported side effect of evoking bruxism in some patients.[16] This can potentially lead to muscle spasm and joint deterioration in susceptible patients. The exact mechanism of SSRI-induced bruxism remains unclear. However, the resulting bruxism can be expected to aggravate some post-treatment conditions, particularly when condyles have been iatrogenically displaced. Additionally, SSRI-induced bruxism can adversely affect maxillary healing after Le Fort surgery. Excessive loading of the maxilla from bruxism can promote non-union of the osteotomy sites and may affect the relapse potential.

SSRI-induced bruxism may be minimized by medical therapy in patients requiring ongoing SSRI treatment. Buspirone, a selective partial agonist at 5-HT 1A receptors (i.e. a serotonin receptor) has been reported to relieve SSRI-induced bruxism and its associated symptoms.[17] Other agents, including gabapentin and bromocriptine, have also been reported to be effective at minimizing SSRI-induced bruxism, though side effects from bromocriptine were poorly tolerated, resulting in a premature termination of the study investigating its efficacy.

Amitriptyline

Amitriptyline is a tricyclic antidepressant with non-selective serotonin and norepinephrine re-uptake inhibitor properties. Amitriptyline has been shown to provide effective relief of many different types of pain by mechanisms that appear to be unrelated to its antidepressant effects. It is speculated that amitriptyline may also benefit bruxers. For example, it been shown to be partly effective in the treatment of chronic headaches,[18] and it is postulated that this effect was due to changed activity of the temporalis muscles, and therefore could possibly help to treat bruxism. Other studies[19] do not support the use of amitriptyline for the treatment of sleep bruxism. However, these studies were limited in scope and design. Research is continuing to define the possible role of amitriptyline in the management of patients who experience nocturnal bruxism.

TMJ LAVAGE

Stephen B. Milam, DDS, PhD

TMJ lavage involves irrigation of the superior joint space of the TMJ. Two 18g needles are inserted into the superior joint space via a preauricular approach to provide an input port and an output port. The superior joint space is then irrigated with 100 ml of an isotonic solution (e.g. 'Normasol'). This large volume irrigation method is effective[20] at reducing concentrations of molecules linked to inflammation and tissue destruction in the TMJ. This procedure has been shown[2] to remove harmful proteins and proteases, including inflammatory neuropeptides, from the superior joint space and surrounding articular tissues. These materials are associated with joint degeneration and pain. At the conclusion of the lavage, medications (e.g. hyaluronic acid, steroids, opioids) may be administered as indicated.[20,2] Duramorph can be introduced to bind the peripheral nerve terminals, decreasing the production of substance 'P', which causes inflammation of the joint structures. The purpose of this is to provide long-term pain relief.

Nishimura et al[21] evaluated TMJ lavage as the initial treatment for 103 patients with internal derangement of the TMJs. They reported a 71% success rate. Nitzan et al[22] selectively treated TMJ patients who had only anterior disc displacement without reduction. They reported success in more than 90% of cases. A meta-analysis review of surgical treatment of TMD supported the use of TMJ lavage over other methods of surgical intervention for patients with disc displacement without reduction.[23]

The efficacy of TMJ lavage as a therapy used to treat advanced TMJ disease remains to be demonstrated.[24]

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CASE AD

This 14.1-year-old female with a severe Class II malocclusion was seen for consultation for occlusal correction. She was referred by her orthodontist. Orthodontic appliances had been in place for 14 months at the time of the initial surgical consultation. Rapid palatal expansion (RPE) and leveling and alignment of the arches had been accomplished. A palatal bar was in place to stabilize the palatal expansion. Diagnosis and treatment were started with the intention of fulfilling the seven goals of treatment. Her patient motivation form indicated a desire for straightening of her upper, lower front and back teeth, making the upper teeth appear shorter, forward movement of the lower teeth, and leveling of the upper front teeth. Facially, the patient wanted the sag removed from under her lower jaw, her chin moved forward, her nose to appear shorter, her midface moved forward, her cheekbones larger, her gums to show less when smiling, easier closure of her lips, reduced strain in her lips, and the appearance of a wider lower face. She had pain in front of both of her ears. TMJ examination and history, clinical facial examination, soft tissue cephalometric examination, and model examination were obtained. The problem list and treatments were as follows:

PROBLEM	TREATMENT
1. High midface	
• Normal	• No treatment
	• Patient requested cheekbone enlargement
2. Maxilla	
Dental	
• Leveling, alignment, RPE completed	• Remove palatal bar to test transverse stability
Skeletal/facial	
• Upper lip upright	• Maxillary advancement
• Nasal base concave	• Maxillary advancement
• Midline 1 mm to the right	• Rotate midline 1 mm left
• 7 mm relaxed incisor exposure	• Le Fort I (LFI) impaction
• Excessive gingival smile	• Le Fort I (LFI) impaction
• Large inter-labial gap and lip strain	• Le Fort I (LFI) impaction
• Steep occlusal plane	• Flatten occlusal plane to provide nasal base and chin balance
• Narrow maxilla in Class I	• Allow for relapse after removal of palatal bar
	• Multi-segment LFI
3. Mandible	
Dental	
• Level and alignment done	• No treatment
	• Orthodontic arch form width maintained - stable
Skeletal/facial	
• Marked chin and lower lip retrusion	• Bilateral sagittal split osteotomy (BSSO) advancement
• Steep occlusal plane	• Flatten occlusal plane to increase chin prominence
4. TMJ	
• Bilateral pain and clicking, decreased opening, condyles small	• Splint + medications after orthodontic preparation for 6 months
	• Possible arthrocentesis for decreased opening
5. Growth potential	
• 14.1-year-old female, unstable condyles at this age	• Medications + splints at age 17
	• Surgery at age 17.6

Orthodontics was started at age 12.9. The RPE was unsuccessful in matching the arch widths and relapse occurred after 3 months of palatal bar removal. At age 15, the orthodontic preparation was complete and the patient was placed on splint therapy and full medications, anticipating surgery in 6 months. Surgery on young females (15.5) with pre-surgical joint changes is ill-advised because of a high incidence of post-surgical joint change and overjet development. To contempate surgery at 15.5 was a mistake in surgical judgement (GWA) initiated solely because orthodontic preparation was complete. She did not cooperate with splint wear, nor did she take medications as prescribed. Fortunately the surgery date was postponed and the patient was informed that surgery would not be successful without splint and medical stabilization of her joints. After this, she strictly cooperated and her opening increased to 35 mm with a slight click and no pain. After progress records and diagnosis, the patient was treatment planned antero-posteriorly and vertically using the seven-step cephalometric treatment plan. The frontal midlines, levels, and outline were treatment planned using the frontal clinical examination.

Fig. 6.11

Figs 6.11 to **6.13** Pre-orthodontic intra-oral photographs taken in centric occlusion, indicating a mild Class II dental relation.

Fig. 6.8

Fig. 6.9

Fig. 6.10

Figs 6.8 to **6.10** Pre-orthodontic facial photographs taken in centric occlusion, indicating a slight Class II malocclusion.

Fig. 6.12

Fig. 6.13

Fig. 6.14

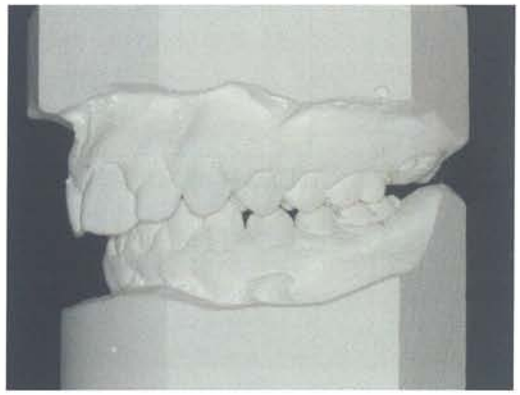


Fig. 6.15

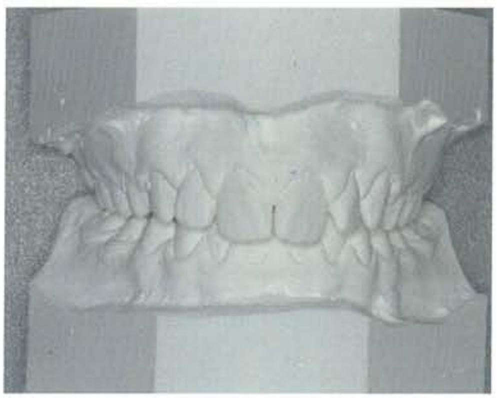


Fig. 6.16

Figs 6.14 to **6.16** Pre-orthodontic models. Models, taken in centric relation, indicate a larger overjet than is indicated by the intra-oral photographs taken in centric occlusion.

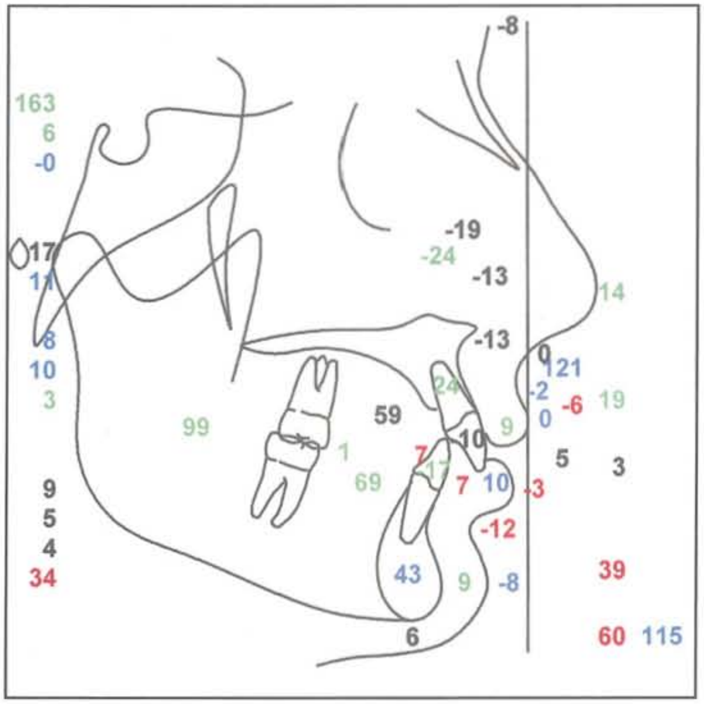


Fig. 6.17 Pre-orthodontic STCA tracing showing cheekbone retrusion (−24, green), upper lip retrusion (0, blue; −6, red; 121, blue; −2, blue), mandibular retrusion (−17, green; −8, blue), 7 mm overjet, steep occlusal plane (99, green), and short anterior chin height (43, blue).

Fig. 6.18 Pre-orthodontic panoral radiograph showing healthy dentition with third molars present.

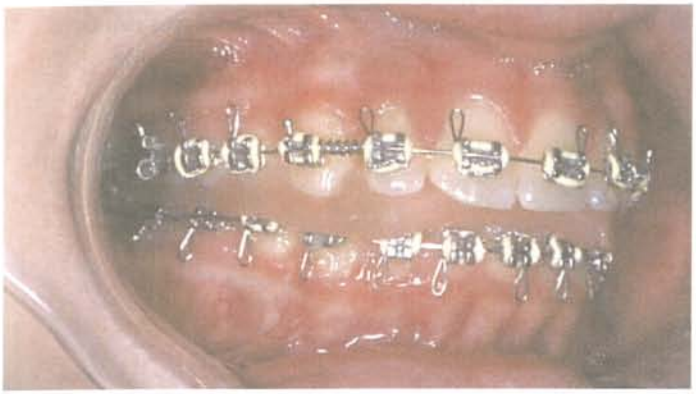


Fig. 6.19

Fig. 6.20

Fig. 6.21

Fig. 6.22

Figs 6.19 to **6.22** Pre-surgical centric relation wax bite photographs demonstrating the actual Class II severity. The waxbite construction is described on pages 101–103.

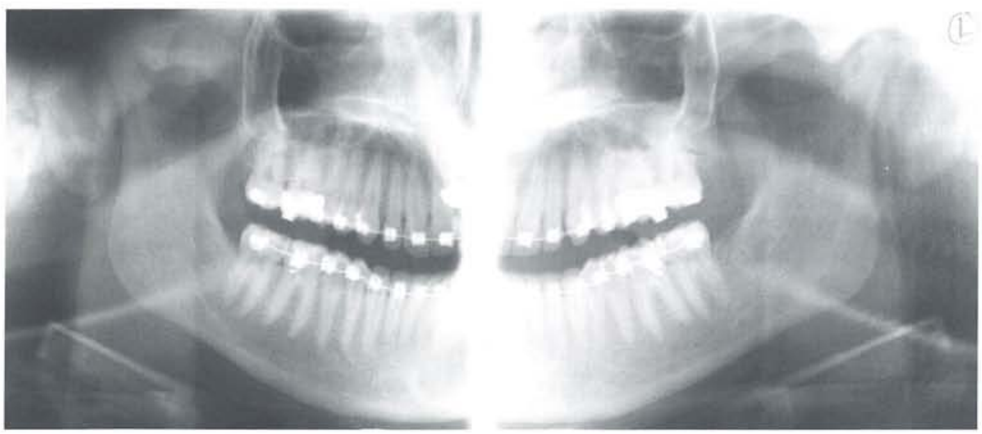


Fig. 6.23 Pre-surgical panoramic radiograph.

At age 17.6, after 6 months of successful joint therapy, surgery was done. A multi-segment LFI and BSSO were necessary to obtain the seven goals of treatment. The multi-segment LFI and BSSO produced facial balance while correcting the occlusion. The counter-clockwise advancement of the maxilla produced adequate chin projection, alleviating the need for a chin augmentation. To stabilize the joints post-surgically, the patient was maintained on doxycyline, amitriptyline, and vitamins C and E. Feldene was not used postoperatively, to avoid the decreased bone healing associated with anti-inflammatory medications.

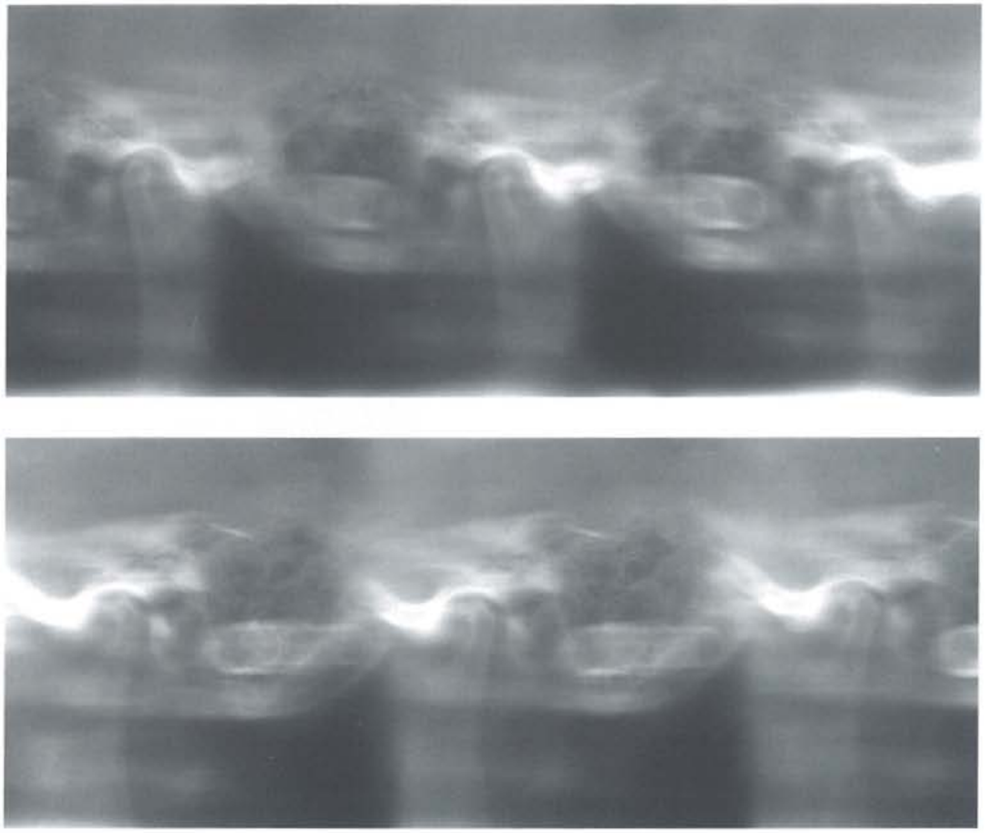


Fig. 6.24 Pre-surgical tomographic radiographs. Note: the small condylar size and superior flattening bilaterally. This is consistent with condylar resorption. The patient was treated with a splint and medication protocol after orthodontic preparation and before surgery. Surgical displacement of these condyles will start more condylar changes and subsequent overjet development,

Figs 6.25 and **6.26** Pre-surgical closed lip and relaxed lip photographs. Note: the normal high midface, upright upper lip, concave nasal base, extreme mandibular retrusion, and lip strain. The patient requested cheekbone augmentation, therefore, this was part of the treatment plan.

Figs 6.27 to **6.29** Pre-surgical closed lip, relaxed lip, and smile photographs. Note: the excessive relaxed lip incisor exposure, excess gingival smile, large inter-labial gap, and lip strain.

Figs 6.30 and **6.31** Pre-surgical right and left three-quarter facial photographs. Note: the small but normal cheekbone contours, retruded mandible, absence of throat length, and ill-defined mandibular inferior border.

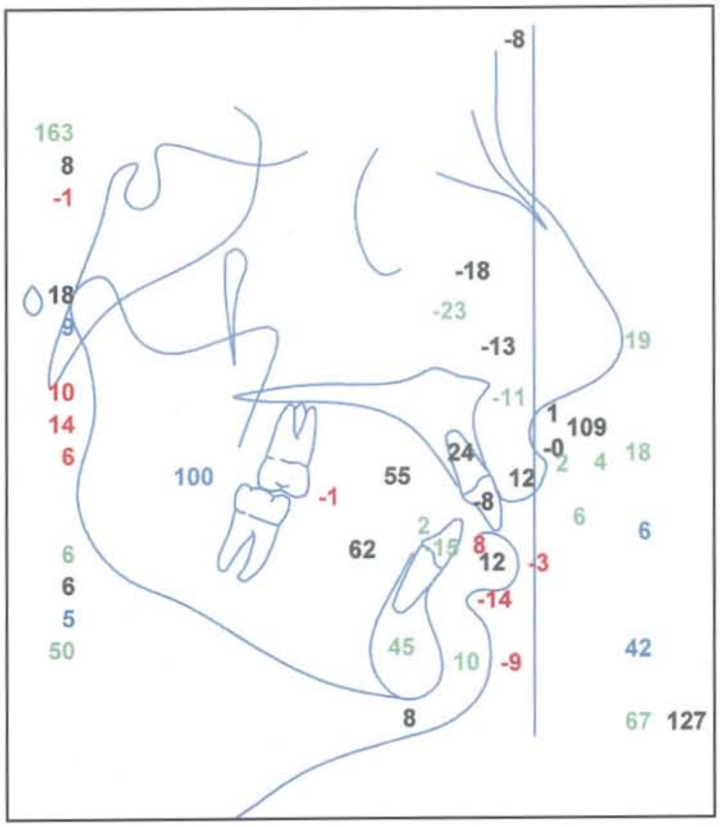


Fig. 6.32 The STCA following orthodontic preparation.

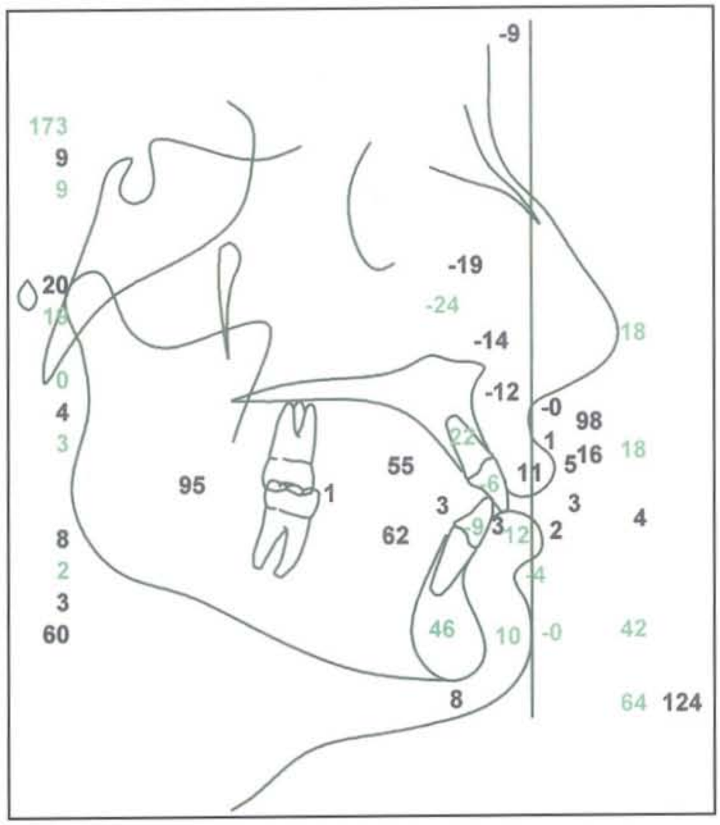


Fig. 6.33 The CTP.

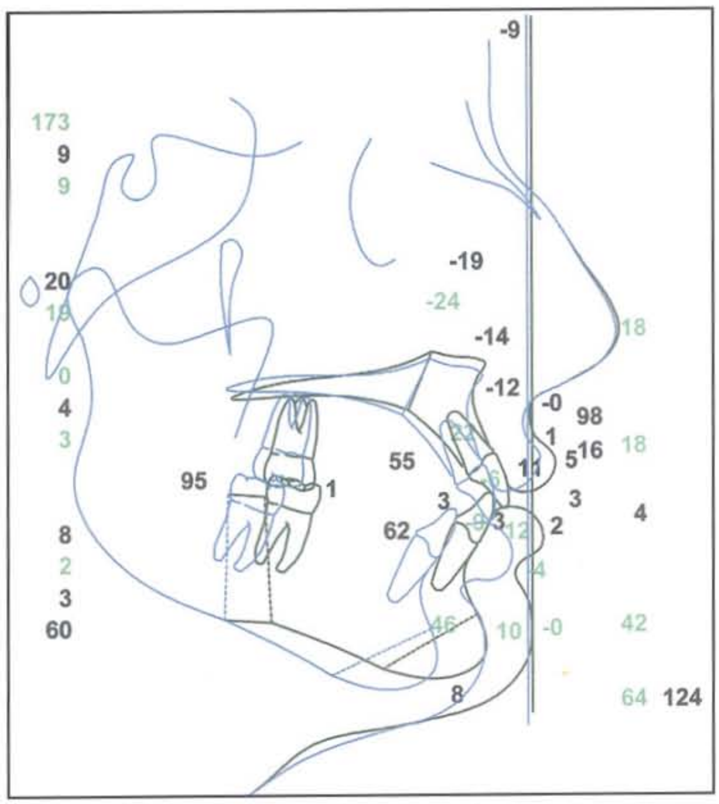


Fig. 6.34 The superimpositions.

Fig. 6.32 The STCA showing mild cheekbone retrusion (−23, green) (agreeing with the patient's assessment), mild upper lip retrusion (4, green; 2, green), moderate mandibular retrusion (−15, green; −9, red), short chin height (45, green), and steep occlusal plane (100, blue).

Fig. 6.33 The CTP showing maxillary dental advancement (−6, green), and mandibular advancement (−9, green). The occlusal plane was flattened (95, black) to produce nasal base and chin esthetics.

Fig. 6.34 The superimpositions showing the change between STCA and CTP.

Fig. 6.35

Fig. 6.36

Fig. 6.37

Fig. 6.38

Figs 6.35 to **6.38** Post-surgical intra-oral photographs.

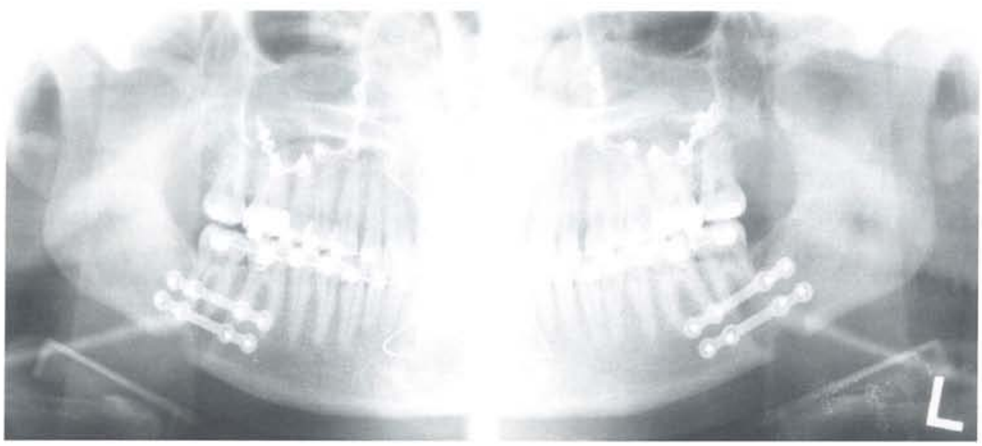


Fig. 6.39 The post-surgical panoramic radiograph. Two plates were used for each sagittal osteotomy to stabilize the large counterclockwise advancements. The plating system is specially designed by OsteoMed for lengthening the posterior maxilla and large mandibular advancements. Plates and unicortical screws are used for mandibular fixation because they do not torque the condyles as bicortical screws may do.

Figs 6.40 and **6.41** Post-treatment closed lip and relaxed lip photographs. Note: normal profile balance.

Figs 6.42 to **6.43** Post-treatment closed lip, relaxed lip, and smile photographs. Note: normal heights and facial outline.

Figs 6.44 and **6.45** Post-treatment right and left three-quarter facial photographs. Note: normal projections and contours.

Figs 6.46 and **6.47** Pre- and post-treatment photographs.

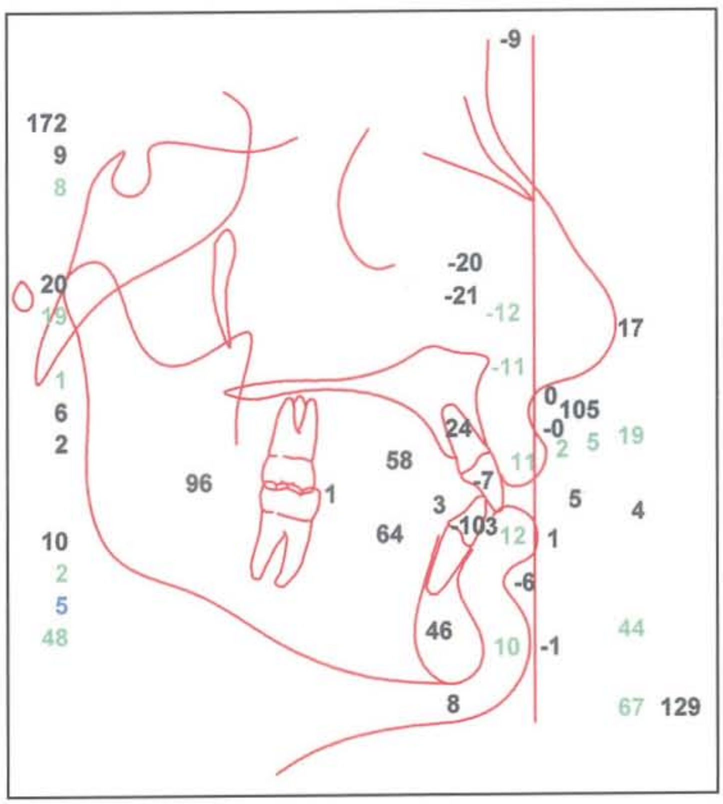


Fig. 6.48 STCA showing slightly short but proportionate upper and lower lips, normal maxillary and mandibular projections. Note the disharmony between soft tissue B and soft tissue pogonion' (5, blue [bottom of left hand column]). Close observation of Fig. 6.41 reveals this disharmony – a deep labial mental fold. No chin augmentation was done, therefore this is the patient's innate chin contour produced by a thick soft tissue chin button (10, green).

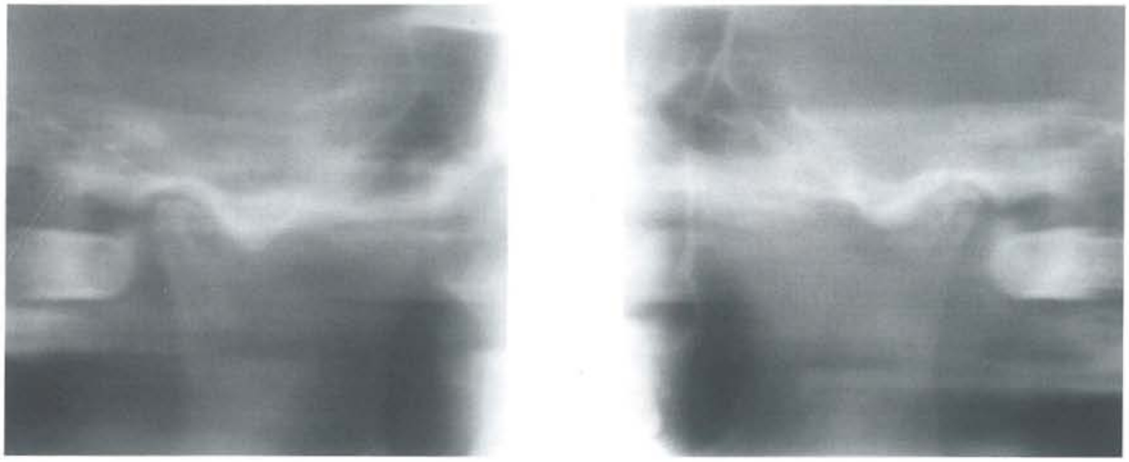


Fig. 6.49 The post-surgical tomograms confirming the condyles centered in the fossae.

The orthodontic treatment for this patient was provided by Dr Frank J. Daniel. The authors gratefully acknowledge his assistance in treating this patient.

7 Facial treatment planning

INTRODUCTION

Chapters 3 and 5 provided information on diagnosis of the face. This chapter will focus on establishing a treatment plan, based on four factors (Fig. 7.1):

1. The patient's motivation for treatment (pp. 33–35)[1]
2. The model examination (pp. 175–183)
3. The facial examination (pp. 51–71)[2,3]
4. The STCA values (pp. 151–160).[4]

These assessments produce a problem list which should then be treated to the goals of treatment (pp. 5–10).

In the past, there have been difficulties with borderline G2 and G3 cases. Errors have been made in attempting G2/G3 borderline treatment in the form of growth modification or dental compensation. Clear surgical cases have been attempted orthodontically, on the basis that 'I'll do the best I can'. Frequently this approach has led to additional problems for the patient, rather than resolving existing problems (Ch. 1). These include possible facial and dental relapse, return of the malocclusion, facial imbalance, periodontal decline, temporomandibular joint decline, patient dissatisfaction with the treatment outcome, and airway compromise. Contemporary orthodontic care should not correct the occlusion at the expense of other goals.

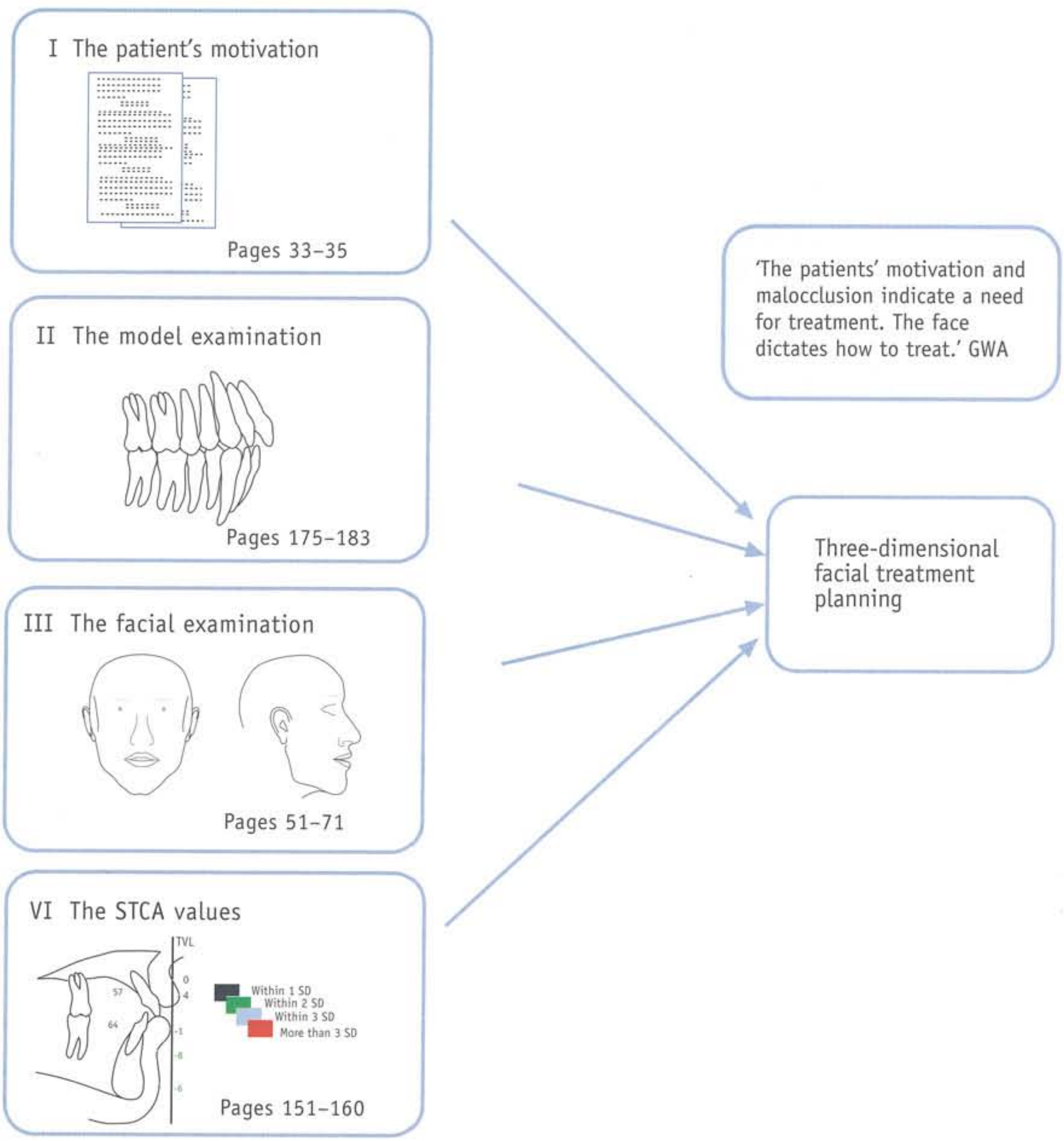


Fig. 7.1

Treatment planning for all three groups of cases should be designed to produce the treatment goals stated in Chapter 1. This chapter presents a protocol to reach those seven goals, with an emphasis on good facial outcomes.

The subject of facial treatment planning is presented in three sections:

- Facial planning for G1 cases – orthodontically assessed
- Facial planning for surgical G3 problems – surgically assessed
- Facial planning for borderline G2 patients – assessed both orthodontically and surgically for comparison.

As indicated above, the G1 cases are assessed orthodontically. The G3 cases are assessed surgically. Both orthodontic and surgical assessment will be recommended for G2 cases, so that the two outcomes can be compared (Fig. 7.2). This double assessment of G2 cases involves some work, and ideally requires computerized analysis. However, by spending time and energy on proper assessment, the correct G2/G3 decision can be made.

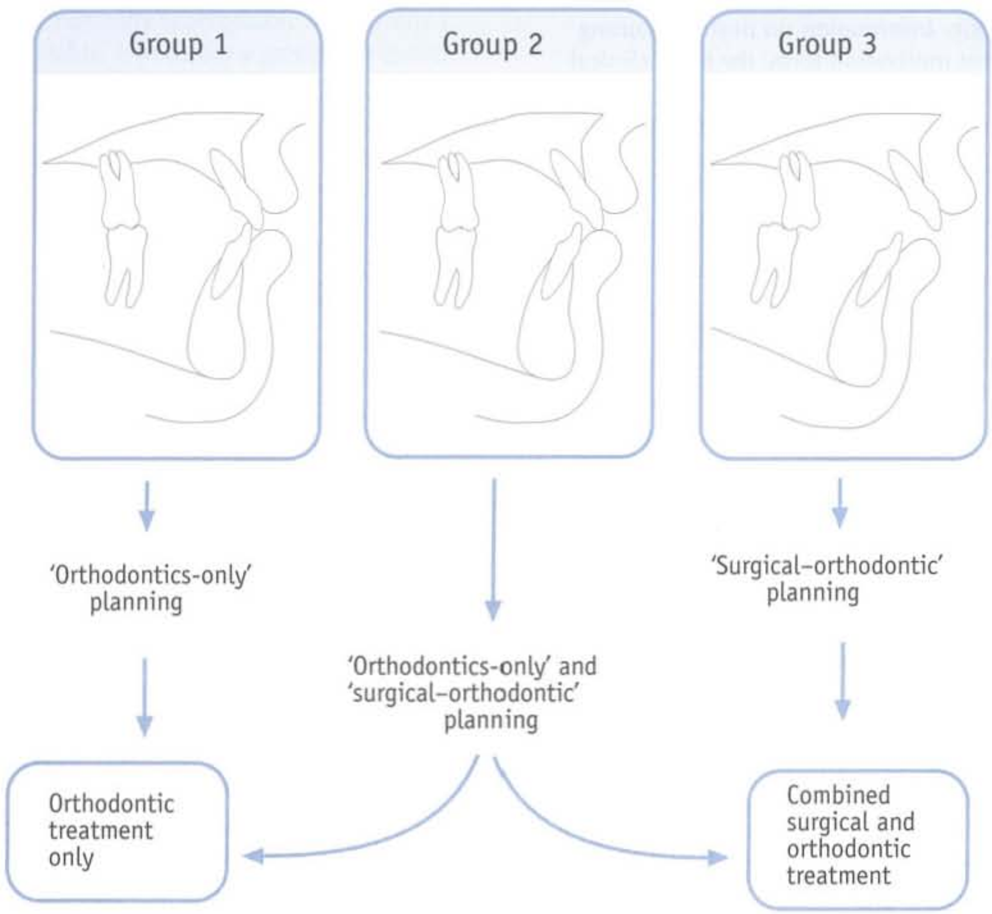


Fig. 7.2 The G1 cases are assessed orthodontically. The G3 cases are assessed surgically. Both orthodontic and surgical assessment is recommended for G2 cases, so that the two outcomes can be compared.

AN OVERVIEW OF THE FACIAL TREATMENT PLANNING PROCESS

The treatment planning process is based on information gathered from three main sources: the patient history (and in particular the patient motivation form[1]), the clinical examination[2,3] (facial, TMJ and intra-oral), and the patient records (STCA,[4] panoramic radiograph, study models, etc.). Potential G1, G2, and G3 patients are analyzed in this fashion and the appropriate treatment plan is established.

The focus of treatment planning will vary among the three groups. Group 1 patients present with well-balanced faces, and little change is needed. Therefore, the focus is on the dentition and possibly the TMJs. The complex group 2 and 3 cases require more involved planning, including the face, the dentition and possibly the TMJs.

Three-dimensional facial planning involves frontal planning and profile planning.[1–4] Information on frontal planning comes mainly from the clinical examination and the patient motivation form. Information on profile planning comes from the patient motivation form, the facial clinical examination, and from the STCA.

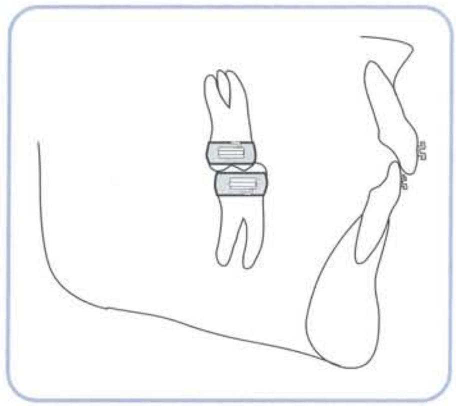
Four treatment methods may be used to obtain the treatment goals:

1. Orthodontics only
2. Orthodontics with lower jaw surgery
3. Orthodontics with upper jaw surgery
4. Orthodontics with upper and lower jaw surgery.

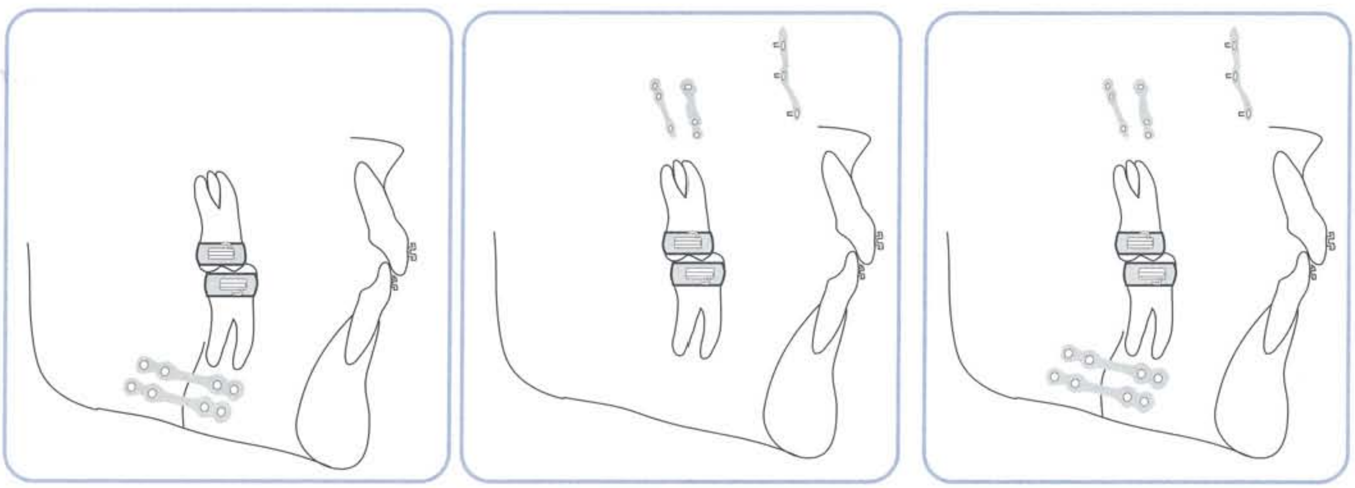
FACIAL PLANNING FOR GROUP 1 PATIENTS (ORTHODONTICS ONLY)

This group includes patients to be treated by orthodontics only, where facial planning is likely to be uncomplicated. Information gathered on these patients will normally appear from the following sources:

1. The patient history and patient motivation form usually reveal that the patient's concerns are primarily dentally related and not facially related. The patient is normally expecting dental correction.
2. The clinical examination reveals a face that is well balanced. This is confirmed with the headfilm and the STCA.
3. The intra-oral examination reveals that the problem is primarily dental. This is later confirmed using the mounted study casts and panoramic radiographs.



Orthodontics only



Orthodontics with lower jaw surgery | Orthodontics with upper jaw surgery | Orthodontics with upper and lower jaw surgery

Four treatment methods may be used to obtain the treatment goals.

Treatment planning of group 1 cases is based on answering the following questions:

1. Does the patient have TMJ concerns (Fig. 7.3A) that require resolving before orthodontic treatment? If so, a treatment plan should be established (Ch. 6).

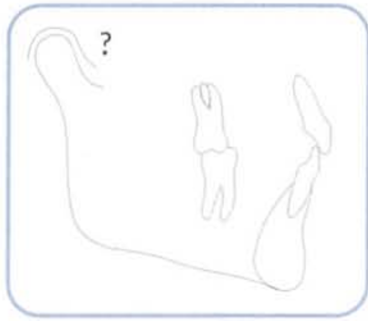


Fig. 7.3A

2. What is the best position that can be achieved orthodontically (Fig. 7.3B) for the upper incisors (the planned incisor position or PIP), and is this position facially acceptable? It normally is acceptable for a group 1 case. If it is not acceptable, it becomes a group 2 or group 3 case.

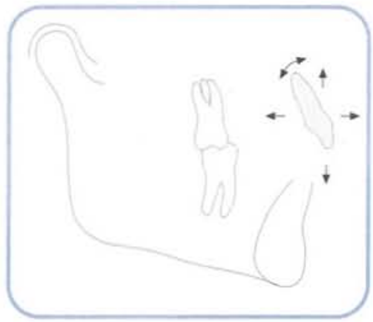


Fig. 7.3B

3. Can the lower incisors be satisfactorily positioned (at close-to-ideal values) relative to the upper incisors (PIP), achieving a 3 mm overbite and 3 mm overjet? Again, the answer is normally 'Yes' (Fig. 7.3C). If the answer is 'No', then the case should be assessed as a group 2 or group 3 case.

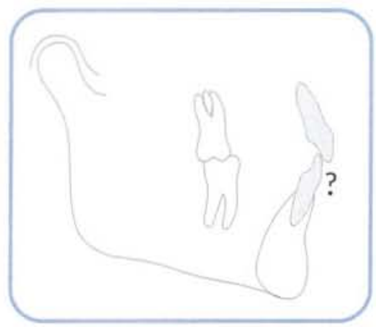


Fig. 7.3C

4. How can the canines and posterior teeth be positioned behind the face and the corrected incisor positions (Fig. 7.3D)? This process involves the use of the dental visualized treatment objectives (VTO) and is explained in Chapter 8.

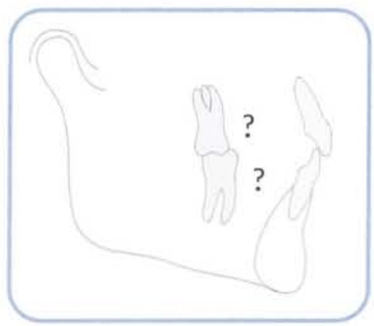


Fig. 7.3D

CASE DP

This 12.0-year-old female presented with a well balanced facial pattern both frontally and in profile view. She showed a Class I skeletal and dental pattern, a deep overbite, upright lower incisor and crowding in the lower anterior segment. It was obvious that surgical intervention would not be necessary.

Fig. 7.7

Figs 7.7 to **7.11** Beginning intra-oral photographs showing a Class I posterior dental relationship, a deep overbite, slight crowding in the upper arch and moderate crowding in the lower arch.

Fig. 7.4

Fig. 7.5

Fig. 7.6

Figs 7.4 to **7.6** Beginning facial photographs of the patient showed a balanced soft tissue profile in the frontal and profile views.

Fig. 7.8

Fig. 7.9

Fig. 7.10

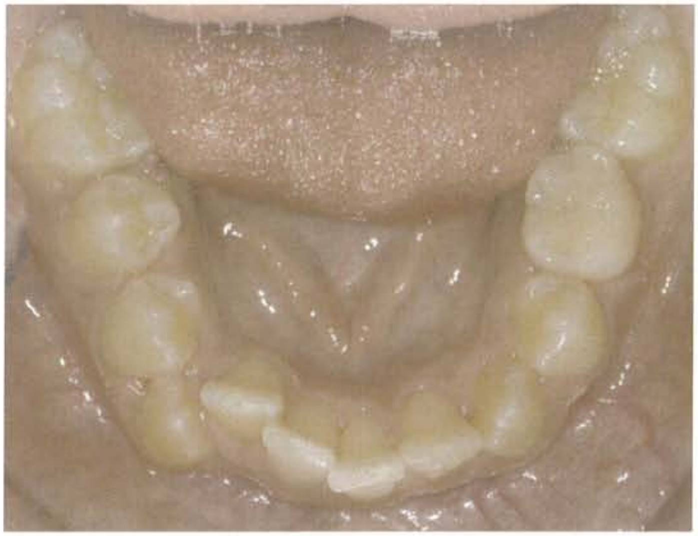


Fig. 7.11

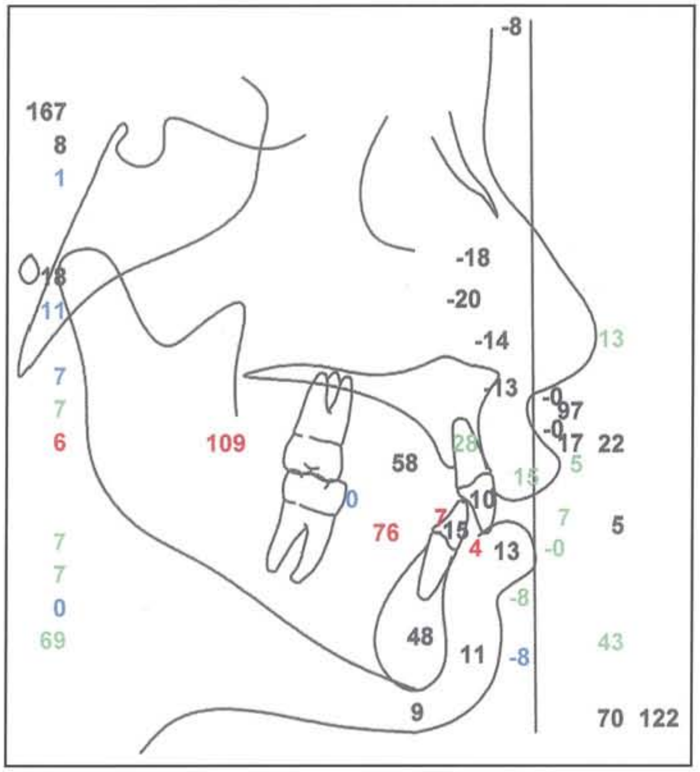


Fig. 7.12 Beginning STCA showing a steep occlusal plane (109, red) (due to the extruded upper incisors), a deep overbite (7, red), upright lower incisors (76, red), and a slightly retrusive chin (–8, blue).

The patient was treated on a non-extraction basis with full banded and bonded orthodontic appliances. Her lower incisors were advanced and interproximal reduction was carried out in the lower anterior segment.

Fig. 7.15

Figs 7.15 to **7.19** Final intra-oral photographs showing a Class I posterior dental relationship, a corrected overbite and overjet, healthy periodontal tissues, and coordinated arches.

Fig. 7.13

Fig. 7.14

Figs 7.13 and **7.14** Final facial photographs of the patient show a balanced soft tissue profile in the frontal and profile views.

Fig. 7.16

Fig. 7.17

Fig. 7.18

Fig. 7.19

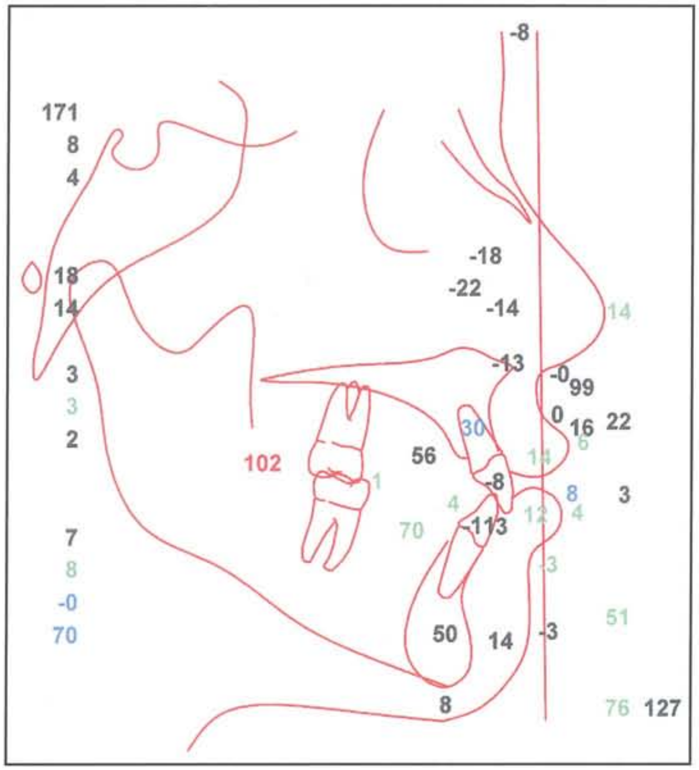


Fig. 7.20 Final STCA showing a steep occusal plane (102, red), a slightly thick upper lip (14, green), and an improved chin position (–3, black) due to good mandibular growth.

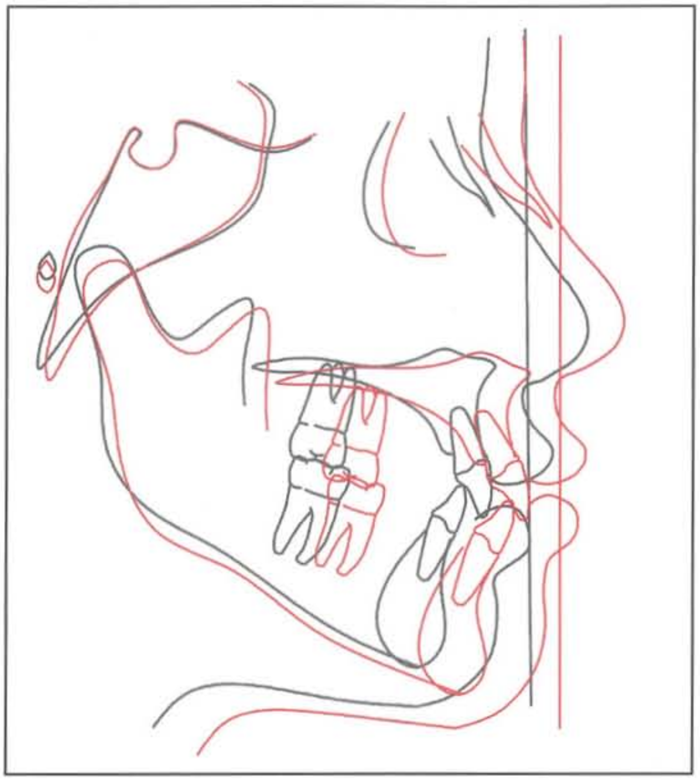


Fig. 7.21 Beginning and final superimpositions on the SN plane. The patient demonstrated a normal facial growth pattern.

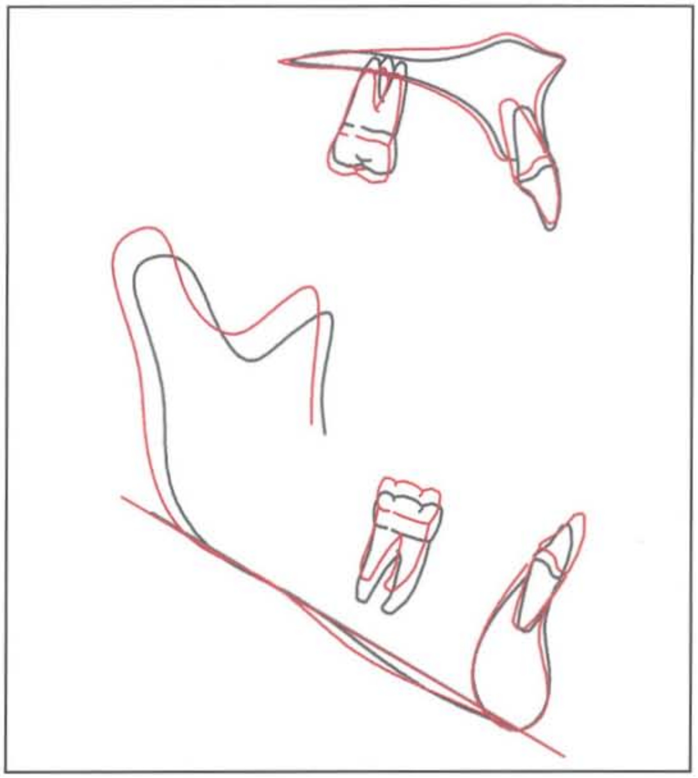


Fig. 7.22 Beginning and final superimpositions on the palatal plane and the mandibular plane. The upper molars showed slight eruption and the upper incisors showed slight intrusion and improvement in inclination (torque). The mandible showed excellent growth with equal eruption of incisors and molars, and slight advancement of lower incisors.

FACIAL PLANNING FOR GROUP 3 PATIENTS (ORTHODONTICS AND SURGERY)

This G3 group includes surgical-orthodontic patients, and dental and facial planning is more extensive. Treatment for these individuals will involve extended orthodontic treatment and surgery to one or both jaws, and they are deserving of the most careful in-depth planning.

Information gathered on surgical-orthodontic patients (Fig. 7.23A–C) will normally appear as follows:

1. *The patient history* (Fig. 7.23A). This may reveal the presence of TMJ symptoms, and the patient motivation[1] form may reveal that the patient has concerns both facially and dentally. If the patient is unaware of the TMJ problems, the consultation visit will require more time for explanation, as the patient may only perceive a dental problem.
2. *The clinical examination*[2,3] (Fig. 7.23B). This reveals a face that is unbalanced, and this is confirmed with the STCA.[4]
3. *The intra-oral examination* (Fig. 7.23C). This reveals that the problem is both skeletal and dental. Later, examination of the models further reveals skeletal problems such as midline misalignments, overjet abnormalities, arch form and arch width mismatches, as well as a possible 2 plane maxillary occlusal plane. Orthodontic treatment without surgery may lead to periodontal decline and relapse in these instances.

Treatment planning of group 3 cases (Fig. 7.24A–C) is based on answering the following questions:

1. Does the patient have TMJ concerns that need to be resolved before orthodontic treatment? If so, a TMJ treatment plan should be established. This needs to be re-evaluated before surgical treatment (Ch. 6).
2. What is the most ideal facial pattern that can be achieved for the patient? This is evaluated both frontally (based on the clinical facial examination) and in lateral projection or profile (based on the clinical facial examination and the STCA).
3. How can the canines and posterior teeth be positioned behind the face and the corrected incisor positions? It is most important to not make dental decisions until facial planning is completed. Again, this dental planning is discussed in detail in Chapter 8.

The three-part facial examination summary form (Fig. 7.25) is used to establish the frontal and profile treatment plan.

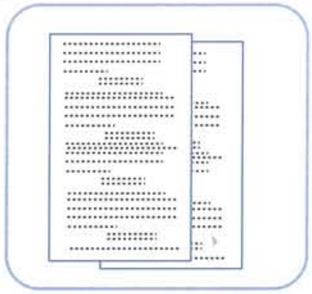


Fig. 7.23A The patient history.

Fig. 7.23B The clinical examination.

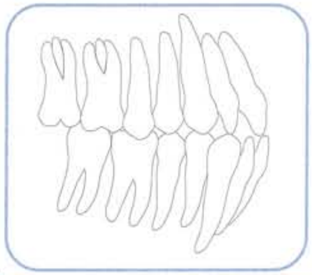


Fig. 7.23C The intra-oral examination (including models).

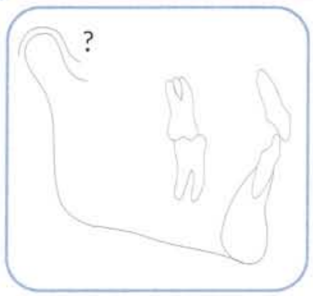


Fig. 7.24A Does the patient have TMJ concerns.

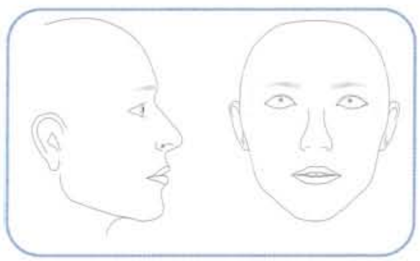


Fig. 7.24B What is the most ideal facial pattern that can be achieved?

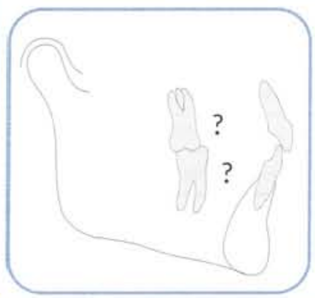


Fig. 7.24C How can the canines and posterior teeth be positioned behind the face?

FACIAL EXAMINATION SUMMARY

Name ______________________ **Age** ________ **Orthodontist** ______________________

FRONTAL VIEW

1. Vertical	Range	Patient	Possible ways to normalize vertical				
Middle 1/3	*62–75mm*						
Overbite	*3 mm*		LFI	BSSO	Crown length change		Orthodontic crown torque change
Upper lip height (a)	*19–22 mm*						Lip length surgery
Inter-labial gap (b)	*1–5 mm*		LFI	BSSO	Overbite correction	Lip posture change	
Lower lip height (c)	*42–48 mm*						Chin osteotomy–change height
Lower 1/3 height	*62–75 mm*	a+b+c				Submental lipectomy	
Mx incisor exposure (reduced)	*1–5 mm*				Crown length change		Crown torque change
Mx incisor exposure (smile)	*8 crown to 2 gingiva*					Lip length surgery	Gingivectomy
Closed lip	*Strain less touch*	strain redundancy		BSSO	Overbite correction		
Mx incisor height	*9.5–11.5 mm*				Crown length change		Gingivectomy
Upper vermillion	*6–9 mm*				Lip reconstruction procedure		
Lower vermillion	*8–12 mm*						

2. Vertical planning	
Mx 1 plan – relaxed lip:	Current relaxed exposure ____ ± desired change ____ = goal ____ (3–5) (>5 mm advancement anticipated? Yes increase impaction)
Mx 1 plan – smile lip:	Current smile exposure ____ ± desired change ____ = goal ____ (8 crown to 2 gingiva)
Anterior facial plan:	± Mx 1 height change ____ ± overbite change ____ = goal ____ ± chin height change ____ = net ____ OK outline–inter-labial gap

3. Midlines	Patient			Possible ways to normalize facial midlines			
Nasal tip	to right		to left	LFI – shorten septum		Isolated septoplasty	
Philtrum	to right		to left			Dental midlines measured to philtum	
Mx 11	to right		to left	LFI		Orthodontics	Canine cant change
Md 11	to right		to left		BSSO		
Chin	to right		to left			Chin osteotomy	

4. Facial levels	Patient				Possible ways to normalize facial levels	
Eyes	R down		L down	Visualize cant Y N	None	
Mx canines	R down		L down	Visualize cant Y N	LFI–skeletal	Orthodontics–dental
Md canines	R down		L down	Visualize cant Y N	BSSO–skeletal	
Md body level	R down		L down	Visualize cant Y N		Heat treated HA augmentation
Chin level	R down		L down	Visualize cant Y N		Chin osteotomy

5. Outline	Patient		Possible ways to normalize facial outline					
General	Round Wide Narrow Long	Short *Normal*	LFI	BSSO	Overbite change	Chin osteotomy–change height	Buccal or submental lipectomy	
Zygomatic arch	R larger wide *normal* narrow	narrow *normal* wide larger L		Heat cured HA augmentation			Reduction osteoplasty	
Md angle	R larger wide *normal* narrow	narrow *normal* wide larger L		BSSO	Midline rotation	Canine cant correction	Cold cure HA graft	Buccal lipectomy
Md body	R larger wide *normal* narrow	narrow *normal* wide larger L						
Chin	Narrow Wide Waist	Flat Angular			Chin osteotomy			
Alar base width	Alar base width ____mm	Intercanthal width ____mm			Alar base cinch		Surgical narrowing	

Fig. 7.25 Facial examination chart (©Arnett Facial Reconstruction Courses Inc. 2003).

FACIAL EXAMINATION SUMMARY (continued)

PROFILE

1. High midface projection	Patient						Ways to normalize high midface projection	
Glabella	Retruded		*Normal*	Prominent			Osteoplasty	
Orbital rim	Flat	Soft	*Normal*	Prominent	R larger	L larger		Heat cured HA augmentation
Cheekbone	Flat	Soft	*Normal*	Prominent	R larger	L larger	Reduction osteoplasty	
Subpupil	Flat	Soft	*Normal*	Prominent	R larger	L larger	LFI (MSLFI advances more than LFI)	

2. Maxillary projection	Patient							Ways to normalize soft tissue nasal base–upper lip projection	
Nasal base	Concave	Flat	Soft	*Convex*	Prominent	R larger	L larger	LFI (MSLFI creates more advancement than LFI)	Desired move _______mm
ULA to TVL	Retruded	*Normal*		Prutruded	Straight MX sulcus		Lip: thin thick	LFI / 11 torque change	Lip thickness change
Upper lip support	Weak	*Normal*		Strong	Support: air teeth gingiva				Desired move _______mm
Nasal projection	Long	*Normal*		Short	Tip: up down	Dorsal: hump saddle		LFI (MSLFI shortens more than LR)	Rhinoplasty
Orthodontics 1	Age	Ext		HG	Elastics	RPE	FA	LFI advancement	Flatten occlusal plane
Orthodontics 2	Age	Ext		HG	Elastics	RPE	FA		

3. Mandibular projection	Patient					Ways to normalize lip and chin projection						
LLA to TLV	Retruded	*Normal*	Protruded 11 deflection	Labiomental fold: accentuated flat		Mx11 torque	LFI	Steepen flatten occlusal plane	Md11 torque	BSSO	Chin	Submental lipectomy
Pog' to TVL	Retruded	*Normal*	Protruded	Pog' relative to lower lip: Protusive Retrusive								
Throat length	Short	*Normal*	Long	Protrusive chin line	Sag							
Overjet	_______mm		Does not indicate source of malocclusion			Ortho	LFI		BSSO			

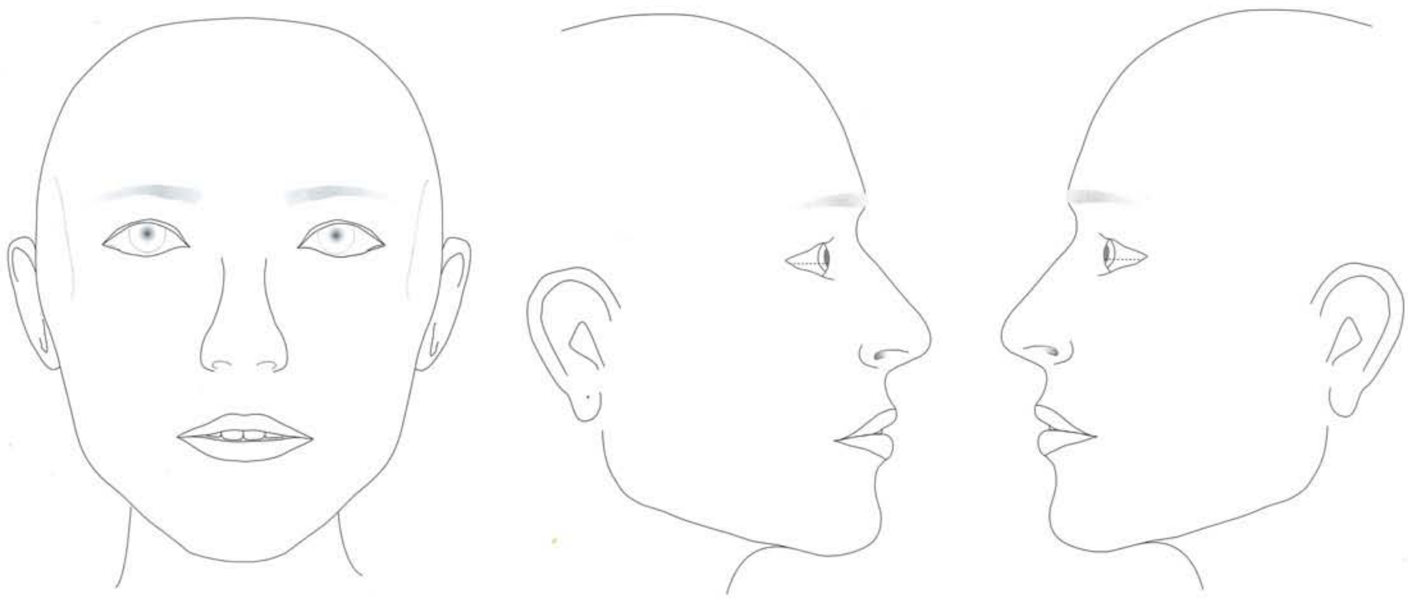


Fig. 7.25 The facial examination summary form from Dr G. William Arnett. This form is divided into three parts: a frontal evaluation, a profile evaluation and facial images for recording information. The left side of the form (white) lists examination factors, the center (yellow) lists the patient abnormalities, and the right side (green) lists treatment possibilities. (©Arnett Facial Reconstruction Courses Inc. 2003)

An overview of frontal facial planning for surgical cases

Frontal facial planning consists of four parts:

1. The vertical dimension	Planned with the STCA (Fig. 7.26a) (the STCA is a profile examination and yet it is used to measure the vertical) and the clinical examination (Fig. 7.26b)
2. The midlines 3. Facial and occlusal cants 4. The general facial outline	Planned with the clinical examination

Vertical facial planning is based on information from the clinical facial examination (pp. 51–71) and objectively confirmed with the STCA (pp. 151–162).

The frontal clinical facial examination is used exclusively to plan three of these frontal factors – facial or occlusal cants, midline deviations, and the general facial outline. These three factors are interrelated for Class II and Class III asymmetry patients and are often abnormal as a group.

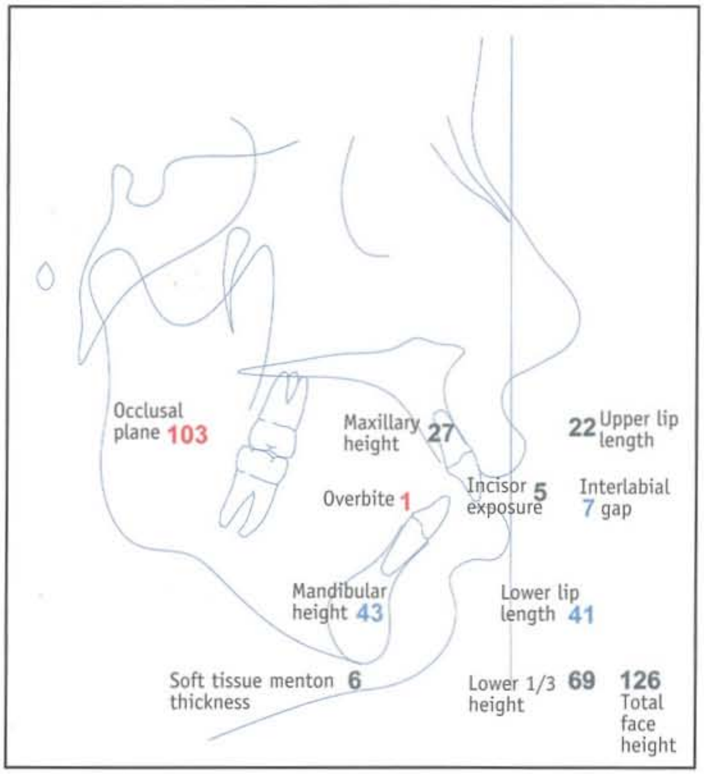


Fig. 7.26a Vertical measurements are shown on the STCA. The vertical dimension is planned utilizing vertical measurements from the STCA and the frontal clinical measurements. Note that the profile STCA is used to develop frontal vertical measurements

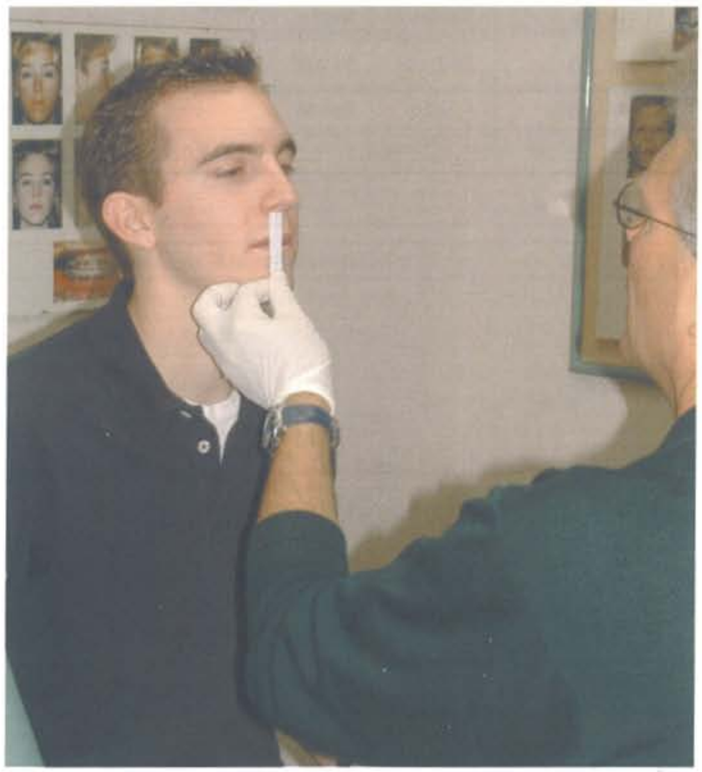


Fig. 7.26b The frontal clinical facial examination is used to plan corrections of occlusal cants, midline deviations, or the general facial outline. Planning of the vertical dimension is based on the STCA findings and the clinical examination.

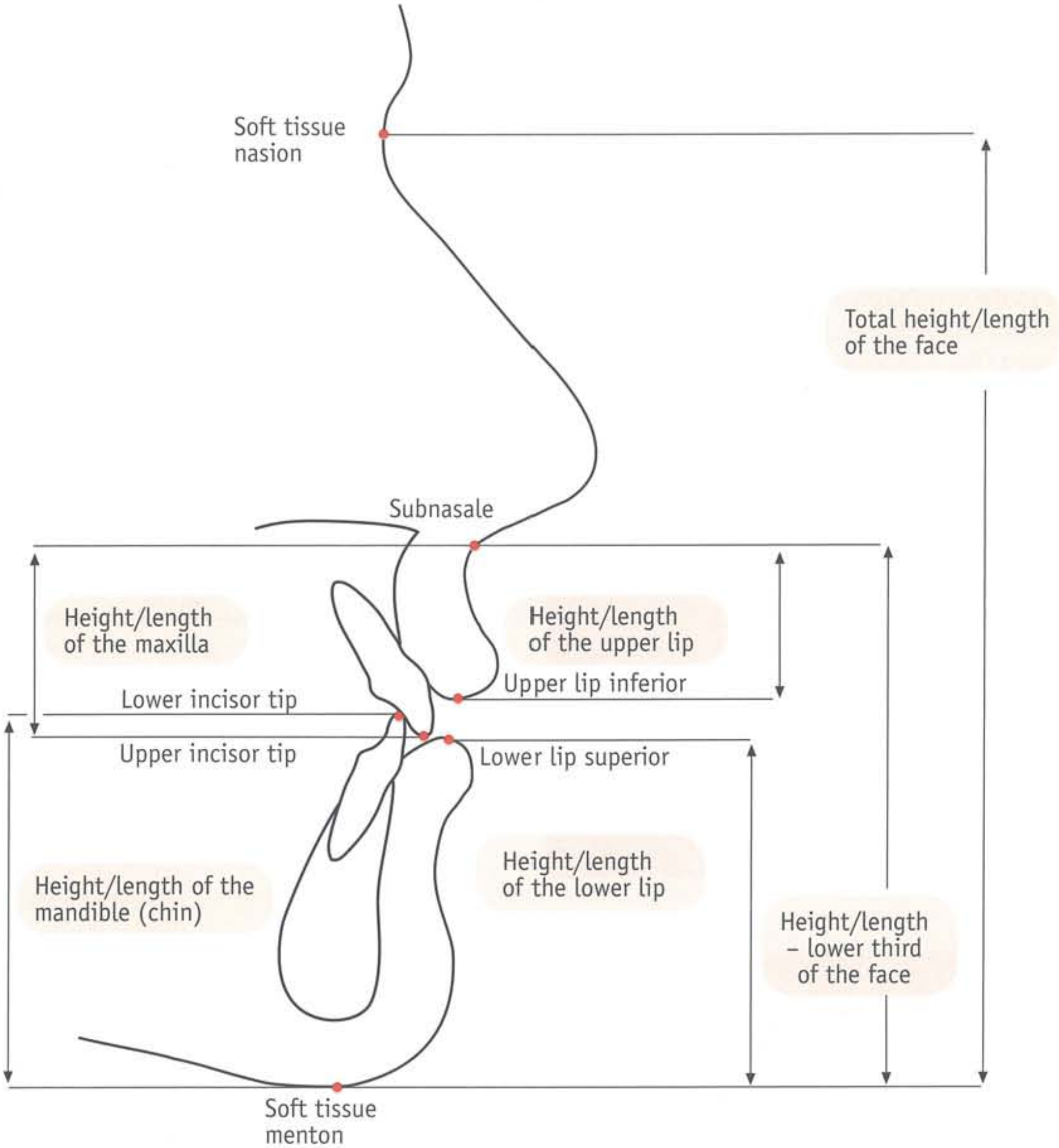


Fig. 7.26c STCA vertical measurements are depicted. The vertical frontal clinical examination is used with the vertical STCA to assess and plan vertical changes.

Three areas of vertical planning are calculated during the clinical facial examination (see 2. Vertical planning, Fig. 7.25):

1. The vertical maxillary incisor exposure with relaxed lips
2. The vertical maxillary incisor position when smiling
3. The anterior facial height.

During vertical facial planning, the first step is to calculate the necessary vertical incisor change, based on relaxed lip posture (Fig. 7.27a). The planned position is then re-assessed, based on incisor exposure when smiling (Fig. 7.27b). Finally, these planned changes in the vertical position of the upper incisors, the overbite, and the chin height will have an effect on the anterior facial height (Fig. 7.28). The new anterior face height needs to be calculated and considered relative to the effect on facial outline and interlabial gap.

Fig. 7.27a

Fig. 7.27b

Fig. 7.27 The upper incisor exposure with relaxed lips, and the upper incisor position when smiling are measured for vertical planning.

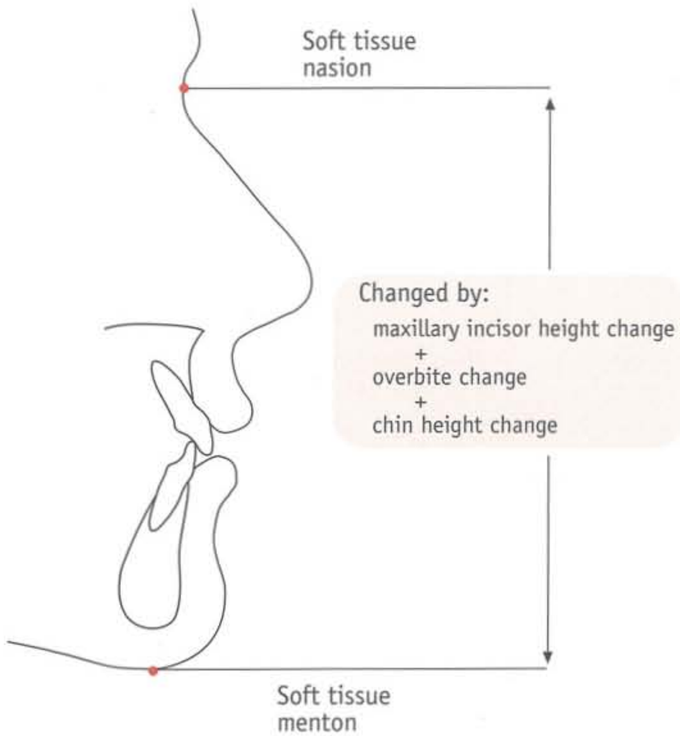


Fig. 7.28 The anterior facial height.

An overview of facial planning for surgical cases

The profile is assessed using *the clinical facial examination*[2,3] and *the STCA*.[4] The possible ways to correct abnormalities are listed on the right-hand side of the facial examination summary form (Fig. 7.25, pp. 234–235). Treating problems at their source produces optimal facial and occlusal change and decreases complications.

- *The clinical examination* is excellent for revealing contours such as cheekbones. It is also very good for assessing vertical dimensions such as upper incisor exposure with relaxed lips.
- *The STCA* provides quantitative information about A/P projections of the profile to TVL, the vertical dimensions, along with the dental and skeletal factors. Any or all of these may need correction to normalize the face and occlusion.

After the profile problems have been identified, the seven-step surgical cephalometric treatment plan[4] (surgical CTP) is used to plan the needed changes (p. 240). Most importantly, the STCA normal values are used during the surgical CTP. These provide an objective basis for the CTP. In this way it is possible to plan ideal positions for dental and skeletal structures – positions which will support the soft tissues of the face and provide a balanced profile.

The aim of surgery

Surgery can control all the dental and skeletal factors which will support the soft tissues of the face. Therefore, the post-surgical profile projection measurements should be within one (black) or two (green) standard deviations. During surgery, every effort should be made to avoid a result with a 'three standard deviation profile'.

There are instances when adequate lip and chin projections to TVL cannot be achieved without placing the occlusal plane and incisor projections outside two standard deviations. This is normally not a problem, because the facial profile is the visible aspect of the treatment. The occlusal plane and incisor projections are concealed. Therefore, some discretion is possible, and for some patients the occlusal plane and incisor projections may be manipulated (blue, 3SD) in order to produce an ideal viewable profile.

The STCA and CTP, as described above, are only reliable for caucasion patients – they were developed by measuring normal caucasian models. The STCA and CTP can be utilized on other ethnic groups as normal values are developed. This has been done for Korean and Japanese patients and is in progress with other ethnic groups.

Cephalometric treatment planning (CTP)[4] for surgical cases

Diagnosis requires information from the patient history, the patient motivation form, the facial examination, the STCA, and the model examination. Facial and dental *treatment planning* begins with cephalometric treatment planning (CTP) (Fig. 7.29).

The CTP is accomplished to correct the occlusion and balance the face. Three examinations determine the CTP (Fig. 7.29):

1. Patient motivation[1]
2. Model examination
3. Facial examination (clinical and STCA).[2–4]

The patient motivation, model examination, and facial examination develop a problem list. The treatment which is capable of correcting the problems, either orthodontics, lower jaw surgery, upper jaw surgery, or both jaws, is selected. The required CTP is selected and used to balance the face while correcting the occlusion.

There are seven steps in the surgical CTP:

1. Correct the torque of the upper incisors
2. Correct the torque of the lower incisors
3. Position the maxillary incisors – with Le Fort I where necessary
4. Auto-rotate the mandible to 3 mm of overbite
5. Move the mandible to 3 mm of overjet (AP movement)
6. Set the occlusal plane
7. Assess the chin height and AP projection to TVL.

CTP determinants – Mx and Md movements

PATIENT MOTIVATION PROBLEMS

1. Dental – Mx or Md
2. Facial – Mx or Md
3. Symptoms

Refer to patient motivation form

MODEL EXAMINATION PROBLEMS

4. Tooth mass
5. Overjet
6. Overbite
7. Arch width mismatch
8. Arch from mismatch
9. Mx dual plane
10. Mx or Md midline off

Refer to model examination form

FACIAL EXAMINATION PROBLEMS

11. Mx or Md canine cant
12. Mx or Md vertically short
13. Mx or Md vertically long
14. Mx or Md midline off
15. Mx or Md protrusion
16. Mx or Md retrusion

Refer to facial examination form and STCA

Treatment options

1. **Orthodontics only**
2. **Lower jaw surgery**
3. **Upper jaw surgery**
4. **Upper and lower jaw**

Select the treatment necessary to correct the problem list (1–16)

Steps 1–7 CTP

Fig. 7.29 Possible problems are identified via the patient motivation questionnaire (1–3), the model examination (4–10), and the facial examination (11–16). The treatment option capable of treating all of the problems in selected. The seven step CTP is then utilized to optimize the dental, occlusal and facial results (Dr G. William Arnett).

The seven-step surgical CTP[4]

Step 1. Correct the torque of the upper incisors

The upper incisors are placed at the correct torque (female 56.8 ± 2.5°, male 57.8 ± 3.0°) to the maxillary occlusal plane (Fig. 7.30).

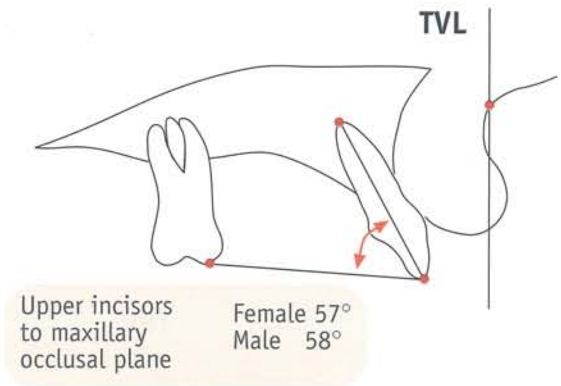


Fig. 7.30 The upper incisors are placed at the correct torque to the maxillary occlusal plane. This is stable with periodontal health.

Step 2. Correct the torque of the lower incisors[4]

The lower incisors are then positioned (female 64.3 ± 3.2°, male 64.0 ± 4.0°) to the mandibular occlusal plane (Fig. 7.31).

The use of the maxillary and mandibular occlusal planes. The incisors are measured to the maxillary and mandibular occlusal planes to eliminate inaccuracy. Incisor measurements to extremely variable and distant landmarks, such as the sella/nasion, Frankfort, and APO line may produce misleading measurements which have little to do with the goals of incisor periodontal health or stability. Also, for surgical cases, the maxillary and mandibular occlusal planes were chosen as necessary supplements to measurements of the incisors to the palatal and mandibular planes. The mandibular and palatal planes themselves are altered by surgery and therefore cannot be used as reference planes. The relationship of Go to Me is changed by the sagittal osteotomy and the relationship of ANS to PNS is changed by the multisegment Le Fort I.

After normal incisor torque has been achieved, the 'skeletal' overjet and overbite are revealed, because the dental compensations have been removed. If, when normal torque is applied, the overbite and overjet are normal (approximately 3 mm, as is often seen in Group 1 cases), there is no antero-posterior nor vertical component to the malocclusion.

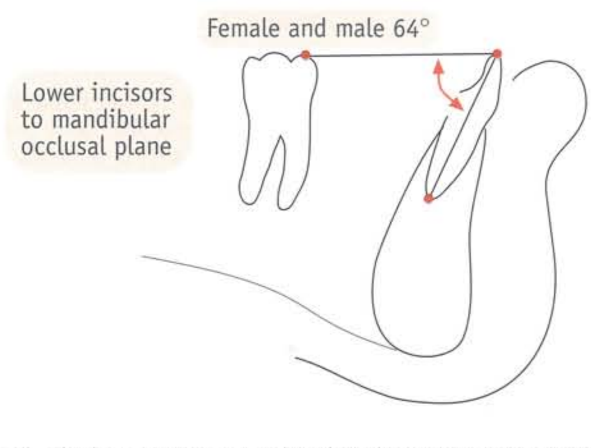


Fig. 7.31 The lower incisors are placed at the correct torque to the mandibular occlusal plane. This is stable with periodontal health.

Correct incisor torque. Correct upper and lower incisor torque is necessary for ideal facial outcomes and should be achieved orthodontically before surgical correction. For example, if the upper incisors are upright (> 58°) or the lower incisors are procumbent (< 60°) at the time of surgical correction, the lower lip, the soft tissue B′ point, and the soft tissue pogonion will be retrusive, relative to the rest of the face (Fig. 7.32). In this example the incorrect incisor torque creates a less-than-ideal profile. The orthodontist has control of incisor torque, and this has a significant impact on the facial outcome.

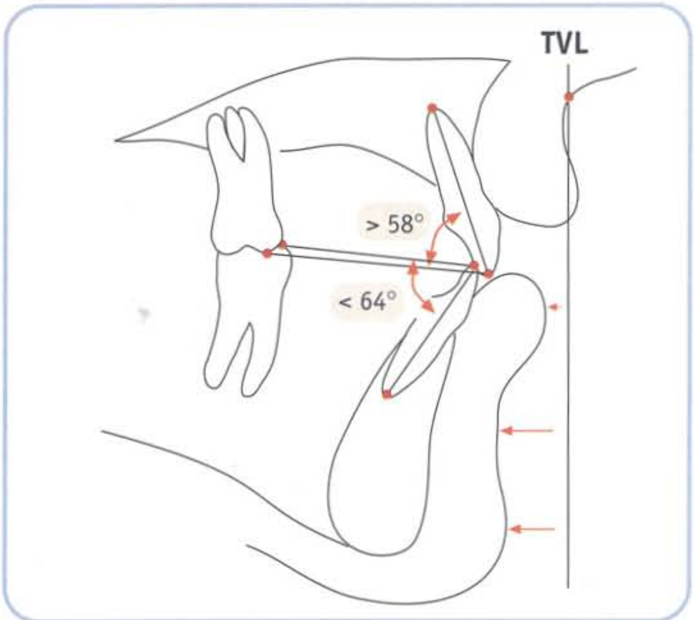


Fig. 7.32 After surgical correction, the lower lip, soft tissue B′ point, and soft tissue pogonion will be retrusive relative to the rest of the face, if the upper incisor is upright (> 58°) or the lower incisor is procumbent (< 60°). This is evidence that orthodontic preparation has profound effects on the surgical facial outcome.

Step 3. Position the maxillary incisors[4]

This step is the key to dentofacial reconstruction. For surgical cases it is accomplished with Le Fort I (LFI) surgical movement. The upper incisors are placed vertically so that 3–5 mm of incisor enamel is visible beneath the relaxed upper lip (Fig. 7.33).

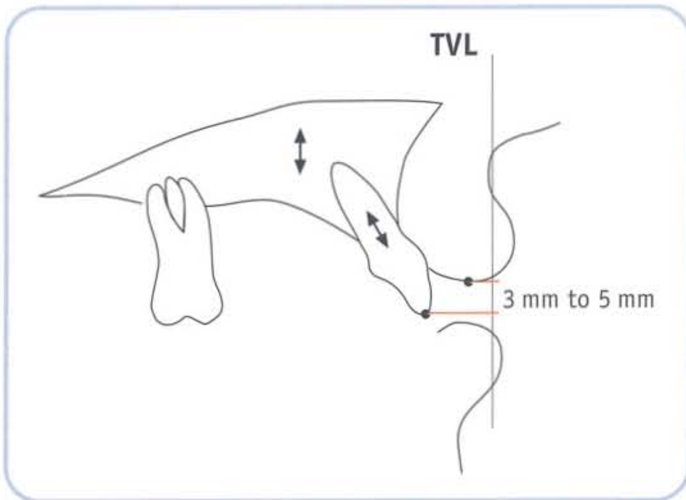


Fig. 7.33 The upper incisors are placed vertically to expose 3–5 mm of the central incisors beneath the relaxed upper lip.

Horizontally, the upper incisors are positioned according to a combination of clinical and STCA findings. *The clinical factors* are the orbital rim, cheekbone, subpupil, nasal base contours, nasal projection, and upper lip support. *The STCA factors* are the upper lip thickness, the upper lip projection to the TVL, and upper lip angle (Fig. 7.34).

The maxilla (and incisors) should be surgically advanced if the nose is long, midface structures are flat, the upper lip lacks incisor support, the upper lip is thick, the upper lip is retrusive, or the angle of the upper lip is upright.

If the orbital rims and cheekbones are flat, heat treated hydroxyapatite–Avitene onlay grafting is necessary to produce simultaneous augmentation in those areas.

If the maxillary incisor position is esthetically correct without treatment, no maxillary surgery is indicated, unless other reasons exist as revealed in the model examination. Such reasons can include a 'dual plane' maxillary occlusion, or mismatches in the arch form, the arch widths, or the midlines.

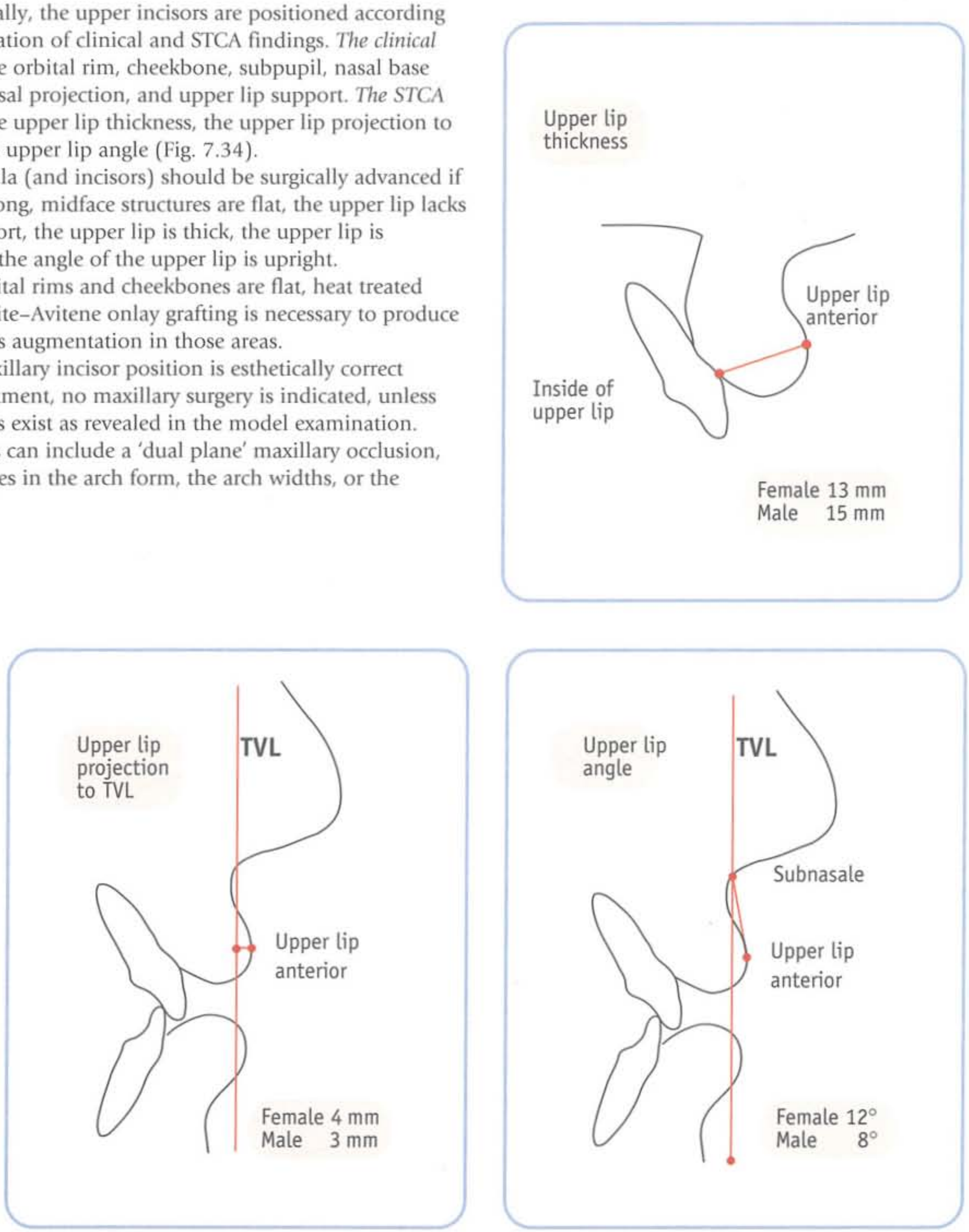


Fig. 7.34 For horizontal positioning of the upper incisors, the STCA factors are the upper lip thickness, the upper lip projection to the TVL, and upper lip angle. When maxillary retrusion is identified with the clinical examination, the TVL is moved forward 1–3 mm (p. 159, Fig. 5.18) and the upper lip projection is then measured.

Step 4. Auto-rotate the mandible to 3 mm of overbite[4]

This reveals the true overjet at the correct vertical dimension of the anterior face (Fig. 7.35). If the rotation produces a class I overjet, an LFI may be all that is necessary if other problems are not present. These other problems may include visible cants, a lower midline deviation, or a steep occlusal plane which prevents adequate chin projection. If after rotation, a Class II or Class III overjet is present, the mandible will need advancement or retraction to produce a Class I occlusion in step 5.

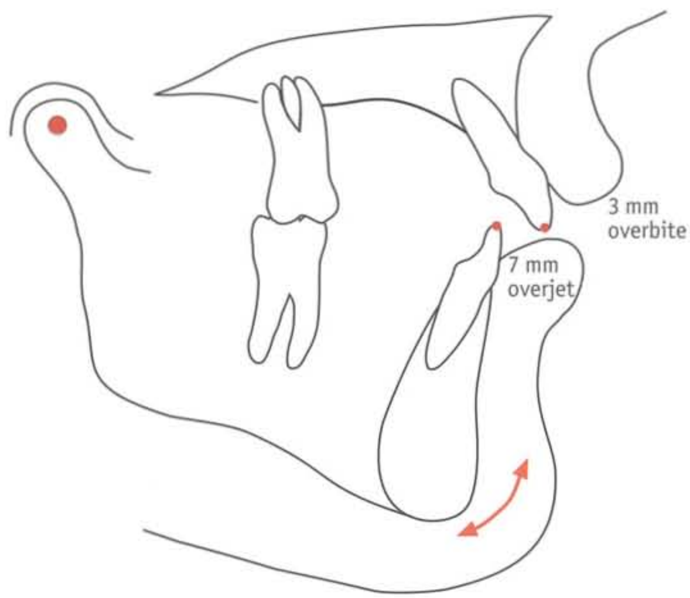


Fig. 7.35 Rotation of the mandible to 3 mm of overbite reveals the true overjet at the correct vertical dimension of the anterior face. In this instance a Class II overjet still exists after autorotation. This is corrected in step 5.

Step 5. Move the mandible to 3 mm of overjet (A/P movement)[4]

If necessary, this step is carried out to correct the incisor overjet to 3 mm with 1.5 mm of overbite in the molars (Fig. 7.36). The lower lip usually needs re-posturing at this time. The lip is rotated, without changing its thickness, until it touches the upper incisors.

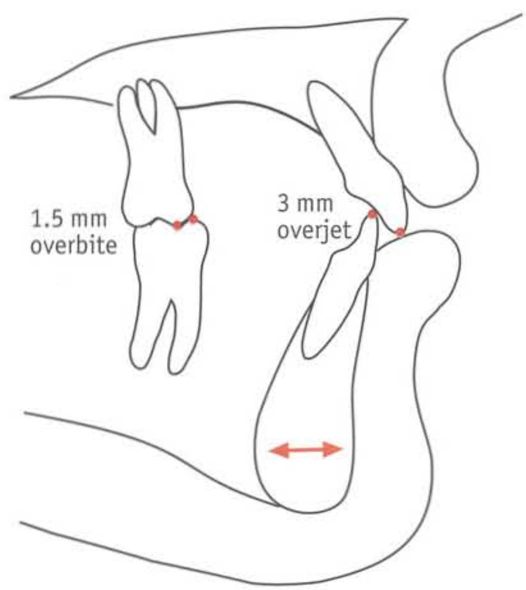


Fig. 7.36 If necessary, A/P movement of the mandible is used to correct the incisor overjet to 3 mm and the overbite to 1.5 mm in the molar regions. In this case, the Class II overjet from step 4 (above) has been corrected with Md advancement in step 5. If after step 4 the overjet is CI, this step may not be necessary.

Step 6. Set the maxillary (upper) occlusal plane[4]

After the overbite and overjet have been set, a position for the upper occlusal plane is decided. The anterior point of the occlusal plane is the maxillary incisor tip. The anterior point is set to expose the upper incisal edge esthetically (as described above in step 3 for upper incisor positioning). The posterior point of the occlusal plane line is the tip of the mesial buccal cusp of the maxillary first molar (Fig. 7.37).

In general, a more superior placement of the upper first molar (relative to the incisor tip) gives a more convex and less pleasing facial profile. A steep occlusal plane (p. 154) produces facial convexity by retracting the chin and protruding the nasal base and subnasale. The profile is usually optimal when the occlusal plane is 93–97° to the true vertical line (Fig. 7.37), soft tissue pogonion is within an appropriate range of the true vertical line (female −2.6 ± 1.9 mm, male −3.5 ± 1.8 mm), and the nasal base support is esthetic. This is achieved by rotating the bimaxillary complex on the maxillary central incisor until esthetic nasal base and chin balance is achieved.

Moving the bimaxillary complex anteriorly or posteriorly. For some cases there is a need for a sub-step in the stage of upper occlusal plane correction. For these individuals the bimaxillary complex (upper and lower jaws) can be moved anteriorly or posteriorly if this is necessary to produce correct chin and nasal base esthetics. Posterior movement from the incisors original projection is generally not indicated, because the consequent retraction of the nasal base and teeth produces nasolabial grooves. These grooves deepen with aging. It should be noted that a multi-segment Le Fort I procedure will produce 2–3 mm more advancement in the nasal base than is shown on the two-dimensional CTP.

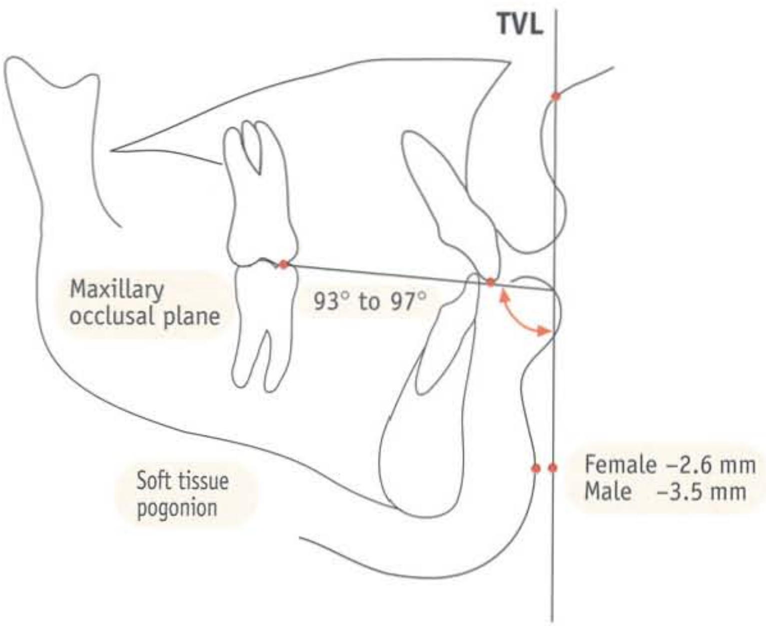


Fig. 7.37 The profile is usually optimal when the occlusal plane is between 93–97° to the TVL, the soft tissue pogonion is within a normal range of the TVL (female −2.6 ± 1.9 mm, male −3.5 ± 1.8 mm), and the nasal base support is esthetic.

Step 7. Assess the chin height and AP projection to TVL[4]

This last step of the CTP is carried out to position the chin AP and vertically. The chin position can be adjusted in two ways:

1. With a sliding chin osteotomy (Fig. 7.38) (Cases MO, p. 275; AC, p. 191) by moving the chin anteroposterior and/or vertically.
2. By changing the occlusal plane to give an increase or decrease in the chin A/P projection to TVL. 'Steepening' the occlusal plane decreases chin projection, and 'flattening' the occlusal plane increases chin projection (Fig. 7.39).

If the chin has a poor contour, the occlusal plane can be steepened. This will allow a chin augmentation (Case MO, p. 274), which will improve the chin contour and projection.

Chin heights. The mean mandibular anterior height (chin height) is 48.6 mm for females and 56.0 mm for males (Fig. 7.38). The ratio of maxillary height (Sn to Mx1) to mandibular height (Md1 to Me') is essentially 1:2 for males and females – this ratio should be achieved with treatment. A chin osteotomy with lengthening or shortening may be used to normalize chin height.

Omitting steps in the CTP. The CTP steps used for lower jaw surgery, upper jaw surgery, and two-jaw surgery are different. If one or more of the seven steps is correct, without alteration, it is omitted. An example of this is lower jaw surgery. Steps 1, 2, 4 and 7 provide a facially correct Class I occlusion (Case MO, p. 274), and therefore steps 3 (Le Fort I upper incisor AP and vertical change) and 6 (occlusal plane modification) are not needed. Step 7, a chin osteotomy, may be used to provide adequate chin prominence, provided this step is not overdone to compensate for a steep occlusal plane angle.

When orthodontics without jaw surgery is adequate for occlusal and facial correction, steps 1,2 and possibly 7 are utilized.

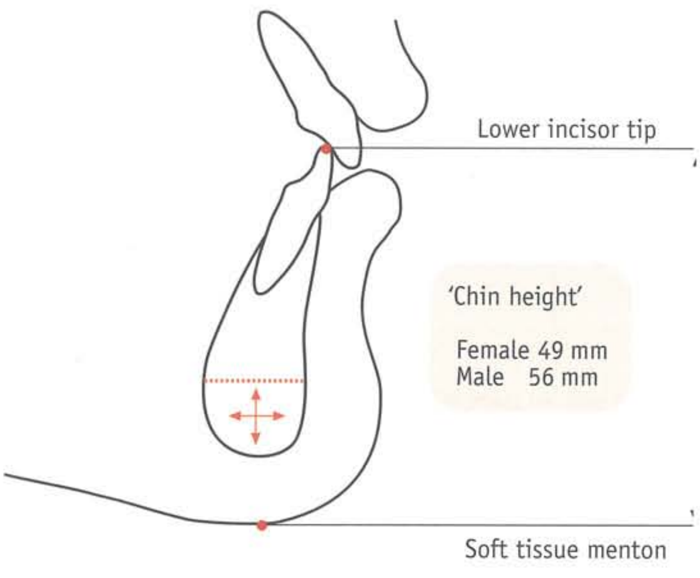


Fig. 7.38 The mean chin height is 48.6 mm for females and 56.0 mm for males. A chin osteotomy with lengthening or shortening may be used to normalize chin height. The chin may be moved anteroposterior to effect projection or alter the shape (i.e. flat chin advancement to increase the shape).

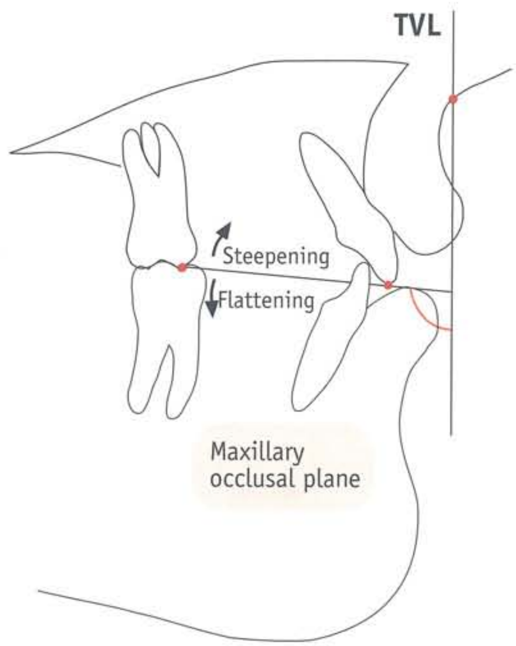


Fig. 7.39 Steepening the occlusal plane decreases chin projection, and flattening the occlusal plane increases chin projection.

CASE RS

This 41.3-year-old male with a Class II malocclusion was seen for consultation. He was referred by his orthodontist. Orthodontic appliances had been in place for 24 months at the time of the initial surgical consultation. Leveling and alignment of the arches had been completed. Diagnosis and treatment were started with the intention of fulfilling the seven goals of treatment. His patient motivation form indicated a desire to move the upper teeth backward and the lower teeth forward. Facially, the patient wanted the chin moved forward. He had no TMJ symptoms but did have a history of night-time clenching. TMJ examination and history, clinical facial examination, soft tissue cephalometric examination, and model examination were obtained. The problem list and treatments were as follows:

PROBLEM	TREATMENT
1. High midface	
• Normal	• No treatment
2. Maxilla	
Orthodontic preparation	• Stable
Dental	
• Leveling and alignment done	• None
• Excessive lingual crown torque	• Labial crown torque
Skeletal/facial	
• Long nasal projection	• Maxillary advancement?
	• Rhinoplasty?
• Midline 1 mm to the left	• Rotate midline 1 mm right
• −2 mm relaxed incisor exposure	• LFI down graft
• Flat occlusal plane	• Steepen occlusal plane
• Arch form and arch shape match in Class I position	• One-piece LFI
3. Mandible	
Dental	
• Level and alignment done	• None
• Excessive labial crown torque	• Lingual crown torque
	• Stripping necessary
Skeletal/facial	
• Chin and lower lip retrusion	• Bilateral sagittal split osteotomy (BSSO) advancement
	• Chin augmentation?
• Flat occlusal plane	• Plan with CTP to produce nasal base + chin harmony
• Short, sag throat length	• Mandible advancement
	• Chin augmentation
	• Submental lipectomy?
• Symmetrical, short facial outline	• LFI down graft
	• Chin lengthening
4. TMJ	
• No signs or symptoms	• No treatment
5. Growth potential	
• 41.3 years old	• Non-factor

Pre-surgical orthodontics was completed in 10 months. After diagnosis, the patient was treatment planned antero-posteriorly and vertically using the seven-step cephalometric treatment plan. The frontal midlines, levels and outline were treatment planned using the frontal clinical examination.

A one-piece LFI down graft and BSSO advancement were necessary to correct the occlusion and produce basic facial balance. The LFI down graft was stabilized with OsteoMed rigid plates, platelet rich plasma, iliac crest bone grafting, Interpore 200 blocks, and amitriptyline at bedtime to prevent clenching. Additional improvement of facial balance was achieved with a 6 mm lengthening and 3 mm advancement of the chin. Additionally, cold cure hydroxyapatite with Avitene was added to the right mandibular lateral body to fill out a contour depression.

Fig. 7.40

Fig. 7.41

Fig. 7.42

Fig. 7.43

Fig. 7.44

Fig. 7.45

Figs 7.40 to **7.45** Pre-orthodontic facial and intra-oral photographs. Note the Class II deep bite malocclusion and the lip redundancy. Facial hair should be removed prior to diagnosis and treatment.

Fig. 7.46 Pre-orthodontic full mouth radiographs.

Fig. 7.47

Fig. 7.48

Fig. 7.49

Fig. 7.47 to **7.49** Pre-orthodontic model photographs indicate a Class II deep bite malocclusion.

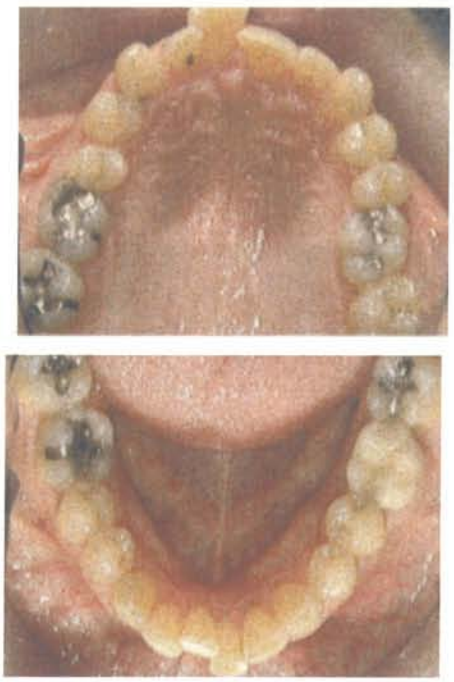


Fig. 7.50 Pre-orthodontic occlusal views.

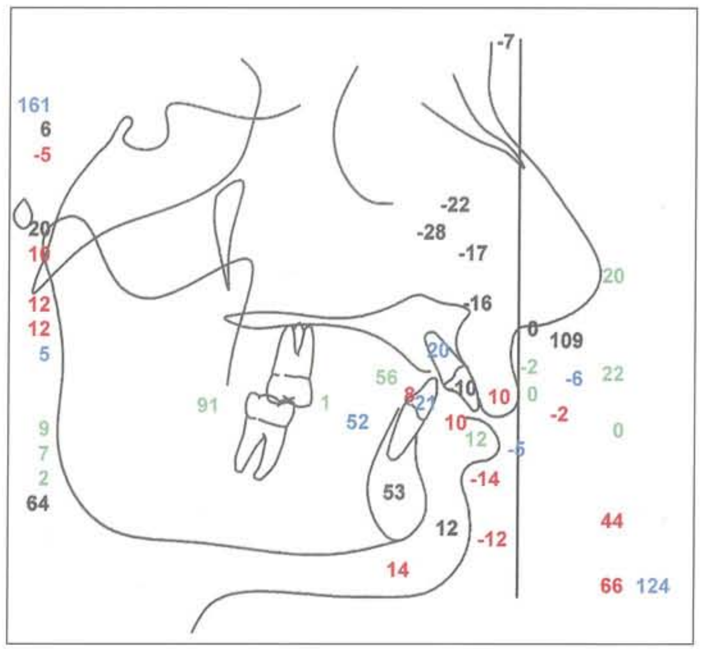


Fig. 7.51 Pre-orthodontic STCA tracing showing normal midface projection (–22, –28, –17, –16, black), upper lip retrusion (–2, green; 0, green; –6, blue), mandibular retrusion (–21, blue; –12, red), deep bite (8, red), and a lack of upper incisor exposure (–2, red).

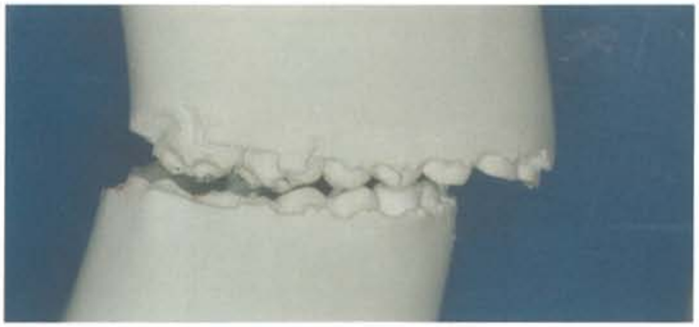


Fig. 7.52

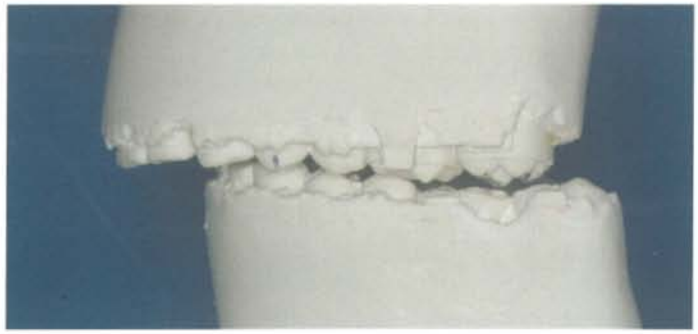


Fig. 7.53

Fig. 7.54

Figs 7.52 to **7.54** Pre-surgical articulator models demonstrating Class II malocclusion in centric relation.

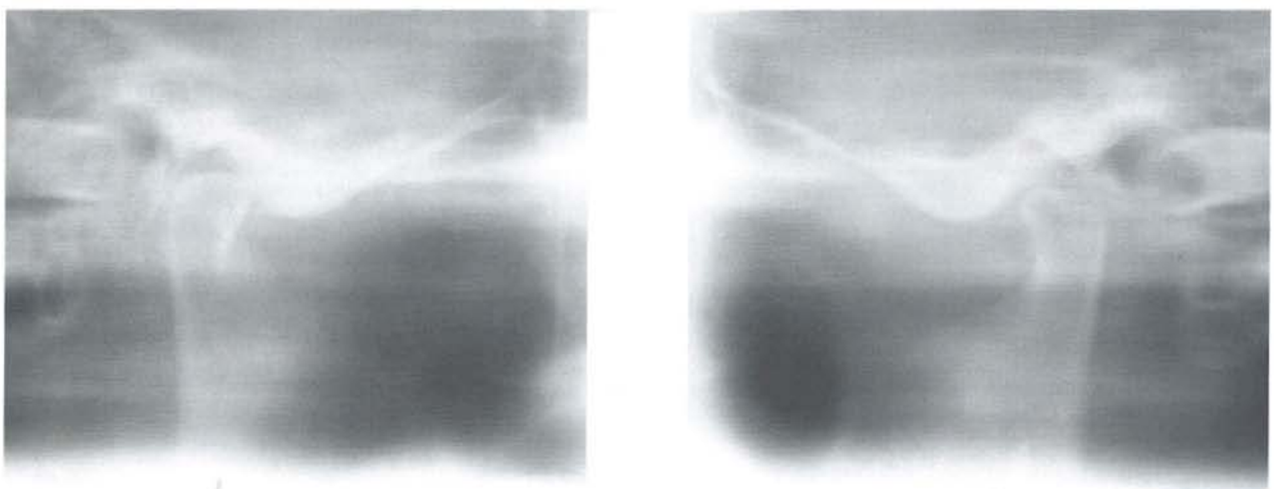


Fig. 7.55 Pre-surgical tomographic radiographs. Note: condylar size, shape, cortication, and position are normal.

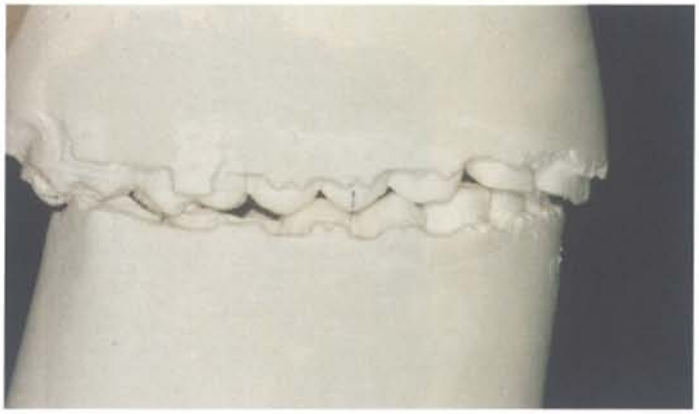


Fig. 7.56

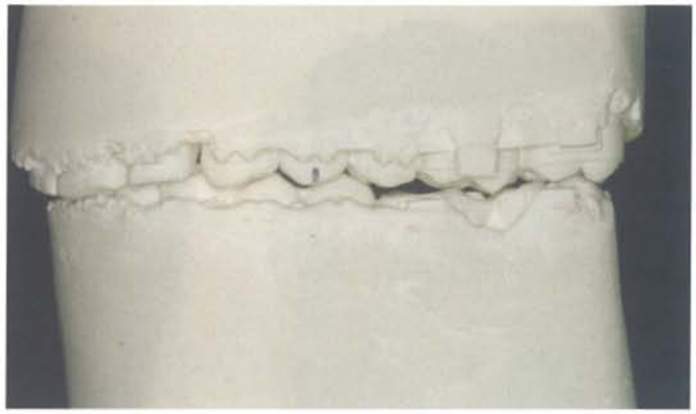


Fig. 7.57

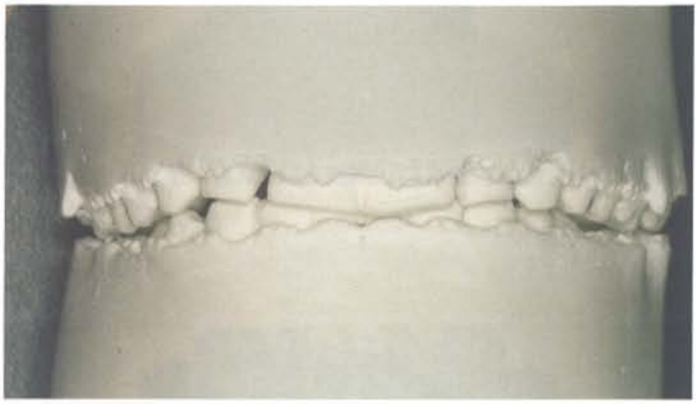


Fig. 7.58

Figs 7.56 to **7.58** Pre-surgical models are hand held in Class I, indicating matching arch forms, arch widths, and planes of occlusion. Multi-segment LFI surgery was not necessary because one-piece maxillary surgery provides an excellent occlusion. The pre-orthodontic models were compared to the post-orthodontic models and there was no orthodontic relapse built into the preparation.

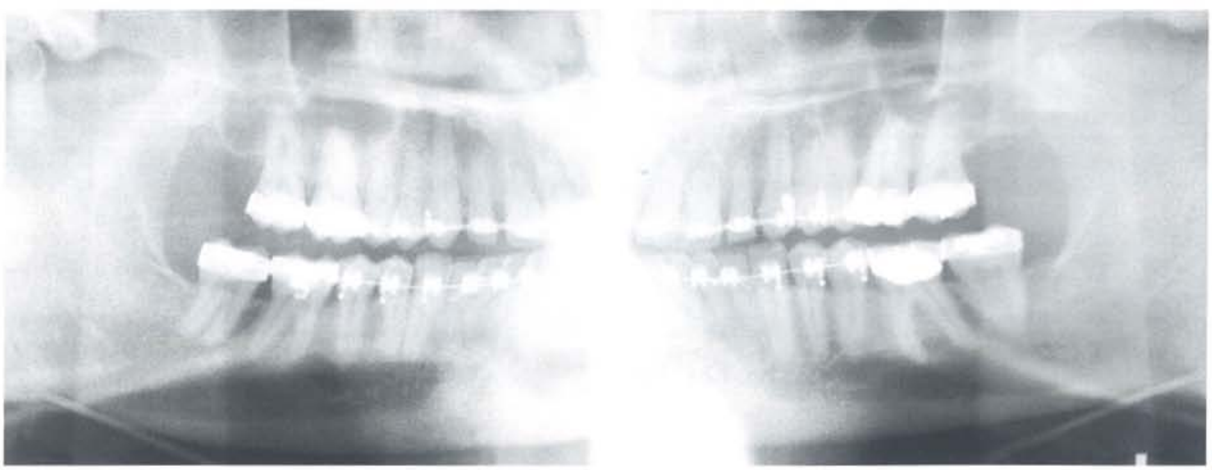


Fig. 7.59 The pre-surgical panoral radiograph.

Fig. 7.60

Fig. 7.61

Fig. 7.62

Figs 7.60 to **7.64** Pre-surgical photographs without a wax bite. Note: lip redundancy and decreased incisor exposure with the smile secondary to vertical maxillary deficiency. Profile demonstrates Class II profile.

Fig. 7.63

Fig. 7.64

Fig. 7.65

Fig. 7.66

Fig. 7.67

Figs 7.65 to **7.69** Pre-surgical photographs with a thick wax bite in place, opening the bite. Note: absence of lip redundancy, and inter-labial gap within the normal range. Profile demonstrates an increase in the Class II profile secondary to downward and backward rotation of the mandible with the thick wax bite. CTP head film, tomograms, facial examination, and model mounting all use this bite-open wax bite.

Fig. 7.68

Fig. 7.69

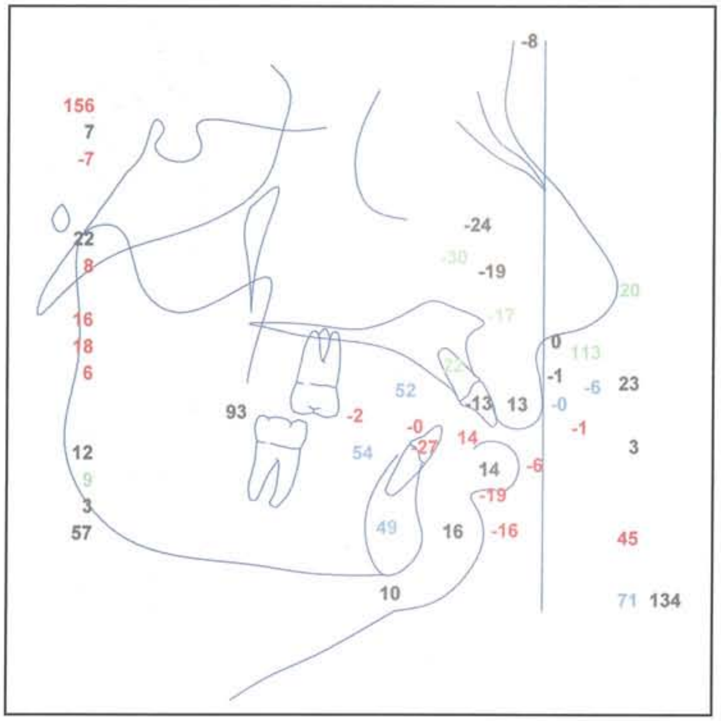


Fig. 7.70 STCA.

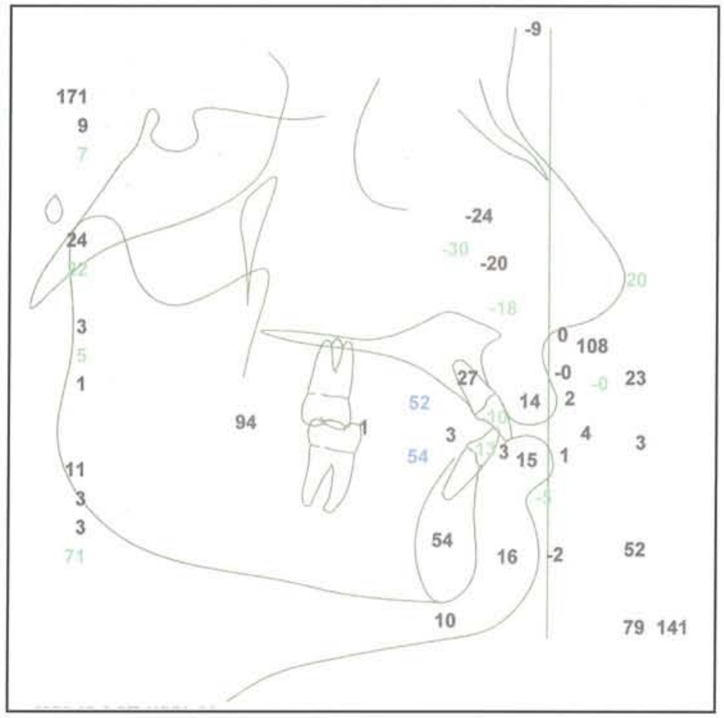


Fig. 7.71 CTP.

Figs 7.70 to **7.72** The STCA (top left) showing a near normal high midface projection (–24, black; –30, green; –19, black; –17, green) upper lip retrusion (–0, blue; –6, blue; 113, green) , severe mandibular retrusion (–27, red; –16, red), short chin height (49, blue), and a normal occlusal plane height (93, black). The CTP (top right) shows maxillary advancement, maxillary anterior and posterior lengthening, mandibular advancement, and chin lengthening, Superimpositions (bottom right) demonstrate the changes between STCA and CTP. The upper (52, blue) and lower (54, blue) incisors are orthodontically flared. Non-extraction (and flaring) was acceptable in this case; there was mild preorthodontic crowding, abundant attached gingiva, and the facial profile was not adversely affected.

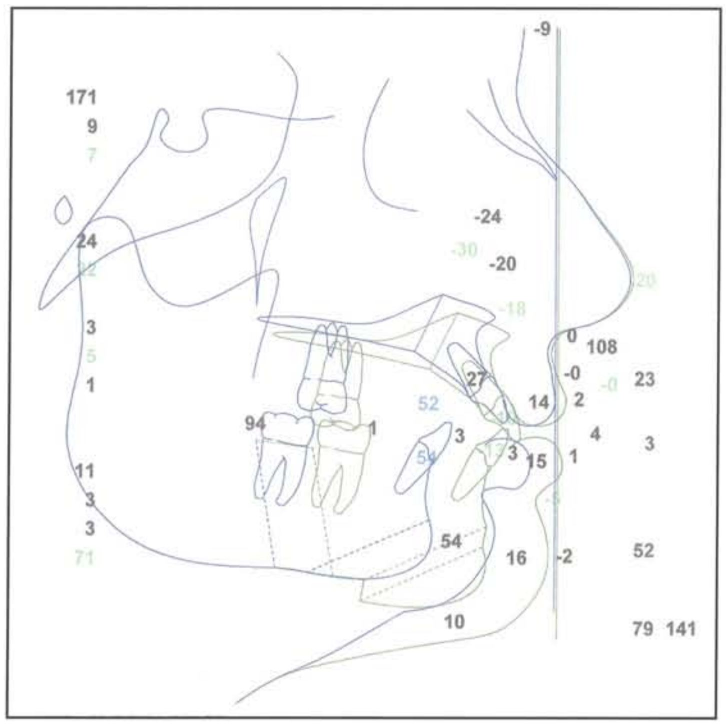


Fig. 7.72 Superimpositions.

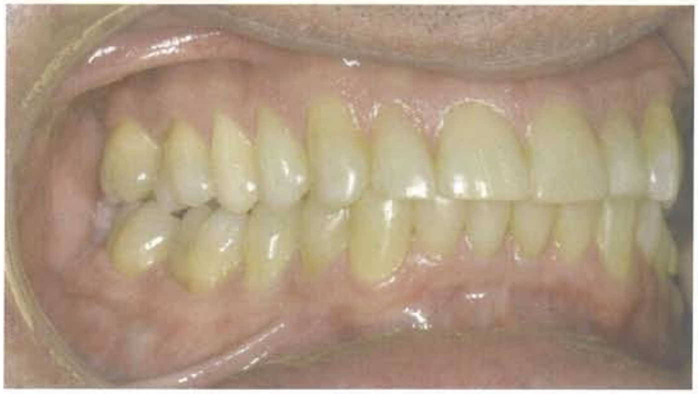


Fig. 7.73

Fig. 7.74

Fig. 7.75

Fig. 7.76

Figs 7.73 to **7.76** Post-surgical intra-oral photographs.

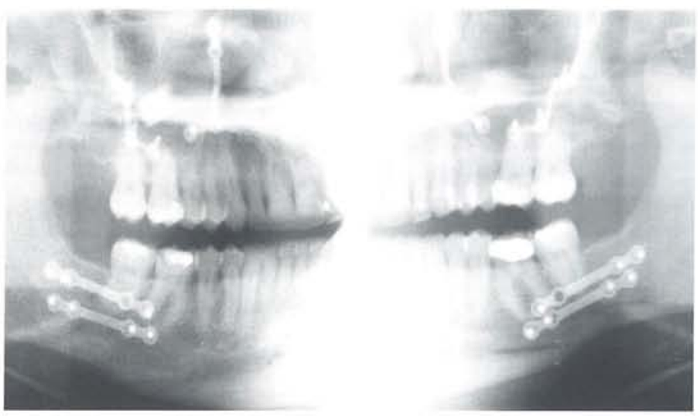


Fig. 7.77

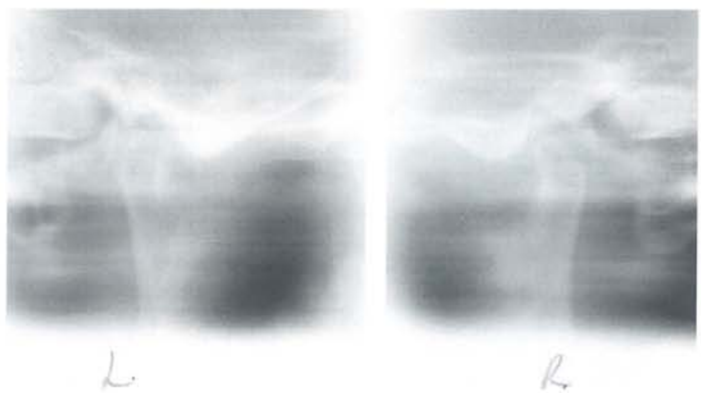
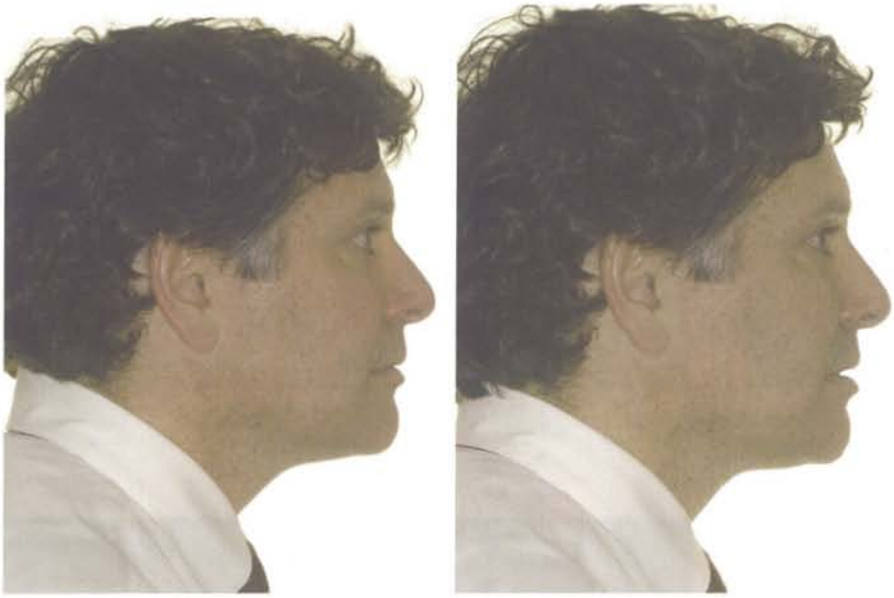


Fig. 7.78

Figs 7.77 and **7.78** Post-surgical panoral radiograph and right and left tomograms. Note in the panoral radiograph: two plates per sagittal osteotomy advancement. Note in the tomograms: the condyles centered in the preoperative CR position.



Figs 7.79 and **7.80** Post-treatment closed lip and relaxed lip photographs. Note: normal facial projection and heights.

Figs 7.81 to **7.83** Post-treatment closed lip, relaxed lip and smile photographs. Note: normal heights and facial outline.

Figs 7.84 and **7.85** Post-treatment right and left three-quarter facial photographs. Note: normal projections and contours.

Figs 7.86 and **7.87** Pre- and post-surgery photographs.

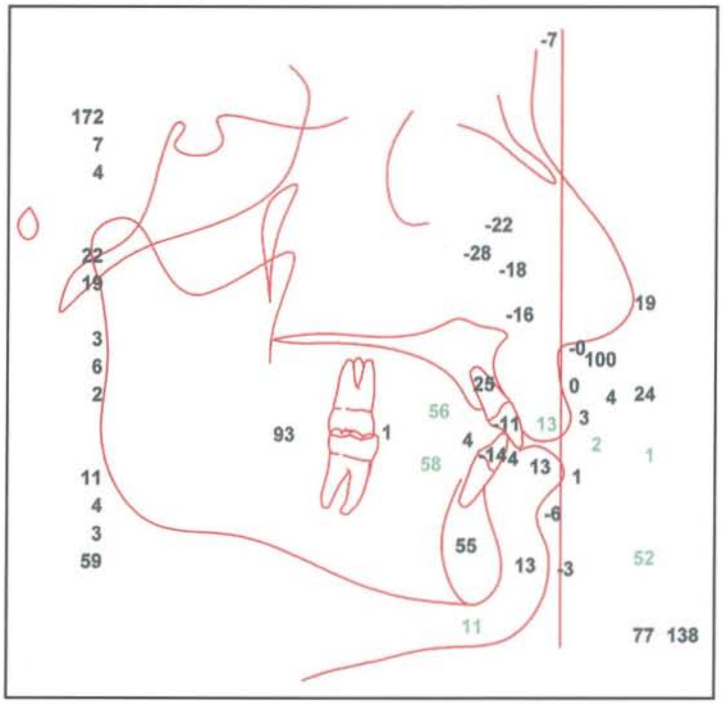


Fig. 7.88 Post-treatment STCA showing adequate projection and heights of the face.

The orthodontic treatment for this patient was provided by Dr Jean L. Seamount. The authors gratefully acknowledge her assistance in treating this patient.

FACIAL PLANNING FOR GROUP 2 PATIENTS – ORTHODONTICS ONLY, OR SURGERY AND ORTHODONTICS?

Group 2 patients often present with challenging problems. They are borderline cases in which the need for treatment by 'orthodontics alone' is not clear, for a number of reasons. For the orthodontist, facial planning takes place against a background of variables. These include growth, patient cooperation, and treatment response to orthodontic forces. The orthodontist has to work within the existing skeletal and soft tissue framework when treating by orthodontics alone.

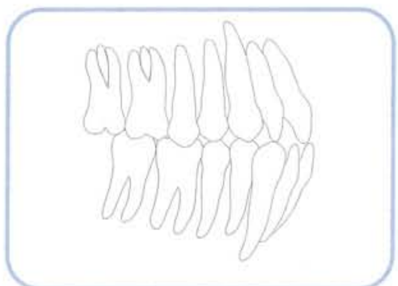
Consequently, although an ideal outcome may be possible for some patients, for others it is inevitable that orthodontic facial planning is aimed at a less-than-ideal result from the start. Although the limits of orthodontic treatment are not well defined, some comments on this subject will be made later. Despite the lack of definable limitations, because of the above cited variables, it is important for the treatment plan to be as accurate as possible from the outset. It then needs to be re-evaluated as treatment proceeds.

Information on Group 2 patients will normally be obtained as follows (Fig. 7.89):

1. *The patient history.* This may reveal the presence of TMJ problems, and the patient motivation form may not reveal that the patient has concerns both facially and dentally. If the patient motivation questionnaire[1] reveals facial change as a desired outcome, the patient may need to be placed into the Group 3 surgical category. Therefore, the consultation visit will frequently require more time and explanation.
2. *The clinical examination.*[2,3] This reveals a face that is somewhat unbalanced, and should receive additional analysis with the headfilm and the STCA.
3. *The intra-oral examination.* This is later confirmed with the mounted study casts and panoramic radiographs, and reveals that the problem is both skeletal and dental.

The patient history

The clinical examination



The intra-oral examination

Fig. 7.89

PLANNING GROUP 2 CASES SURGICALLY AND ORTHODONTICALLY, FOR COMPARISON

Double treatment planning is recommended for Group 2 cases:

- as a surgical/orthodontic case, using the *'seven-step surgical CTP'* described above
- and for orthodontics only, using the *'six-step orthodontic CTP'* described below.

The two options can then be compared, and, most importantly, the patient can be shown the two treatment possibilities (Fig. 7.90).

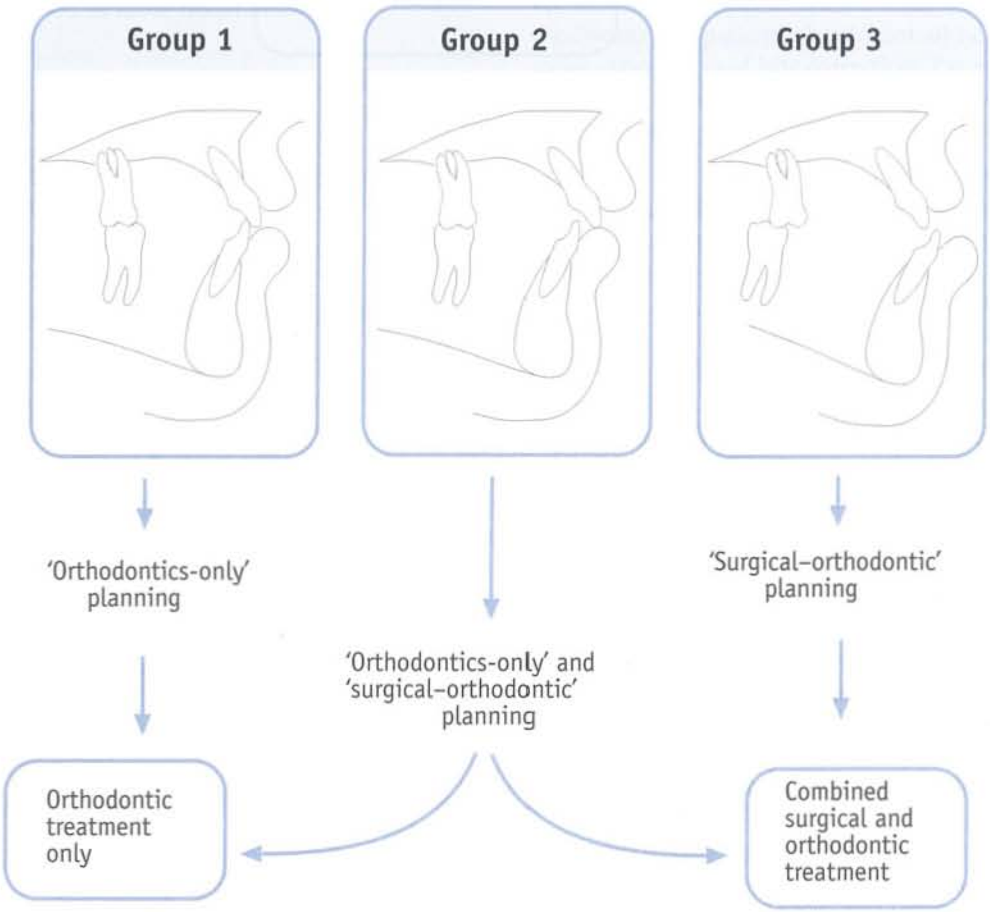
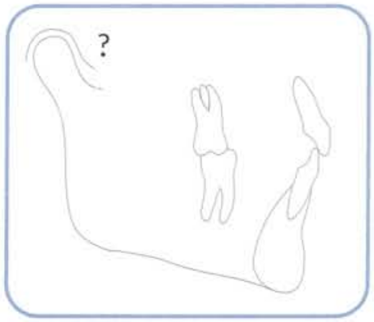


Fig. 7.90 Double treatment planning is recommended for Group 2 cases.

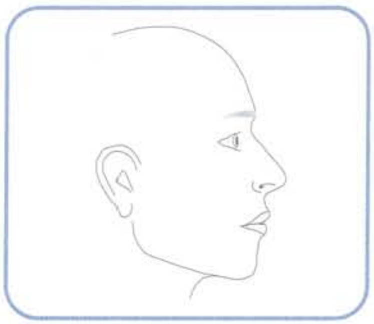
The following questions should be asked (Fig. 7.91A–E) with these G2 cases:

1. Does the patient have TMJ concerns that require treatment before orthodontic treatment? If so, a TMJ treatment plan is needed (Chapter 6). This plan has to be re-evaluated before surgery.

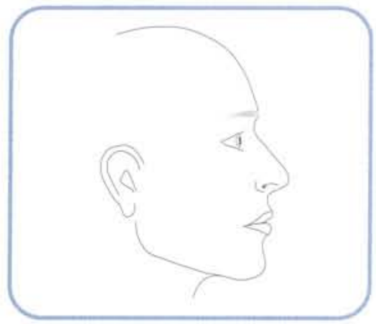


Does the patient have TMJ concerns?

2. What is the most ideal facial pattern that can be achieved for the patient surgically, and the most ideal facial pattern that can be achieved with orthodontics only? If the orthodontist believes that an unsatisfactory result will be achieved with orthodontics alone, the case should be placed in the group 3 category, and treatment by 'orthodontics alone' should be declined if the patient will not agree to surgery.

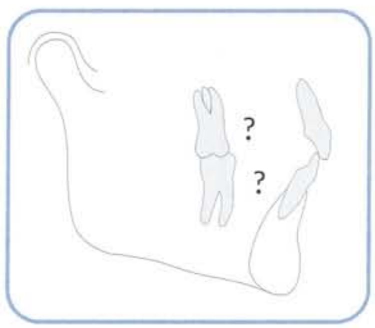


What is the best profile that can be achieved by orthodontics only?

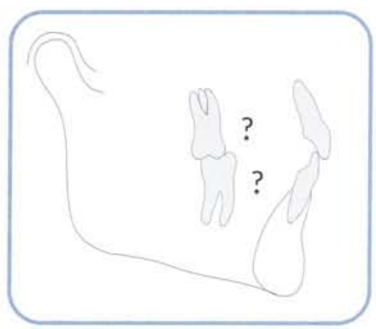


What is the best profile that can be achieved by surgery and orthodontics?

3. How can the canines and posterior teeth be positioned behind the corrected positions of the incisors and lips with each treatment option? Once again, it is important to not make dental decisions until facial planning for each option is completed. If the 'orthodontics only' option requires unreasonable amounts of dental movements, or movements beyond the limits of the alveolar bone (resulting in periodontal decline), then this approach should be rejected.



How can the canines and posterior teeth be positioned behind the orthodontically positioned incisors and lips?



How can the canines and posterior teeth be positioned behind the corrected incisor positions?

Fig. 7.91

The six-step orthodontic CTP for group 2 cases

After the method described for group 3 surgical treatment planning (p. 233) has been carried out on the group 2 case, the case can be reassessed as a possible orthodontic case with the following six-step orthodontic CTP:

1. Correct the torque of the upper incisors.
2. Correct the torque of the lower incisors.
3. Evaluate the true overjet and overbite.
4. Consider growth and growth modification.
5. Consider dental compensation.
6. Evaluate the compromise versus the ideal treatment.

Each of these is discussed in more detail below.

1. Correct the torque of the upper incisors

The upper incisors are placed (female $56.8 \pm 2.5°$, male $57.8 \pm 3.0°$) to the maxillary occlusal plane (Fig. 7.30, p. 241).

2. Correct the torque of the lower incisors

The lower incisors are then positioned (female $64.3 \pm 3.2°$, male $64.0 \pm 4.0°$) to the mandibular occlusal plane (Fig. 7.31, p. 241).

3. Evaluate the true overjet and overbite

As with surgical cases, it is very helpful to evaluate the true A/P and vertical relationships of the incisors after steps 1 and 2 have been completed. This information alone may lead the orthodontist to a 'surgical-orthodontic' or 'orthodontics only' decision. At this point, if it is clear that dental compensations can correct the overbite and overjet, without periodontal or facial decline, the case becomes an 'orthodontics only' group 1 case.

4. Consider growth and growth modification

The orthodontist sees patients aged 6–12 years who have considerable facial disharmony, but with a lot of growth to come. The disproportionate growth is likely to continue throughout the growth period, and a clear G2/G3 decision cannot be made for several years. There is normally parental concern over facial appearance, often shared by the child. Early assessment is beneficial for these young patients with moderate to severe facial imbalance, in order to identify the underlying causes of the disharmony. However, this is an area of great difficulty for the orthodontist, for the following reasons.

Growth prediction. To date, growth prediction has not been proven to be accurate, and therefore it is impossible to predict exactly how an individual patient will grow. This is mainly because of the great variation in vertical facial growth, which is the greatest growth dimension of the face. Computer programs for growth prediction rely on average estimates of growth, based on figures such as the Bolton normals. They seem to basically enlarge the face in proportionate amounts. However, individual variations from these normals can be significant and patients should not all be treated with the same expectation of bite correction. Patients who may have inadequate mandibular growth or be expected to respond poorly to functional therapy can be identified with the following factors:

1. *TMJ health and condylar size and morphology.* Joints which are in closed locks, or exhibit pops and/or clicks, may inhibit normal mandibular growth and limit mandibular growth stimulation. Additionally, condyles which are small, finger shaped and with flat surfaces may be expected to show decreased growth potential. Normally they do not respond favorably to growth modification.
2. *The anatomical shape of the mandibular ramus.* Björk[5] described two types of mandibular growth rotation: *forward growth rotation*, which occurs with significant vertical ramus growth and an upward and forward direction of condylar growth; and *backward growth rotation*, which occurs with a short ramus growth and a more distal direction of condylar growth. The shape of the ramus, therefore provides insight into the adequacy of growth that may occur.
3. *The amount of anterior vertical facial growth.* This occurs in three areas, the nasal cartilages, the maxillary alveolar process, and the mandibular alveolar process. Each of these areas can be evaluated for potential vertical growth.

The orthodontic response to treatment. The orthodontic response to treatment will vary greatly, depending on such variables as the magnitude of the malocclusion, patient cooperation, age at the start of treatment, the length of treatment, and the method of treatment being used. Despite these variables, early treatment should be considered, in an attempt to produce favorable changes during the growth period, thereby avoiding the need for surgery later on. This treatment should not be done if the case will deteriorate periodontally or facially.

Early treatment for growing Class II/1 cases. Treatment should be considered to deal with soft tissue factors. If thumb or finger sucking activity can be abandoned at an early age, this is normally beneficial. Likewise, these young patients can be encouraged to modify an unfavorable tongue position or activity. This can be difficult to achieve, but it is appropriate to refer patients to experts in this area, to attempt some improvement.

Early facial analysis of these Class II/1 cases, with photographs and a cephalometric radiograph, may reveal overdevelopment of the maxilla. This is rare. Early headgear treatment can be considered for these individuals.

More typically, Class II/1 cases show underdevelopment of the mandible, and there is evidence[6] that early use of functional appliances can be dentally beneficial. In some cases early use of functional appliances can correct the bite but leave the facial imbalances, and it is preferable to use a type of functional appliance which does not produce excessive dental compensation.

Early treatment for growing Class III cases. Many children with developing Class III malocclusions also have anterior displacements. Consequently, both condyles are slightly forward in the fossae at centric occlusion, and this can have a 'functional appliance' effect, releasing every possible millimeter of mandibular growth. Therefore, early orthodontic correction of anterior displacements is beneficial, where possible. This eliminates the anterior displacement, which allows development of a more normal incisor relationship and growth pattern.

Early facial analysis of developing Class III cases, using photographs and a cephalometric radiograph, will normally reveal either a short maxilla, a retruded maxilla, or a long mandible, or a combination of these possibilities. There is conflicting evidence about the possibility of enhancing the growth of the maxilla, using rapid maxillary expansion (RME) and a face mask. Some clinicians will wish to consider this type of approach if the maxilla is mildly underdeveloped.

It is now widely accepted that growth restriction of the mandible, using a chin cap, is not effective. Accordingly, for a child aged 8–10 years, with a mandible which is overdeveloped, it is accepted good practice to observe the mandibular growth, taking regular cephalometric radiographs. Treatment decisions can then be made at age 15 years or later, using the group 2 facial planning protocols.

5. *Consider dental compensation*

When considering dental compensation, three important questions should be asked:

1. What will be the effect on the face as a result of this compensation?
2. Will dental compensation potentially lead to periodontal problems, stability problems, or poor occlusal tooth fit problems?
3. Will disproportionate growth during or after orthodontic treatment be beyond the range of compensation? Growth is often disproportionate throughout the growth years – the malocclusion may worsen. Dental compensation treatment should consider this possibility and be postponed if the anticipated malocclusion might be beyond the scope of reasonable compensations.

Facial changes in response to dental compensation
When considering acceptable facial patterns, a number of variables come into play. These include racial and cultural variables, individual patient perceptions, clinician abilities and perspectives, financial considerations and access to adequate care. Despite this, it is the responsibility of the orthodontist to attempt to be as objective as possible in recommending appropriate facial treatment plans for their patients.

The soft tissue cephalometric analysis (STCA) provides objective insight into these challenging decisions. All measurements of the analysis are important and can be easily reviewed, but two groups of factors require indepth attention by the orthodontist in deciding between surgery and orthodontics only. These groups are the *soft tissue disharmony factors* and the *upper lip factors*.

Soft tissue disharmony factors
Sn to soft tissue Pogonion'
Soft tissue A' to soft tissue B'
Upper lip anterior to lower lip anterior.

Upper lip factors
Upper lip anterior projection
Upper lip angle
Upper incisor exposure – relaxed lip.

As a general rule, the soft tissue disharmony factors reveal skeletal problems which may not be amenable to correction (seven goals) by orthodontics only. The upper lip factors are particularly important to esthetic orthodontic results. When they are abnormal, they are easily visualized.

The dental and periodontal response to dental compensation

It has always been a challenge to the orthodontist to establish the range of possible movement of the incisors. It is a relatively new concept to commence orthodontic treatment planning with the upper incisor.[7] Consequently, there is a lack of good research evidence about the range of possible movements. It is hoped that more evidence-based information will gradually become available. Meantime, the comments below are based on present knowledge and experience, and can act as guidelines.

The upper incisors. The torque, A/P position, and the vertical position of the upper incisors must be considered. Upper incisor torque ideals are 57° for females and 58° for males (to the upper occlusal plane), and 110° to 115° to the palatal plane. As torque is changed, the upper incisor to TVL value also changes, by approximately 3 mm for every 10° of torque. This is a 'rule of thumb' – values vary, depending on factors such as the size of the teeth and the pivot point for the torque.

If upper incisors are retroclined beyond 100° to the palatal plane or 67° to the occlusal plane in Class II/1 cases, unesthetic and possibly periodontally compromised results can be anticipated. Class II/1 cases are particularly susceptible to these negative changes. Class II/2 cases are less susceptible, because they do not involve the same retraction of incisal edges. In Class III treatment, if upper incisors are proclined to more than 120° to the palatal plane or 47° to the occlusal plane, occlusal and periodontal problems may occur.

Antero-posteriorly, the ideal values for upper incisor to TVL are –9 mm for adult females and –12 mm for adult males. There is a small range of A/P bodily movement of incisors in the bone. Growth of the maxilla, or growth restriction, has an effect also, but the torque changes described above are most important.

Vertically, the upper incisor exposure ideals are 4–5 mm for adult females and 3–4 mm for adult males. Orthodontically, a small range of vertical movement of incisors is possible. Extrusion is easier to achieve than intrusion although it may not be stable. Vertical growth of the maxilla and upper incisor torque changes also have an effect.

The lower incisors. As with the upper incisors, the torque, the A/P position, and the vertical position of the lower incisor must be considered. The ideals for lower incisor torque (to lower occlusal plane) are 64° for both females and males, and 90–95° degrees to the mandibular plane.

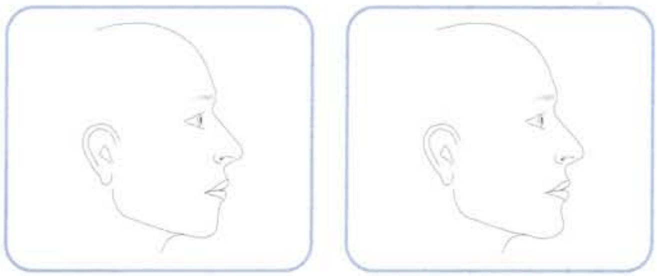
As lower incisor torque is changed, the lower incisor to TVL value changes by approximately 3 mm for every 10° of torque. If lower incisors are proclined beyond 100° to the mandibular plane or 54° to the occlusal plane in Class II cases, instability and potential periodontal problems become a concern. If lower incisors are retroclined to less than 80° to the mandibular plane or more than 54° to the occlusal plane in Class III cases, periodontal concerns become significant.

The ideal A/P values are for an overjet in both males and females of 3 mm. The lower incisor to TVL ideals are –12 mm for adult females and –15 mm for adult males. Because of the anatomy of the mandibular bone, it is normally not possible to plan for A/P bodily movement of lower incisors. As with the upper incisor, torque changes are most important. Growth, and growth enhancement, can have a major effect in a growing individual. It is generally accepted that growth restriction of the mandible is not possible.

Vertically, the ideal overbite for males and females is 3 mm. A few millimeters of extrusion or intrusion of lower incisors is possible orthodontically, and forms part of many treatments.

6. Evaluate the compromise versus the ideal treatment

After evaluation of a borderline group 2/group 3 case, accurate and revealing comparisons can be made between 'orthodontics alone' treatment and 'surgical-orthodontic'



treatment. In the past, the comparison process was tedious and time consuming, and most clinicians did not go through it. However, with digital facial and dental imaging, computerized cephalometric digitizing and analysis, and computerized cephalometric and facial treatment planning, the process can be carried out in minutes. As a result, better treatment decisions can be made and more informed explanations can be offered to patients.

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CASE MC

This 10.0-year-old female presented with a moderate to severe Class II skeletal and dental pattern in the mixed dentition stage. Her deciduous teeth showed excessive wear due to a clenching and grinding habit. She showed a long lower facial height and a slight anterior open bite. Her maxilla was narrow and her upper and lower arches showed minimal crowding.

Fig. 7.94

Figs 7.94 to **7.98** Beginning intra-oral photographs showing a moderate Class II dental relationship in the mixed dentition stage. Her deciduous teeth showed excessive wear due to a clenching and grinding habit. She showed a slight anterior open bite. Her maxilla was narrow and her upper and lower arches showed minimal crowding.

Figs 7.92 and **7.93** Beginning facial pattern with a long lower facial height. Her lips were not at rest in the photographs, and she showed mentalis strain with the lips together. She did show good facial symmetry.

Fig. 7.92

Fig. 7.93

Fig. 7.95

Fig. 7.96

Fig. 7.97

Fig. 7.98

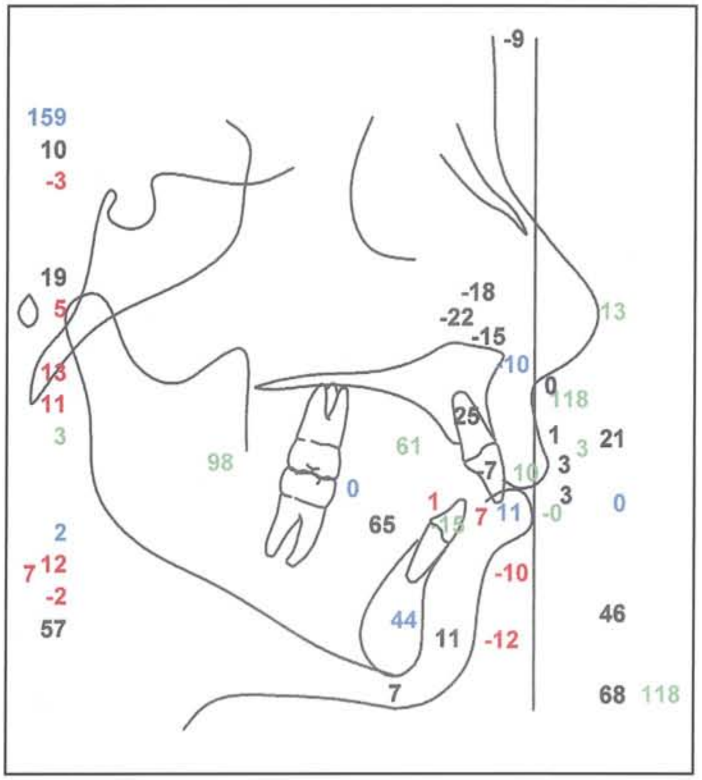


Fig. 7.99 Beginning STCA showing only a slight steep occlusal plane (98, green) (due to the anterior open bite), and a retrusive mandible (−15, green; −12, red).

The patient was treated in her first phase with a functional appliance (Twin Block). This was followed by full banded orthodontic treatment on a non-extraction basis. Vertical control of the face was adequate and, fortunately, she demonstrated good mandibular growth response.

Fig. 7.103

Figs 7.103 to **7.107** Final intra-oral photographs showing a Class I posterior dental relationship, a corrected overbite and overjet, healthy periodontal tissue, and coordinated arches.

Fig. 7.100

Fig. 7.101

Fig. 7.102

Figs 7.100 to **7.102** Final facial photographs of the patient showed improved facial balance in the profile view. Frontally, the patient continues to show good symmetry.

Fig. 7.104

Fig. 7.105

Fig. 7.106

Fig. 7.107

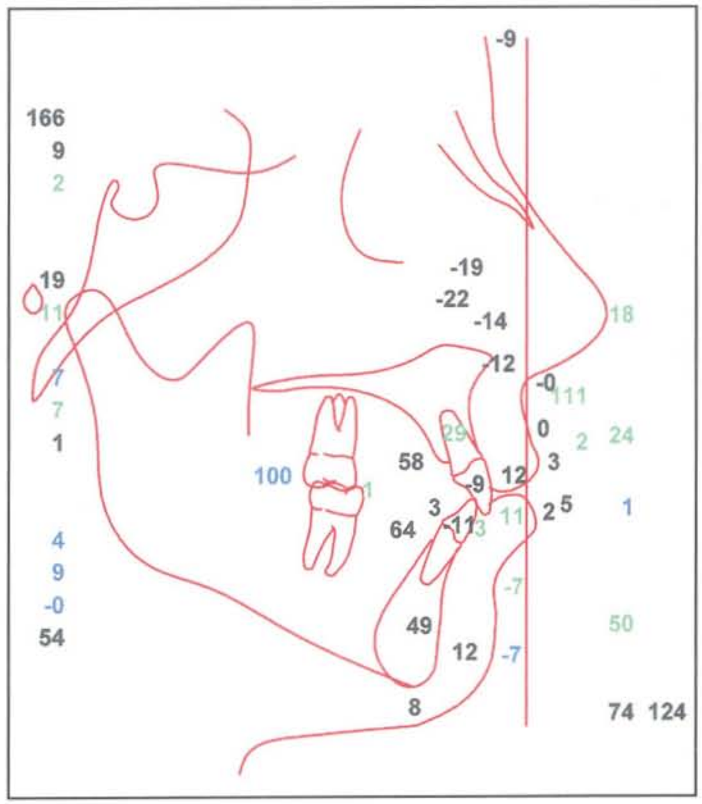


Fig. 7.108 Final STCA showing a slightly steep occlusal plane (100, blue), and slight retrusion to the chin (-7, blue), but improvement from her beginning STCA due to good mandibular growth. A chin osteotomy could be used to place the chin into the favorable range.

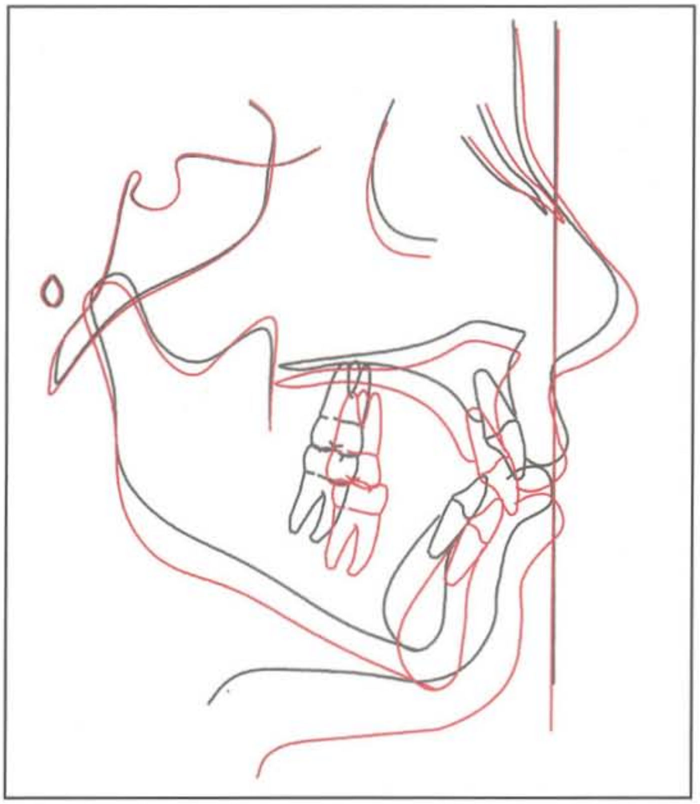


Fig. 7.109 Beginning and final superimpositions on the SN plane. The patient demonstrated a normal facial growth pattern, rather than a strong vertical component of growth, which may have been anticiapted.

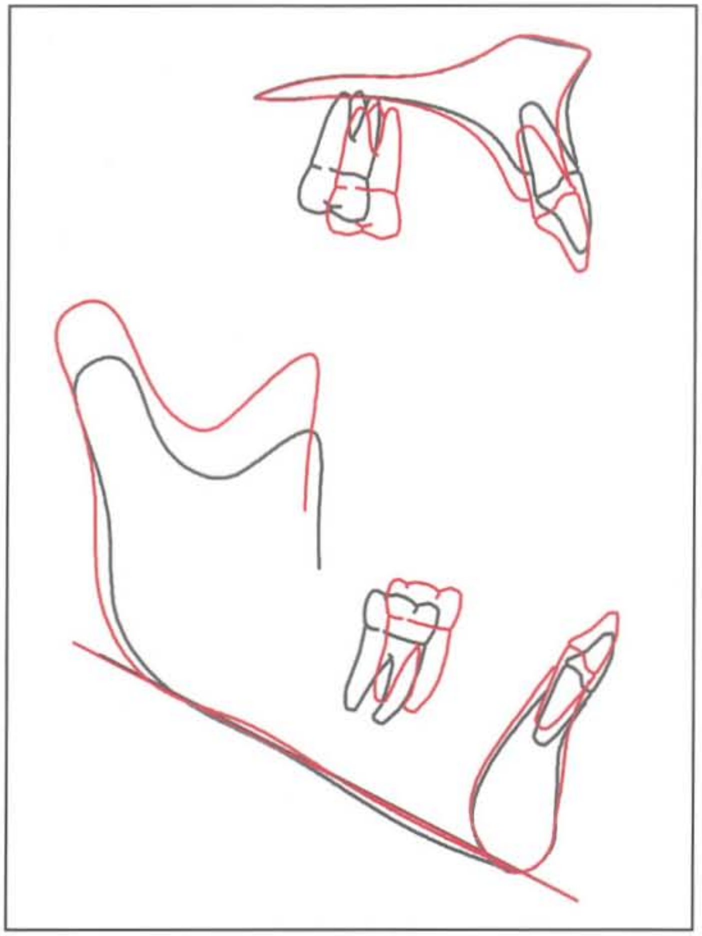


Fig. 7.110 Beginning and final superimpositions on the palatal and the mandibular plane. The upper molars showed slightly less vertical eruption than the upper incisors, which helped in closure of the open bite. The mandible showed excellent growth with equal eruption of incisors and molars.

CASE MO

This 14-year-old female was seen for consultation for occlusal correction. She was referred by her orthodontist. Diagnosis and treatment were started with the intention of fulfilling the seven goals of treatment. Her patient motivation form indicated a desire for straightening of her teeth and forward advancement of her chin. TMJ examination and history, clinical facial examination, soft tissue cephalometric examination, and model examination were obtained. The problem list and treatments were as follows:

PROBLEM	TREATMENT
1. High midface	
• Normal	• None
2. Maxilla	
Dental	
• Mild crowding	• Orthodontics
Skeletal/facial	
• Normal maxillary projection	• No treatment
• No dental deviations	• No treatment
• Normal incisor exposure	• No treatment
• A narrow maxilla in Class I position	• Multi-segment LFI widening? • Orthodontic expansion?
• Level curve of Spee	• No treatment
3. Mandible	
Dental	
• Moderate crowding	• Orthodontics • Interproximal stripping
Skeletal/facial	
• Moderate chin and lower lip retrusion	• BSSO advancement • Chin augmentation
• No dental deviations	• No treatment
• Short chin height	• Lengthening and augmentation chin osteotomy
• Wide mandible in Class I position	• Narrow with midline osteotomy of mandible?
• Level curve of Spee	• No treatment
4. TMJ	
• Muscle discomfort + condylar changes	• Splint + medications for 6 months after orthodontic preparation
5. Growth potential	
• 14 years old – disproportionate future growth	• Orthodontics to be completed by age 17 • Splint + medications for 6 months • Surgery at age 17.6

After diagnosis, the patient was treatment planned antero-posteriorly and vertically using the seven-step cephalometric treatment plan. The mandibular advancement plus augmentation and lengthening genioplasty produced excellent facial balance while correcting the overbite and overjet. Three choices were considered for matching the arch widths of the upper and lower jaws; however, a midline osteotomy of the mandible was the chosen treatment. This eliminated the need for surgical expansion of the maxilla. Additionally, this eliminated orthodontic expansion of the maxilla, which tends to relapse and cause periodontal decline. To maintain joint stability following surgery, a splint plus medications were used preoperatively and the patient was maintained on joint medications for 9 months post-surgically.

Fig. 7.111

Fig. 7.112

Fig. 7.113

Fig. 7.114

Fig. 7.115

Fig. 7.116

Figs 7.111 to **7.118** Pre-orthodontic facial and intra-oral photographs in centric occlusion. Note: mild maxillary crowding, moderate mandibular crowding requiring stripping.

Fig. 7.117

Fig. 7.118

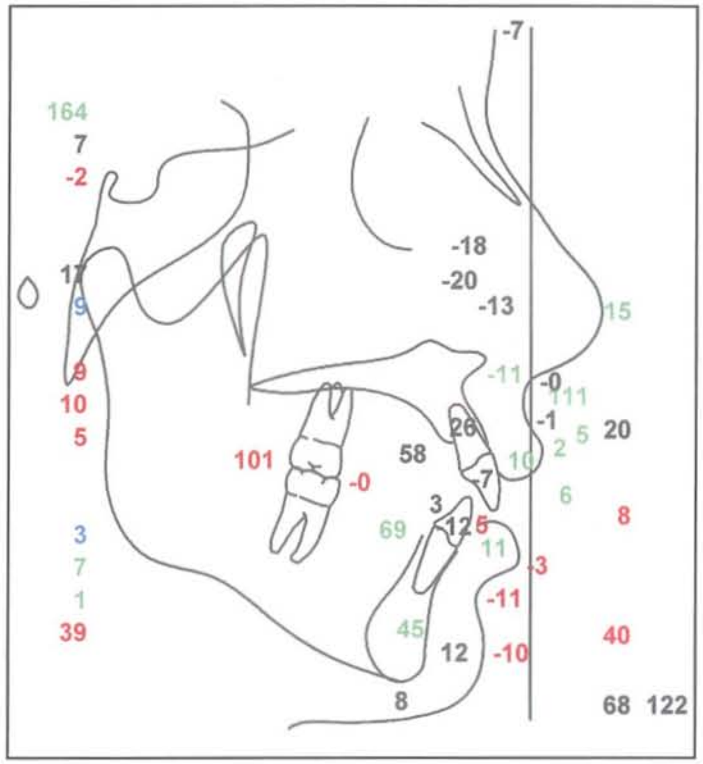


Fig. 7.119 The CR pre-orthodontic STCA tracing showing a steep occlusal plane (101, red) and a retrusive mandible (–10, red).

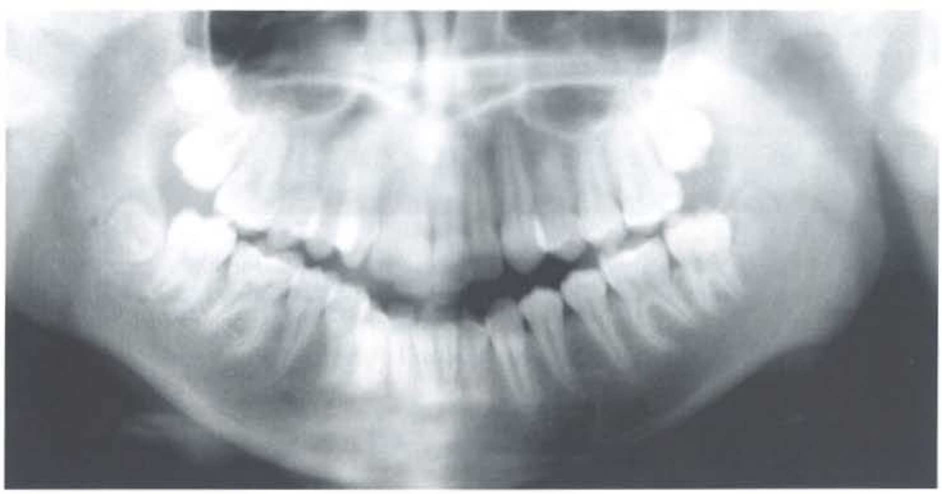


Fig. 7.120 Pre-orthodontic panoral radiograph showing a healthy dentition and third molars that are present.

Fig. 7.121

Fig. 7.122

Fig. 7.123

Fig. 7.124

Figs 7.121 to **7.124** The pre-surgical orthodontic set-up, showing a Class II anterior open bite malocclusion. The photographs were carefully taken in CR without the wax bite to demonstrate the occlusion clearly.

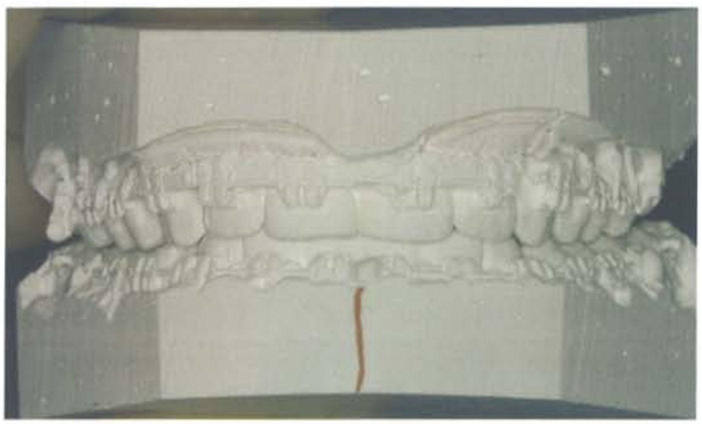


Fig. 7.125 The pre-surgical models held in Class I canine position. Note: the transverse excess of the posterior mandible.

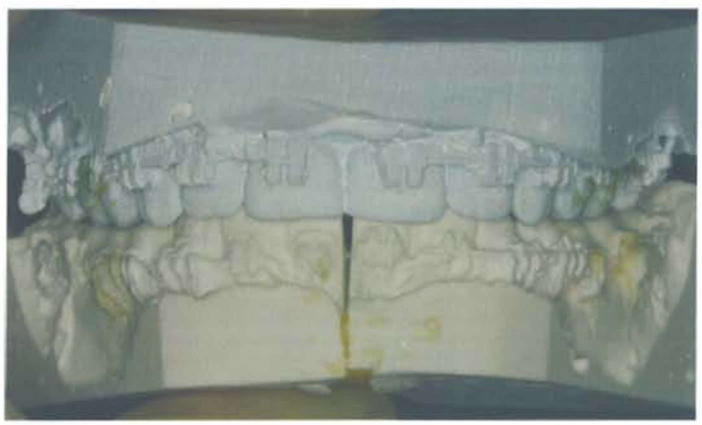
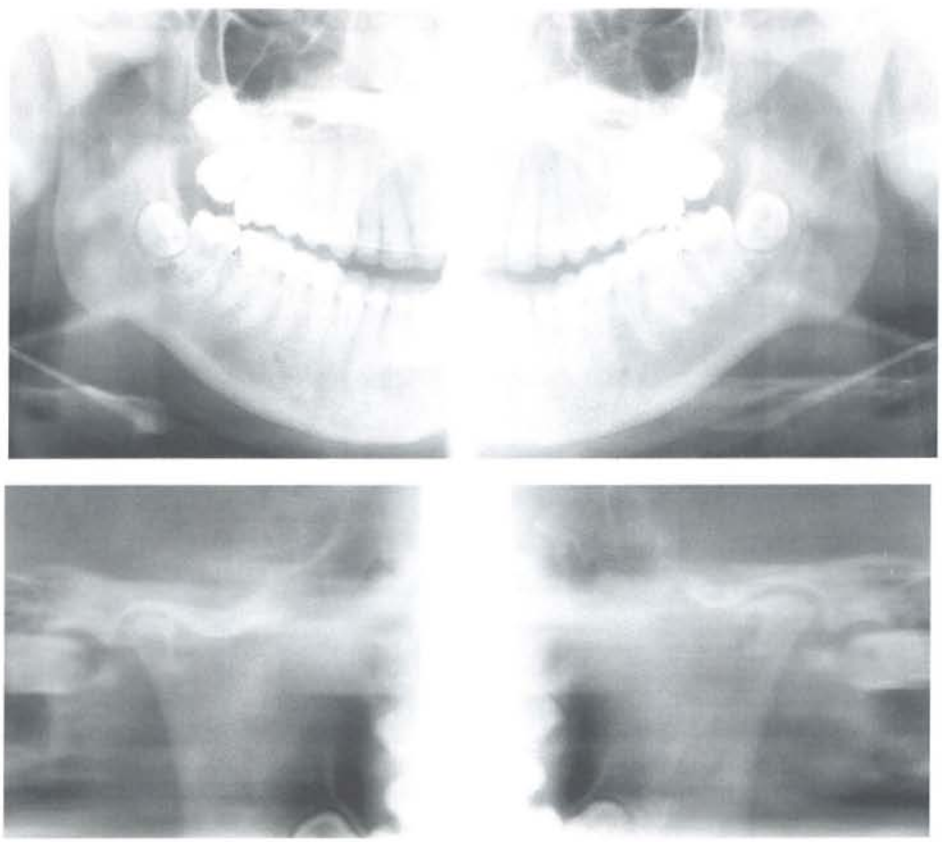


Fig. 7.126 The pre-surgical models held in Class I canine position after midline osteotomy. Note: the arch widths matched, improved posterior intercuspation and increased overbite.

Figs 7.127 and **7.128** The pre-surgical closed lip and relaxed lip photographs. Note: the normal high midface, normal maxillary projection, extreme mandibular retrusion and lip strain.

Figs 7.129 to **7.131** The pre-surgical closed lip, relaxed lip, and smile photographs. Note: the lip strain, short chin height, normal relaxed and smile maxillary incisor exposure.

Figs 7.132 and **7.133** The pre-surgical right and left three-quarter facial photographs. Note: the normal high midface and maxilla, with retruded mandible.



Figs 7.134 and **7.135** The pre-surgical panoral and tomographic radiographs. Note: the small condylar size, and superior flattening consistent with condylar resorption. The patient was treated with splint and medication protocol after orthodontic preparation and before surgery.

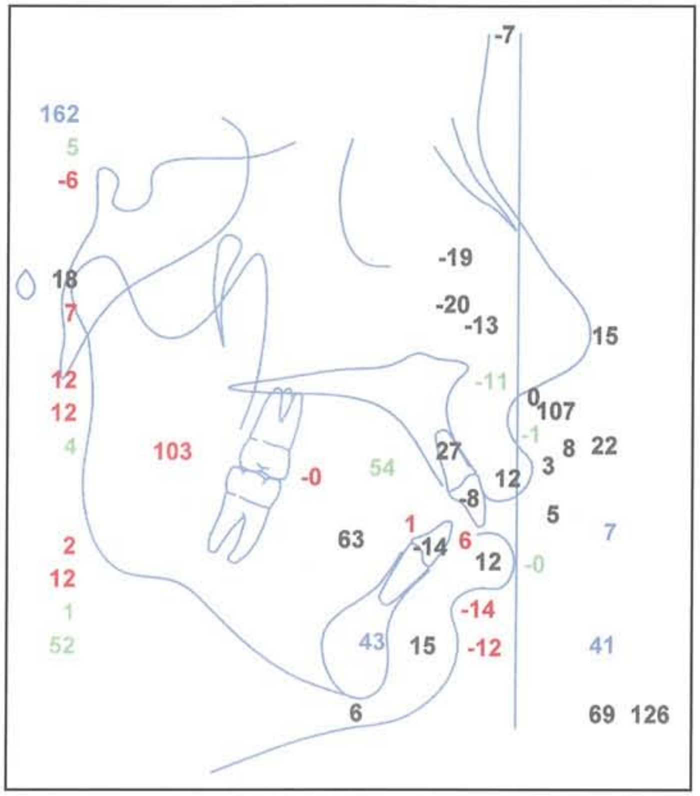


Fig. 7.136 The STCA.

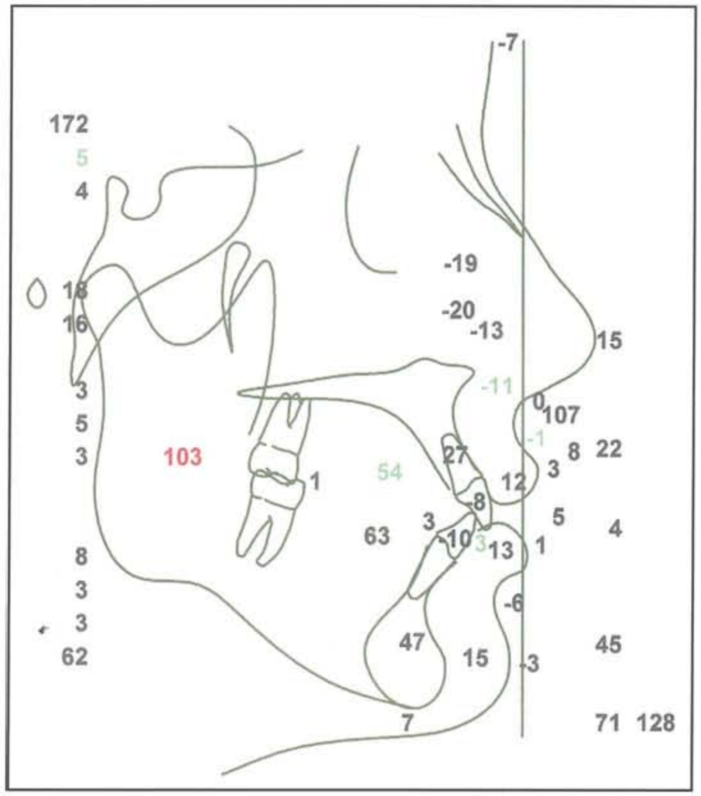


Fig. 7.137 The CTP.

Fig. 7.136 The STCA showing normal high midface (−19, −20, −13, black), normal maxillary projection (−8, 3, 8, 107, black), mandibular retrusion (−12, red), short chin height (43, blue) and steep occlusal plane (103, red). Note the overjet (6, red) in spite of normal maxillary (−8, black) and mandibular (−14, black) projections. This occurred because the incisors are on the opposite ends of their respective normal ranges.

Fig. 7.137 The CTP showing mandibular advancement, chin augmentation and lengthening, which produce normal facial projections and heights. Note: the chin augmentation was necessary secondary to the steep occlusal plane.

Fig. 7.138 The superimpositions, demonstrating changes between STCA and CTP.

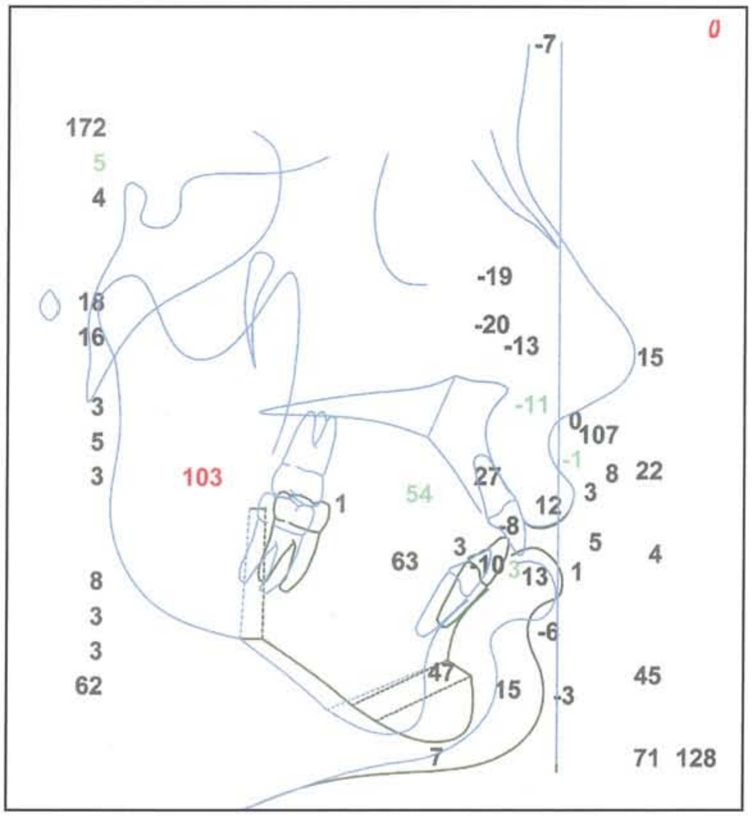


Fig. 7.138 The superimpositions.

Figs 7.139 and **7.140** The post-treatment right and left three-quarter facial photographs. Note: the normal projections and contours.

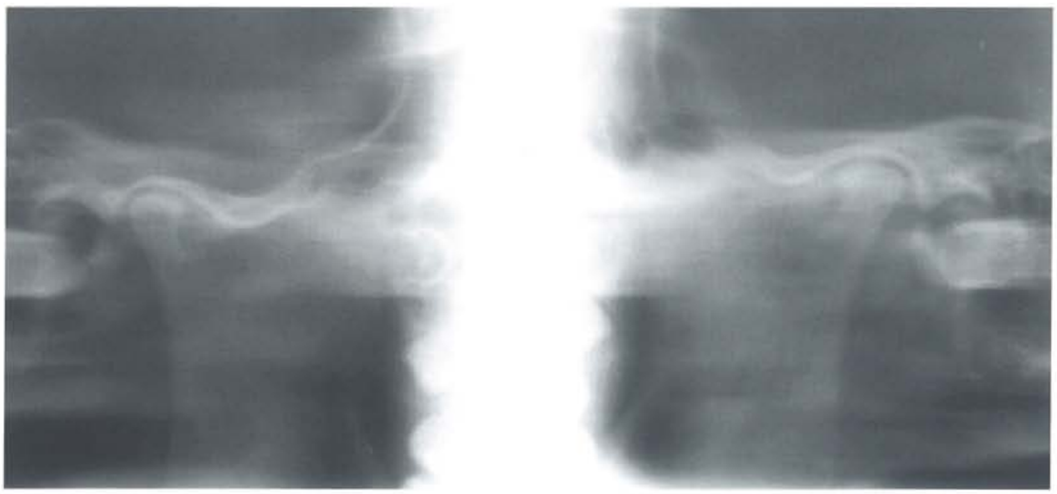


Fig. 7.141 The 4 days post-surgical tomograms. Note in the tomograms: the condyles centered in the fossae.

Fig. 7.142

Fig. 7.143

Fig. 7.144

Fig. 7.145

Figs 7.142 to **7.145** The post-treatment intra-oral photographs.

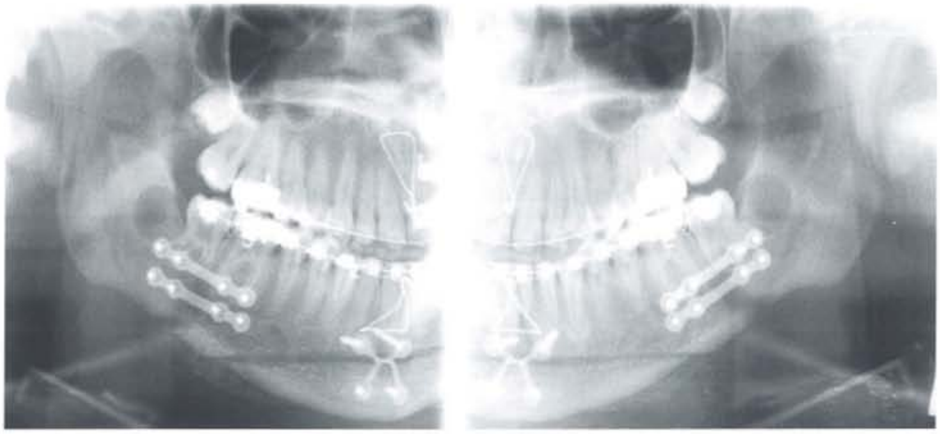


Fig. 7.146 The 4 days post-surgical panoral radiograph. Note: two plates per sagittal osteotomy advancement, and removal of the lower wisdom teeth. The skeletal wires were utilized to attach vertical elastics to maintain a deep post-surgical overbite. Elastics were worn full time for 8 weeks and then nights only until the hooks were removed at 16 weeks.

Figs 7.147 and **7.148** The post-treatment closed lip and relaxed lip photographs. Note: normal facial projections and heights.

Figs 7.149 to **7.151** The post-treatment closed lip, relaxed lip, and smile photographs. Note: normal height and facial outline.

Figs 7.152 and **7.153** Pre- and post-treatment photographs.

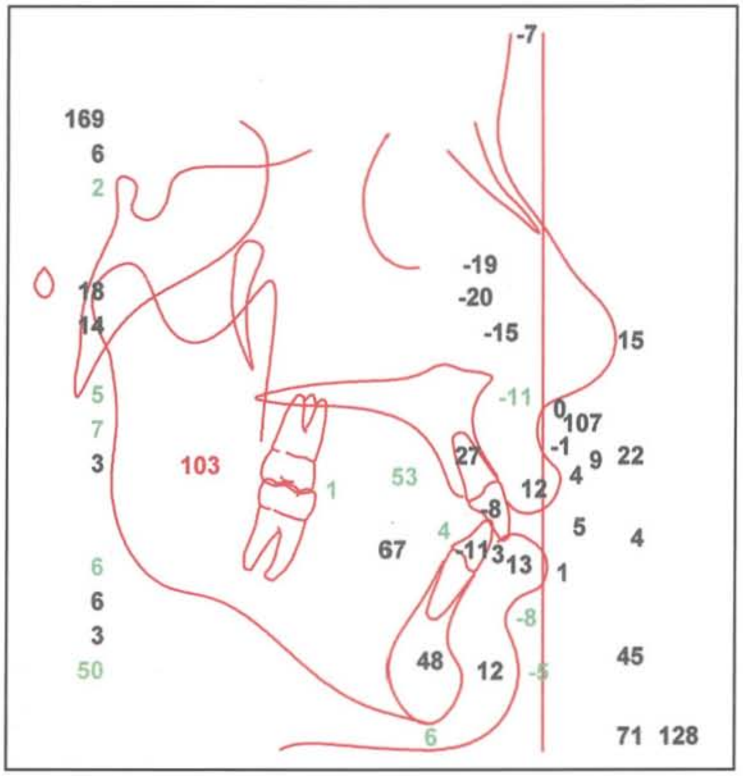


Fig. 7.154 The post-treatment STCA showing normal heights (22, 4, 45, 71, 5, black), normal maxillary projections (4, −1, 107, 9, black), and slight mandibular retrusion (−5, green), which was secondary to the steep occlusal plane (103, red).

The orthodontic treatment for this patient was provided by Dr Stewart E. White. The authors gratefully acknowledge his assistance in treating this patient.

8

Orthodontic treatment planning

DECISIONS BEFORE ORTHODONTIC TREATMENT PLANNING

Treatment planning for the dentition and orthodontic tooth movement should be the last steps in the diagnosis and treatment planning process. Before this, a number of decisions should have been made.

- *Restorative procedures.* Does the case require any restorative procedures that should be carried out before orthodontic treatment? And, if restorative procedures will be required after orthodontic or surgical orthodontic treatment, has a treatment plan been established and explained to the patient?
- *Periodontal health.* Does the patient have any periodontal problems that need attention prior to or after orthodontic treatment, and has a treatment plan been established? And, is the patient's oral hygiene adequate to start orthodontic treatment, or are there periodontal risks to orthodontic tooth movement?
- *TMJ health.* Have the patients TMJ issues been adequately dealt with before starting orthodontic treatment? And, if orthognathic surgery is indicated, has a pre-surgical protocol been established for TMJ stabilization?
- *Accuracy of records.* Has the case been properly mounted in centric relation, so that accurate facial and dental decisions can be made? And, have dental relationships recorded at the initial examination been confirmed with the mounted study models?
- *Facial planning.* Has a facial treatment plan been established, and have the positional changes required for the upper and lower incisors been clearly defined? This is critical, as the dentition needs to be built behind the incisors.

A GENERAL OVERVIEW OF DENTAL PLANNING

After a decision has been made concerning the best possible position for the incisors in the dental arches and the face, it is necessary for the orthodontist to position the remainder of the dentition relative to the desired incisor positions. There are multiple decisions to be made in this regard. What are the vertical, horizontal and transverse considerations for the dentition? What are the arch length considerations? Can the case be treated on a non-extraction basis, or will extractions be necessary? What about habits, and other influences on the dentition? Is the case surgical, or can dental compensations be established that are healthy, stable and esthetic?

Desired tooth movements are planned to establish the best possible result, and these movements should not be based only on intuition, experience and subjective judgment. Growth is difficult or impossible to predict. However, reasonable estimates can be made, basing objective decisions on all the known factors. Growth can be monitored as treatment proceeds, so that the best possible decisions are made for the patient.

Certain basic questions can be answered, and these in turn provide valuable information about many other factors. These questions are:

1. After incisor positions have been established, how are the midlines to be set up?
2. Where are the canines to be moved?
3. Where are the molars to be moved?

After these questions have been answered, premolars and second molars can be positioned accordingly. In non-growing patients, accurate calculations can be made on all midline, canine and molar movements. For growing patients, lower arch dental movements can be calculated accurately. However, upper dental movements must be estimated initially and monitored as growth and treatment progress.

THE DENTAL VTO

The analysis described in this chapter is referred to as 'the dental VTO', and is designed to answer the above questions. It has been previously published elsewhere[1,2] but has been slightly modified here for further clarity. Describing and explaining the analysis requires some time. However, the analysis itself is uncomplicated, takes little time to complete, and occupies only a small area on the treatment card. It is also available in computerized form[3] which makes the process even easier.

The dental VTO provides specific information concerning the movement of midlines, canines and molars after the desired incisor positions have been established using the soft tissue cephalometric analysis (STCA) and cephalometric treatment planning (CTP). It can be used for both orthodontic cases (using three charts) and surgical-orthodontic cases (using five charts) – see Figures 8.1 and 8.2.

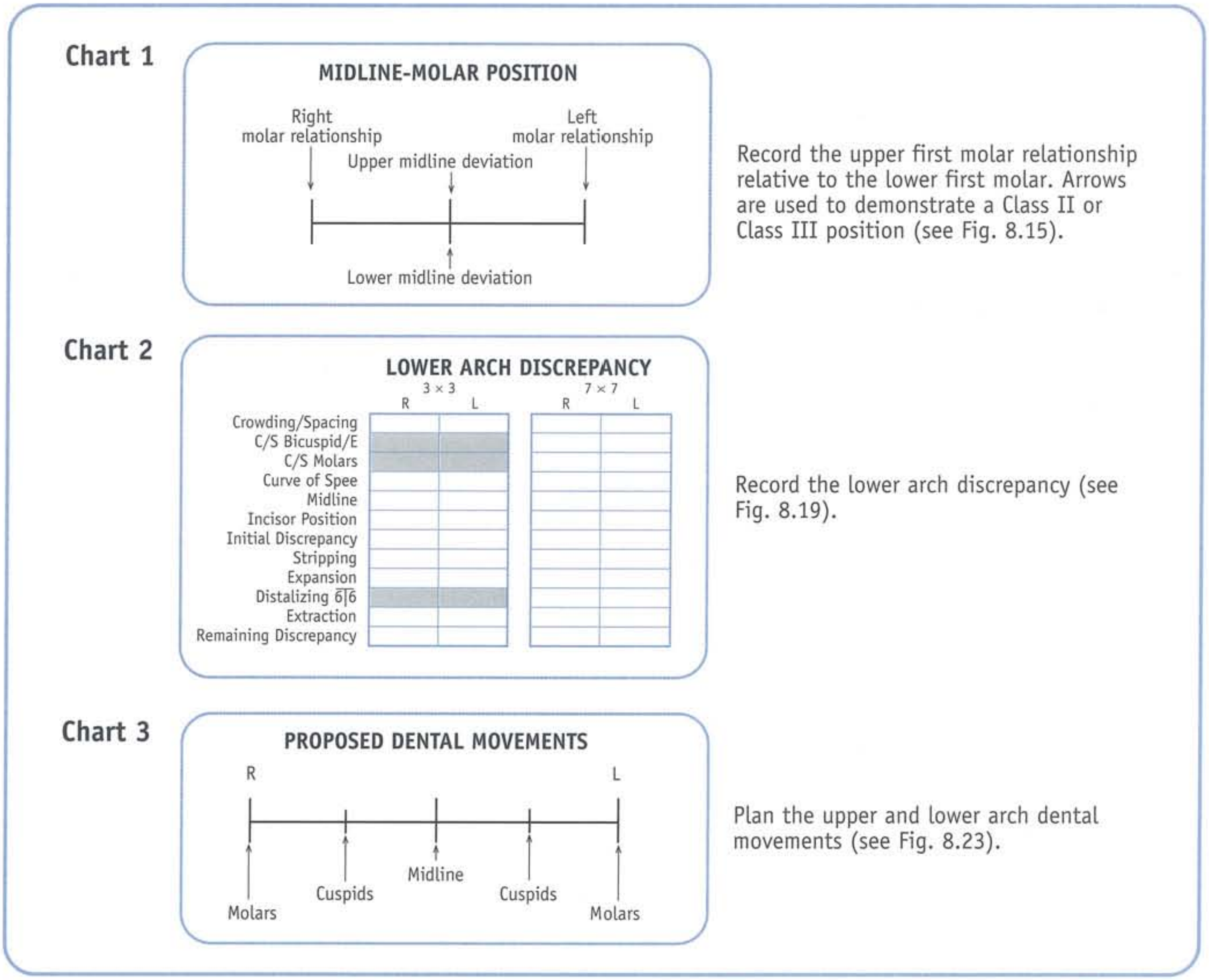
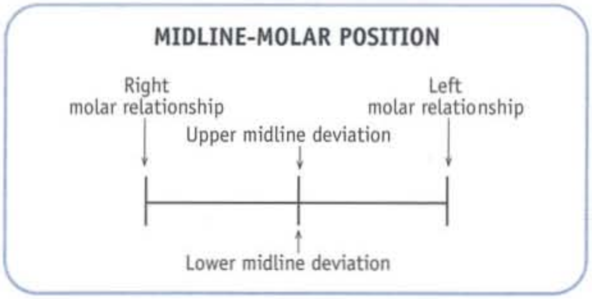


Fig. 8.1 The dental VTO for an orthodontic case.

Chart 1



Record the upper first molar relationship relative to the lower first molar. Arrows are used to demonstrate a Class II or Class III position (see Fig. 8.55).

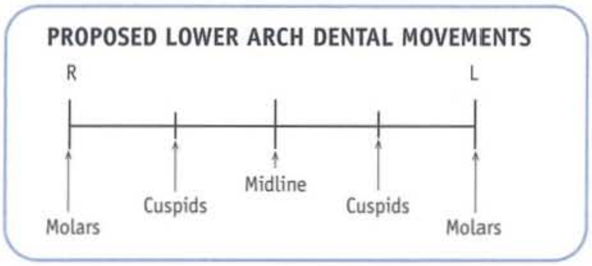
Chart 2

LOWER ARCH DISCREPANCY

	3 × 3 R	3 × 3 L	7 × 7 R	7 × 7 L
Crowding/Spacing				
C/S Bicuspid/E				
C/S Molars				
Curve of Spee				
Midline				
Incisor Position				
Initial Discrepancy				
Stripping				
Expansion				
Distalizing $\overline{6|}\overline{|6}$				
Extraction				
Remaining Discrepancy				

Record the lower arch discrepancy (see Fig. 8.59).

Chart 3



Plan the upper and lower arch dental movements (see Fig. 8.60).

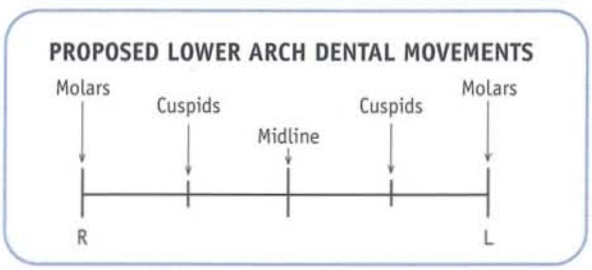
Chart 4

UPPER ARCH DISCREPANCY

	3 × 3 R	3 × 3 L	7 × 7 R	7 × 7 L
Crowding/Spacing				
C/S Bicuspid/E				
C/S Molars				
Curve of Spee				
Midline				
Incisor Position				
Initial Discrepancy				
Stripping				
Expansion				
Distalizing $\underline{6|}\underline{|6}$				
Extraction				
Remaining Discrepancy				

Record the upper arch disrepancy (see Fig. 8.63).

Chart 5



Plan the upper arch dental movements (see Fig. 8.64).

Fig. 8.2 The dental V TO for a surgical–orthodontic case.

USING THE DENTAL VTO FOR AN ORTHODONTIC CASE

CASE MS

This male patient, aged 11 years and 4 months, shows a slight Class II skeletal pattern, and a Class I dental relationship. There is slight dental protrusion and moderate to severe crowding (Figs 8.3–8.11).

Fig. 8.3

Fig. 8.4

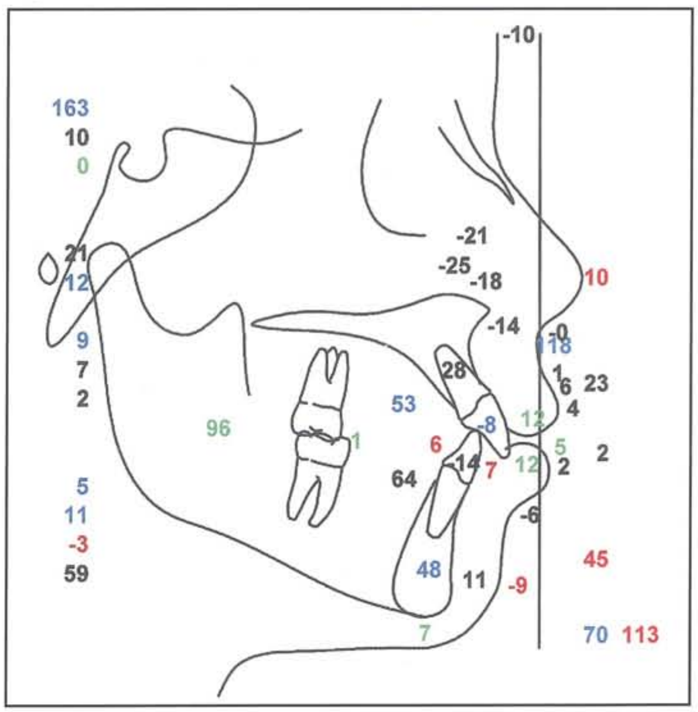


Fig. 8.5

Figs 8.3 to **8.11** This male patient, aged 11 years and 4 months, shows a slight Class II skeletal pattern (7, red; −9, red), a Class I dental relationship, a slight dental protrusion (53, blue) and moderate to severe crowding.

Fig. 8.6

Fig. 8.7

Fig. 8.8

Fig. 8.9

Fig. 8.10

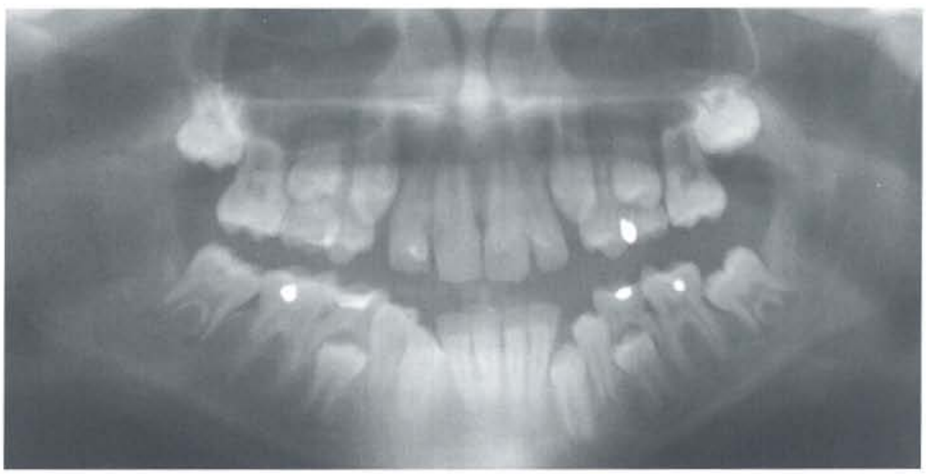


Fig. 8.11

Using the three charts for an orthodontic case: Chart 1 – recording the initial position of the molars and midlines

Chart 1 is provided to record midline and molar relationships. It is essential that these factors be recorded with the mandible in centric relation (Figs 8.12–8.14). Arrows are used to record the direction of Class II or Class III molar relationships and left or right midline deviations. In the lower arch, midline deviations should be recorded as dental (D) and/or skeletal (S). Midline deviations due to functional side shifts are not recorded, since they represent deviations from centric relation (CR), and the case needs to be analyzed in CR. Numbers in millimeters are placed adjacent to the arrows in each area (Fig. 8.15). During computerized use of the dental VTO, measurements can be recorded by left clicking on the up or down guides in the respective areas.

Fig. 8.12

Fig. 8.13

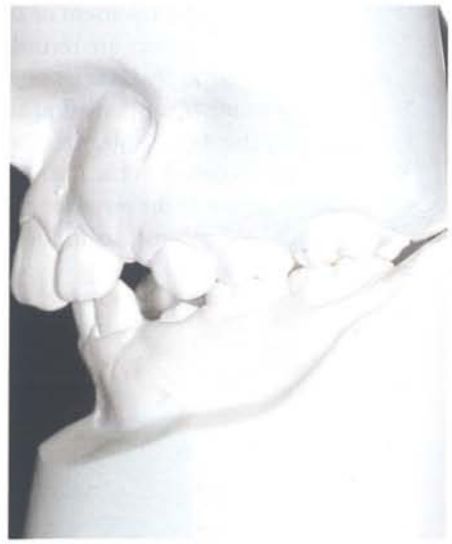


Fig. 8.14

Figs 8.12 to **8.14** Midline and molar relationships are recorded with the mandible at CR.

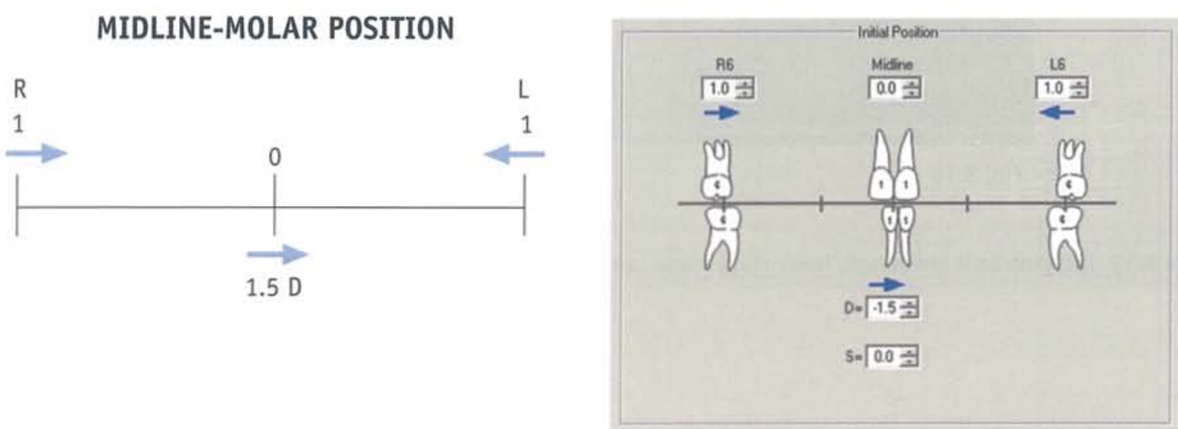


Fig. 8.15 Chart 1. The patient shows molars that are 1 mm Class II on each side. The upper dental midline is correct (centered on upper lip) and the lower dental midline is 1.5 mm to the left. The chart on the left is handwritten and the chart on the right is the computerized version (Dolphin Imaging™). The lower midline deviation can be recorded as dental (D) or skeletal (S).

Using the three charts for an orthodontic case: Chart 2 – recording the lower arch discrepancy

Chart 2 records lower arch discrepancies in two columns:

- The 3 to 3 column on the left, for factors occurring from canine to canine, and
- The 7 to 7 column on the right, for factors related to the entire lower arch.

Each column is further divided into right and left sides. These breakdowns are required to provide specific information concerning movement of the canines and the molars. The following factors are recorded:

1. *Crowding or spacing in the anterior segment.* This is recorded as a negative number for crowding and a positive number for spacing in the 3 to 3 column. The same figures are automatically recorded in the 7 to 7 column.
2. *Crowding or spacing in the premolar regions.* This is recorded only in the 7 to 7 column, as it does not affect the anterior segment from 3 to 3.
3. *Crowding or spacing in the molar area.* This is also recorded only in the 7 to 7 column.
4. *Curve of Spee.* By placing a ruler from the most distal molar to the central incisor on each side of the lower arch, the deepest point of the curve of Spee (usually in the premolar region) can be measured in millimeters. This figure is divided in half and placed on the left and right side in the 3 to 3 column. The curve of Spee may be different on the left and right side. Similar amounts are automatically recorded in the 7 to 7 column.
5. *Midlines.* Negative or positive figures are recorded in both the 3 to 3 and 7 to 7 columns based on lower dental midline deviations recorded in Chart 1. If lower skeletal midline deviations exist, and a decision is made to correct these deviations with dental compensation, the correction must be added to the lower dental midline area of Chart 1 and then to Chart 2. If the skeletal deviation is to be corrected surgically, then no correction is added to Chart 2.

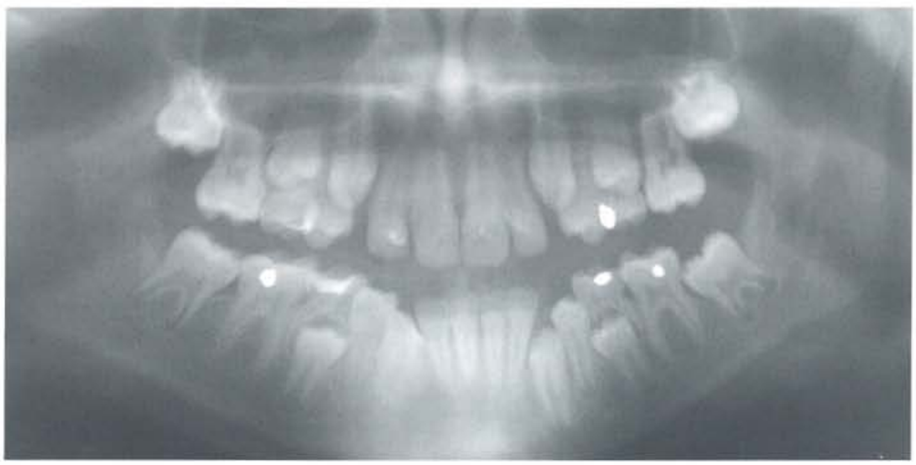


Fig. 8.16

Figs 8.16 to **8.19** The panoramic radiograph, lower study model, and the initial information recorded in the first five areas of Chart 2.

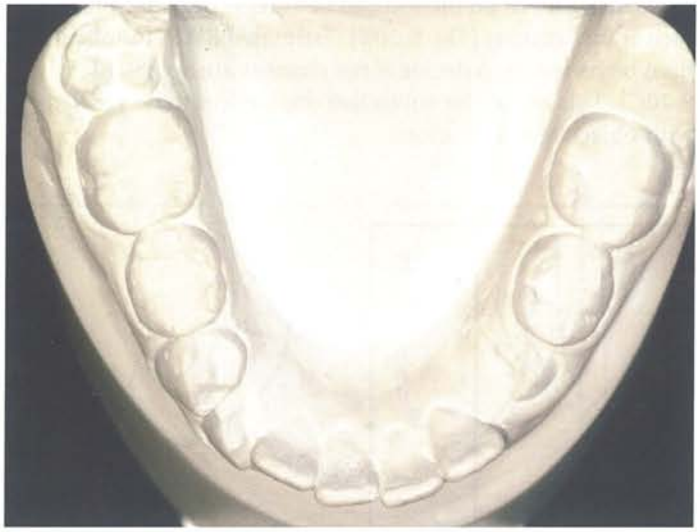


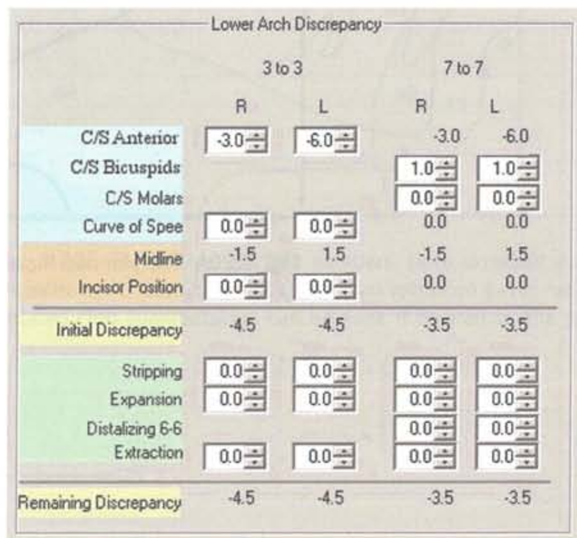
Fig. 8.17 The crowding/spacing in the lower arch is evaluated and recorded.

Fig. 8.18 The curve of Spee is measured at the deepest part of the curve.

LOWER ARCH DISCREPANCY

	3 × 3 R	3 × 3 L	7 × 7 R	7 × 7 L
Crowding/Spacing	−3	−6	−3	−6
C/S Bicuspid/E			1	1
C/S Molars			0	0
Curve of Spee	0	0	0	0
Midline	−1.5	1.5	−1.5	1.5
Incisor Position				
Initial Discrepancy	−4.5	−4.5	−3.5	−3.5
Stripping				
Expansion				
Distalizing $\overline{6|6}$				
Extraction				
Remaining Discrepancy				

M.S.


Lower Arch Discrepancy

	3 to 3 R	3 to 3 L	7 to 7 R	7 to 7 L
C/S Anterior	-3.0	-6.0	-3.0	-6.0
C/S Bicuspids			1.0	1.0
C/S Molars			0.0	0.0
Curve of Spee	0.0	0.0	0.0	0.0
Midline	-1.5	1.5	-1.5	1.5
Incisor Position	0.0	0.0	0.0	0.0
Initial Discrepancy	-4.5	-4.5	-3.5	-3.5
Stripping	0.0	0.0	0.0	0.0
Expansion	0.0	0.0	0.0	0.0
Distalizing 6-6			0.0	0.0
Extraction	0.0	0.0	0.0	0.0
Remaining Discrepancy	-4.5	-4.5	-3.5	-3.5

Fig. 8.19 Chart 2 records the lower arch discrepancy.

6. *Incisor position*. Anterior or posterior movement of the lower incisors is recorded as positive or negative numbers. The amount of this movement is based on the STCA and on the orthodontic CTP. For example, 1 mm of anterior movement provides 1 mm of space per side, and would be recorded on the right and left sides of the 3 to 3 column. The same figures would also be recorded in the 7 to 7 column. Similarly, 2 mm of posterior incisor movement would be recorded as minus 2 mm in both the 3 to 3 and the 7 to 7 columns.

In this case example, a decision was made to leave the lower incisors in their original A/P position and to limit their vertical eruption as the posterior teeth erupted. The upper incisors could then be retracted approximately 2 mm, reducing upper and lower lip protrusion (Fig. 8.20A). An estimated growth prediction can be carried out after planned incisor movements (Fig. 8.20B). Estimated STCA numbers can than be reviewed to decide if the changes are acceptable (Fig. 8.20C). This allows for subjective preferences to be verified with objective information.

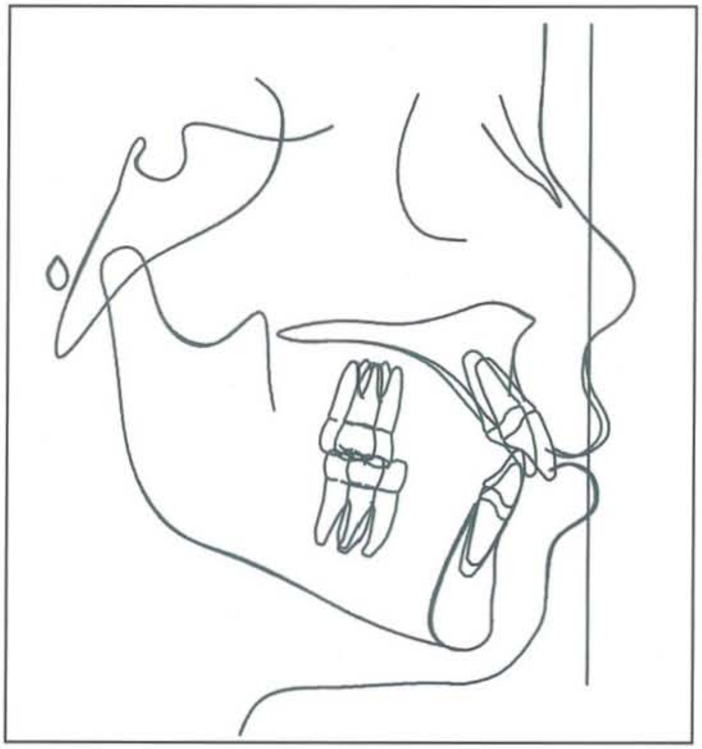


Fig. 8.20A The planned incisor changes.

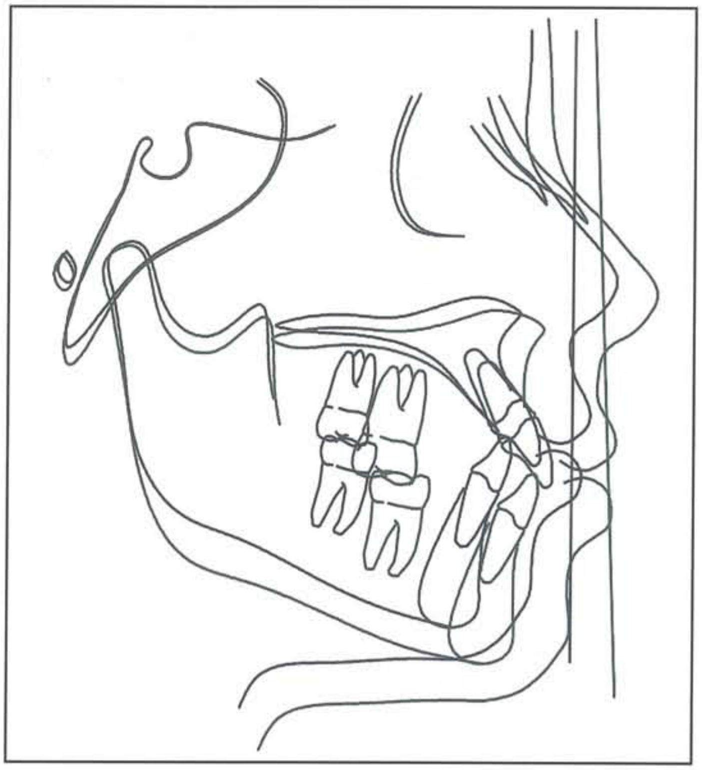


Fig. 8.20B The growth prediction with the changes in Fig. 8.20A.

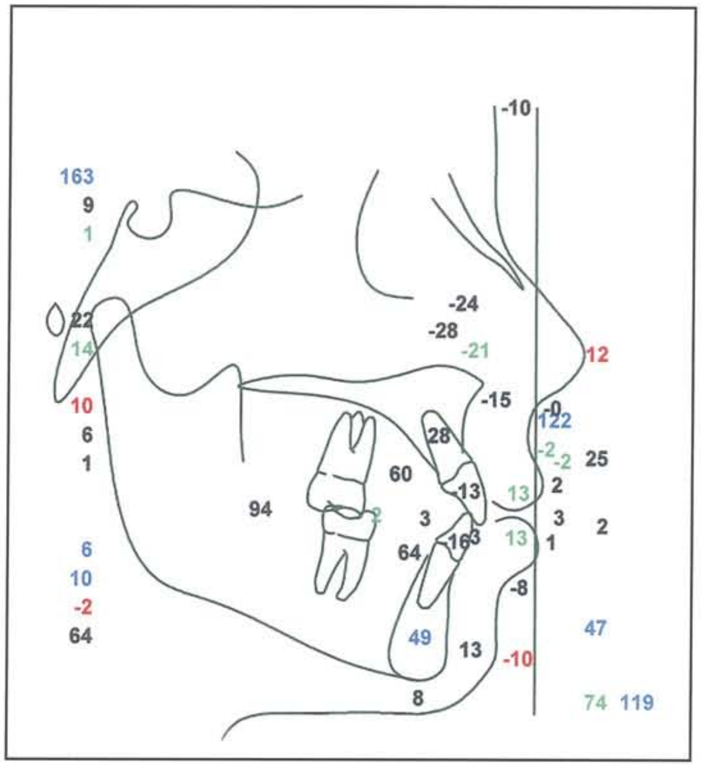


Fig. 8.20C The STCA prediction numbers. Note excellent lip projections (2, black; 1, black) but chin retrusion (–10, red). An isolated chin augmentation can be done if desired by the patient.

7. *Initial discrepancy.* This amount is calculated, and represents the total of the information gathered to this point in the lower arch analysis (Fig. 8.21). This is an appropriate time to decide if the case will be treated on a non-extraction basis (with possible interproximal reduction, expansion or distalizing of first molars), or if extraction treatment is indicated.
8. *Interproximal enamel reduction (stripping).* If enamel reduction is indicated from canine to canine, this figure is recorded as positive figures in the 3 to 3 column. The same amounts should be recorded in the 7 to 7 column. If enamel reduction is needed in the premolar or molar areas, the amounts must be added to the 7 to 7 column (in addition to the 3 to 3 amounts).
9. *Expansion.* If it is decided that inter-canine expansion is planned in a particular case, this figure is recorded as positive figures in the 3 to 3 column. The same amounts should be recorded in the 7 to 7 column. If premolar or molar expansion accompanies this 3 to 3 expansion (which is usually the case), the amounts must be added to the 7 to 7 column (in addition to the 3 to 3 amounts).

LOWER ARCH DISCREPANCY

	3 × 3		7 × 7	
	R	L	R	L
Crowding/Spacing	−3	−6	−3	−6
C/S Bicuspid/E			1	1
C/S Molars			0	0
Curve of Spee	0	0	0	0
Midline	−1.5	1.5	−1.5	1.5
Incisor Position	0	0	0	0
Initial Discrepancy	−4.5	−4.5	−3.5	−3.5
Stripping				
Expansion				
Distalizing $\overline{6|6}$				
Extraction				
Remaining Discrepancy				

M.S.

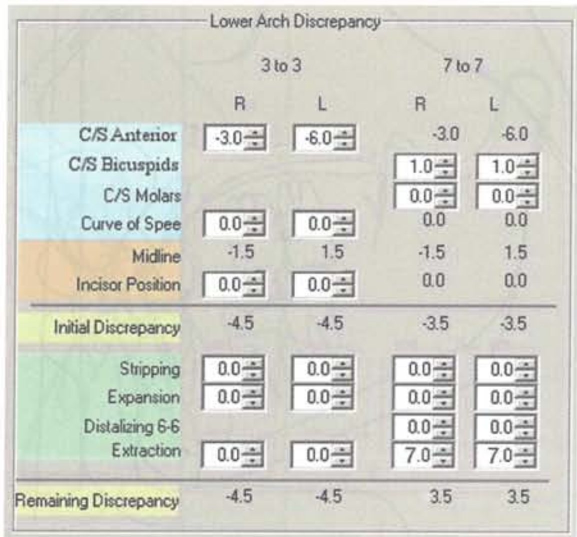


Fig. 8.21 The information recorded down to the completion of the initial discrepancy.

10. *Distalizing of lower first molars.* If an attempt will be made to upright or distalize the lower first molars, then positive numbers can be recorded in the 7 to 7 column only, since this will not affect the 3 to 3 discrepancy.
11. *Extraction.* If a lower incisor is to be extracted, then the millimeters gained can be recorded in the left or right areas of the 3 to 3 column. The same amounts will be automatically recorded in the 7 to 7 column. If premolars (or occasionally first molars) are to be extracted, positive numbers can be recorded in the 7 to 7 column.
12. *Remaining discrepancy.* This records a total of the initial discrepancy and the space gained in millimeters by the treatment methods used in the lower half of the chart in both 3 to 3 and 7 to 7 columns.

In the case example, because of the significant crowding, a decision was made to extract four first premolars. This information is recorded in a lower part of Chart 2 (Fig. 8.22). The figures obtained in the 3 to 3 column under 'Remaining Discrepancy' indicate the number of millimeters that lower canines must be retracted, which is 4.5 mm.

LOWER ARCH DISCREPANCY

	3 × 3 R	3 × 3 L	7 × 7 R	7 × 7 L
Crowding/Spacing	−3	−6	−3	−6
C/S Bicuspid/E			1	1
C/S Molars			0	0
Curve of Spee	0	0	0	0
Midline	−1.5	1.5	−1.5	1.5
Incisor Position	0	0	0	0
Initial Discrepancy	−4.5	−4.5	−3.5	−3.5
Stripping	0	0	0	0
Expansion	0	0	0	0
Distalizing 6|6			0	0
Extraction	0	0	7	7
Remaining Discrepancy	−4.5	−4.5	3.5	3.5

M.S.

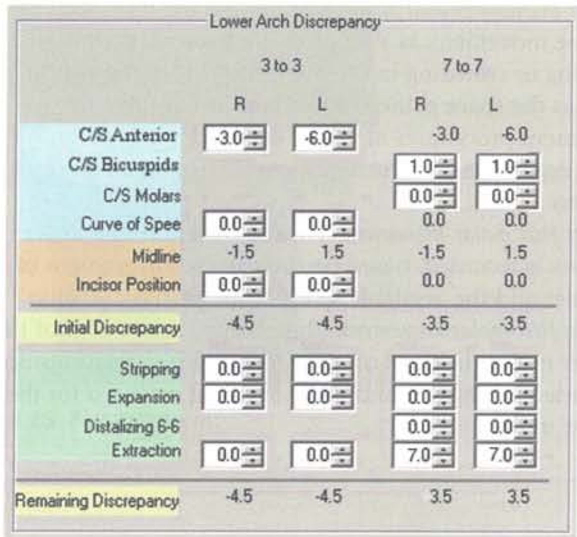


Fig. 8.22 The completion of Chart 2. The decision was made to extract four first premolars.

Using the three charts for an orthodontic case: Chart 3 – planning the proposed dental movements

Chart 3 provides specific information on the planned movement of the midlines, canines and molars. The following process is carried out:

1. *Lower midline correction.* This is based on the original lower dental midline position recorded in Chart 1.
2. *Lower canine movement.* This is based on the 'Remaining Discrepancy' at the bottom of the 3 to 3 column in Chart 2. A negative figure in this column requires distal movement of the canine an equivalent amount. A positive figure in this column requires mesial movement of the canine an equivalent amount.
3. *Lower premolar/molar space.* Just behind the recorded lower canine movement, is a figure that represents the original spacing or crowding in the premolar/first molar region, as well as the space gained in this area as a result such treatment procedures as extractions, stripping, posterior arch expansion or constriction, or distalizing of first molars.
4. *Lower first molar movement.* The movement of the lower molars is recorded, based on the required movement of the canines and the available space in the premolar region.
5. *Upper first molar movement.* The planned movement of the upper molars is based on the original molar relationship recorded in Chart 1, and the movement recorded for the lower molars.

   This is a static calculation, and does not take into account growth changes. A growth prediction can be carried out on the original cephalometric radiograph, but such predictions are based on average estimates, and cannot be relied upon for accuracy.
6. *Upper premolar/molar space.* Just anterior to the recorded upper molar movement is a figure that represents the original spacing or crowding in the premolar/first molar region, as well as the space gained in this area as a result of treatment procedures such as extractions, stripping, posterior arch expansion or constriction, or distalizing of first molars.
7. *Upper canine movement.* The movement of the upper canines is then recorded, based on necessary movement of the upper molars and the available space in the premolar region.
8. *Upper midline correction.* This is based on the original upper dental midline position recorded in Chart 1.

In the lower arch 8 mm of space was estimated to be available on each side. This was 7 mm from the premolar extraction and 1 mm of leeway space. In the upper arch 9 mm was estimated from the extraction and 2 mm of leeway space. Calculations on the dental changes for the patient's midlines, canines and molars are recorded in Figure 8.23.

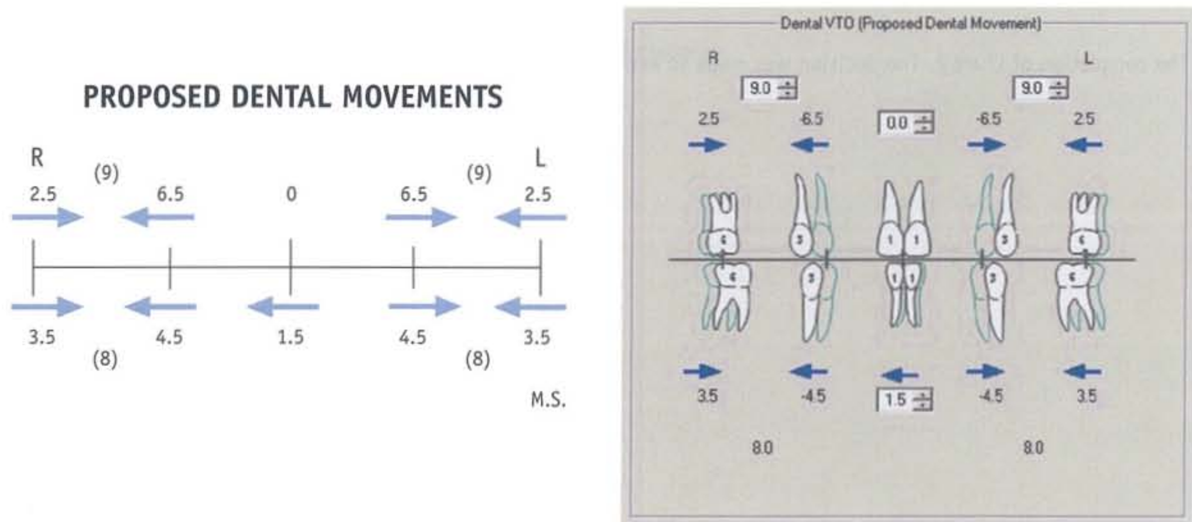


Fig. 8.23 Chart 3 shows the planned dental movements for the midlines, canines and molars. The computer is capable of graphically illustrating these changes.

The following pictures show the final results of the case example. The incisors were placed in the face to provide a balanced profile and the dentition was positioned behind the incisors. Four premolars were extracted. Dental protrusions of this type can normally be well treated orthodontically.

Fig. 8.24 Post-treatment.

Fig. 8.25 Post-treatment.

Figs 8.24 to **8.36** Final records of the case, showing that the incisors were placed in the face to provide a balanced profile, and the dentition was positioned behind the incisors on an extraction basis. The upper and lower lip projections are ideal (3, 0, black). The mild chin recession (–7, blue) can be addressed with a chin augmentation if the patient desires.

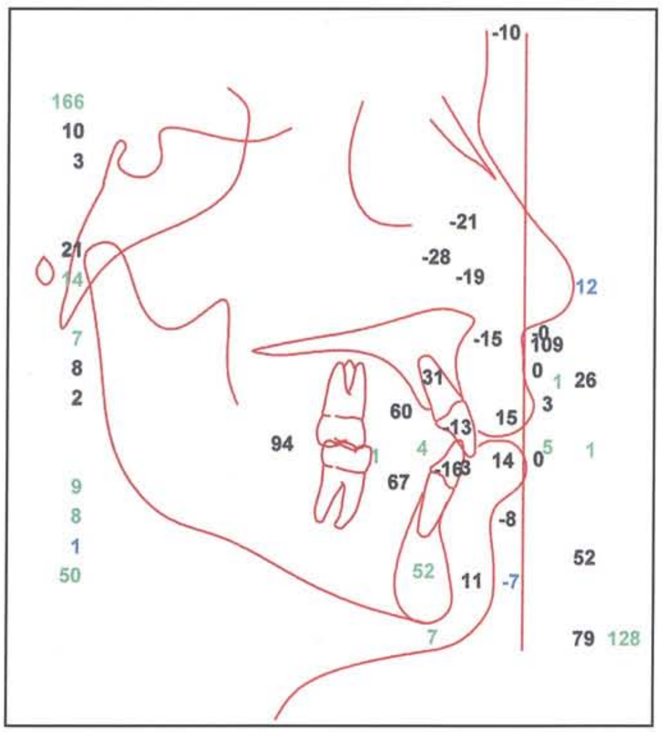


Fig. 8.26

Fig. 8.27 Pre-treatment.

Fig. 8.28 Post-treatment.

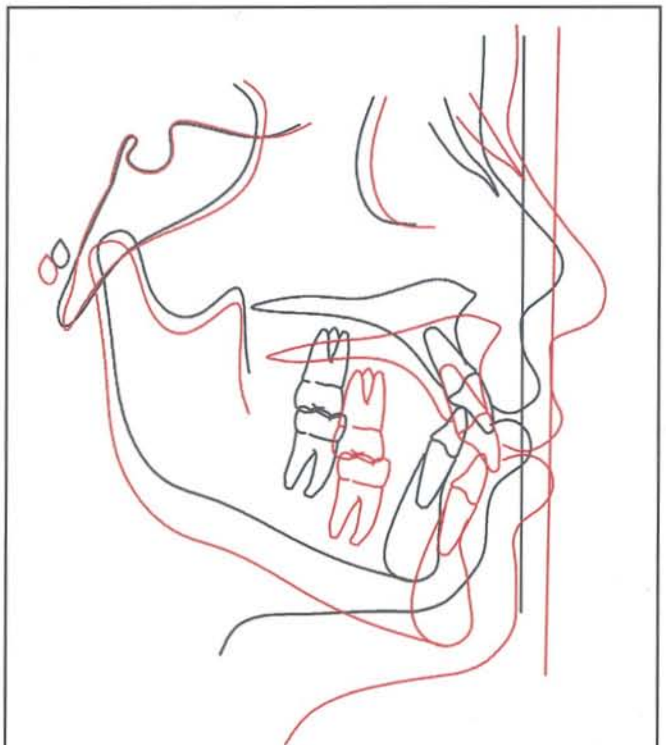


Fig. 8.29 Beginning and final superimposition on SN showing normal downward and forward facial growth.

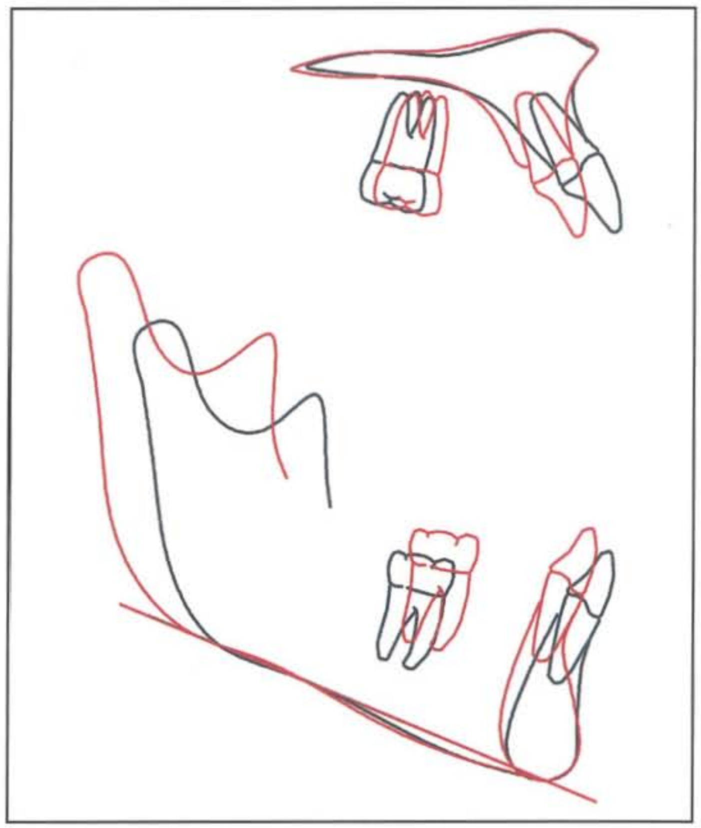


Fig. 8.30 Maxillary superimposition showing slight retraction of the dentition. Mandibular superimposition showing excellent mandibular growth, upward and backward eruption of the lower incisors and upward and forward eruption of the lower molars.

Fig. 8.31

Fig. 8.32

Fig. 8.33

Fig. 8.34

Fig. 8.35

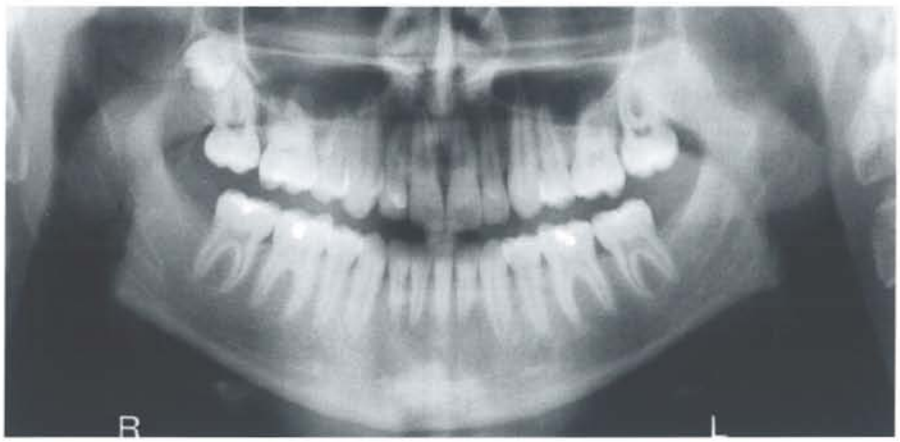


Fig. 8.36

USING THE DENTAL VTO FOR A SURGICAL-ORTHODONTIC CASE

For surgical-orthodontic cases, the inter-arch changes will be carried out by the oral surgeon. Therefore the orthodontist treats the upper and lower arches independently before surgery. Five charts are used when dental planning for a surgical-orthodontic case, as shown in Figure 8.37.

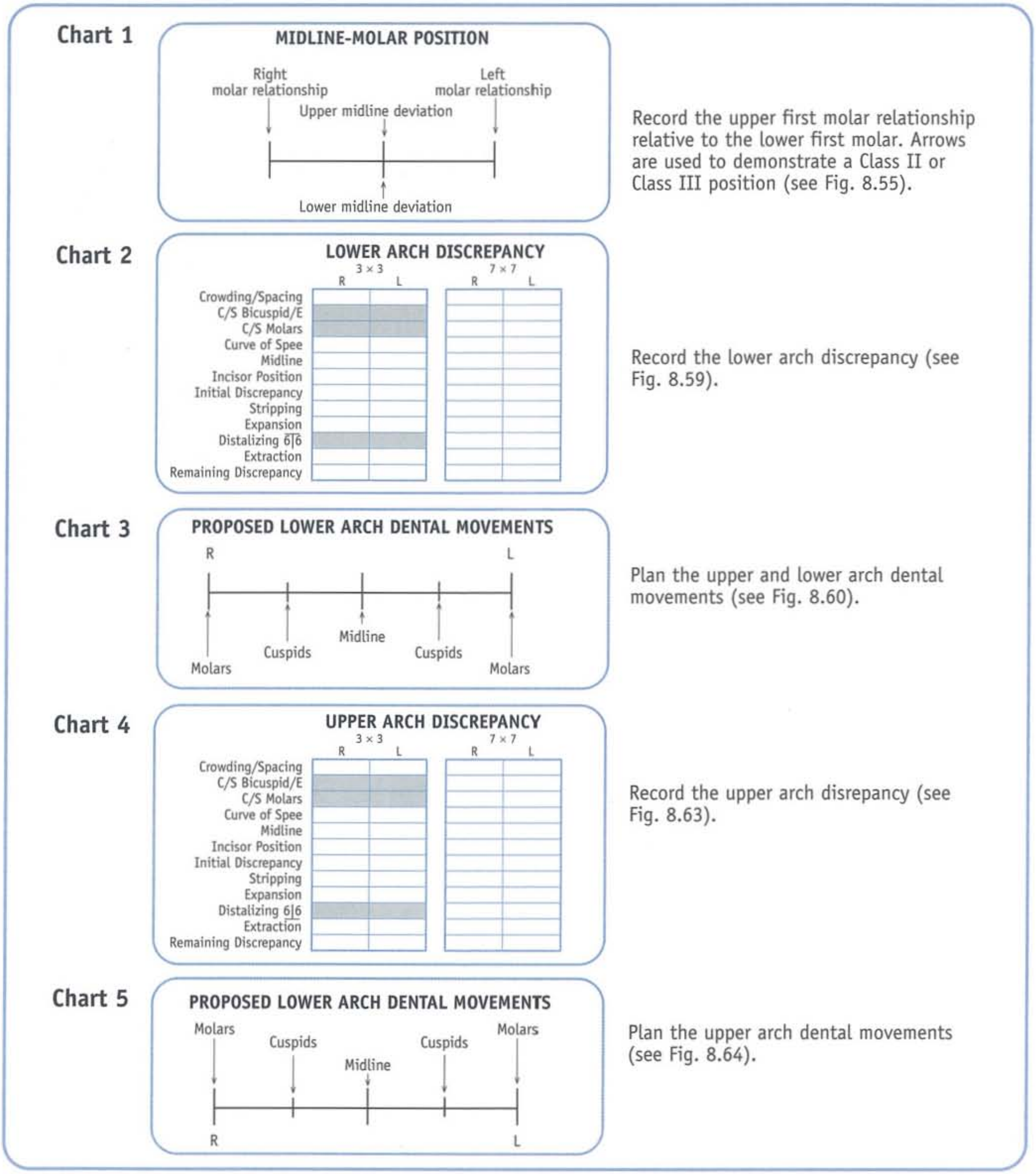


Fig. 8.37 Five charts are used when planning a surgical-orthodontic case.

CASE AI

This 22-year-old female with severe Class II anterior open bite was seen for consultation for bite correction. She was referred by her orthodontist. Diagnosis and treatment were started with the intention of fulfilling the seven goals of treatment. The patient filled out a patient motivation form, which indicated a desire for straightening of her lower front teeth, making the upper front teeth appear shorter, forward movement of the lower teeth, and leveling of the upper front teeth. Facially, the patient wanted the chin moved forward and a reduction in the strain with lip closure. She had no symptoms. TMJ examination and history, clinical facial examination, soft tissue cephalometric examination, and model examinations were obtained. The problem list and treatments were as follows:

After diagnosis, the patient was treatment planned anteroposteriorly and vertically using the seven-step cephalometric treatment plan. The frontal midlines, levels, and outline were treatment planned using the frontal clinical examination. During orthodontic preparation, the orthodontist cut the maxillary archwire between the first and second bicuspids – this was the location which would produce maximum intercuspation with the anticipated multi-segment LFI. The multi-segment LFI produced basic facial balance while correcting the occlusion. Perfection of facial balance was achieved with heat treated HA cheekbone grafts.

PROBLEM	TREATMENT
1. High midface	
• Soft cheekbone contour	• Heat treated hydroxyapatite (HA) cheekbone augmentations
2. Maxilla	
Dental	
• Lingual crown torque	• Mx11 labial torque
• Orthodontic preparation stability	• Stable
Skeletal/facial	
• Large nasal projection	• Maxillary advancement
• 1.5 mm right nasal deviation	• Shorten septum
• Normal incisor exposure	• Maintain
• Class I hand held – maxilla narrow	• Multi-segment Le Fort I (LFI) expansion
• Accentuated curve of Spee	• Multi-segment LFI
• Large inter-labial gap	• Multi-segment LFI posterior impaction
• Lip strain with closure	• Multi-segment LFI posterior impaction
3. Mandible	
Dental	
• Mild crowding	• Orthodontics, 3 to 3 stripping
• Orthodontic preparation stability	• Stable
Skeletal/facial	
• Chin, and lip retrusion, short throat length	• Autorotation of mandible with LFI impaction
4. TMJ	
• No signs or symptoms	• No treatment
5. Growth potential	
• 22 years old	• Non-factor

The following case is used to describe the use of the dental VTO for surgical cases.

Fig. 8.38

Fig. 8.39

Fig. 8.40

Figs 8.38 to **8.47** This patient shows a severe anterior open bite (–4, red), with moderate crowding in the lower anterior segment and a narrow tapered maxillary arch. The lateral facial photographs show lips together and lips at rest.

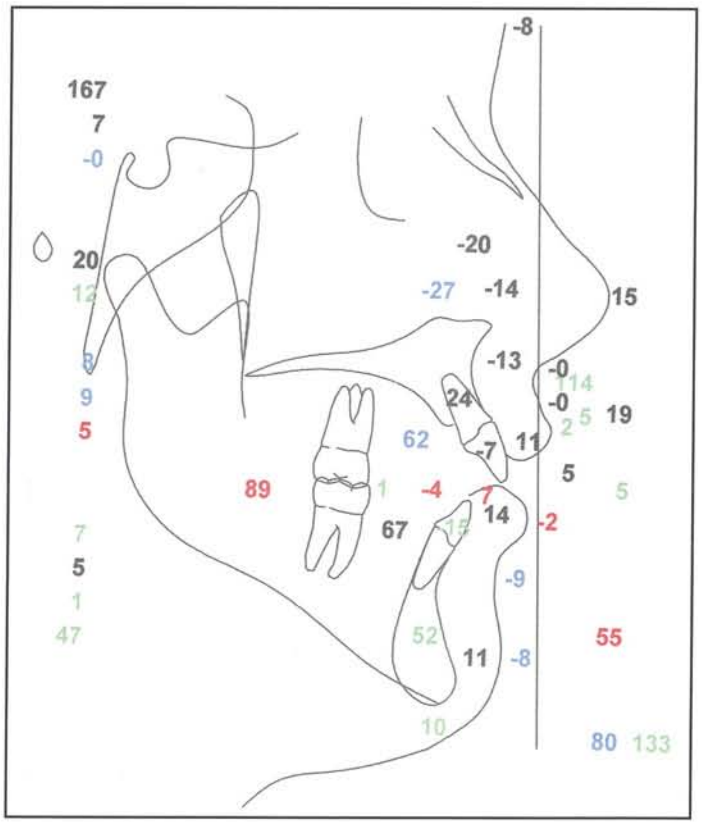


Fig. 8.41


Fig. 8.42


Fig. 8.43


Fig. 8.44


Fig. 8.45


Fig. 8.46

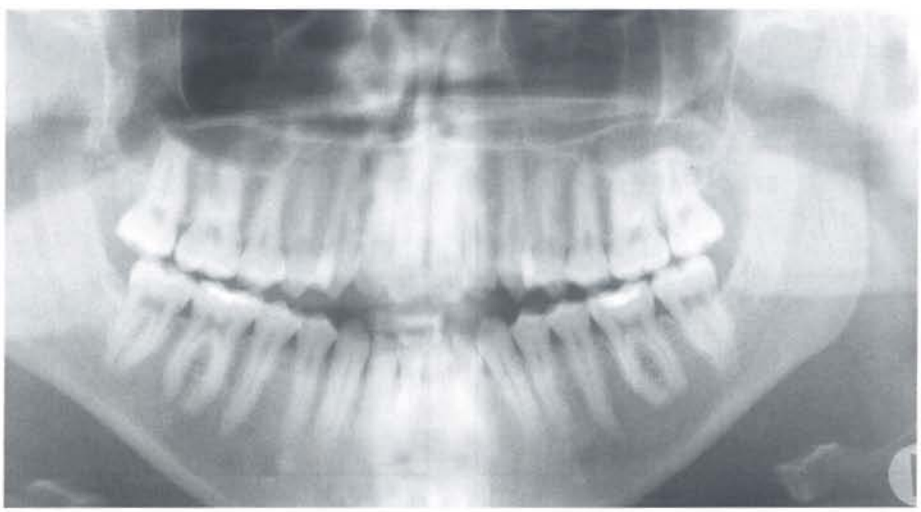


Fig. 8.47

Before carrying out the pre-surgical dental VTO, it is important to complete a cephalometric treatment plan for the patient. Figures 8.48–8.51 show the projected facial change, superimposition of the projected treatment plan, and the estimated STCA numbers.

Fig. 8.48

Fig. 8.49

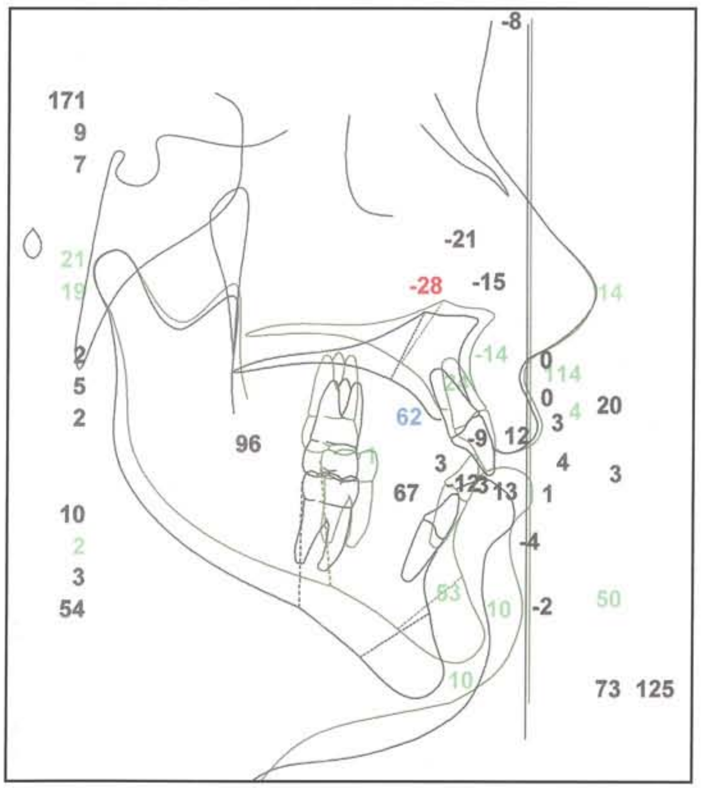


Fig. 8.50

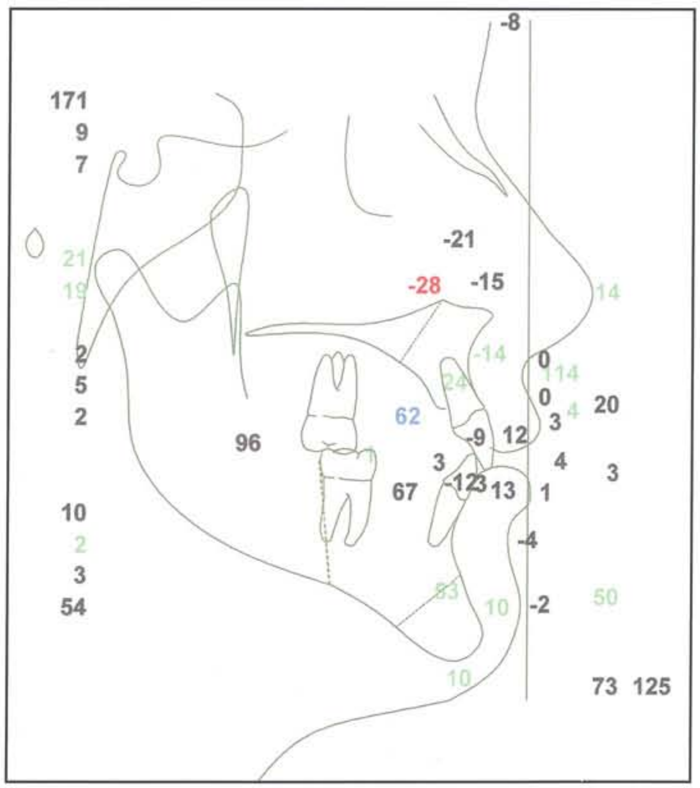


Fig. 8.51

Figs 8.48 to **8.51** The projected facial change, superimposition of the projected treatment plan, and the estimated STCA numbers.

Using the five charts for a surgical-orthodontic case: Chart 1 – recording the initial position of molars and midlines

Chart 1 is completed in the same way as for orthodontic cases. Figures 8.52–8.55 show the midline and molar relationship recordings.

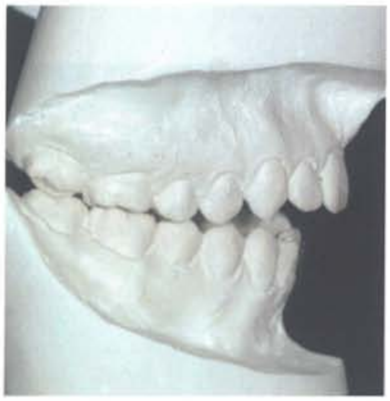


Fig. 8.52

Fig. 8.53

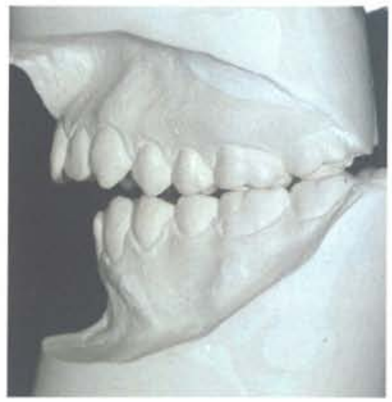


Fig. 8.54

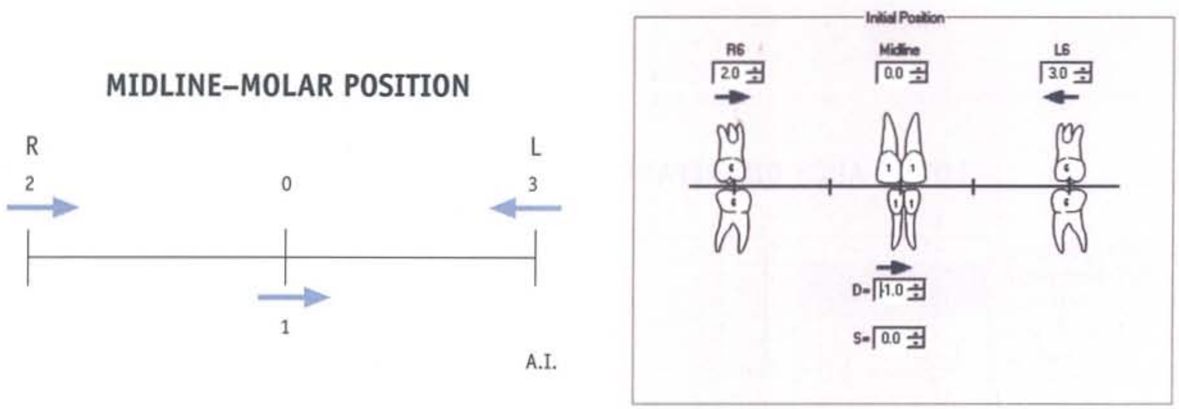


Fig. 8.55

Figs 8.52 to **8.55** The patient shows a right molar relationship that is 2 mm Class II, and a left molar relationship that is 3 mm Class II. The upper midline is correct and the lower midline is dentally deviated 1 mm to the left.

Using the five charts for a surgical-orthodontic case: Chart 2 – recording the lower arch discrepancy

Chart 2 is completed in the same way as for an orthodontic case (p. 293).

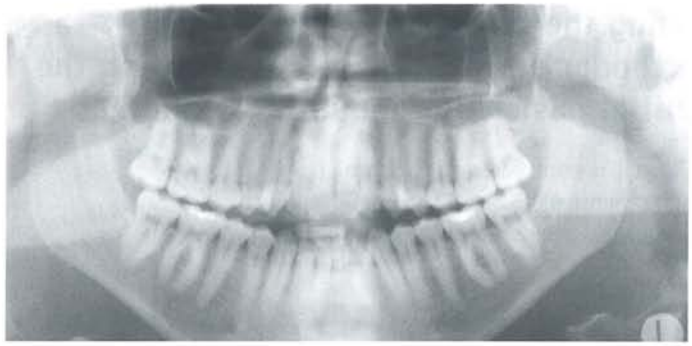


Fig. 8.56

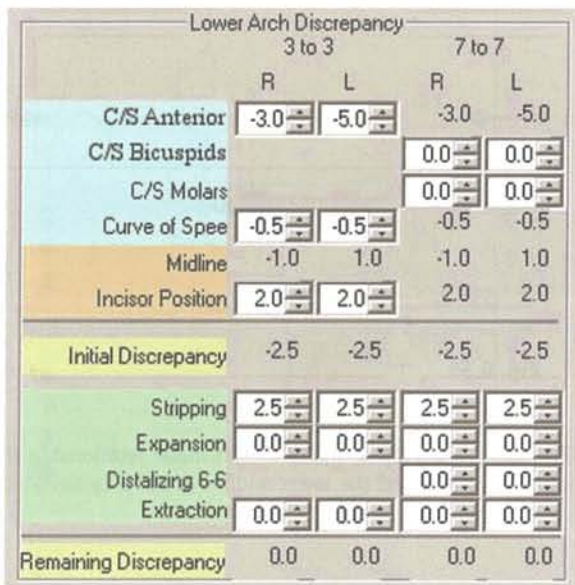
Fig. 8.57

Fig. 8.58

LOWER ARCH DISCREPANCY

	3 × 3 R	3 × 3 L	7 × 7 R	7 × 7 L
Crowding/Spacing	−3	−5	−3	−5
C/S Bicuspid/E			0	0
C/S Molars			0	0
Curve of Spee	−0.5	−0.5	−0.5	−0.5
Midline	−1	1	−1	1
Incisor Position	2	2	2	2
Initial Discrepancy	−2.5	−2.5	−2.5	−2.5
Stripping	2.5	2.5	2.5	2.5
Expansion	0	0	0	0
Distalizing $\overline{6|6}$			0	0
Extraction	0	0	0	0
Remaining Discrepancy	0	0	0	0

A.I.



Lower Arch Discrepancy

	3 to 3 R	3 to 3 L	7 to 7 R	7 to 7 L
C/S Anterior	-3.0	-5.0	-3.0	-5.0
C/S Bicuspids			0.0	0.0
C/S Molars			0.0	0.0
Curve of Spee	-0.5	-0.5	-0.5	-0.5
Midline	-1.0	1.0	-1.0	1.0
Incisor Position	2.0	2.0	2.0	2.0
Initial Discrepancy	-2.5	-2.5	-2.5	-2.5
Stripping	2.5	2.5	2.5	2.5
Expansion	0.0	0.0	0.0	0.0
Distalizing 6-6			0.0	0.0
Extraction	0.0	0.0	0.0	0.0
Remaining Discrepancy	0.0	0.0	0.0	0.0

Fig. 8.59

Figs 8.56 to **8.59** The lower study model, the lower arch analysis, and the panoramic radiograph. The patient has 8 mm of lower anterior crowding, a slightly deep curve of Spee, and a midline that is 1 mm to the left. These discrepancies are corrected by advancing the lower incisors 2 mm and stripping a total of 5 mm of enamel from the lower eight anterior teeth.

Using the five charts for a surgical-orthodontic case: Chart 3 – planning the lower arch tooth movements

This chart is completed in the same way as the *lower half* of Chart 3 for an orthodontic case (Fig. 8.60).

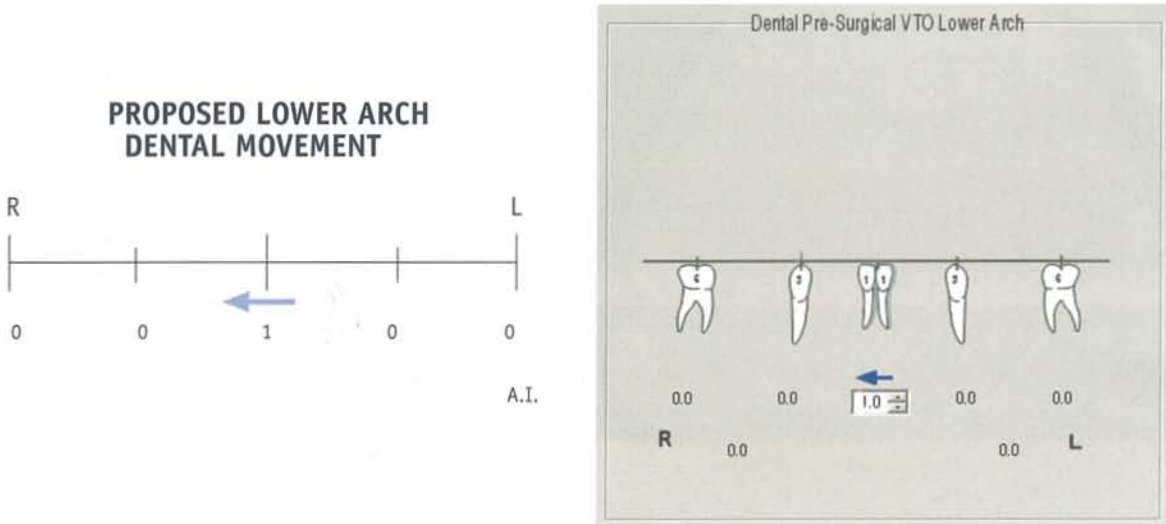


Fig. 8.60 Proposed dental movements for the lower arch before surgery. The only recorded value is 1 mm of midline correction.

Using the five charts for a surgical-orthodontic case: Chart 4 – recording the upper arch discrepancy

This chart is completed in the same way as Chart 2 for an orthodontic case, but it is completed only for the upper arch (Fig. 8.63). Inter-arch movements will be carried out by the surgeon.

Fig. 8.61

Fig. 8.62

UPPER ARCH DISCREPANCY

	3 × 3		7 × 7	
	R	L	R	L
Crowding/Spacing	−1	−1	−1	−1
C/S Bicuspid/E			0	0
C/S Molars			0	0
Curve of Spee	−1	−1	−1	−1
Midline	0	0	0	0
Incisor Position	1	1	1	1
Initial Discrepancy	−1	−1	−1	−1
Stripping	0	0	0	0
Expansion	1	1	1	1
Distalizing 6|6			0	0
Extraction	0	0	0	0
Remaining Discrepancy	0	0	0	0

Upper Arch Discrepancy

	3 to 3		7 to 7	
	R	L	R	L
C/S Anterior	-1.0	-1.0	-1.0	-1.0
C/S Bicuspids			0.0	0.0
C/S Molars			0.0	0.0
Curve of Spee	-1.0	-1.0	-1.0	-1.0
Midline	0.0	0.0	0.0	0.0
Incisor Position	1.0	1.0	1.0	1.0
Initial Discrepancy	-1.0	-1.0	-1.0	-1.0
Stripping	0.0	0.0	0.0	0.0
Expansion	1.0	1.0	1.0	1.0
Distalizing 6-6			0.0	0.0
Extraction	0.0	0.0	0.0	0.0
Remaining Discrepancy	0.0	0.0	0.0	0.0

Fig. 8.63

Figs 8.61 to **8.63** The upper study model, and the upper arch analysis. The patient shows only 2 mm of crowding in the upper anterior segment and a moderate reverse curve of Spee. These discrepancies will be corrected with surgical arch expansion.

Using the five charts for a surgical-orthodontic case: Chart 5 – planning the upper arch tooth movements

This chart is completed in the same way as the *upper half* of Chart 3 for an orthodontic case. Figure 8.64 shows the pre-surgical planned orthodontic tooth movements in the upper arch.

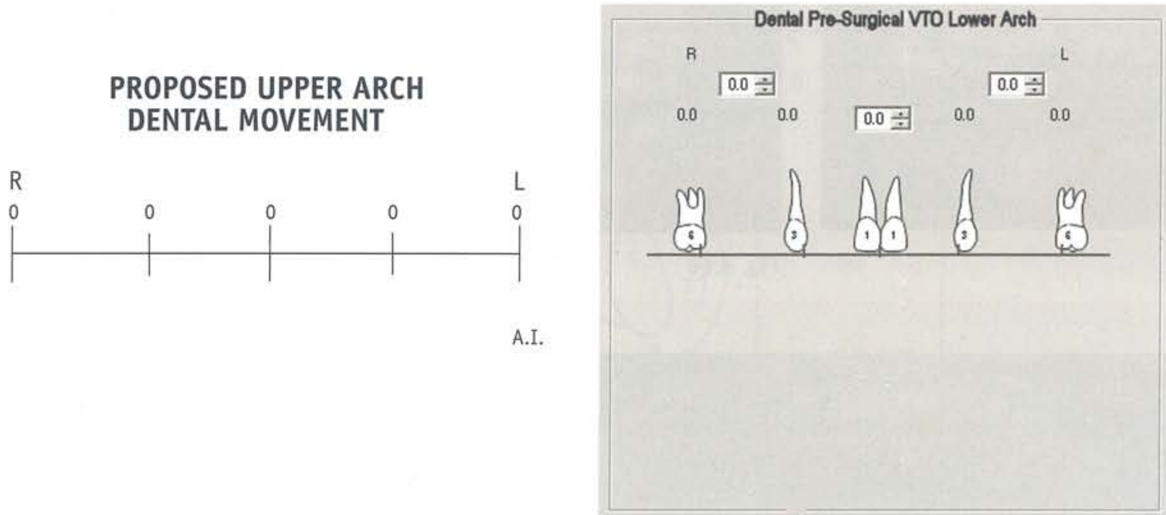


Fig. 8.64 The pre-surgical planned orthodontic tooth movements for the upper arch. Only minimal segmental tooth alignment is required in the upper arch before surgery.

RE-EVALUATION OF THE CASE BEFORE SURGERY

After the upper and lower arches have been treated independently by the orthodontist, the case has to be re-evaluated before surgical treatment. Figures 8.65–8.70 shows the pre-surgical orthodontic preparation of the case and the progress STCA. Very little change occurred from the pre-treatment records, and the original treatment prediction would therefore be similar to any treatment predictions made here.

Fig. 8.65

Fig. 8.66

Fig. 8.67

Fig. 8.68

Fig. 8.69

Figs 8.65 to **8.70** The pre-surgical orthodontic preparation of the case and the progress STCA. Very little change occurred from the pre-treatment records, and the original treatment prediction would be similar to any prediction made here.

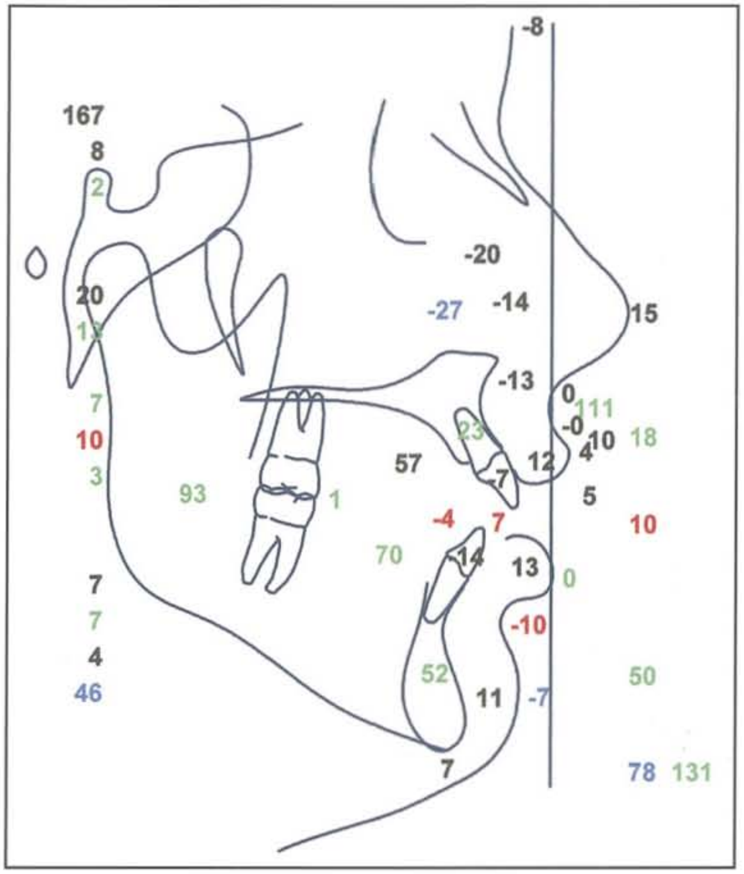


Fig. 8.70 Normal incisor exposure (5,black), chin retrusion (–7, blue), open bite (–4, red), large interlabial gap (10, red) and long lower third of the face (78, blue).

Fig. 8.71

Fig. 8.72

Fig. 8.73

Fig. 8.74

Figs 8.71 to **8.74** Pre-surgical photographs; smile, relaxed lips, lips together and lateral facial with relaxed lips.

The following illustrations show the patient's occlusion immediately after surgery and the final records.

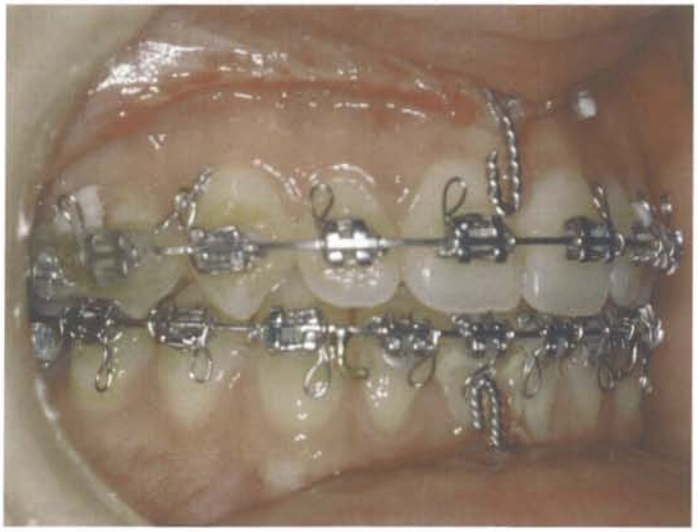


Fig. 8.75

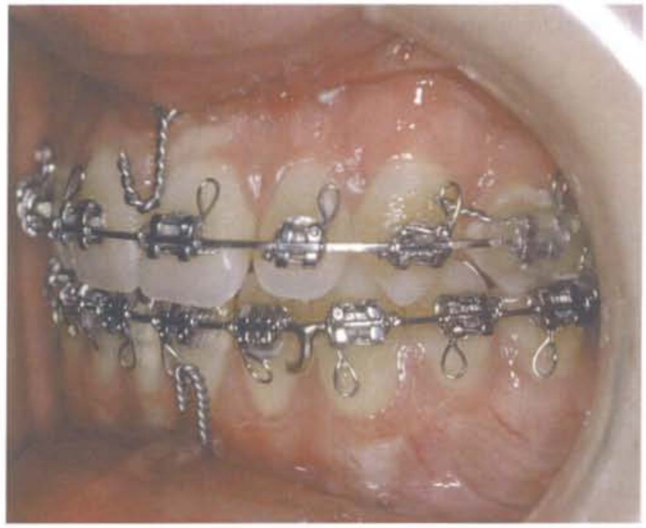


Fig. 8.76

Fig. 8.77

Figs 8.75 to **8.85** The patient's occlusion immediately after surgery and her final records. Note the acrylic across the interdental osteotomy site between the first and second bicuspids. The segmental oseotomy was placed in this location as it was the point of change in the two plane occlusion.

Fig. 8.78

Fig. 8.79

Fig. 8.80

Fig. 8.81

Fig. 8.82

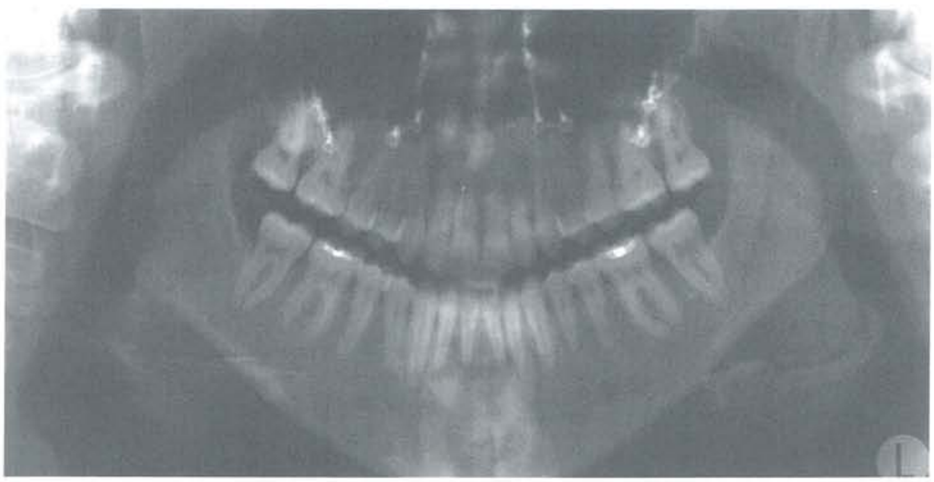


Fig. 8.83

Fig. 8.84

Fig. 8.85

Fig. 8.86

Fig. 8.87

Fig. 8.88

Figs 8.84 to **8.88** The post-treatment closed lip and relaxed lip facial photographs.

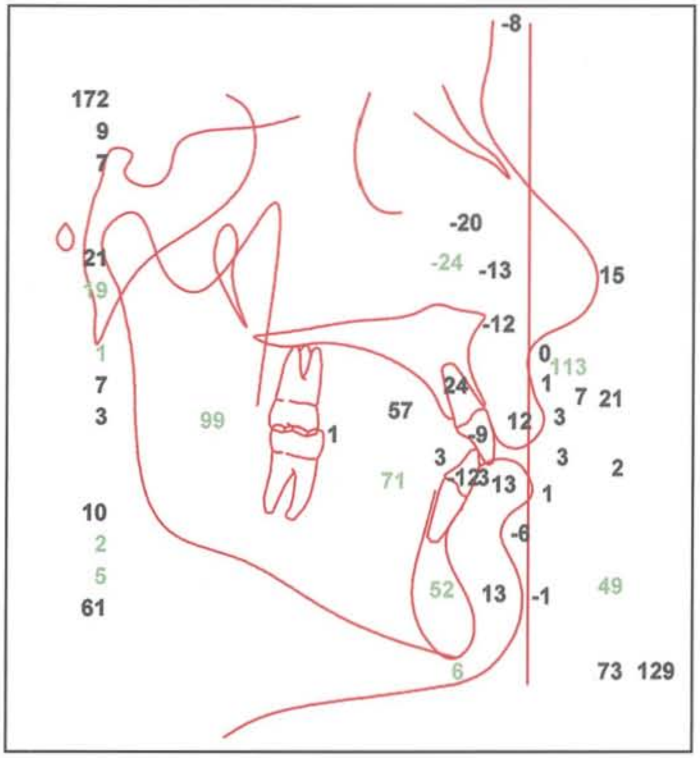


Fig. 8.90 Post orthognonthic surgery tracing. Note the intra-mandibular harmony values at the bottom of the left hand column. The soft tissue pogonion' is in disharmony with soft tissue B (5, green), as well as the lower lip anterior (2, green). This demonstrates how effective harmony values are at detecting facial imbalance. Examination of this patient's facial photograph (Fig. 8.92) verifies these discrepancies.

Fig. 8.91 Pre-treatment.

Fig. 8.92 Post-treatment.

In summary, this chapter has reviewed a technique for evaluating the required dental movements in both orthodontic cases and surgical-orthodontic cases. The VTO is most useful in the diagnosis and treatment planning process, and in making correct extraction/non-extraction decisions. Also, when patients present for their regular adjustment appointments, it is helpful to refer to the dental VTO as a reminder of planned tooth movements and anchorage needs.

REFERENCES

1 McLaughlin R P, Bennett J C 1999 The dental VTO: an analysis of orthodontic tooth movement. Journal of Clinical Orthodontics 33:394–403

2 McLaughlin R P, Bennett J C 1999 An analysis of orthodontic tooth movement – The dental VTO. Revista Espanola de Ortodoncia 29(Suppl. 2):10–29

3 Dolphin Imaging, www.dolphinimaging.com, 6325 De Soto Avenue, Suite A, Woodland Hills, CA 91367 USA

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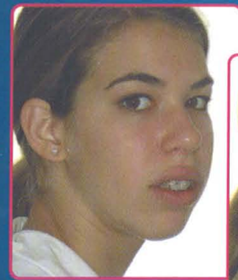
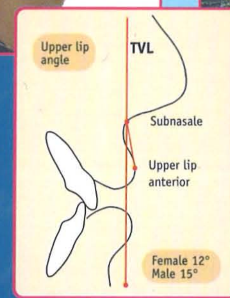
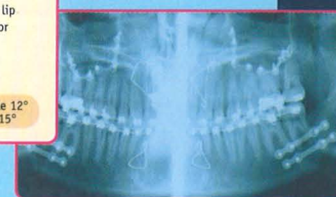
Facial and Dental Planning for Orthodontists and Oral Surgeons







Facial beauty can be recognized, but it is difficult to define objectively the components of this beauty. Objectivity, however, is necessary for orthodontists and surgeons who are attempting to maximize facial harmony and balance. They need a systemized and objective approach to facial planning, which reflects the difference between female and male faces, and which has the potential to be developed and applied to different ethnic and age groups.

This book presents a new and groundbreaking approach to facial planning in orthodontic and orthognathic surgery cases. It describes an objective, computerized method of facial analysis and treatment planning, which is backed up by a methodical and standardized method of case documentation. In its emphasis on the True Vertical Line and movement away from the traditional cranial base measurements, it represents a turning point in facial planning.

Facial and Dental Planning for Orthodontists and Oral Surgeons is a practical and superbly illustrated manual from a world-renowned author team.

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