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Forensic Podiatry

Principles and Methods

Humana Press

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Preface

The human foot is a complex body part composed of 52 bones, which are 25% of all the bones in the body. Because of the foot's unique structure it allows the human being to stand up and walk on two feet with a stride that cannot be duplicated by any other creature on earth. That being said however, the foot is viewed by the public and the medical professions as a "minor" part of the body, held in low esteem and hidden in a shoe.

Forensic Podiatry – Principles and Methods has finally been completed after numerous requests by the podiatric community for such a work. The main premise of Hilderbrand's book, *Footwear – The Missed Evidence*, is the underutilization of footwear evidence.

Coincidentally, the importance of pedal evidence has also been undervalued. As footwear evidence has become more commonly utilized in forensic situations so has pedal evidence. Over the past 20 years, the discipline of forensic podiatry has grown and developed to become an important addition to the forensic community.

Since this field is still in its relative infancy compared with the other disciplines, this work should be considered as capturing developments in the field to date and these developments are expected to continue for the forseeable future. The principles and methods utilized in this text are scientifically based, and have been accepted and tested by the general and podiatric communities over the years. One caveat that must be emphasized is that teamwork is important, whether it's pedal evidence or baseball. The forensic podiatrist is part of the forensic team including, most commonly, the footwear or marks examiner, laboratory personnel, criminalist, case detective, investigator, and forensic anthropologist.

This book can be utilized in many different areas in the forensic and medical fields. The undergraduate and postgraduate medical students and the student of criminal justice studies should find this text an excellent resource. The podiatrist who is well-versed in foot morphology, pathology, and biomechanics will find this book helpful relative to the forensic sciences that must be understood fully. The criminalists will utilize this as a review of the techniques used at the crime scene as well as the techniques used to fabricate exemplars. The footwear examiner, forensic anthropologist, attorneys, lawyers, and investigators will find it invaluable in researching the field as well as understanding the methodologies and principles used in determining the value of the pedal evidence.

This book is divided into four parts:

Part I discusses general forensic concerns, including the crime scene, from an informative perspective as well as the tasks performed by the crime laboratory. For the forensic podiatric practitioner this will be informative and apply to the general knowledge that is required. It also includes forensic podiatry principles and the subject of human identification. The basics of the forensic methodology that are utilized for physical evidence, the method, ACE-V (R), and other aspects of human identification are presented.

Part II deals with specific forensic podiatry concerns. Included is a chapter on digital photographic techniques that will provide a review for some and teach the basics to others who are interested in performing these tasks themselves. The reader will find the chapter on bare footprint identification and footwear examination and analysis undeniably the most important chapters in the book relative to the majority of pedal evidence concerns. Chapter 6 on forensic gait and analysis presents what might be considered the newest exciting addition to the podiatrist's forensics armamentarium. Chapter 7 deals with the identification of pedal remains from podiatry records that are important primarily but not exclusively in mass disaster scenes.

Part III of the book deals with actual forensic podiatry cases from the UK and the USA. These case summaries will give the reader a perspective of what case work entails in different situations.

Part IV of the book concentrates on forensic podiatry practice standards that in many instances parallel expert witness responsibilities. It is essential to understand and comply with rulings, such as Daubert and others to integrate adequately with the law enforcement community. The "Ten Essentials for Forensic Podiatry Practice" should be part of any forensic expert's standards.

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Derbyshire — Wesley Vernon

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Contents

Part I
General Forensic Concerns

Chapter 1
The Crime Scene and Crime Laboratory

Keywords Pedal evidence • Footprint evidence • Bare footprints • Chain of custody • Crime laboratory

Evidence collection is one of the most important components of a criminal investigation and subsequent prosecution. Physical evidence can positively link a suspect to a crime, or it can prove one's innocence. Continued advancements in technology and instrumentation have assisted law enforcement with its ability to collect forensic evidence.

Crime scene processing and evidence collection has become even more important recently, possibly due to the increased awareness by the general public of techniques that are widely seen on forensic television programs, and the additional burden this public expectation places on real-life people to solve crimes in a similar manner. Items that may or may not have evidentiary value need to be discovered, identified, collected, and analyzed, and this has been assisted by technological advances.

1.1 General Concerns Regarding Pedal Evidence

It is not usual for forensic podiatrists to recover evidence from the scene of a crime, this being the duty of the Scene of Crime Officer (SOCO), Crime Scene Investigator (CSI), or Crime Scene Officer (CSO), depending on the country of origin (Vernon et al. 2009). It can, however, be helpful for the forensic podiatrist to understand the general processes involved in order to understand what has taken place prior to evidence being placed in his or her possession. It is also possible that specialist advice may be requested from crime scene specialists where pedal evidence is apparent at the scene, providing further need for the processes involved to be understood.

If a single footprint is present at a crime scene, then it is quite possible that additional footprints could also be present. The theory postulated by French forensic scientist Edward Locard stated that "every contact between people and/or objects will result in the exchange of evidence of the contact between the two" (Siegel 2007, p. 12). Knowing that such transference and exchange is to be expected suggests that diligent searching for additional prints may therefore be more productive.

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In the not too distant past, pedal evidence was not considered to be of great value, especially if there were no suspects. With the advent of the certified footwear examiner (CFWE) and the forensic podiatrist, that thinking is changing. After entry into the crime scene and visual overall observation, the investigator will have crime scene personnel look for pedal evidence in the most obvious locations. In many cases the crime scene is chaotic. There may be multiple crime scene footprints that are from Emergency Medical Team(s) (EMT's) or police officers, but it is advisable to collect and exclude later, as opposed to not collecting these prints at all. There is always the chance that one of the prints belongs to the suspect. It must be remembered that every footprint has the potential for providing information about the person who made it because of the high levels of individuality represented by every footprint, including differences between the right and left foot of the same person.

In addition to the obvious areas, systematic searches need to be performed, and these should include the exterior and peripheral areas of the crime scene.

1.2 Crime Scene

The main objectives of personnel at the crime scene are to protect, identify, collect, and preserve evidence and to maintain a chain of custody. A general knowledge of the protocols required at a crime scene should be maintained by the investigator even though, as noted above, it will not usually be necessary for the forensic podiatrist to attend a crime scene. Some considerations relative to footprint evidence include those relating to climatic conditions. For example, where there has been recent rain at an outdoor scene, this may be conducive to the formation of three-dimensional foot or shoe prints but, conversely, heavy precipitation may possibly destroy any of these footprints or make them less usable. Often the point of entry can be the most productive area of the crime scene for finding evidence related to that entry such as tool marks, foot or shoe impressions, fingerprints, etc. A very thorough search around the perimeter of the crime scene can be valuable and is something that needs to be diligently undertaken by crime scene personnel.

Securing the scene is most important to prevent unnecessary contamination and to allow for the preservation and subsequently the best representation of physical evidence present at the crime scene. Protocols usually involve an officer securing the scene and logging in only those individuals who are required to be present at the scene. In a high-profile case it can be difficult to keep a crime scene under control. One of the main problems, albeit unintentional, is with the arrival of the EMTs and other emergency personnel. Their primary task is to save lives and, as they enter a crime scene, they may inadvertently leave their own prints at the scene, obliterating pedal evidence as they do so. Where there has been the potential for this situation to have taken place, prints should be taken from those who were present at the crime scene. While this will obviously not bring back obliterated prints, it will allow the prints of such personnel to be identified and eliminated from the inquiry.

1.3 Discovery of Physical Evidence

At the stage that a podiatrist becomes involved in identification involving bare footprints, it is usually the case that crime officers at the scene will have already found and captured the bare footprint for comparison purposes. It is, however, useful to briefly consider the process both for contextual understanding and also to provide a basic knowledge of the procedures involved should the podiatrist be asked to assist in the finding and collection of bare footprints. It is generally inevitable that the perpetrator of a crime will have entered and left the crime scene and in doing so will have left "traces of their footwear at that scene" (Hilderbrand 1999) and bare footprints can also be left at the scene, too. These foot or shoe prints may not initially be apparent and need to be discovered in order to be of use. The investigator will, in the first instance, need to view the crime scene in its entirety and consider within that scenario where foot or shoe prints are likely to be found. If, for example, there has been entry through a broken window, there is a reasonable possibility of prints being present at either side of this window as the perpetrator has passed through it the window. In a murder case, involving acts of direct physical violence, prints may be anticipated in the vicinity of the body. After considering the scene in this way, there may be a requirement to use specialized lighting techniques to show the presence of bare footprints in these areas, as these may not be immediately obvious to the naked eye. The investigator will then note any footprints present and record their position for later image capture and/or collection. The investigator may also continue to look further for prints – either when footprints are not present or to increase the number of prints available for later comparison. Bare footprints can be either two or three dimensional. Three-dimensional prints are those made in softer ground, where the foot has sunk into that ground, creating a three-dimensional impression (often referred to as a bare foot impression), while two-dimensional prints are those made on a harder surface in which the foot could not create a three-dimensional impression (DiMaggio 2005). Three-dimensional footprints of adequate quality are usually by definition obvious, while two-dimensional prints may be more occult. When searching for two-dimensional prints, the combination of surface form and possible substrates that may present on the print will need to be considered as some surface/substrate combinations are more conducive to the formation of prints than others (DiMaggio 2005; Bodziak 2000).

Where footwear is involved, such complex collection processes as described are not required, with the task being simply to seize or collect the footwear item using police scene-of-crime protocols.

1.4 Enhancing Bare Footprint Evidence

When the areas in which bare footprints may be present at a scene of crime have been defined, the task will be to collect and, if necessary, enhance the print for examination purposes. Collection can take place prior to enhancement or vice versa.

Enhancement before collection usually takes place when the method of collection at the scene is that of photography. Experience has suggested that footprints captured at crime scenes by photography are the most usual form of evidence presented to podiatrists for later examination, as opposed to the use of the actual removed footprints, or the collection of three-dimensional footprints through casting techniques.

The enhancement of footprints prior to collection may be undertaken by the investigator to either optimize the detail in prints that are already apparent or to alternatively search for prints that are not immediately obvious. This task is usually facilitated by the introduction of lighting variables, which can be used in combination with chemical enhancement of the prints, if indicated. The simplest lighting variable used is the introduction of oblique light to the scene. This is the use of a light source that is angled to the print in order to make that print and/or detail within that print more apparent (Fig. 1.1). Oblique lighting can be used with equal success in two- and three-dimensional prints. In dealing with three-dimensional prints, the print can become optimized by oblique lighting techniques through the introduction of shadow effects and increasing the contrast between the various areas of the print (Fig. 1.2).

Various specialized forms of lighting can also be used by the SOCO, CSI, or CSO. These are most commonly described as Forensic Light Sources (FLS) or Alternate

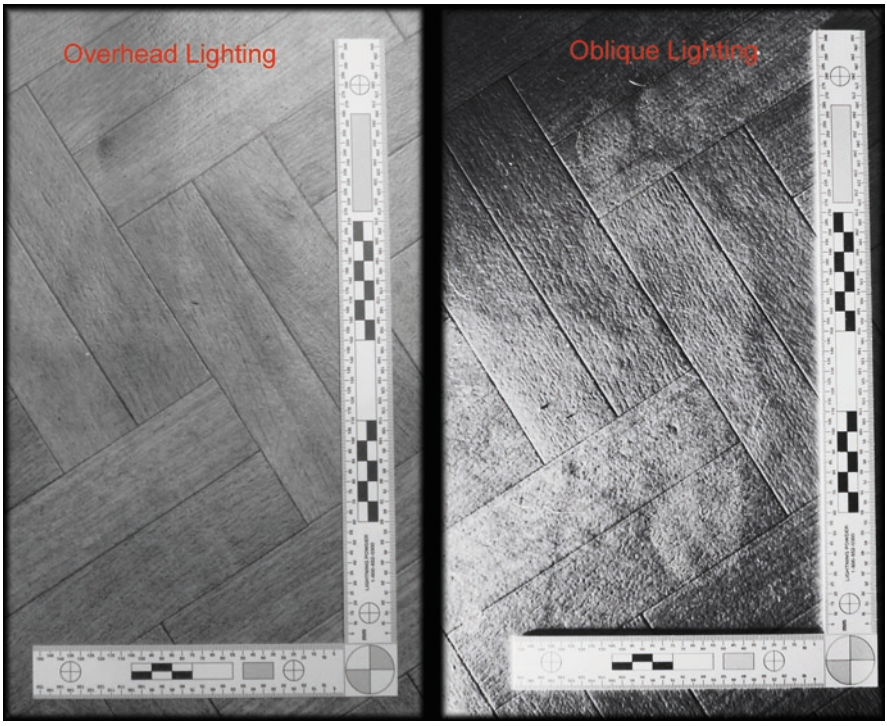

Fig. 1.1 Comparison of foot impressions under normal and oblique lighting conditions

Fig. 1.2 Effect of oblique lighting on a three-dimensional foot impression

Light Sources (ALS), between them covering all aspects of the visible spectrum plus infrared and ultraviolet wavelengths. By adjusting the wavelength within the visible spectrum, already-visible prints can be enhanced, showing detail that may not be immediately apparent under basic white light illumination, while the use of wavelengths outside the visible spectrum can be used to show the presence of prints not immediately apparent to the observer (Fig. 1.3). Of particular note in relation to the enhancement of prints is the use of luminol to chemically enhance prints, which may have been left in blood. Luminol has been described as "a chemicoluminescent compound that is used as a presumptive, catalytic test for the presence of blood," and it is said to be so sensitive as to fluoresce with blood present in just one part in five million (Redsicker 2001, p. 229). In use, luminol is sprayed onto the area under consideration, then viewed in darkened conditions, where it fluoresces and glows when it contacts traces of blood (although it is known also to react in contact with other agents too, such as paint, porcelain, metal, and hypochlorite (bleach) (Eckert 1997)). In dealing with prints where the foot has trodden in blood at the crime scene, those areas of the foot that have contacted the blood show up clearly with the luminol test. Obviously, if the entire plantar surface has contacted blood, then it is possible for the

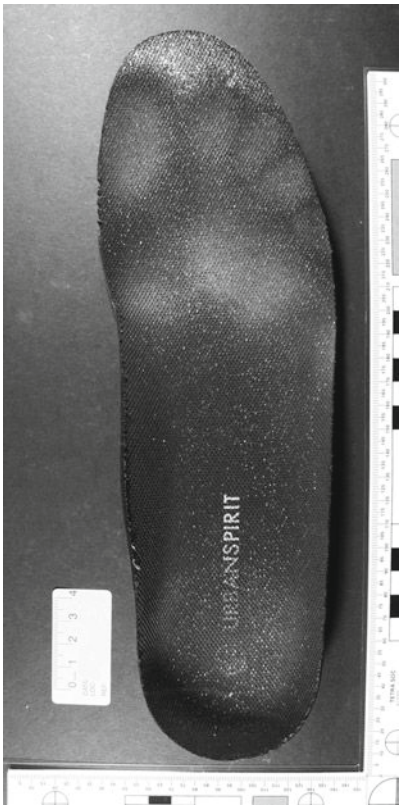

Fig. 1.3 Enhancement of foot impressions through the use of specialized lighting sources

whole footprint to become apparent through the application of luminol. Once the print has been treated with luminol, it is possible to photograph this luminol-enhanced print for later assessment and comparison.

1.5 Collecting Questioned Bare Footprint Evidence

There are a number of textbooks that comprehensively consider the process of finding, enhancing, and collecting shoeprints for identification purposes. The techniques of capture and enhancement of footwear as described in this text translate directly to the capture and enhancement of bare footprints present at the scene of crime, and the interested reader is directed to the following literature to gain a comprehensive understanding of these tasks and processes:

- Abbott JR (1964) Footwear Evidence. Charles C. Thomas, Springfield
- Bodziak WJ (2000) Footwear Impression Evidence: Detection, recovery and examination, 2nd edn. CRC Press, London

- Cassidy MJ (1987) Footwear Identification. RCMP, Ottawa
- Hilderbrand DS (1999) Footwear, the Missed Evidence: A field guide to the collection and preservation of forensic footwear impression evidence. Staggs, Temecula

While it is unlikely that forensic podiatrists will be required to collect footprint evidence directly, an understanding of this process can be useful for contextual reasons. A variety of techniques are used to collect footprints for examination purposes and these are considered briefly, below:

The physical removal of bare footprint evidence: It may be possible to physically remove a bare footprint from a scene of crime for later examination and comparison purposes. Examples of situations in which footprints would be removed include those in which the footprint has been made on a door, which can be physically removed from its hinges, or where the footprint has been made on a loose item at the scene, for example, a sheet of paper, which can then be easily taken away for examination. If necessary, material containing a clear bare footprint can be physically cut away from the scene prior to removal. This could apply to bare footprints present on a section of carpet or on an area of wooden floorboard.

Lifting: Lifting techniques can be utilized when a two-dimensional bare footprint is available for examination purposes. They are defined as "a way of transferring a two-dimensional impression from its original surface to a surface that will provide better contrast" (Bodziak 2000). Through lifting, the footprint can be removed for later examination. There are many techniques of lifting two-dimensional impressions, each with its own distinct advantages and disadvantages. Such techniques include adhesive and gelatin lifts, both of which allow dusty prints to be collected (Hilderbrand 1999), electrostatic lifts, which rely on the use of static electricity to collect dusty prints (Bodziak 2000), and various silicone-based products that adhere to the prints and which when set allow the print to be removed. The choice of lift used depends on the type of bare footprint, available for removal, the surface upon which the bare footprint is present, and the contrast available through the background color of the lifting surface. Whichever lifting method is selected, the print should always be photographed prior to lifting, should anything go wrong with the lifting process, thereby spoiling the print.

Casting: While lifting is a method of choice for the removal of two-dimensional impressions, casting is the preferred method for the capture and removal of three-dimensional bare footprints/foot impressions. The purpose of casting is to collect the bare footprint while retaining as much fine detail as possible. This process has been defined in the context of footwear as "The filling of a three-dimensional footwear impression with a material that will acquire and retain the characteristics that were left in that impression by the footwear" (Bodziak 2000). Various materials are available for casting, including differing grades of dental stone, silicon-based materials, alginates, paraffin wax, and sulfur. Again, the properties of these materials are diverse and the casting method needs be selected carefully, according to circumstances. Some of these methods, for example, sulfur and paraffin wax, allow casts to be taken from prints in snow. As in the lifting techniques, it is again usual for the

three-dimensional prints to be photographed prior to casting in case damage to the print occurs during the casting process.

Photography: The final method to be considered in capturing the prints is that of photography, which should be used in conjunction with any of the other methods of footprint capture. The photographic process will be considered in detail in Chap. 3. As stated, while podiatrists are unlikely to find themselves at crime scenes, it is nevertheless important that any evidence-quality photographic images that are passed to them later for examination have been taken to the standards required. It is therefore essential that the examining podiatrist ensures that this has been the case prior to starting work on the examination and comparison of such images.

1.6 Collection of Evidence

Each item of evidence must be placed in a separate and appropriate secure container. All items must be appropriately marked and the packaging sealed utilizing standard protocols. In considering the type of container needed for this purpose, factors should be considered such as whether or not the material represents a biohazard, thereby requiring special precautions and labeling to be used, whether the material is fragile, thereby needing additional protection, and whether the evidence will or will not be suitable for placing into packaging which is occlusive and thereby brings about the risk of undesirable effects such as the formation of mold.

1.7 Chain of Custody

The purpose of maintaining a chain of custody is to be able to clearly identify the evidence and show that it has remained secure and free from external influence at all times from seizure to conclusion. To do this, a continuous audit trail is required, in which it can be shown, in order, exactly who had secure possession of and access to that item. If the exhibit has been properly identified by this method, the chain of custody is complete.

1.8 Crime Laboratory

Crime laboratories have been present in the USA since 1924, when the first laboratory attached to a police department was developed by the Los Angeles Police Department (Eckert 1997). Later, laboratories were introduced by the federal government across the country and now include the Federal Bureau of Investigation (FBI), Drug Enforcement Agency (DEA), and Alcohol Tobacco and Firearms Bureau (ATF) Laboratories (Eckert 1997). Today, crime laboratories are often operated on a local, independent basis by the various agencies involved in law enforcement.

In the UK, forensic laboratory services fall predominantly under the auspices of Forensic Science Service (FSS). This was established as semi-independent from the UK Home Office in the early 1990s, although, as an organization, the FSS has been around for much longer than that. In 2004, the FSS was estimated to be providing approximately 85% of forensic science services in the UK (House of Commons 2005). The remaining forensic science services in the UK are provided by a limited number of large, independent laboratories and independent individual ("sole trader") suppliers. In 2005, these "sole trader" suppliers accounted for just 3% of provision (House of Commons 2005). Despite these different providers being available in the UK, work is under way "to develop a set of 'industry specific' quality standards for all forensic processes" across irrespective of provider (Rennison 2009, p. 12).

In Canada, forensic science services are provided through three government funded institutes: the Institute of Legal Medicine of Police Science, the Center of Forensic Sciences, and the Royal Canadian Mounted Police (RCMP) Regional Laboratories. More than 100 countries throughout the world have at least one laboratory facility offering forensic science services (Saferstein 2009).

A full-service forensic laboratory offers many services, and laboratory personnel can also supply expert testimony in court and provide answers to many other technical questions that may be asked of the laboratory. The various services offered include latent fingerprints, toxicology, photographic unit, firearms unit, document examination, footwear and bare foot examination. In the USA, pedal evidence concerns are usually addressed by the photographic unit of the laboratory, whose task is to use photography to capture such evidence for later evaluation. The photographic personnel can also use various techniques to enhance photographs for better visualization.

The maintenance of a close working relationship between a forensic podiatrist and laboratory personnel is very important and close communication with the podiatristwill help the laboratory staff to understand what they can do to assist. After the capture of the questioned bare footprint or footwear item, removal to a laboratory, and possible subsequent examination by a forensic scientist, this is the usually the point at which a forensic podiatrist may be asked to become involved in a case of identification involving bare footprints or footwear. In the case of bare footprints, the task is to compare a bare footprint or prints that have been present at the scene of crime with bare footprints that have been made by a known person (usually the suspect) in order to determine whether he or she is the owner of the questioned or unknown print. In the case of footwear, the task of the forensic podiatrist is usually to examine the potential for a link between the footwear item and person who is suspected of wearing that shoe.

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Chapter 2
Forensic Podiatry Principles and Human Identification

Keywords Physical evidence • Class characteristics • Individual characteristics • ACE-V

This chapter will introduce the reader to the scientific approach that is required to both comprehend and safely practice forensic podiatry. A thorough explanation of what is needed for evidential purposes, a discussion of class and individual characteristics, and a short explanation of the Bayesian approach to forming conclusions in the consideration of pedal evidence is provided. A discussion of evidence handling and the methodology that would be utilized which parallels that of other disciplines is given (including the ACE-V(R) – Analysis, Comparison, Evaluation, Verification, Reporting approach). Some basic information relative to the requirements necessary to be a credible expert witness in this field is also presented.

2.1 The Purpose of Human Identification

> In modern Society, ordinary citizens accept certain personal responsibilities. In return, society guarantees fundamental personal and civil rights. These facts constitute the major reason why every citizen must retain personal identity throughout life and beyond death (Keiser-Neilson 1980, p. 1).

The fact that identification is required within society is widely understood. The reasons why personal identity is required are, however, rarely considered in depth by the public. In the statement above, Keiser-Neilson succinctly defined the reasons why the maintenance of identity is so important throughout both life and death. In the case of death, every single body that has been discovered does at that point belong to someone missing, so in an orderly society, every human body must be identified as quickly as possible (Keiser-Neilsen 1980) to enable societal order to continue. Problems that can occur in the case of a missing person can involve the settlement of estates, the need to pay out insurance awards, ascertainment that no foul play is involved, and the need to avoid the possibility of bigamy (Reisner and Wooldridge 1977). Where the missing person supports a family and it is not known

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whether that person is alive or dead, financial burdens may be placed on the family until the individual is officially pronounced as dead. In such cases, "assumed death" can replace the death certificates, but a period up to several years can be stipulated before an application for this verdict can be made. Because of this, serious legal complications are created when a person becomes missing. By law, minimum non-physical data are recorded for everyone on birth certificates representing social identity, and death certificates are used to officially record death. These are important legal documents and until the death certificate is issued, missing persons must be considered alive and entitled to the full protection of their personal and civil rights.

Where a crime has taken place and human evidence has been left by the perpetrator, there is again a need within society to identify that person as quickly as possible. While that person is alive, they remain fully responsible for keeping their actions within the acceptable constraints defined by the society within which they live. Again, there are legal implications when the rules of society have been broken and the associated person cannot be identified. In the case of a crime scene, the requirement is to identify the perpetrator of the crime as soon as possible in order to prevent further occurrence and to allow justice to be administered.

Personal identity is formed from infinite combinations of physical and mental features, few of which in isolation can be seen as individual. In the deceased person, loss of identity may occur through the body becoming severely traumatized, being unknown, or through the process of decomposition. In the living person, loss of identity most commonly occurs in relation to crime, where the perpetrator can deliberately make attempts to hide their identity at varying levels. This can range from simply leaving the scene of crime and hoping to never be associated with the event, to being forensically aware and going to great lengths to avoid leaving any evidence of their presence at the scene and possibly destroying such evidence after the event.

To establish the identity of an unknown person, the process of person identification is used in which data of a known person is compared with that available from an unknown person – either the dead, the amnesiac, or the criminal – with a view to attempting to establish a match (identification) or mismatch (exclusion) of the unknown. When authorities are satisfied of a match, and identity is re-established, subsequent actions can, respectively, include the issuing of death certificates, rehabilitation, and the criminal conviction of the person concerned.

Personal identity is important in society and its loss through death, memory loss, or denial as in crime situations may require help from the forensic examiner to re-establish that identity.

2.2 Forensic Podiatry Practice: Principles and Definitions

2.2.1 Forensic Podiatry Is a Science

Thomas Samuel Kuhn was a science philosopher of great significance. It was Kuhn's belief that *normal science* "meant research firmly based upon one or more past scientific achievements, which within that community provides the foundation

for further practice" (Kuhn 1970, p. 10). Kuhn referred to these scientific achievements as *paradigms*, which he described as essentially a set of agreements shared by scientists about how problems are to be understood. He believed that paradigms are essential to scientific inquiry because "no natural history can be interpreted in the absence of an implicit body of theoretical and methodological belief that allows selection, evaluation, and criticism" (Kuhn 1970, pp. 16–17). A paradigm therefore guides the research efforts of scientific communities, and as such its presence most clearly identifies a field of knowledge as a science.

Following the establishment of paradigms, the formation of professional groups and their attendant activities (e.g., journals, educational programs, etc.) usually takes place, all of which are centered on those with assumed knowledge of the paradigm in question. Kuhn believed that a scientific community cannot practice its trade without such a set of received beliefs, which rigorously prepares and authorizes the student for professional practice within that science.

The knowledge utilized by podiatrists as part of their forensic practice must therefore be that component of their knowledge base, which can be described as scientific. Podiatry was formally founded under a national body in 1895 in the USA, with the first school of podiatry opening in 1911 (Weinstein 1968). In the UK, podiatry was established in 1912 (Dagnall 1987), where it then sought full professional recognition with a specialist knowledge base for many years, only in recent times managing to achieve this status. In 1983, Larkin (1983) noted that chiropodists[1] needed to prove their worth and, at the time of writing, had not developed their own science. In his doctoral study, Vernon (2000) noted that his work had revealed certain knowledge limitations among podiatrists. Professional groups have both a theoretical and a practical knowledge basis (Eraut 1994), with further tacit knowledge being developed through practical experience, where reflection on that experience is required (Fleming 1994). "Knowing how" has been previously described as the non-propositional knowledge developed by practitioners through practice and experience, some of which may be tacit (Polyani 1967). Vernon (2000) speculated that such knowledge may not have developed to the level expected among podiatrists because of the immediate effects that many podiatry interventions are known to have, which in turn may impair the level of reflection otherwise anticipated.

The knowledge available to podiatrists is therefore not only that with a scientific basis, but also that which can be described as "pre-scientific" or that concerned with everyday practice (Frolov 1984) and which in podiatry may not have developed to the level expected. Given this scenario, caution is needed in the practice of forensic podiatry in order to ensure that the knowledge used is that which is scientific and robust and not those aspects of a podiatrist's knowledge which are tacit and also may be underdeveloped.

[1]In the USA up to the mid-1950s and in the UK up to 1983, chiropody was the predominant title of the professional groups dealing with the health of the foot. The profession of podiatry developed from this basis, with both the term and practice of chiropody now fading into obsolescence.

2.2.2 Forensic Podiatry Is Science Used for Forensic Purposes

Forensic science is science used for the purposes of the law, particularly in the detection of crime and the administration of justice (House of Commons 2004–2005). In its broadest sense, the full spectrum of forensic science includes all related activities within that discipline from basic research to applied technology. The term "forensic science" therefore refers not only to the typical services offered by the main forensic science providers, such as those involving toxicology, drug and document analysis, DNA, hair, fiber, footwear, tool mark, and firearms comparisons; but also to the research that underpins the development, testing, and introduction of new forensic technology. Forensic pathology, the examination of human bodies to determine the cause and manner of death in criminal or suspicious circumstances, is also included within this definition, as is the use of fingerprints for identification purposes. In the UK, around the majority of forensic services are delivered by the scientific laboratories of the Forensic Science Services (FSS) and in the United States, through the many organizational levels of crime laboratories. Forensic podiatry is currently practiced outside this context; however, the approach must remain scientific and by definition must be used for forensic purposes.

Fundamentally, although the scientific aspects of the podiatry knowledge base are used in clinical practice, in forensic podiatry work, the context of practice and the way that science is used in forensic work are fundamentally different. For example, in clinical diagnosis, the propositional knowledge approach predominates, with scientific adjustments and excursions being required where that approach is not immediately successful. Conversely, in forensic practice, the approach must use the principles of applied science from the start, with there being no potential for "diagnostic" adjustments as the work progresses. Forensic podiatry work therefore needs to be approached cautiously due to the fact that the use of science for forensic purposes requires a different overall approach than that of clinical practice.

2.2.3 Pedal Evidence Is One Form of Physical Evidence

Physical evidence is diverse in nature and can include, for example, body fluids, fibers, fingerprints, footprints, explosive materials, and the like. This type of evidence has a number of functions as follows:

- To prove that a crime has been committed
- To provide investigative leads
- To link a crime to a suspect
- To corroborate or refute a suspects' position
- To identify a suspect
- To induce a confession from a suspect

- To exonerate the innocent
- To provide expert testimony in court (Eckert 1997, pp. 33–34)

Forensic podiatry is concerned with the identification of either the deceased, or more usually, the association of persons with scenes of crime using the podiatrist's knowledge base and expertise. There are many approaches within forensic science, which are available to identify people, using features as wide ranging as fingerprints, DNA, teeth, bone structure, and shoeprints. Many of the techniques used in the identification can be considered mainstream and are used as standard approaches because they are evidence-based, proven in practice, tested, and widely available. Occasionally, however, material available for identification relates to the expertise of the podiatrist as opposed to any other specialist and this is where the work of the forensic podiatrist is required. The forensic podiatrist may be required in the following circumstances:

1. Where there is no material available to enable any of the standard approaches to identification to be used
2. Where the standard approaches have only elicited conclusions of limited value and the investigators wish to strengthen the conclusions
3. Where more complex questions need to be addressed, which the standard approaches cannot assist with and which fall within the knowledge base of podiatrists
4. In criminal cases, where the defense position requires additional work to be undertaken in order to investigate the validity of the link between items already associated with the scene of crime and the suspect

It should therefore be understood that most forensic investigations do not require the input of podiatrists and indeed to do so may create an unnecessary tier of investigation where the evidence already presented by traditional mainstream approaches is strong and compelling. This appreciation should not, however, lessen the value of forensic podiatry input where required and indeed many examples exist in which the input of podiatrists has proven essential to the outcome of the case.

2.2.4 Criteria for Usable Physical Evidence

The physical evidence considered by podiatrists, as in other disciplines, needs to meet certain general criteria in order to be of value. These criteria are briefly considered below:

Physical evidence needs to be available: Without the availability of physical evidence, very little further can be done to identify a person. This is a factor that forensically aware criminals attempt to exploit when attempting to destroy all evidence that could link their presence to a scene of crime.

Physical evidence needs to be of reasonable quality: Even if physical evidence is present and available, this evidence will be of minimal to no value if it is not of reasonable quality. Examples of physical evidence of inadequate quality in forensic podiatry terms include footprints that have been heavily smeared through

slippage, the insoles of shoes in which the barefoot impression is unclear, and CCTV images in which the gait of the person of interest is blurred and indistinct. For this reason, one of the first tasks that should be undertaken by forensic podiatrists is that of a quality check to determine whether or not the evidence presented is usable.

Physical evidence needs to be able to express individuality: Even if physical evidence is available and of high quality, this evidence may still be of limited value if it does not express some degree of individuality. An example of this issue in podiatric terms would be the clear presence of five toes in a barefoot impression. Although the fact that the barefoot impression contains five toes may be incontrovertible, where comparison with the general population is required, this fact on its own will be of limited use as the majority of the general population exhibit this same feature.

Physical evidence ideally needs to be stable as a feature: Physical evidence can be present, of high quality, and presenting a high degree of individuality, yet still could be of limited value if that evidence is not stable. In podiatric terms, stability means that the evidence is unlikely to be altered in any way, for example, through the effects of function, external influences, and the passage of time, which may include the impact of the aging process. An example of a stable feature would be a bony deformity of the foot (e.g., a true hammer toe), which is only likely to be amended through surgery or trauma. An example of instability could include the presence of a corn, which is present because someone is wearing a poorly fitting shoe, which may later resolve when the poorly fitting footwear situation has been addressed by that person. Where instability is a factor, the evidence can still be of value, however, potentially for a shorter period of time.

The need for stability brings in complications in relation to some podiatric aspects of forensic identification. For example, it has been demonstrated that shoe outsole wear patterns are not as stable a feature as was first thought, being subject to the influence of multiple variable effects (Vernon 2000). Such features should therefore be handled cautiously in the identification process. Similarly, undertaking identification using podiatry records, where superficial skin lesions are being considered (corns, callus, pressure points, etc.), it may not be possible to state that these lesions are stable. The fact of antemortem records showing the presence or absence of such lesions does not necessarily mean that they are going to be present at a later date. This does not mean that such features cannot be used, but instead that the podiatric examiner must be aware of their limitations if stability is not guaranteed. In the forensic work of the footwear, or marks examiners, accidental characteristics of shoe outsoles are known to be virtually unique (Stone 1984) and as such, this is one of the most valuable sources of evidence in identification. Despite this, the causative shoe may need to be found quickly after the shoe impression has been left as it is possible for the accidental features that were then present to be obliterated and replaced in time by new areas of trauma and damage.

2.2.5 Class and Individual Characteristics

Physical evidence can express different levels of individuality ranging from features that a large proportion of the population can demonstrate, to features that can be considered as unique. An understanding of this fact is fundamental to the use of evidence in case work. In this sense, two different levels of physical evidence have been described – individual- and class-level characteristics.

Individual-level characteristics are features that are unique (Paulisick 1994). They have also been described as identifying, unique, random (Bodziak 2000), and accidental (Cassidy 1987) characteristics, depending on the context of use. Such characteristics are as unique as it is possible to be within the natural world. When dealing with this level of evidence, the probability of a chance match is so remote as to be considered impossible (Stone 1984). In footwear terms, examples of individual characteristics include the random cut and nick marks under the outsole, which have formed through damage as the shoe has been worn. These can then transfer to a surface through a shoe print and can be used for comparison purposes when a suspected shoe is available for examination.

Class-level characteristics have been given a number of different definitions (Bodziak 2000; Cooke 1984; Cassidy 1987; Osterberg 1967). Common to these definitions, however, is an implicit understanding that class characteristics are features that are not unique, but do instead demonstrate incontrovertible compatibility between similar items. In footwear terms, the marked size would be an example of a class-level feature. The marked size of a shoe is certainly not a unique feature, but where a shoe impression is being compared with the same make and type of shoe that has a different marked size, it can be stated with certainty that the shoe impression has not been formed by that shoe. Other examples of class characteristics in relation to footwear include the shoe style, color, make, model, fastening device, etc. Class characteristics show consistency and compatibility. They do not show uniqueness. In combination, however, class characteristics can create a picture of much stronger individuality than they would on their own as long as those characteristics are independently variable from one another. The use of class characteristics in this way involves considerations of known data (e.g., prevalence and survey data) for the class features under consideration.

It is fundamentally important to note that there is currently no evidence considered and utilized by forensic podiatrists that has been demonstrated at the individual (unique) identification level. Forensic podiatrists therefore exclusively operate at class level only. In the future, this situation may change as knowledge and understanding improve; however, such change is not anticipated in the foreseeable future.

2.2.6 Class Characteristics Differ in Evidential Value

Although forensic podiatry evidence exists exclusively at class level, the evidential weight of each item of evidence differs considerably. The presence of a condition

that is known to be present in 20% of the population, for example, would be weaker in evidential value than one present in just 0.1% of the population. In recent times, consideration has been given to a number of class characteristics that have not been proved to be unique but do nevertheless represent very high levels of individuality (Kennedy 1996), and it has been suggested that these could be considered as a type of intermediate characteristic between that of class and unique. These intermediate characteristics are, however, still formally recognized as class characteristics and should be considered as such until consensual opinion in the forensic science world is that these should be defined separately.

In the UK, Bayesian approaches to dealing with evidence have been developed. These involve the use of likelihood ratios to express the strength of an item of evidence. The statistical theories underlying this approach were developed by a team of forensic statisticians lead by Dr. Ian Evett (Cook et al. 1998; Evett et al. 1998' 2000), and these have been adopted and further developed across Europe by the European Network of Forensic Science Institutions (ENSFI) (Yetti 2006). The approach involves creating a framework of propositions, that are formed from likelihood ratio calculations. In these calculations, the proposition that a particular person has undertaken an action that has led to the transfer of evidence is compared with an alternative proposition that someone other than that individual could have undertaken that particular action resulting in the transfer of that evidence. While widely used in many areas of forensic practice, these approaches can be somewhat complicated to understand and incorrect working of the likelihood ratios can lead to erroneous results. Alternately, basic probability estimates can also be used to determine the evidential value of compared items in which the probability of independently recognized variable features occurring in the same item of evidence is considered.

The task in forensic podiatry is to identify features of podiatric relevance in the questioned and known items being compared for identification purposes. The individuality represented by these features is determined by considering population prevalence and the likelihood of all such independent variables being present within the same evidential item. At the same time, features that suggest that the evidential items do not match are also sought. This task can be addressed using Dr. Evett's approach or, alternately, by using a basic probability calculation. Whichever approach is utilized, it is essential to be comfortable with the methods adopted and the reader is directed to literature in this area, where the likelihood ratio approach is being considered (Cook et al. 1998; Evett et al. 1998, 2000).

2.2.7 Physical Evidence and the Chain of Custody

Even powerful evidence can have its value completely destroyed by not maintaining what is described as a chain of custody. At its most basic level, the chain of custody is the demonstrable care and isolation of the evidence under consideration. From seizure to court, all persons holding the item of evidence, including the podiatric examiner, must be able to demonstrate that the evidence has been free from external

influence and contamination at all times. Individual responsibility is limited to the period that the evidence is held in their possession. Maintaining the chain of custody will include the following:

- Using sealed bags to isolate the evidence under consideration
- Storing the sealed evidence bags in a safe, lockable area
- Recording with signature and personal details the names, date and time of opening, and possession of the evidence
- Working with the evidence in an appropriately clean area
- Ensuring appropriate care is given to the storage of such evidence (e.g., sealing a wet shoe in a polythene bag can lead to mold damage, and placing weights on top of a shoe to be used as the evidence in storage can interfere with podiatric considerations in relation to functional distortion of that shoe)

2.2.8 Expert Opinion Standards

In the USA, Daubert hearings are used to determine the general acceptance of reliability of expert scientific testimony in a given forensic discipline when evidence is presented (Daubert 1993). There is not yet an equivalent process in the UK, although this has recently been considered (The Law Commission 2009). The principles involved in Daubert hearings do, however, appear to be eminently sensible, especially in relation to relatively new disciplines such as forensic podiatry, where particular attention needs to be given on the reliability of the evidence presented. For this reason, forensic podiatrists undertaking case work are advised to consider their work in relation to the factors seen as pertinent to Daubert, i.e.,

- To briefly name the technique or techniques employed in the work
- To consider whether the scientific technique or theory used can be tested
- To ensure that the technique or theory has been subject to peer review and publication
- To consider the potential rate of error of the technique
- To note the standards used for controlling the operation of the technique
- To find information to support the scientific theory or method being accepted within a relevant scientific community

These considerations link to the earlier principle that forensic podiatry is a science. If the work undertaken by forensic podiatrists meets the criteria for scientific classification, it should then, by definition, also be capable of meeting the Daubert, or similar, criteria.

2.2.9 ACE-V(R) Methodology

ACE-V or ACE-V(R) simply refers to the outline process, which should be followed by forensic podiatrists in the investigation. The acronym ACE-V(R) is used to represent:

Analysis: This is the phase of work in which the evidence is assessed for both the known and unknown items that are to be compared. Here, it is important to observe, note, measure, and record what is seen using justified approaches. This assessment will also include consideration of the evidence to ensure that it is of "reasonable" quality[2] to determine if it is possible to proceed further.

Comparison: Here, comparison is made between what has been observed in both the known and unknown items. Any similarities and differences are noted between these items. These can relate to both descriptive and quantifiable aspects of the evidence under consideration.

Evaluation: Evaluation is the crux of the work and this is where the examiner must come to a conclusion as to the strength of evidence in terms of match or mismatch between the items examined. It is here that the likelihood ratio will be stated.

Verification: Verification is a quality check of the work undertaken, which is especially important as there is a subjective (opinion) element involved in reaching conclusions in forensic work. In this, a colleague with an understanding of the process involved checks through all aspects of the work and, on completion, countersigns that work to indicate that they are in agreement with the findings. As in all scientific approaches, the work should be replicable by any other competent examiner and, in effect, this is what the verification is confirming.

Reporting: The reporting (R) component of the ACE-V(R) approach refers to the need to have produced a report, which is the anticipated output on conclusion of the process. It is this report that will be tested in court, should this later be required and the examiner should be certain that all aspects of the report will bear scrutiny and challenge. The report is nearly always read out in the absence of the expert and therefore musty be clear and accurate throughout.

2.3 Expert Witness Background and Qualifications

Personal credibility is necessary for the forensic podiatrist acting as an expert witness. This fundamental principle cannot be overstated. There are two types of witness – the lay witness and the expert witness. The expert witness is someone who has knowledge and/or skills derived through education and/or experience, which qualify that individual to take a set of facts and reach conclusions not attainable by the average person (including the judge and the jury) (Siegel 2007). This expertise can be qualification-based, but can also relate to people with very specific experience in a particular area. In forensic podiatry work, the expertise is more likely to be established by both education and experience in this area of work. In court, attorneys

[2] See earlier comments under Sect. 2.2.4 noting that "physical evidence needs to be of reasonable quality."

usually take a considerable amount of time and effort to establish the credibility of an expert at the start of their questioning and it is essential that a forensic podiatrists' background justifies their presence as an expert in court. Typical factors that demonstrate the expertise required could include:

- Higher educational qualifications (PhD, master's degree) if relevant to the case work undertaken
- Postgraduate qualifications, for example, courses that provided specific training in the area of consideration
- Forensic case experience, not only the number of cases undertaken, but also the length of time that the expert has practiced in this area
- Relevant clinical podiatry experience, again in terms of patient numbers and the length of time in practice
- Experience of specialty footwear work (if relevant) including a specific interest in and focus on footwear work in practice
- Relevant research that the expert has personally been involved in
- Personal peer reviewed publications
- The number, type, and level of court presentations made
- Membership of relevant professional bodies (both podiatric and forensic)
- Distinction through award or position of esteem (if relevant)

It is important to note that credibility will only be enhanced by factors relevant to the work undertaken (e.g., possession of a PhD in the sociological history of podiatry will not demonstrate expertise in footwear examination).

These then are the most basic principles of forensic podiatry practice. Any podiatrist working in the forensic context should be familiar with these principles and adherence to these at all times should prevent any problems from being experienced during case work.

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Part II
Podiatric Forensic Concerns

Chapter 3
Photographic Techniques

Keywords Image capture • Forensic light source • Natural size • Photographic techniques • Equipment

The use of photography is essential to the forensic podiatrist and will be used to capture images of footprints, footwear, insoles (sock liners), shoe wear, the feet of those under consideration, and closer detail from any of these objects. Those undertaking this work need to become familiar with the equipment used and should be practiced in the techniques required. Consideration is given here initially to the selection of equipment for forensic podiatry use and later instruction and recommendations in relation to procedure. All of these techniques can be practiced without cost, and for the "trainee" forensic podiatrist such practice is recommended to build the skills and experience required in actual case work.

It is essential for the forensic podiatrist to have general knowledge of photographic techniques, equipment, and terminology involved to ensure the best representation of the evidence available for examination purposes. If the podiatrist is not able to do the photography themselves for any reason, then this can be performed by the crime scene unit or other knowledgeable personnel depending on the needs of the case.

3.1 Digital Camera Revolution

Photography for the forensic podiatrist has become simpler and more accessible over recent years with the digital photography revolution. Initially, only poor resolution was possible with digital cameras, which were inadequate for forensic as opposed to leisure photography; however, subsequent improvements have lead to their widespread adoption in this field. This has meant that the costs involved in digital photography have lowered considerably compared with the traditional photographic approach, and the less experienced photographer can now delete mistakes prior to committing the image to expensive photographic paper. Digital photography also allows the forensic podiatrist to practice the techniques involved without the costs of film or processing. There are various pitfalls to be aware of with digital photography, but as long as these are understood and a rigorous protocol is adopted, these should not be problematic.

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3.2 Equipment Requirements

3.2.1 Camera

The range of digital cameras available is extensive, somewhat bewildering, and subject to regular change as further technological advances are made. In this specialized area of photography, a digital single lens reflex (SLR) camera has many advantages and is the camera of choice, allowing lenses to be changed as required during use. The pixel rating is one factor to consider in relation to the quality of image that the camera is capable of producing. The pixel is a measure of the image sensor sizes of the camera – the larger the image sensor, the higher amount of image data captured by the camera (Grotta and Grotta 2004, p. 14). It has been generally considered that a camera with a megapixel rating of four or above should capture an adequate amount of data for leisure photographers, and most digital cameras now have a pixel rating considerably higher than this. In forensic work, the greater the amount of image data captured, the better; however, the data required for forensic podiatry purposes is less than that required, for example, in fingerprint analysis. This is because the podiatrist will mainly be dealing with larger objects, such as whole footprints, or shoe insoles (sock liners). In one study, it was noted that "digital cameras of 6 and 14 megapixel resolution are both acceptable substitutes for the 35 mm film" camera in most regular shoeprint cases (Blitzer 2007). The Scientific Working Group Imaging Technology of the IAI currently recommend that for photographing footwear evidence, a "Professional camera, minimum 35 mm or digital SLR with a minimum eight (8) megapixel native resolution" is required (SWGIT, 2010). Taking the more recent recommendation for into account, it is suggested that a camera of at least eight megapixels would be required in forensic podiatry work in order to match the more stringent recommendation made for forensic footwear examiners. This should allow the image to be enlarged to life-size, as required in this field of work, without pixilation occurring (pixilation being the point where the individual square pixels become visible to the eye, thereby affecting the quality of the displayed image). In addition, pixels also vary in size according to the sensor available within the camera. The sensors capable of producing larger and deeper pixels allow more light to be collected and this can provide a higher quality image with sharper detail (Grotta and Grotta 2004, p. 15). The general rule is that larger sensors produce larger pixels; therefore, a camera with a larger sensor will also be an important factor in equipment selection.

It is also equally important to consider the quality of the lens of the camera selected. In this respect, it is advisable to research the camera market carefully and seek the advice of a specialist retailer at the time of purchase.

Most digital cameras have an integral flash unit. This will not be adequate for capturing evidence-quality images in forensic podiatry work. The facility to allow the use of a more flexible flash unit will be essential; therefore, the camera must have a hot shoe to allow the attachment of an external flash unit. It will also be necessary for the camera to have a wide range of user control options as opposed to offering automatic and programmable photography only. Particularly important in this respect is the ability to manually adjust the lens to the exact focal length required.

The camera should also be equipped with a mechanism to enable the image to be captured with the camera being situated remotely from the operator, such as while fitted onto a tripod. This is to minimize the potential for movement, especially where slow shutter speeds are in operation. Two such facilities are commonly found on digital cameras. The first of these is a delayed shutter release (or self-timer), which allows the operator to compose the image and then trigger the delay feature, which releases the shutter a short period of time. The second such mechanism is that of a remote control handset that allows the operator to directly control the shutter release away from the camera. This remote-controlled operation can be through a wired or wireless connection with the camera. Ideally, both features should be available on the chosen camera. In practice, the delayed shutter release option can take up a considerable amount of additional time during the working day. A delay function of 12 s takes approximately 20 s to set up and operate. If 180 images are captured during the working day, the use of the delay feature adds an additional 36 min of time to the overall operation. Conversely, a remote function can be used almost instantaneously. Both methods will, however, produce equally good results. The use of camera delay will not require the additional expense of a remote; however, use of a remote is the option of preference because of the improved efficiencies associated with this device.

It is recommended that the camera itself be equipped with either a spot meter, or exposure compensation facility. The spot meter is a camera function in which the metering for each shot is taken from a defined "spot" in the center of the frame, irrespective of the metering value of the surrounding detail. This allows the exposure to optimally bring out important detail for later analysis under certain circumstances, particularly where extremes of light and dark are present within the image being photographed. In the absence of a spot meter, the exposure can be compensated for through the camera's compensation adjustment, which is present on most digital cameras. Alternately, the exposure can be adjusted later using digital imaging software. However, if this can be accounted for at source through the use of a spot meter or compensation adjustment the stages involved in producing evidence-quality images will be reduced and time saved accordingly.

Some thought should also be given to the quality of camera construction. In professional use, the camera will be subjected to a hard life and it is important that the camera is robust and strong enough to cope with a relatively high degree of trauma. It is also recommended that the camera be of a professional appearance. Even if the camera has a technical specification that matches those recommended, the use of bargain equipment that appears to lend itself well to a holiday snapshot scenario will not enhance professional standing, and, should a case reach court presentation stage, could provide a legal representative with ammunition to attack personal credibility. It is also recommended that a second or even a third camera is available as "back-up" should there be technical problems with the primary equipment, and such equipment should also meet the recommended specifications. All cameras used should have spare power sources, which could include a second battery pack and an electric or alternating current (A/C) adaptor where available.

Digital cameras store data on memory cards with various formats being available. When taking forensic-quality images, the camera will be used on its highest quality image setting, which in turn will occupy more of the card memory than regular default settings. Additionally, a large number of images may be required when working a case. The card used in the camera should therefore be of the largest capacity possible. At the time of writing, cards of up to 2 gigabyte (GB) capacity are readily available in most formats and up to 32 GB in some formats, although not all digital cameras are capable of taking the larger capacity cards. If in doubt, this should be checked with the retailer or manufacturer. Spare cards should be carried both for additional capacity and also in case there is technical failure of a card. It is recommended that one has the capacity to take at least 200 examination-quality photographs when attending a typical case, although capturing more than 100 images would not be frequently required, with 60–100 images being more typical. For practical purposes, it is recommended that the "back-up" camera equipment shares a common digital memory card format to the primary camera.

The focal length of the camera lens is critical in forensic podiatry work. In digital cameras the focal length is the distance between the surface of the lens and the camera image sensor, which is measured in millimeters. As the focal length changes, the angle of view will change, too. A 50-mm lens is generally considered to represent the same angle of view as that of the human eye, with lenses of a longer focal length "producing telephoto effects and lenses with shorter focal lengths producing wide-angle distortion" (Stagg 2005, p. 14). This setting is required for photography in forensic podiatry. Where markedly different focal length settings are used, this can create changes in perspective, which affect scale and compromise the quality of the photographic evidence. As digital cameras often have an adjustable focal length, the camera selected should be capable of adjustment over a range that covers the 50-mm focal length. There is, however, an important point to note in relation to digital cameras. Because digital cameras function differently from traditional film cameras, the given focal length of the digital camera will differ from that of the film camera. This means that a digital camera set at a focal length of 50 mm will not necessarily have the same focal length as the film camera. For this reason, digital camera manufacturers will give a focal length multiplier or crop factor value for their camera. This is a number by which the focal length of the digital camera can be multiplied to show how it would be functioning in terms of focal length, if it were a film camera. For example, if a digital camera has a focal length multiplier of 1.6 and is set at a focal length of 50 mm, this camera will be functioning as a film camera with a focal length of 80 mm. Given that the camera is required to be set around a true focal length of 50 mm, it is important to consider this when taking the image. Some digital cameras, however, do not require such a calculation to be carried out – the so called full frame digital SLR cameras. When the camera is purchased, it is essential to know what the focal length multiplier is for that particular camera so that the proper lens can be obtained and used on the correct setting, allowing the camera to be operated correctly in the context of evidence-quality image capture. It is clearly advantageous to have a camera that does not require such multiplication to be carried out.

When film cameras were used for forensic photography, it was generally recommended that a camera with detachable lenses be used (Bodziak 2000). As digital photography has developed, and considering the less comprehensive photographic requirements of the forensic podiatrist, a fixed-lens digital camera with the right specifications should be adequate.

Some digital cameras allow the viewfinder screen to be adjusted to various angles for operation. While not essential, such adjustability can be useful when the camera is being used on a vertical support, allowing the operator to gain a clear view of the image without unnecessary contortion, or the use of step ladders being required.

Previous recommendations from the days of film-based photography advised that manual focusing should be possible on the camera selected for evidence photography (Bodziak 2000). A wide range of flexibility is required of the camera used in forensic podiatry photography in order for the camera to cope with different conditions of lighting, varying degrees of evidence clarity, and varying wear impression topography. The camera used should therefore have functions in addition to automatic or program-based use to enable the operator to deal with these variables through manual adjustment. Such functions should including manual override, the ability to switch off the flash function, and aperture priority selection.

3.2.2 Camera Support

In forensic podiatry evidence photography, the use of an appropriate support for the camera is as important as the camera itself. Two different forms of support will be needed – the copy stand and tripod. Each will be required for used in different working situations.

3.2.3 Copy Stand

The copy stand is an item of equipment used widely by amateur and professional photographers alike. A copy stand is a heavy-based unit with a calibrated vertical sliding mount upon which a camera is mounted (Fig. 3.1). The camera is attached to the mount and used to take photographs of an object placed on the stand base unit. The base unit will typically be of a neutral color in order to reduce the potential for interference of the exposure of the image of interest. The stand is also used in conjunction with adjustable side lighting units, and many are sold with such lighting units being integrated into the product. The copy stand is the support of preference for the capture and handling of evidence photography in the typical laboratory or workbench situation. Its advantages are those of providing a robust, vibration-free platform, adjustability, and minimal potential for error when setting up the work to be photographed. It also allows the use of integral and well-placed

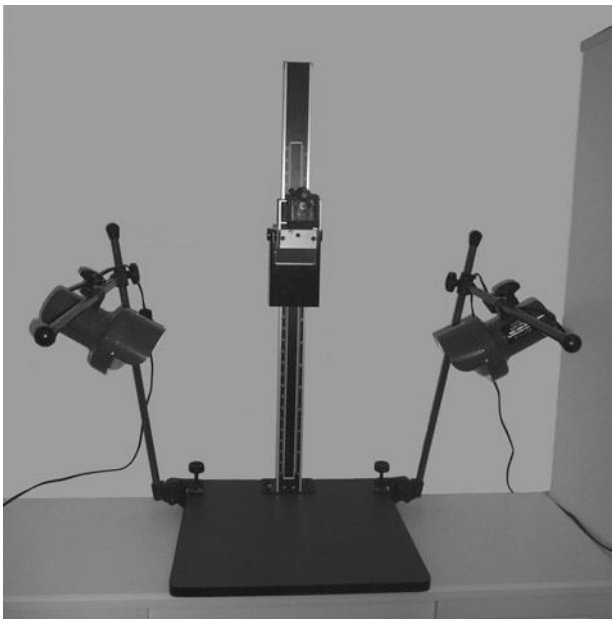

Fig. 3.1 Copy stand

lighting. Such devices are, however, not easily transported to other sites for evidence examination, such as may often be required in case work scenarios. Where the evidence can be brought to one's own workplace for bench examination, however, the copy stand is ideal.

3.2.4 Tripod

Tripods have one major advantage over the copy stand in that they are designed to be portable. This means that in forensic podiatry use, they can be transported and used in any situation and, although more adjustment variables are introduced with the tripod, which may not be as robust as the copy stand, the tripod's greater flexibility means that in practice it will invariably have more overall case use. There are a multitude of tripods on the market, however, many are unsuitable for the capture of forensic podiatry evidence. The tripod selected should be robust. It is also highly advantageous for the tripod to have a facility for suspending the camera between its legs. This will allow vertical image capture from directly overhead the evidence under consideration without the legs of the tripod coming into the frame (Fig. 3.2). It is also useful for the tripod to be used in conjunction with a fast camera release mechanism, as the camera may be required to take different images of specific evidence items in different situations during the case work. Some tripods are available with such fast release mechanisms integrated into their design. In other cases, fast release mechanisms can be purchased separately as an aftermarket

Fig. 3.2 Tripod

accessory. Where such mechanisms are used by the operator, care should be taken to ensure that these are of the same type across all of the individual operator's equipment, as the formats differ. Neglecting to consider this could this could prevent the ability to attach the camera to some of the supports being used. A small coin or stubby screwdriver with a wide head will be required to connect and disconnect these accessories according to need.

3.2.5 Lighting

The ability to set up and use a wide range of lighting variables is essential. In practice, flash may not usually be required by the forensic podiatrist, although alternative lighting arrangements certainly will. The camera operator will usually need to set up various external lighting sources in order to optimize the detail shown in the evidence being considered. While two-dimensional image capture (e.g., inked footprints) are relatively simple to photograph, taking evidence-quality photographs of three-dimensional images, such as shoe insoles (sock liners), is a more complicated matter. The objective in this case is to capture detailed images of the impressions caused by the foot, and these impressions may be very shallow or faint in appearance. Contrast therefore

needs to be optimized. Here, the ability to adjust lighting conditions to define borders and, through the manipulation of lighting and shadows, bring out the minor color changes associated with staining is fundamental. The lighting equipment selected should be capable of a wide range of adjustment in respect of the light type, color, and angle of light to the image being captured.

3.2.6 Flash

While flash may not necessarily be required in the photography required in forensic podiatry, where its use is indicated, the integral flash units of a digital camera are inadequate as stated earlier. This is because such integral flash units cannot be adjusted to alter the angle of light to the object being captured. For this reason, where flash is required, a separate flash unit of good quality with a bounce facility to allow the flash head to be angled and light from the unit to be reflected from another surface will be needed. It can also be advantageous for the flash unit to function off the camera through, for example, the use of a dedicated bracket and off shoe camera cord. The flash unit should also be compatible with the digital camera used. This may be more critical for digital cameras as opposed to nondigital cameras, as some manufacturers warn of the potential for damage to the camera when an inappropriate unit is used. If in doubt, care should be taken to follow the manufacturer's recommendation. It may also be helpful to obtain a slave flash unit with connection lead for use with a second flash situated off the camera. The slave unit is a flash-sensitive attachment that will set off a second flash at the same time as the primary flash. This can allow experimentation with lighting angles when attempting to optimize the image detail.

3.2.7 External Lighting

In practice, the forensic podiatrist will rely on external lighting far more than flash photography to capture the images required in this type of work. In its most basic form, this can mean the simple use of oblique natural light, in which the object to be photographed is positioned in such a way as to be illuminated by natural light entering from the side (Fig. 3.3). More sophisticated lighting conditions will, however, usually be required. In the workbench situation, where copy stands are in use, these stands often have integral lighting sources situated at either side of the object to be photographed, allowing angles of lighting to be adjusted to bring out the detail required. The ideal position is determined through adjustment, while observing the image through the camera's view screen, and such adjustment may involve either one or both side lights and from an infinite range of angle variations.

When working away from the workbench using a tripod-based approach, there are often practical difficulties in transporting copy-stand-based lighting equipment to a field site. In this case, a cost-effective and portable alternative can be used in

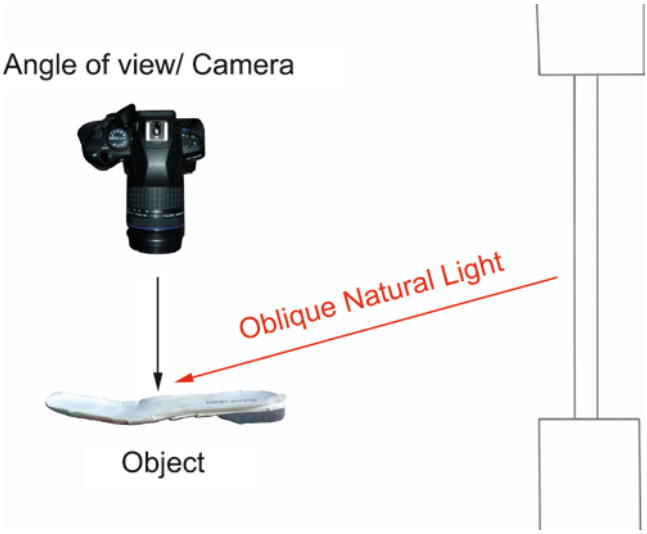

Fig. 3.3 Oblique natural lighting conditions

the form of two adjustable table lamps, one placed on either side of the image. Such lamps allow side lighting to be introduced in the same way as on the copy stand, and again this allows a wide range of adjustment to optimize the image to be captured. Such lights are not as powerful as the dedicated copy stand alternatives and may not be as robust in construction; however, they can produce acceptable results and are usually preferable to, and less limited than, the flash alternative.

3.2.8 Forensic Light Sources

Forensic light sources are used widely in identification work to bring out images that may not be readily apparent to the naked eye. The use of such equipment has proven value in highlighting very faint footprint images that may be present on shoe insoles or sock liners. These light sources consist of powerful adjustable lamps that cover a wide range of wavelengths within the ultraviolet, visible, and infrared spectrums.

These light sources can be so powerful that safety features may be required to protect the operator from eye damage. Most are also very expensive and as such may be out of reach of most independently operating forensic podiatrists. More cost-effective alternatives are now available in the form of LED light sources, which are available to cover a wide range of the light spectrum. These alternatives are gradually gaining in popularity and, while not having the adjustability of the traditional forensic light sources, are available in a range of wavelengths, covering a wide portion of the light spectrum. The task of such light sources is to optimize contrast in order to optimally show the detail required

in later analysis, and experimentation will be required in every case to find the most appropriate combination of lighting and lighting position. In using a specialized light source, filters are also essential. These include filters are on the camera to allow the optimal image to be captured. Such filters are also worn as eye goggles to prevent damage to the eyes and to allow the operator to view the image in precisely the same way as that being captured by the filtered camera.

3.2.9 Accessory Equipment

Various items of accessory equipment will be required in the task of evidence-quality image capture. These cover the processes involved in preparation, providing essential detail within the image and in the general support of the process.

3.3 Preparing for Image Capture

In preparing the setting for evidence-quality image capture of an object, it will not be enough to simply place the camera on a support over the object to be photographed with adequate lighting. The camera will need to be aligned in the same plane as the object to be photographed and, as such, a small accurate spirit (bubble) level will be required. Dedicated photographic spirit levels are available that fit into the hot shoe of a camera, and these are ideal for the purpose. The use of two such levels is recommended, so that one can be mounted on the camera, while the other can be used simultaneously to verify the level of the surface on which the photographed object has been placed. It is advisable to check that both levels are functioning to the same degree of accuracy prior to their use.

In setting up the image, an often-overlooked but vital accessory is that of the electric extension cord and A/C adapter. An electricity supply may be required for lighting or to directly power the camera using a electrical (line power) connection and invariably, the work area may be too distant from an electrical source. A cable reel extension lead is then essential. This should be at least 5 m long and should have the ability to connect two or more electrical items simultaneously. In case one is required to work abroad, a selection of electric adapters for international usage should also be kept.

It is also important to keep spare batteries or alternative power sources for all electrically powered items. Here, a spare camera battery and alternative electrical connection should be obtained, along with batteries for the flash unit and a flashlight (torch). Rechargeable batteries can be useful as they can prove more cost-effective in the long term; however, these tend to lose their charge before long-life non-rechargeable batteries. For this reason, a selection of both rechargeable and long-life non-rechargeable batteries should be kept.

Essential detail within the image. Each object to be photographed should be carefully labeled with an identifying code, description, and date of image capture. A labeling method will therefore be required and, while dedicated pro forma labels can be purchased, it is acceptable for the operator to create his/her own labels using card stock and marker pens. It is desirable to have a range of label options, including different size card stock and adhesive and nonadhesive labeling options to suit a wide range of working situations. A range of colors is recommended for the marker pens to assist in differentiating separate sequences or categories of image.

Evidence-quality images should always include a size scale. While any known object (e.g., a coin, paper clip, business card, etc.) placed into the image could serve as a scale (Hilderbrand 1999, p. 44), this is not best practice and a dedicated measurement scale should preferably be used within the image. Whatever scale is used, the same scale should be retained for later re-examination of the work. While simple rulers of varying types have been used as scales in such photographs, variations can occur between such rulers and a high-quality dedicated scale is recommended instead. The ideal scale for use in evidence-quality photography is the Bureau Reference Scale (Fig. 3.4), which was developed in the USA by FBI-based footwear examiners for this specific purpose. The Bureau Reference Scale is L-shaped with a 30-cm long side and 15-cm short side. One side of the scale is dark and one is light, allowing flexibility according to lighting conditions. Both sides are nonreflective and the construction contains alternate black and white bars that can assist in reading the scale, where over- or underexposure has been necessary to produce a correct exposure of the object of interest. Crosshair circles are also present on the scale, which can be used to verify perspective and assist in correction, where errors affecting perspective have occurred. As a reference scale, manufacturing is to FBI specifications, which provide a more standardized product. When purchased, a shorter separate 15-cm straight scale is often provided with the large L-shaped

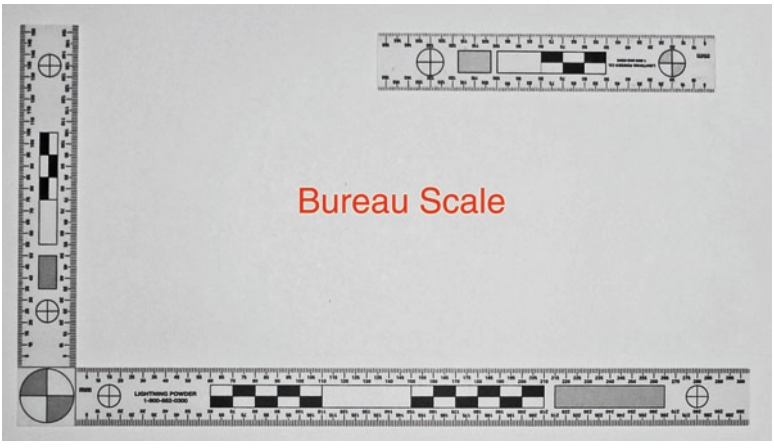

Fig. 3.4 Bureau scale

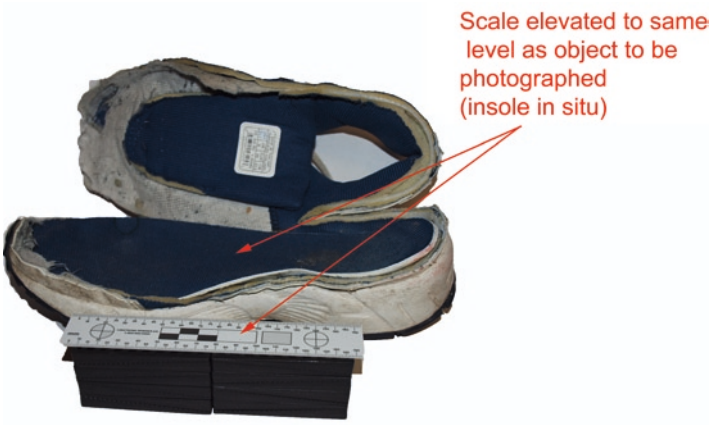

Fig. 3.5 Same level placement of scale as the object to be photographed

scale, and this can be used elsewhere in the image to facilitate easier scale checking. The Bureau Reference Scales are the "gold standard" scale for use in evidence-quality photography and their presence is recommended within every image taken for forensic podiatry purposes.

When photographing images with a scale incorporated into the frame, it is essential for the scale to be placed on the same plane as the detail of the object being photographed. Failure to take this precaution can create misleading impressions of the dimensions of the object being examined. In this sense, it may sometimes be necessary to elevate the scale. This can be achieved very simply through the use of wedges, or alternately, piles of coins placed underneath the scale until the correct height is achieved (Fig. 3.5).

It may sometimes be necessary to indicate the angle of lighting within the image for reference purposes, should there be a need to replicate the conditions for later comparison. This can be achieved through the use of a simple golf tee placed upside down (point upwards) within the frame. Any accompanying shadow will indicate the angle of light for future reference (Hilderbrand 1999, p. 45).

Another item of recommended equipment, is a good flashlight (torch), which can be useful in setting up the equipment in potentially dark areas. The beam from the flashlight can also be shone onto the object to be photographed at various angles, which can give an indication of the optimal position for placing any light source to be used when capturing the image.

A selection of backgrounds for the object being captured will be required. A plain dark green cloth is suitable for some images and can be easily transported from site to site. Dark and light cardstock in both A3 (tabloid) and A2 (poster) sizes are also useful, and, while not as portable as cloth, provide a cheap and stable background that can easily be set up. With these backgrounds, it is also recommended to include masking and electrical tape and a pressure adhesive (e.g., Blu Tack), so that the operator can secure objects for photography as required. A white board at

least 50 cm square is also useful to reflect light onto the object to be captured, to vary and optimize the lighting conditions.

3.4 General Support of the Process

3.4.1 Hardware

Digital photography requires a computer system for the captured images to be saved, managed, and printed out for assessment and comparison purposes. Most modern personal computers are capable of managing the images required in forensic podiatry work. As such, work is with graphics images with higher memory demands than those of text processing; it is recommended that careful research is undertaken before purchasing a system for this purpose. Greater RAM memory and faster processors will enable the operator to complete the work with less frustration as the images are managed, saved, and printed, while a large internal memory will allow the large number of high-resolution images that will need to be stored to be held on that computer. While desktop personal computers tend to have greater power and work capability, there can also be value in using the more portable laptop or notebook computers, which can be carried to the preferred site of use. A computer should therefore be selected that is capable of superior power and performance in terms of image management. Whatever system is used, care should be taken to ensure that it is secure from tampering or theft, and laptop/notebook computers are particularly vulnerable in this respect. The computer and any linked data storage devices should be password protected, have up to date virus protection, and be physically secured when not in the possession of the operator (e.g., locked away and/or secured with a security cable, etc). It is also being recommended that the computer used for this purpose is only connected to the internet for virus protection and other essential software updates. All captured images placed on the computer should be backed-up at least once and, here, the large memory external hard drives are ideal. The back-up device should be subjected to the same security measures as the primary computer involved. The images can also be archived to CD or DVD media, but again with adequate security measures being taken.

3.4.2 Printer

The printer required for forensic purposes should be capable of printing out full-size foot, insole, and shoeprint images for examination and comparison. The widely available A4 printers are not adequate for this purpose, with some shoe prints being too large to fit completely on A4 sized paper when printed out. An A3 (tabloid size) printer will therefore be required and this should be of graphics-quality. While an inkjet printer is capable of printing high-quality images, if the printer is not used

regularly, there is a potential problem of expensive ink cartridges drying out causing inconvenience, delay, and potentially high running costs. A laser printer will not dry out in between usage (and is therefore likely to incur much lower running costs) and is capable of much faster graphics printing than the inkjet alternative; however, this type of printer will have a lower resolution than the inkjet option.

3.4.3 Software

Digital photography also relies on appropriate software to manage and produce the image that has been captured. Most digital cameras are purchased with their own dedicated software, which is quite adequate for the process of taking basic digital images, downloading these to computer, processing, enhancing, and printing these images. Most of these dedicated software packages do not, however, have the varied functions required to manage and print out images for forensic podiatry evidence purposes. Adobe produces reasonably priced software packages that are ideal for this purpose. One such example is the popular Adobe Photoshop. This program will allow the image to be downloaded, saved, and printed out life-size by the operator, which will enable meaningful comparison of known and unknown images. While Adobe makes a range of digital image processing software, some of the programs are expensive. The more basic programs are considerably cheaper and contain all the functions required for forensic podiatry purposes. An alternative is the GIMP software (GNU Image Manipulation Program), which can be downloaded for free from the GIMP website (www.gimp.org) and has a wide range of image management facilities. The Adobe Photoshop programs are widely regarded as the industry standard.

3.5 Digital Image Capture Techniques

The techniques of digital image capture the forensic podiatrist will need to employ differ from those of the conventional leisure photographer. There are, however, some common considerations, such as immobilizing the camera, framing, image quality, focus, and lighting, although in a different context. Here, a step-by-step guide is presented to lead the examiner through the process of basic evidence-quality digital image capture for forensic podiatry purposes.

3.5.1 Equipment Selection

Firstly, the task in hand should be considered, particularly the issues of what needs be photographed and where. From the equipment requirements stated above, equipment should be selected according to the circumstances of the case. Here, the type of stand and lighting will be considered with issues of portability in mind. While

the camera and various other items (including scale) will always be necessary, the other accessory equipment should be considered and selected as required. Here, it is advisable to prepare a checklist of the requirements for each case.

3.5.2 Equipment Inspection

Having selected the equipment, each item should be carefully examined to verify that it is in working order. Test shots should be taken with the camera using all memory cards to be used and immediately deleted. The camera, flash unit back-up cameras, and all other rechargeable electrical items should be fully charged. Non-rechargeable batteries should be unused and within their shelf life and the electrical extension cord tested by use. The lighting source to be used should be inspected carefully to verify that all bulbs are in working order and, if transportation is required, these should then be packed carefully to prevent breakage. Marker pens to be used for frame labeling should be tested to ensure that these have not dried out since their previous use. In relation to the camera support, where an optional quick release mechanism has been obtained, this mechanism and any adapters for the camera base should be in place to ensure compatibility of the attachments.

3.5.3 Equipment Set Up

At the site where the evidence is to be considered, a clean private area should be sought, with access to an electricity supply and preferably a sturdy table. The electric supply should be within range of the electric extension cord and there should be space to store equipment where it will not be in the way. The camera support is then considered. If in the office setting, this is likely to be the copy stand. If away from the workbench, the tripod for use will be selected, opened, adjusted to the approximate height required, and placed into position. The lighting to be used should also be placed into the approximate position required.

Having selected the working area and support, the object (evidence) to be photographed is selected and the appropriate background considered for the image. In considering the appropriate background, the forensic podiatrist should attempt to provide some contrast between the object and background, to allow the outline of the image to be clearly defined. At the same time, however, extreme contrast should be avoided between the object and background (a very dark object being placed over a white background and vice versa). Such a mismatch may lead to lost detail through the effect of these extreme contrasts on exposure. If a copy stand is being used, the copy stand base itself may present an appropriately plain and moderately contrasting background and may not require covering with an alternative background material.

The camera is then mounted securely onto the support. If the viewing screen of the camera is capable of adjustment, it is at this stage that the screen is tilted into

its optimal position for ease of operation. Checks are then made on the camera mounting, commencing with the security of the camera on this mount. The camera should be set at the 50 mm lens position (or its equivalent if a focal length multiplier is required) and the camera should be set at the approximate height required in order to fill the frame with the object to be photographed. A check should be made to ensure that there are no cords, straps, or lens caps dangling from the camera, where they would interfere with the image. The level of the camera is then matched with the level of the base upon which the object of interest will be placed. The important factor here is that the images are on the same plane as problems with scale will occur if either the camera or bases are set at different levels.

The object to be captured is then placed onto the chosen background in a central position, where it is checked for security. If the image to be photographed is a two-dimension footprint, this may be secured carefully with tape, while ensuring that the tape is not placed over the object to be captured and that it will not damage the evidence under consideration. If the object is three-dimensional (e.g., an insole or footwear item), then the object should have enough inherent stability to remain in place on its own accord.

The bureau scale and additional second scale, if required, are then placed neatly by the side of the object, close enough to be seen in a cropped version of the image, yet not so close as to obscure any detail (Fig. 3.6). If the detail to be captured is elevated above the background base, then the scale will at this stage need to be elevated using stacks of coins or wedges so that it sits in the same plane as the detail of interest. A label is created and placed in an appropriate position by the side of the object. It is essential that neither scale nor labels used are placed over any aspect of the object as this will inevitably lead to later problems, when the image is being evaluated. At this stage, the camera should be switched on and the image checked in the viewfinder. The object, scale, and label should fill the screen, although care should be taken to ensure that no detail has been lost through the object being situated too close to the borders of the frame. If necessary, the camera should be raised or lowered slightly on its support until a satisfactory framed image is shown.

At this stage, the lighting should be considered. If the object is two-dimensional, this should be straightforward; if the object is three-dimensional, some experimentation will be required. While observing the object through the viewfinder, one can shine a flashlight around the object. This will give an indication of the best lighting angle to capture the image detail required. Experimentation should also consider the effects of reflected light, using a white reflecting board to direct the light source to the optimal angle for the detail required to be shown. This may be especially useful in situations where flash photography is preferred. The lighting set at the angle required is then switched on in preparation for the image capture. If using a forensic light source (FLS), the required protective goggles should be selected and worn and any associated filters placed on the camera prior to use. Where filters are placed on the camera, the level should be carefully checked again, to ensure that this has not been disturbed, with any remedial adjustments to level being made as necessary.

Fig. 3.6 Bureau scale positioning

Having determined the required lighting angles, unless the lighting preparation work has suggested that flash photography is a preferable option (which may be an infrequent preference), the automatic flash mode of the camera should be switched off to ensure that the built-in flash will not operate. Until you become experienced and confident it is recommended that the camera is set to automatic. This will ensure that when the appropriate lighting adjustments have been made, the exposure will be correct for the image to be captured. If color images are to be used, care should be taken to match the white balance settings of the camera with the light source in use. In professional photography, there is a concept of color temperature and different light sources will exhibit a different range of temperatures, which in turn can affect the color of the image captured. Digital cameras of the quality required will have a facility to allow the white balance to be changed in order to compensate for the color temperature conditions experienced. For example, domestic light bulbs are usually tungsten and, without compensation, the color will take on a more golden yellow overall appearance than that observed. If such adjustment is not possible on the camera being used, this can be compensated for later, with the photo software package, however, it is better to deal with this at source. The camera

should also be placed on its highest resolution setting and the image should be captured either in TIFF, or RAW format, not JPEG. This is because, unlike JPEG, TIFF and RAW are lossless formats. This means that every time a JPEG file is opened, some detail will be lost through the way in which this format operates, while this is not the case with TIFF, or RAW. Of the two formats, TIFF and RAW, TIFF is often preferable, because with RAW, there can be compatibility issues between different manufacturing systems, which may be problematic at a later stage.

If the camera has the facility to adjust the focusing area, this should now be placed on its widest setting. At this stage, if the spot meter is to be used, this function should be selected on the camera, the focus should be checked, and the remote function or timer delay should be set in final preparation for the image capture, which can then proceed. The first image taken should be checked carefully to ensure that this is of the required quality. This can be done on some cameras by using the zoom function, to gain a close up view of known detail within the captured image (e.g., a section of bureau scale), to check for pin-sharp focusing. If this facility is not available, then the image should be immediately downloaded onto a laptop computer, where quality can be checked using digital image software. Once satisfied that the image is going to be of the required quality, it is recommended that several images are taken with varying lighting conditions and that each image is protected on the camera immediately, using the camera image protection function, which will prevent accidental deletion.

3.5.4 Image Management

When the images to be used in a case have been photographed, they must then be stored safely and securely, on a suitable computer, again using TIFF or RAW formats and prepared for printing out to scale. Although the images should have been protected on the camera, at the first available opportunity, this protection should be temporarily removed and all images downloaded (usually by USB connection) onto a computer. Due to the sensitive nature of case evidence, the computer should be password protected with security measures applied at all times, to prevent unauthorized access and guard against theft. As multiple images may be involved, it is important to manage these very carefully from the start, with suitably named and categorized files related to the case being prepared and the images being logically and clearly named and copied into these files accordingly. Each image should be examined and any of poor quality should not be deleted but transferred to a nonworking file, where they can still be accessed should they be required in the future. The software cropping function can be used to “trim” the edges of each image, in order to improve its appearance, however, care should be taken here not to accidentally remove any aspect of the object to be examined, or leave any aspect of the object too close to the borders of the photograph. In the same way, care

should also be taken to avoid accidental removal of detail shown in the scale used within the image as this is essential to demonstrate the true size of the object and allow that object to be printed out life-size. It is recommended that, before cropping, all original photographs are kept without amendment and the cropped image "saved as" a copy. The copy can then be worked on, while all original images are present and can be returned to later in case of error.

When the images of the detail quality required have been selected, the next task is to consider whether color or black-and-white images are preferred. The image management software should allow the color to be changed to black-and-white and, where color images are preferred, will allow color and contrast to be enhanced by slight adjustment. It is important to note that at all stages of image management, contemporaneous notes must be kept. Digital images are potentially prone to challenges that the images may have been manipulated and in doing so that the information present in these images may have been corrupted. If notes are kept of each stage of the image management, then these are available if required to show exactly what has taken place, to allow others to replicate and verify that work if required, and to refute accusations of inappropriate or erroneous manipulation. Adobe Elements and Photoshop is capable of collecting audit data to show exactly how and when any changes to the image were made and, in addition to note taking, this information can be printed out and kept with the case file as evidence of the image management procedures performed. The color hue, saturation, brightness, and contrast adjustment functions of the software can all be adjusted slightly to optimize the detail required within the image presented on screen. If the image is clear enough without such adjustment, then the recommendation is to work without adjustment, if possible.

One of the most important needs is to be able to print out the image showing the object as life-size. At this stage the scale used within the image becomes essential. The instructions given for this task are based on the basic Adobe Elements and Photoshop program. Adobe Elements and Photoshop are regularly updated, but the principles apply to later versions, or any other software selected for this purpose.

- Open the required image file.
- Move the image visible on the screen to show the horizontal and vertical aspects of the scale clearly.
- Use the layer function to flatten the image – in effect, placing all layers that may be present together.
- Place a grid on the screen by selection the View/Grid function.
- Use the Image/Rotate/Free Rotate layer function to rotate the image and align vertical aspect of the scale perfectly with the corresponding aspect of the grid.
- Remove the grid by deselecting the View/Grid function.
- Magnify the image so that a given length of the scale within the image (e.g., 10 cm) extends from top to bottom of the computer screen.
- Ensure that the Info Tab is selected.
- Select the rectangular Marquee Tool and use the cursor to carefully create a box with one line of this box being placed along the scale within the image to a defined length (e.g., 10 cm).

- The Info Tab will now show the length of the length of the line that has been placed along the scale in millimeters. This information is the length that line will be when the image is printed out.
- Calculate the percentage difference between the image sizes shown at that stage, with that of the life-size image required (divide image length selected on the scale by the image length shown for the line drawn along that scale and multiply by 100).
- From the top menu select Image/Resize/Image Size.
- The display will show the document width and length to be printed out in centimeters (cm).
- Click on the arrow to the right of the width display and select document width and length as percentage values. This will present the document width as 100%.
- Ensure that the Constrain Proportions box is checked.
- Enter the percentage value as calculated above into the document length box.
- Click OK.
- Repeat the measurement using the Rectangular Marquee tool as described above. The measurement shown in the Info tab should now match that indicated by the defined length of the line placed along the scale.
- If a minor variation is shown, repeat the procedure more accurately.
- When the vertical width has been matched to life-size in this way, check the horizontal dimension of the scale in the same way. This should match (or very closely match within 0.05%). If any significant discrepancy is shown, there may have been a problem with alignment at the image capture stage. If this occurs and it is not possible to retake the image, it is best dealt with through professional assistance via a digital photo laboratory unless the photographer has personal extensive knowledge of the software required to adjust such images. Again, notes should be taken of the work required to adjust the image in this way, should this be questioned later (Fig. 3.7).

When the image size has been set to life-size, the image can be cropped as necessary, to improve the clarity of the presented image, by removing extraneous peripheral detail. It is important, however, to retain not only the full outline of the object to be considered but also the scale and label used in the digital photograph. After cropping, the image should be printed out using an A3 (tabloid) color graphics printer onto the photographic paper recommended for use with that printer. Care will be required at this stage to adjust the printed settings to those required for photographic paper of the type used. Failure to follow this final step could lead to image problems at this printing stage. It is also advisable to use the print preview function as a final check that the image will fit successfully on the selected paper size and by previewing the image to be printed; this will provide final confirmation that no major errors of scale have occurred when adjusting the image to life-size. When the image has successfully printed out, a final manual check should be made of the scale within the image using the very same scale present within that image. If all stages above have been followed, this should be perfectly matched and the image is ready for comparison and evaluation.

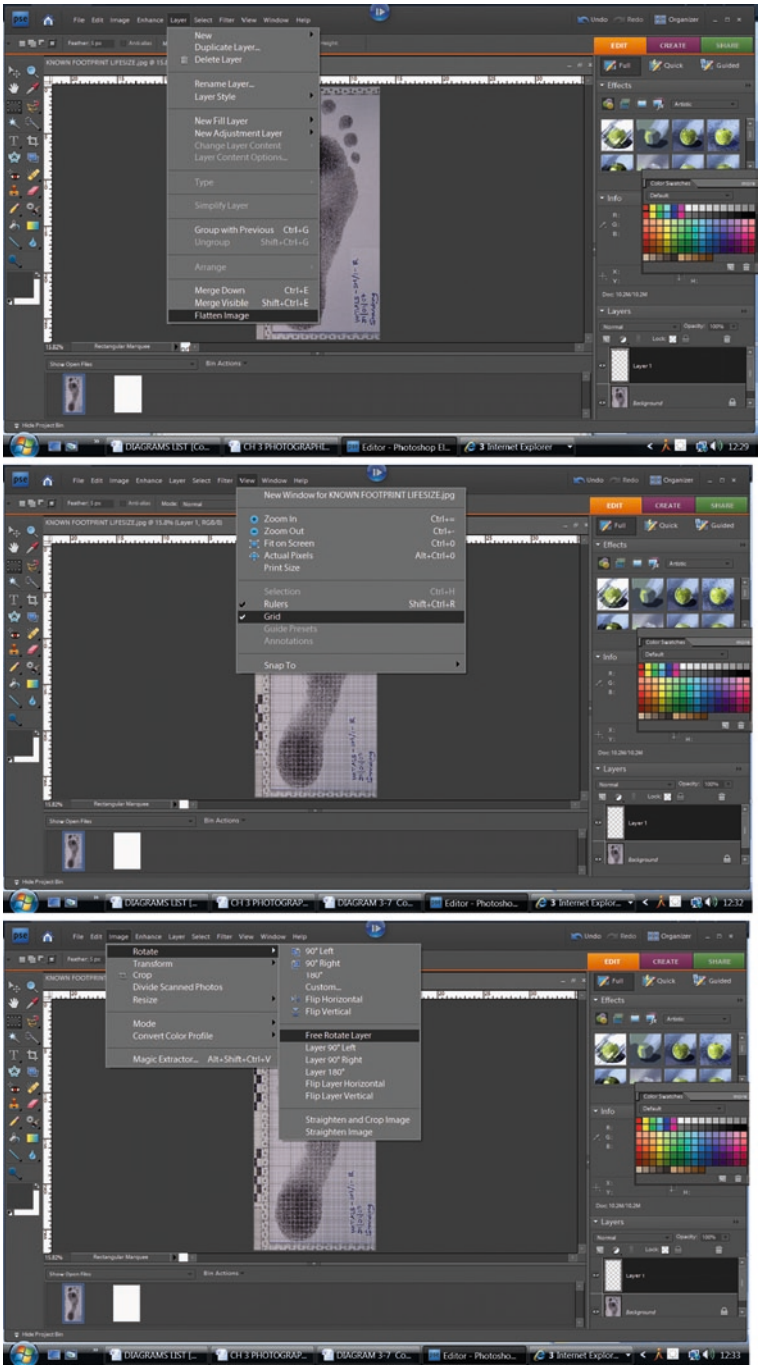

Fig. 3.7 Conversion of the photograph to natural (life) size

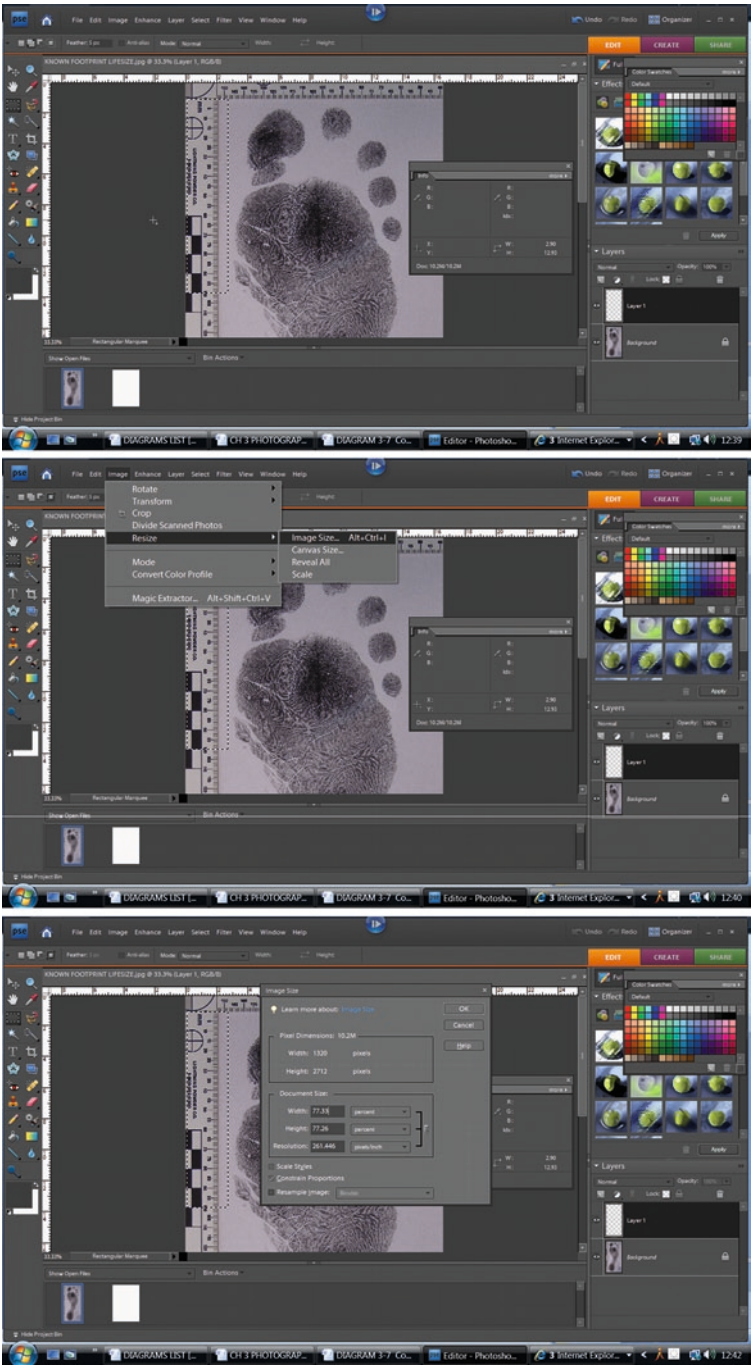

Fig. 3.7 (continued)

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Chapter 4
Bare Footprint[1] Identification

Keywords Known/unknown • Exemplars • Biomechanics • Bare footprints • Comparisons

This chapter commences with a brief history of the use of bare footprints in identification – in areas in which several disciplines can have involvement – a competent technician can perform some of these tasks as well as undertake an initial assessment to determine whether the evidence is of adequate quality to proceed further. There are times, however, when it may be desirable for this entire process to be lead specifically by the forensic podiatrist. Methods of collecting exemplar prints are presented along with variations of these methods and comparison of these approaches. The assessment of bare footprints is also considered with note being made of various features of these prints that may be of interest to the forensic podiatrist. Some situations that could compromise the quality of bare footprints are also presented.

The chapter continues to note techniques for the "measurement," comparison, and assessment of bare footprints and it is noted that podiatric assessment will involve interpretation of the features apparent.

Finally, in considering the evaluation of bare footprints after assessment and comparison, some considerations are presented that may be involved in reaching final conclusions in which the significance of similarities and differences between the known and unknown bare footprint items examined are considered.

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[1]Terminology in relation to this feature has varied considerably throughout the literature. The terms "barefoot print," "barefoot impression," "barefoot impressions," "naked foot marks," "barefoot footprints," "bare footprints," and "footprints" have all been used to describe this type of print. A footprint could not exist without being "bare," however, the term "footprint" is often used synonymously to describe a "shoeprint," which acts to further confuse. While the term "barefoot print" is the most accurate description, describing as it does the state of the foot as opposed to that of the print, this term does not mirror the frequently used term "shoeprint" used to described the print of a shoe, hence the term footprint would, in this sense be more appropriate. To avoid confusion, it would however also be helpful to include the word "bare" before footprint. Despite being a less accurate descriptive term than "barefoot print," the authors have therefore decided to use the term "bare footprint" to describe this feature throughout the text.

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4.1 Brief History

Bare footprint identification is the use of a bare footprint that has usually been left at a scene of crime by the perpetrator of that crime. This is a relatively unusual technique used in the identification process in the Western world, where the shod foot predominates. Bare footprint identification is, however, more frequently used as a method in identification in those countries, where barefoot walking is commonplace (Qamra et al. 1980). There are, however, circumstances where footprints can be associated with crime scenes in the West. These can include crimes of a sexual nature (Barker and Scheuer 1998), where the perpetrator has removed his clothing prior to, or during the crime and where the offenders with forensic awareness have removed their footwear prior to the criminal act in the mistaken belief that they would be safer from conviction when leaving only a bare footprint at the scene. There have also been examples of footprints being used as evidence in crimes of violence, where the criminal has removed and destroyed their blood-stained clothing and footwear, inadvertently leaving their bare footprints in blood at the scene (Newsquest 2006).

The human footprint has been the subject of various publications that have considered their use in human identification (Robbins 1985; Gunn 1991; Bodziak 2000; Vernon 2006a). It has also been the subject of various research studies (Laskowski and Kyle 1988; Barker and Scheuer 1998; Reel et al. 2010), one of which was long-term and involved a sample of 24,000 bare footprints collected from 12,000 volunteers (Kennedy 2005a). Various approaches have been suggested and tested that could be used to express the individuality of the human footprint and to allow one footprint to be compared against another to determine whether these footprints could have been formed by the same person, or whether its dimensions and features would preclude that possibility. Several disciplines have been involved in the consideration of bare footprint evidence, including forensic identification specialists (Kennedy 1996), anthropologists (Topinard 1877; Robbins 1978), and podiatrists (Reel et al. 2010; Vernon 2006a, b). The added value podiatrists bring into the process is in their understanding of the functioning foot and the effects which that function may have on the form of the human footprint. Anthropologists can assist with interpreting the dimensions of the print, and forensic identification specialists have general knowledge of the identification process across many areas, which can bring additional understanding to considering footprints as evidence.

4.2 Obtaining Exemplar Prints

While is it possible to make some assumptions from a footprint in isolation, the true value of a bare footprint in identification relates to the ability to compare the questioned print with a print collected from a known person under controlled conditions, the latter being known as the exemplar print. The circumstances of collecting

exemplar prints may vary and can include collection from prisoners held on remand, from willing volunteers where the examiner has been instructed by a defense team, or where a particular person is at the stage of assisting the police in their investigation. It can also be necessary to compare the questioned prints with those of persons known to have been at the scene and not involved in the crime (e.g., relatives, attending personnel such as paramedics, victims, and the like). The process should, however, follow the same approach irrespective of circumstance and will require the following equipment:

- Inkless paper system
- Long roll of brown or white paper
- Ink and roller
- Marker tape
- Masking tape
- Permanent writing equipment
- Video recording equipment (× 2)

In the collection of exemplar prints, an uninterrupted straight walkway is required, ideally of the minimum length required for podiatric gait analysis, typically approximately 20 ft. It is recommended that two podiatrists be present to observe the subject walking during the footprint collection. A line is selected or made on the floor with marker tape and the subject asked to stand behind this with the toes of both feet touching the line and looking straight ahead. A mark is then selected or taped onto the wall surface at the subject's eye level and the subject asked to look towards this line at all times. The subject is asked to walk normally towards the wall marker, stepping off with the foot opposite that from which the exemplar print is to be taken and, at the end of the first stride (the second step), the landing position of the foot in question should be noted. An inkless paper sheet is placed in line with, but not at that stage directly over, this position. This process is then repeated a number of times until a reasonably consistent landing place is identified for that foot. The inkless paper sheet is then then quickly and securely taped at this site. Recording equipment, placed to the side and rear of the selected landing position, is switched on and the subject is asked to walk again, this time with the intention being that the foot in question should land completely within the confines of the secured inkless paper sheet, leaving a complete footprint. The process is repeated until a collection of six or more good quality footprints has been obtained, and then the process is repeated for the opposite foot. It is inevitable that a number of prints will be spoiled or partial and these should be carefully filed separately. On each occasion that the foot in question lands on the inkless paper, the observing podiatrists should note whether the step onto the paper appeared to reflect the typical/anticipated walking pattern of the subject, particularly noting whether there had been any attempt by the subject to amend the gait pattern in order to alter the form of their footprint. Typical examples of such amendments include pulling back the toes to avoid leaving a toe imprint, contracting the foot during the stance phase to leave only a partial impression, attempting to smudge the footprint by introducing shearing or torsion movements during the stance phase, and leaving only a partial

footprint by not placing the foot within the confines of the inkless paper during collection of the bare footprint. The observing podiatrists should compare their observational notes after each footprint has been left to verify areas of doubt and confirm whether or not the stance phase observed was acceptable in terms of apparent normality for that subject.

An alternative approach would involve the use of the long sheet of brown paper, ink, and roller. Here, instead of utilizing an inkless paper system, the walkway is covered with the brown or white paper roll, and, as before, a marker placed on the adjacent wall. The subject's feet are comprehensively inked; the subject stands at the end of the roll facing the marker and, when asked, walks across the roll towards that marker. A long sequence of footprints can be collected by this method.

Each of these approaches has advantages and disadvantages. While the inkless paper method is clean and has the potential to collect extremely clear footprints, it can nevertheless be difficult to set up, time consuming (especially where the subject is being uncooperative), and is incapable of collecting a sequence of prints. The ink and roller method is messy and the quality of print left will not be as good. The method is, however, much quicker to set up and use than the inkless paper approach, with less potential for the uncooperative subject to avoid leaving a footprint. This method will also collect a sequence of multiple prints, from which those of the best quality can easily be selected for later examination. The method selected should be that which is the most applicable to each particular circumstance.

4.3 Variations in the Exemplar Footprint Collection Phase

While the use of the inkless paper method to collect exemplar prints is one of the most common approaches to collecting bare footprints, it is sometimes advisable to collect bare footprints that reflect the situations in which they have been found at the scene of crime. Here, the examiner may wish to replicate the type of surface on which the questioned bare footprints have been found. Examples of surface variables upon which the bare footprints may have been found include carpet, wooden boarding, and concrete slabs. The examiner plans the approach according to the surface to be replicated. Where carpet is involved, for example, a roll of carpet could be appropriately used, with the plantar surfaces of the subject's feet being liberally covered with ink prior to walking across the carpet. From the sequence of prints left, the examiner selects those of the highest quality for examination, while still bearing in mind observations made over any possible attempts to alter the footprint form. Where slabs or wooden surfaces are being considered, the examiner places a sample of the surface type being considered at the point at which the footprint is to be collected and again, uses inked prints as described above.

Having collected exemplar bare footprints for comparison with the questioned bare footprints, the examination and comparison process continues using the ACEV-R approach described in Chap. 2.

4.4 Assessment of the Bare Footprint

The initial task is that of assessing each footprint selected for comparison. Here, a footprint is evaluated in isolation using an appropriate selection from a range of objective measurement and descriptive tools, which are used in combination where possible. Here, the purpose is to describe the footprint being examined. Objective dimensions are stated, outline morphology is traced, and any features apparent within the footprint are factually described. Such features could relate to the positioning of toes, or missing aspects of the footprint (e.g., an absence of toe impressions, the presence of only partial heel or ball impressions). Footprints may also show the presence of ridge detail or blemishes may be apparent within the print, all of which should be recorded along with the area of the print that such detail was observed. In this case, the podiatrist normally forwards such information to an appropriate expert, as expertise in the examination of such features falls outside the specialized knowledge of podiatrists.

A complete bare footprint consists of five toe prints (sometimes with stem prints), a ball of foot impression, heel impression, lateral mid-foot impression, and an arch profile (Fig. 4.1). It is the size, orientation, and shape of these features that

Fig. 4.1 Bare footprint

provide information that can be of help in the identification process. Here, the information expressed by these features in an unknown (or "questioned") footprint can be compared with exemplar footprints, which have been collected from someone suspected of leaving an unknown bare footprint at a crime scene. Without the possibility of exemplar footprints being available for this comparison, the questioned footprint will be of little use in identification. The questioned bare footprint may, however, have some value in providing an indication of the approximate shoe size of the individual responsible for the print along with providing very approximate height estimation for that individual.[2] While it is possible to collect clear and accurate bare footprints from the suspected person for comparison purposes, the presence of a near-perfect questioned footprint is unusual. Footprints can be compromised in a variety of ways, thereby impairing their usefulness to the identification process, some of which are considered below.

Firstly, the bare footprint can be incomplete. This problem can take many forms, including absent or partial heel prints, missing toe prints, and a general incompleteness across the medial dimension, where the individual may have placed the foot into ground contact while exhibiting an excessive amount of inversion (Fig. 4.2).

Secondly, the footprint may be complete but smeared through the act of slippage or through a turning movement having occurred at the time of leaving the footprint.

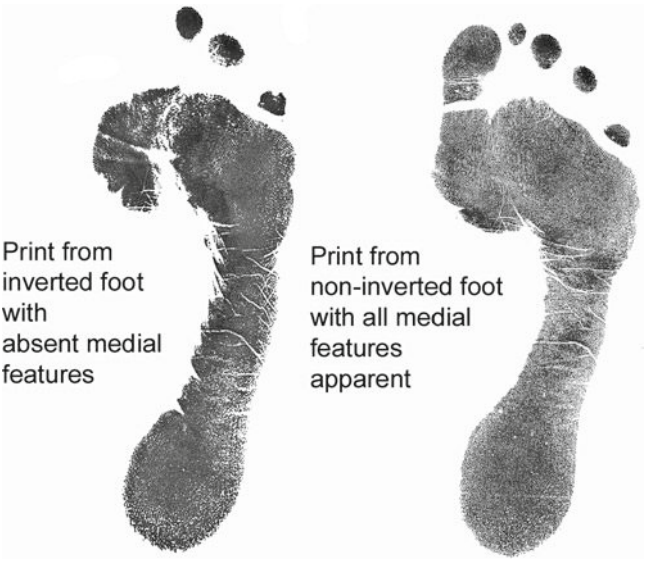

Fig. 4.2 Effect of inversion on the bare footprint

[2]This would not be possible with any degree of accuracy and, at the time of writing, this should be approached cautiously, with careful reference to the various differing findings in the literature around foot length versus height estimations.

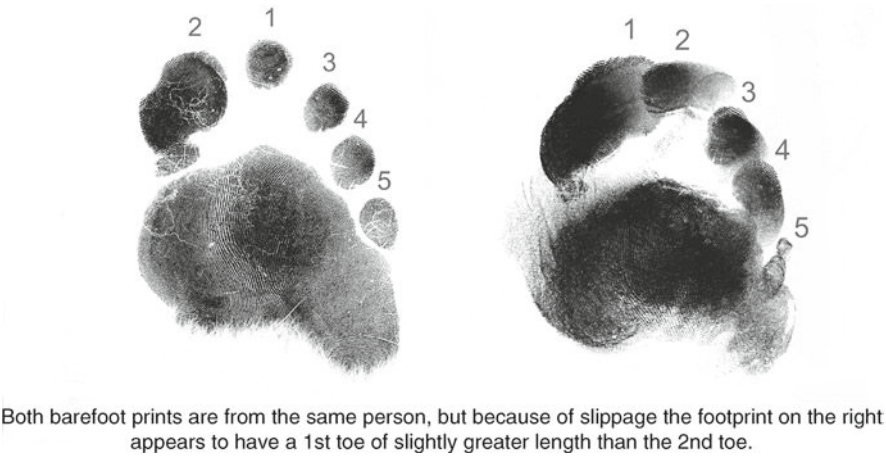

Fig. 4.3 Potential effect of slippage on toe formula

Here, areas of the footprint can be rendered unclear through the smearing or smudging of the features and/or through an apparent lengthening of the footprint, where the slippage has been linear. Where such slippage has involved both linear and a turning motion concurrently, this can lead to the footprint suggesting the presence of a different toe formula than would have been created by the foot under more ideal conditions (Fig. 4.3). The problem of slippage can be typically seen in footprints made in blood, where the nature of the substrate predisposes to such movement.

Bare footprints can also be compromised where they have been partially obliterated through the presence of additional footprints over the footprint being examined, obscuring or even completely obliterating the features of interest. Such additional footprints can come from the one person, either where there has been a high level of activity at the scene, or where the foot has been lifted and placed twice in the same area as part of a single attempted movement. They can also arise from the presence of third parties – either the victim, where there may have been frantic activity during acts of violence, from someone who has assisted with the crime, or alternatively from an unconnected third party (e.g., someone who discovered the crime scene after the event). They may also be compromised by the shoeprints of those officially visiting the scene of crime after the event, such as ambulance drivers, scene-of-crime officers, or police personnel, who may have been unaware of the possible presence of such evidence and its evidential value.

Where a near perfect footprint has been left at a crime scene, footprint evidence can be extremely valuable. The value, however, will decrease where the footprint has been compromised, as in the circumstances described above. Investigators should be aware of this fact and be prepared to deal with uncertainties associated with this data loss through adjusting levels of certainty expressed in their report-based conclusions about the strength of such evidence.

Various approaches have been devised to allow footprints to be objectively "measured" and compared for identification purposes. The most commonly used approaches are the Gunn, optical center, and overlay methods.

4.4.1 Gunn Method

Dr. Norman Gunn began forensic podiatry work in Canada in the early 1970s. In his case work, Dr. Gunn was asked to compare unknown footprints found at a scene of crime with footprints of suspected perpetrators of that crime, and he developed an objective process to assist with that comparison. He produced a system in which various linear measurements were taken from each of the footprints involved and used these measurements to objectively describe and compare these prints (Vernon 2006a). This approach helped to form a conclusion as to whether there was a match or mismatch between the footprints being compared. The technique commences with the drawing of six lines. Five of these lines are drawn from the rearmost aspect of the heel of the footprint to the tips of each of the five toes. A sixth line is then drawn across the widest part of the ball of foot area. These six lines represent the most basic form of the Gunn method (Fig. 4.4). The lines are then carefully measured and the

Fig. 4.4 Gunn method

Fig. 4.5 Gunn method utilized for partial print analysis

measurements taken are then used to compare the footprints being examined. Additional lines can be introduced into this approach if necessary, for example, when dealing with a partial footprint (Fig. 4.5), or when wishing to strengthen the evidence provided. When adding additional lines, any of the points used to draw the basic six lines of this approach can be used as reference points for adding further lines (Fig. 4.6). This technique is simple to use in practice and is likely to be one of the primary methods selected by the examining podiatrist in the footprint comparison process.

4.4.2 Optical Center Method

The optical center method was utilized in the 1990s by the Royal Canadian Mounted Police as part of a long-term study intended to strengthen the value of the human footprint in identification (Kennedy 2005a, b, 1996; Kennedy and Yamashita 2007; Kennedy et al. 2003). It is a development of the Gunn method and shares similarities with Gunn's approach in that it is based on the measurement and comparison of lines drawn between various morphological landmarks of the footprint. It differs from the Gunn method, however, in the source and destination points from which many of these lines are drawn. Instead of using peripheral reference points on which to base the connecting lines, optical centers are used in this technique. An optical center is the dead center of a morphological feature as represented by the center of a circle when placed into a "best fit" position within that particular feature (Fig. 4.7). This optical center can be calculated by software used for design purposes, or alternatively by a manual approach in which the investigator places a series of concentric circles over the feature being examined into the best fit position and marks the very center of those concentric circles. The mark thus created is used as one of the reference points for a measurement taken using this approach (Fig. 4.7).

Fig. 4.6 Extended Gunn method

As in the Gunn method, six basic measurements are taken. Five separate lines are drawn from the optical center of the heel to the optical centre of each toe. As in the Gunn approach, a line is also drawn directly across the widest part of the ball of foot area. As the optical center cannot be used to determine medial and lateral positions of the ball of the foot, no attempt is made to calculate optical centers for this measurement. While again being simple to use in practice, this approach is more useful where the examiner has access to the relevant software, as personal experience has suggested that human error, when this approach is used manually, can create a higher level of ambiguity than that afforded by the Gunn approach.

4.4.3 Overlay Method

The overlay method was initially developed in the UK for forensic identification purposes when using plantar impressions of footprints (Facey 2005). This was later modified by DiMaggio (2005), when descriptive terms were added to the various morphological features apparent on the bare footprint outlines (Fig. 4.8). Linear measurements are not used in this approach. The technique instead relies

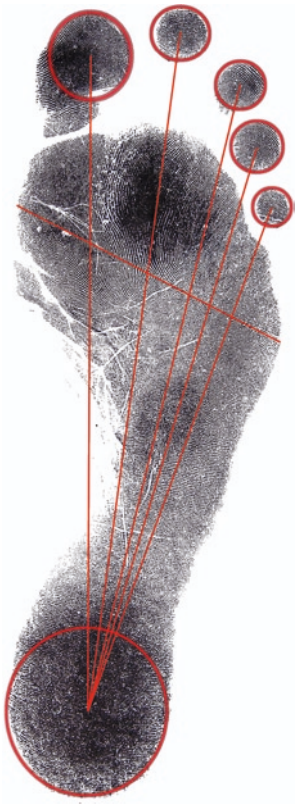

Fig. 4.7 Optical center method

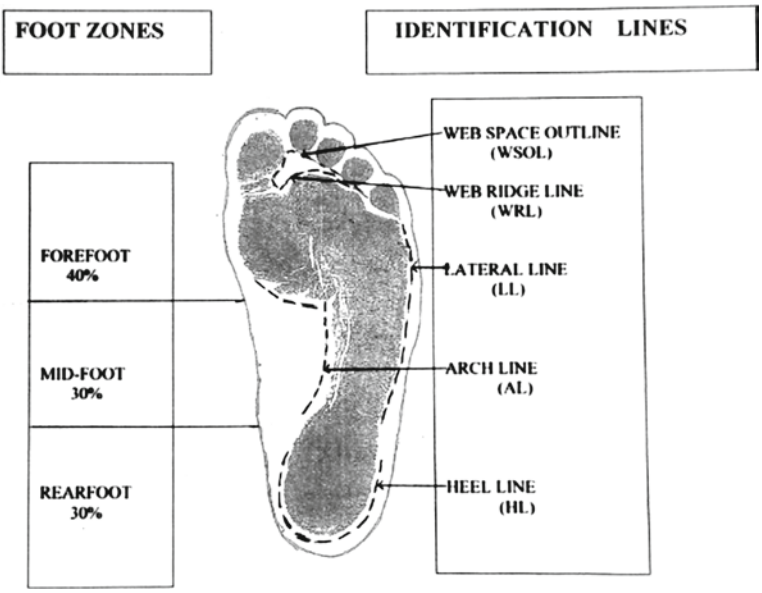

Fig. 4.8 Morphological ID lines and foot zones

Fig. 4.9 Overlay method

on tracing (by various methods) of the outline of a known footprint onto a clear background and placing this tracing on top of an unknown footprint being examined, thereby allowing comparison of these two footprints (Fig. 4.9). In comparing two footprints in this manner, various features are compared to determine compatibility. Such features include the position, shape, and outline detail of toes, the anterior ball of foot area (web ridge line), and the heel areas. Soft tissue deformities, scarring, and creasing of the plantar print can also be compared using this method. In practice, the overlay method is simple to perform and the accuracy of the technique has improved with the development of digital cameras, which allow for tighter depictions of the footprint outline to be collected than that afforded by traditional hand-tracings. Some digital imaging software allows the superimposition of two or more images and these can be used for an overlay comparison in addition to the manual approach.

4.4.4 *Defining the Rearmost Aspect of the Heel*

While other methods of footprint description, measurement, and comparison exist, these three approaches are the most commonly used in identification processes involving bare footprints. One other approach does, however, merit a brief consideration in relation to the use of the Gunn method. The Gunn method is based around an initial series of measurements taken from the very rearmost aspect of the heel. It is important that when used for comparison purposes, this measurement is taken from the same position every time, as it has been determined that even quite small variations in the selected measurement point can lead to apparent differences in measurement (Kennedy et al. 2003). An objective means of locating the rearmost aspect of the heel should therefore be adopted. Such a means is available through the measurement technique advocated in the Rossi system of podometrics (Rossi 1992). With this system, Rossi developed a series of measurements for the clinical description and categorization of the human footprint. While this was not developed by Rossi for forensic identification purposes, two of the initial measurements he advocated connect the outermost lateral aspect of the heel print with the lateral aspect of the ball of foot area, and the innermost medial aspect of the heel with the medial aspect of the ball of foot area (Fig. 4.10). In considering

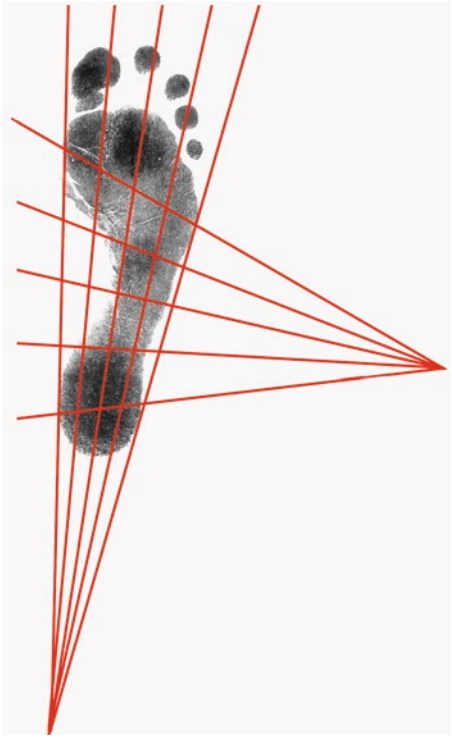

Fig. 4.10 Rossi's system of podometrics

most footprints, these lines would be expected to intersect at a point posterior to the heel. This intersection could form a reference point from which the rearmost aspect of the heel could be objectively selected for measurements taken for identification purposes. The reference point would be used by taking equidistant measurements along the intersecting lines, from the reference point until a line connecting these lines just touches the rearmost aspect of the heel. The point at which this line meets the heel would then be considered to be the rearmost aspect of the heel and used as a second reference point from which footprint comparison measurements could be taken.

An alternative approach to defining the rearmost aspect of the heel would be to place a grid line over the footprint image. The grid would be aligned over the image in such a way that the most lateral aspects of forefoot and heel are perfectly aligned with one of the vertical grid lines. At this point, the rearmost aspect of the

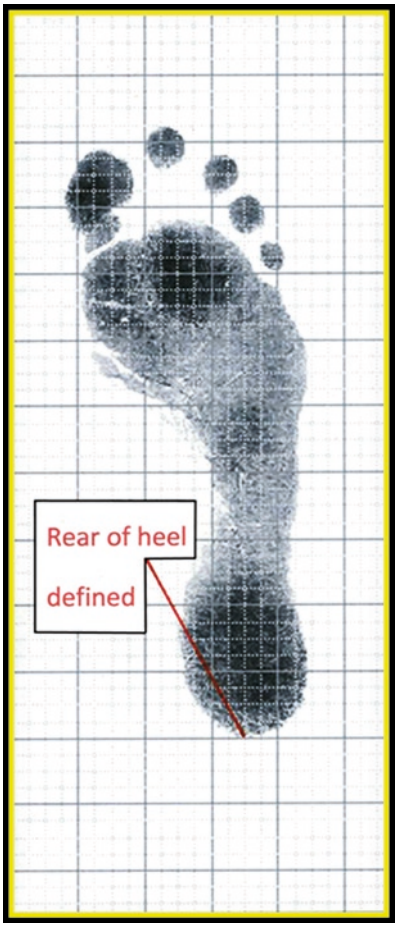

Fig. 4.11 Defining the rearmost aspect of the heel

heel can be determined from its proximity to the first horizontal grid line distal to the heel (Fig. 4.11).

Whichever approach is used, it is essential that it is used consistently throughout the case being worked, to ensure standardization.

In practice, the forensic podiatrist would be advised to use at least two of the different measurement systems defined above – one involving linear measurements in conjunction with the overlay method. This would allow the collection of both quantitative and descriptive comparison data, and the collection of additional points for comparison to strengthen the value of the evidence. It would also provide some form of triangulation to support any conclusions reached.

4.4.5 Interpretative Aspects

In addition to the use of direct measurements and descriptions, the podiatric examiner would also consider interpretative aspects of each bare footprint being examined, here bringing podiatric knowledge and understanding into play. Such interpretations can include consideration of the implied foot size and the toe and metatarsal formula as represented within the bare footprint being considered. It should be remembered that a bare footprint on a hard surface would represent only those aspects of the foot which have contacted the ground. The extreme aspects of toes, heel, and cross ball width, which would represent the true length and width of the foot, would not have contributed to formation of the bare footprint unless that bare footprint was formed in a soft substrate that had allowed the foot to sink deeper into the surface. A footprint on a firm surface would therefore appear shorter than and not as wide as the actual foot responsible for that bare footprint (Fig. 4.12). An approximate "rule of thumb" has been used to suggest the overall foot length implied by a complete two-dimensional footprint, in which 1.5–2 cm is added to the overall footprint length to suggest an implied overall foot length. Unpublished research has also taken place to consider an objective formula from which the length of a foot can be calculated (Grant 2006). Because of the small sample size and the wide confidence intervals involved, this work is not conclusive. It must be stressed that the approximation of the true foot size by adding 1.5–2 cm to the total bare footprint length is an approximation only and as such should be dealt with accordingly in the resultant evidence report, if used at all.

Related to interpretative aspects of the footprint would also be the recognition of the presence of toe features such as a Greek ideal, where the second toe is situated distally in relation to the first toe position (Fig. 4.13). Other features indicated by toe position could include the presence of hallux valgus, mallet toes, hammer toes, surgically or congenitally shortened toes, etc. (Fig. 4.14). Within the footprint, missing toe prints may also be apparent. The examiner will need to consider whether these relate to actual missing toes, whether they relate to contracted/retracted toes that have not contacted with the ground during stance, or whether the foot function itself could have lead to an absence of ground contact at the site of the apparently missing toe. Indications of the foot type suggested by the footprint form

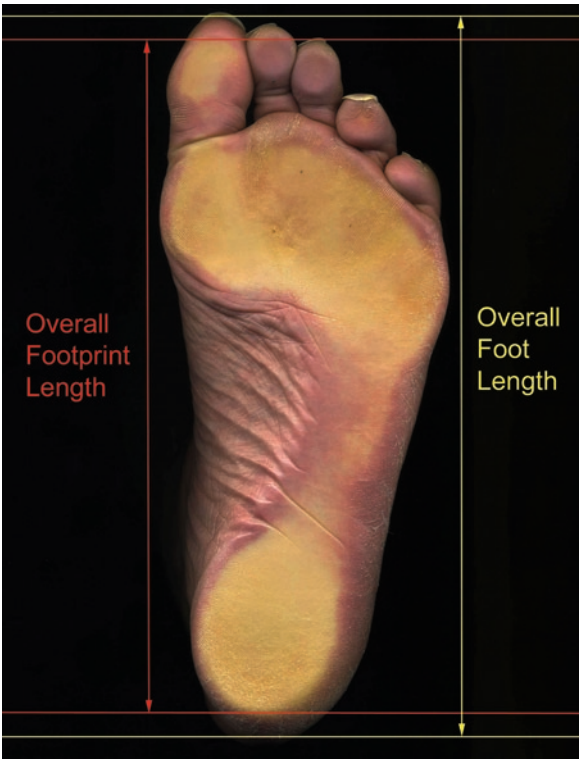

Fig. 4.12 Overall foot length versus overall bare footprint length

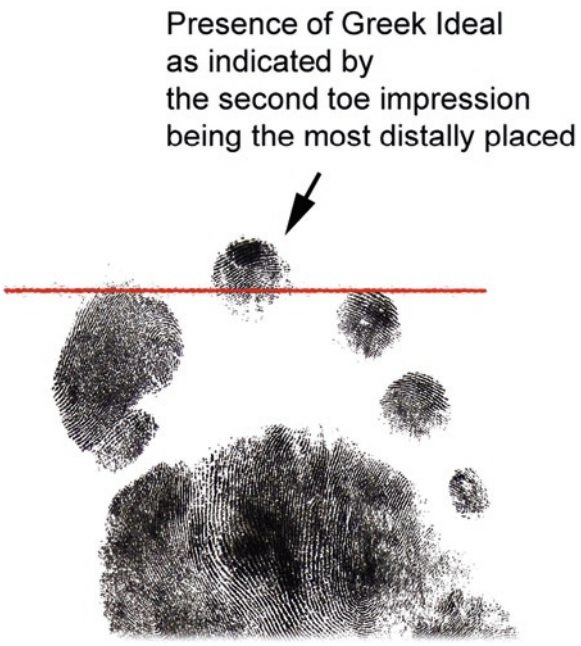

Fig. 4.13 Greek ideal

Fig. 4.14 Congenitally short fifth toe (no purchase)

can also be apparent and scuffing or smearing patterns related to the print may indicate functional considerations involved in the footprint formation.

In considering the ball of foot area, the presence of pathological or unusual features may be indicated. Here for example, the presence of an extreme bunion deformity or Tailors bunion may be demonstrated through the ball of foot extending beyond its usual confines when compared to the toe positions observed. The presence of higher pressure areas can also be apparent through darker patterns observable within the print (Fig. 4.15), either relating to functional or structural features.

The morphological detail of the arch area of the bare footprint may also indicate the presence of foot pathology. Pes planus (flat feet), pronatory tendencies, or when viewed in conjunction with toe positions, indications of pes cavus (high arch) in the causative foot can become apparent through the shape of the arch area of the examined footprint (Fig. 4.16).

Similarly, the foot width versus length ratio can be calculated and these particular footprint dimensions may be used to describe the overall foot shape. It has also been suggested that the foot can be subdivided into three distinct zones, and that the ratio of the size of each zone can also be used in this comparison process (DiMaggio 2005). Here, in addition to the identification of broad feet, or long narrow feet, pathological aspects may also be apparent in relation to hallux valgus or pes cavus foot types where these have affected the foot shape. It would only be advisable to

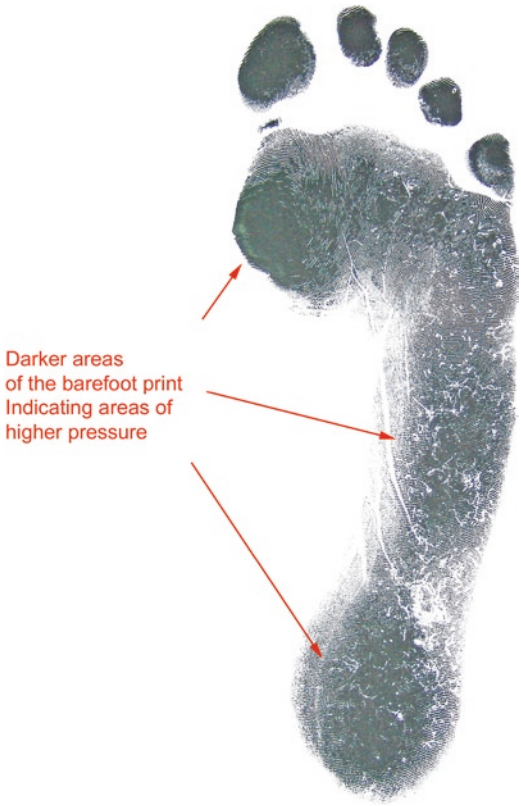

Fig. 4.15 Effect of high pressure areas on the bare footprint

undertake such an assessment if the footprint is clear and complete, as attempting to calculate the foot width versus length ratio could be misleading in the presence of incomplete measurement data. It has also been previously suggested by a podiatrist with an interest in podiatric archaeology that foot dimensions can also relate to the ancestral origin of the owner of the foot (Jackson 1995), which in turn could be theoretically interpreted from the footprint. Extreme caution in using such interpretations in forensic podiatry work would, however, be recommended until further research is undertaken within this area to validate these observations.

Various blemishes may be noted in the detail apparent within the footprint, and it is possible to interpret these as sites of scar tissue and of preexisting skin lesions (Fig. 4.17). Where these are found to be present within a bare footprint, the site and nature of such lesions should be carefully recorded alongside the interpretive description. Friction ridge detail may also be apparent within the examined footprint and the presence of such detail should be noted for the later involvement of an examiner with expertise in the examination and comparison of such detail. Other features that can be apparent from the bare footprint include more detailed variations in morphological outlines (Fig. 4.18) and the presence of crease lines within the footprint (Massey 2004). Again, the site and nature of such lesions should be recorded and described when present, with the possibility of involving a ridge detail analyst being considered.

Fig. 4.16 Arch shape (narrow) and lateral "C" shape of cavus foot

Fig. 4.17 Scar tissue

Fig. 4.18 Morphological variations: WRL (web ridge line) on left: AL (arch line) on right

In addition to seeking the features within the footprint as described above, consideration should also be given to signs of smudging, smearing, and slippage within and around the bare footprint. This may be useful later in the comparison and evaluation stages, when considering repeated features that may reflect an usual foot function of the individual responsible for the print. This detail may also be useful when considering any differences between the prints being examined as indications of slippage or other motion, and may demonstrate that the form of the footprint has been amended through the functional variation that has lead to the smudging, smearing, or slippage.

4.5 Biomechanical Examination

In addition to the simple assessment of known and unknown footprints, it can also be advisable, if possible, to clinically and functionally examine the suspected "owner" of the questioned footprint. This is because features present on the questioned footprint can not only be compared with exemplar footprints, but also with the foot status and lower limb function of the person leaving a known footprint for comparison purposes.

4.6 Comparison

Having assessed the available footprints as described above, the next task is that of comparing the unknown (questioned) bare footprint/footprints with the known exemplar bare footprint/footprints, which have been collected from a suspect as well as the foot status and lower limb function of that person.

Fig. 4.19 Initial tracing of questioned partial bloody footprint

In practical terms, it can be useful to first utilize a basic preliminary comparison process in order to eliminate the more obvious mismatched bare footprint. This would take the form of initial "rough" tracing comparisons of known and unknown (questioned) prints to eliminate the mismatches as well as creating a shortlist of apparently matched prints for more accurate evaluation (Fig. 4.19). Once this "shortlist" has been created, more accurate comparisons would be undertaken on the shortlisted prints using proprietary digital image programs such as Adobe Photoshop.

The comparison process should sequentially work through the comparison of all measurements, shapes and features, which have been recorded and determined using the following approaches and considerations:

Objective measurement comparisons: Here any measurements taken using either the Gunn or optical center methods are compared directly, with any differences between each measurement being additionally recorded in tabular form.

Morphological comparisons: Similarly, morphological similarities and differences as indicated by the overlay method would be compared and recorded feature by feature. This would typically include compatibility of toe, heel, and ball positions, and the outline shapes formed by all toes, the ball including the web ridge line (DiMaggio 2005), inner longitudinal arch, and heel of the foot.

Pathological feature comparisons: The podiatrist is a highly specialized health professional/physician trained in the recognition and treatment of the various pathologies of and affecting the foot including both structural and functional problems. Where the presence of such conditions has been apparent from examination of the bare footprint, these should be recorded in tables relating to both known and unknown (questioned) footprints with a view to assessing compatibility.

Detailed comparisons: The assessment process may have noted the presence of a number of additional details including the presence of skin lesions, position and shape of crease lines, close morphological details, unusual features, and friction ridge detail. Relevant podiatric information of this type from both known and unknown footprints should be compared item by item, with the presence or absence of such features, and their position and shape being recorded for all footprints examined with a view to assessing compatibility. Where friction ridge detail has been apparent, comparison of these features is beyond the expertise of podiatrists who are not also trained in friction ridge detail analysis, and the involvement of such an analyst should be sought if this has not already been obtained.

Missing feature comparisons: It is possible that some features may be missing from the footprints being examined. Any areas of such missing data from the bare footprints should be compared point by point. Such comparisons will have two uses during evaluation. Firstly, they can show that a comparison of a particular area of the footprint could not be carried out due to missing "data" and secondly they could also potentially indicate the presence of a repeated feature in relation to a repeated foot function or stance position.

Foot ratio comparisons: Where it has been possible to calculate foot ratios, these ratios should be compared side by side for similarity and compatibility.

Interpretative comparisons: Where forensic podiatrists have been able to interpret various aspects of the bare footprint and make implications in relation to the causative foot from their observations, these observations should be compared between known and unknown footprints feature by feature.

Functional aspect comparisons: Functional aspect comparisons are also interpretative. Here, any features that have been noted within the bare footprints being examined and have functional significance should also be compared. For example, the presence of a toe or toes that have not come into ground contact could be compared, as could print anomalies indicating, for example, inversion of the foot, smudging, smearing and slippage, or lack of heel strike.

4.7 Evaluation

Finally, the examiner will need to evaluate the evidence through careful consideration of the detail that has been subject to examination and comparison. This is the crux of the process and, without an evaluation, a conclusion cannot be reached. The first consideration of the examiner is whether it is possible to reach a conclusion in cases where the evidence is "spoiled," inadequate, or erroneous. This can be due, for example, to problems in photographic perspective, where errors have been made in setting the image to evidence quality standards. This can also occur when the mark is incomplete, or where the evidence is very old and therefore not necessarily still relevant in a comparison with the foot status of the suspect, making it impossible to reach a valid conclusion. If this is the case, the examiner should be prepared to state this and, at the

point that this has become apparent, to not proceed any further with the investigation. It could be, however, that recommendations can be made as to the potential for other expert involvement, or for remedial action to be taken to correct the situation (e.g., perspective correction in evidence photography, a search for further evidence, photographing the evidence with a strength scale where this has not been included, etc.).

Assuming that it is deemed possible to reach a conclusion, the comparison made of class characteristics, gross measurements, interpretations, and observations will need to be evaluated. Here, those factors that are compatible and those that are incompatible will be stated and a conclusion made as to whether the compared prints could belong to the same person or whether differences are apparent that could only demonstrate a mismatch. If any incompatible features are found, a conclusion that a mismatch is apparent can be made at this stage, with typical excluding features being a clear discrepancy in the length and shape of the compared footprints and obvious pathological features being present on one footprint and not the other. If the compared footprints are found to be similar in these respects, more detailed consideration can then be given to the overall length of the questioned and known footprints. This would be an interpretive evaluation in which the implied lengths of the causative feet would be suggested, to determine whether or not these are similar. In turn, the suggested sizes could then be related to the population data, specifically to suggest the proportion of the population (often the male population), which are known to have a foot size within the implied range. Data considered here may be published information or, where this does not exist, personal database information could be used, with any accompanying limitations being stated.

Where common pathologies have been noted between known and unknown bare footprints, then published data on the incidence of that feature in the general population can be considered in order to show how unusual such features are in this population. In the absence of published data, personal database information (in effect, a collection of footprints held by the examiner that can be used to show the suggested incidence data of a known feature) could be used. At the time of writing the American Society of Forensic Podiatry was establishing a library of bare footprint data that will be available as a reference source to all professionals in relation to their case needs. Similarly, known data on functional conditions can be used in the same way, where such conditions are apparent from the footprints examined.

The next consideration as part of the evaluation process is whether toe positions between the known and unknown samples are broadly compatible, or whether they are too dissimilar for the compared prints to have been made by the same individual. Here, the examiner will need to give careful attention to the possible confounding effects of function, bringing known functional understanding into play in this particular interpretation. Here, factors relating to the questioned footprint position and sequence may need to be considered. Of particular interest would be whether the position or sequence of the footprint suggests that the footprint has been produced in standing, walking, running, turning, or jumping situations or in circumstances in which an individual had made the print while manipulating a burden. If so, the examiner should consider to what extent the suggested variable could have amended the toe positioning and whether any differences observed could still be within the range that could have been produced by the same person. If a footprint has been found, for

example, on a landing at the top of a flight of stairs, positioned at 90° to the flight of the stairs, it is probable that the person responsible for that print was in the process of turning at the time that the print was formed. A footprint at the base of a high wall, facing away from that wall, and adjacent to the opposing footprint could very well have been produced by someone landing after jumping from the wall, again with the potential for the form of the footprint to have been amended. Conversely, a complete footprint situated mid-way within a sequence of footprints present along a short corridor is unlikely to have been formed by anything other than a basic walking function, unless there are indications that the person had been dragging or carrying an object at the same time.

Taking all these factors into account, it should be possible for the examiner to determine whether any differences observed between known and unknown footprints examined could be justified, or whether a true incompatibility between the person responsible for each footprint is implied.

The next consideration relates to how objective linear measurements recorded by the Gunn and optical center methods compare. The work of Kennedy et al. (Kennedy and Yamashita 2007) used an error margin of ±5 mm in comparisons of footprints within their research database and this error margin should be considered for each measurement compared. The more measurements there are within these limits, the greater the likelihood that the prints have been formed by the same person. Where measurements have fallen outside this range, the footprints should be examined closely for signs of the print being incomplete, having been amended by function, sources of error, or whether this appears to be a true difference. Where true differences are found to exist, consideration will need to be given as to whether these are great enough in terms of the size and number of differences present to preclude the possibility of these prints having being made by the same person.

The next stage of the evaluation is to consider fine morphological detail comparisons. Here, the detail recorded and compared in relation to outline shape, highly individual features (scarring, crease lines, skin lesion presence, etc.) would be considered. The examiner would be considering whether the feature observed has been apparent in both compared prints and whether the absence of such features in one print or the other would preclude the possibility of a match, or whether this difference could be justified through print incompleteness or smudging, for example. Again, where dermatoglyphic detail comparison is required, this should be referred on to a ridge detail analyst for further examination.

Similarly, it is almost inevitable that some aspects of the questioned footprint will be missing, unclear, or show signs of slippage, torsion, or other movement. During the evaluation, the examiner should consider such areas and what they imply in relation to the footprint, particularly whether such implied movements could have amended the footprint form, or whether differences observed could only have been caused by the footprints being created by different persons. Where slippage, repeated feature absence, or evidence of torsion during movement is apparent within the questioned footprint, this may imply that the person responsible for producing the questioned footprint has a particular repeatable foot/lower limb function. Where this is apparent, the implications in terms of individualization should be noted in the

evaluation, referring to known research or population databases for considerations of incidence. Any observations of this type have the potential to be triangulated through the results of a full clinical and functional analysis of the suspect.

Finally, the conclusion derived through the evaluation should be stated in terms of how strong the evidence is that is being presented. Here, the level of support offered for the proposition that the questioned and known bare footprints have been made by the same person and also that the prints have been made by different persons would be derived. Each and every feature that has been compared and evaluated would be considered in the light of current understanding. In dealing with footprints, central to this is the understanding gained from Kennedy et al. (Kennedy 2005a, b, 1996; Kennedy and Yamashita 2007; Kennedy et al. 2003) in that every one of the footprints in their database of 24,000 prints has been proved to be different. Kennedy's database, however, consists of footprints collected under standardized conditions and it is inevitable that this given state will not apply to questioned footprints found in real-world situations.

After all independent variables have been considered as per the above methods, these would finally be subjected to likelihood ratio calculation. Here, the consideration is of what the likelihood would be of replicating all observed independent features in the population being considered, using the approaches outlined in Chap. 2. The published data under consideration should be applicable to the relevant population (e.g., if it is a white UK male under consideration, published data from the Japanese population should not be utilized, as this could be misleading). In order to consider the likelihood ratio as opposed to just likelihood, features suggesting a mismatch would be sought as closely as those that suggest a match as would alternative explanations for the presence of the features observed.

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Chapter 5
Footwear Examination and Analysis

Keywords Impression evidence • Footwear assessment • Shoe sizing • Evidence assessment • Footwear evaluation

The examination of footwear that has been associated with a crime scene is a multidisciplinary task in the context of identification. Podiatrists usually become involved in forensic footwear examination where a suspect has been found and the task is to associate or disassociate that person to footwear already linked with the crime scene. A podiatrist's assessment of shoes in this context involves the analysis, comparison, and evaluation of wear features of the insole/sock liner and the internal and external aspects of the upper structure of the shoe and the outsole. In addition to comparing known and questioned footwear items together, the forensic podiatrist may also wish to examine the suspected wearer or wearers of the shoes to look for features of the foot that may provide additional linking or disassociating factors. This chapter describes the processes involved in the forensic podiatry analysis of footwear in the identification process.

5.1 Introduction

Footwear can be associated with scenes of crime for a wide variety of reasons. These frequently include the finding of shoeprints at the scene of crime, which could then potentially be linked to the outsole of the shoe that made these prints. Where the shoeprint is available at the crime scene, the task is to match that print to a shoe later found or seized from a suspect. This is the work of forensic footwear examiners (USA) or marks examiners (UK), and the frequency with which this work is required means that these are the main specialists involved in the forensic examination of footwear. The techniques predominantly used by these specialists to link a shoe outsole to a shoeprint found at a scene of crime are the matching of the class characteristics (compatible features usually relating to the shoe manufacturing process) and accidental characteristics (areas of damage on the shoe outsole) apparent on the questioned shoeprint and known shoe outsole. As the accidental

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characteristics are randomly formed they are considered to be unique[1] and these are therefore extremely powerful sources of evidence.

Other scenarios that can be encountered are those in which footwear has been left at a crime scene. This can occur with crimes involving rape, where the perpetrator has removed their clothing, or in crimes involving other forms of violence, where during a struggle, the person has been separated from his or her footwear and has fled from the scene of crime, leaving their footwear behind. Here, the task required is not that of linking the shoe to the scene, but instead of linking the shoe to a suspected wearer of that shoe. Other forms of evidence could be involved in making this connection include DNA-based evidence present on the shoe (such as the presence of blood of the victim on the shoes), or fibers present within the shoe, which could link the shoe to the crime. Cases also occur where footwear not present at the crime scene has been seized and linked to the scene through shoeprints or other forms of evidence as considered above (DNA, fibers, etc.) and the suspected wearer then denies ownership of these shoes. Variations on such denials include claims that there have been multiple wearers of the shoes involved, that although the shoes have been found in the suspect's possession, they belong to someone else, that the shoes had been loaned to another person at the time of the crime, or that they are simply being framed for the crime by the police authorities through the deliberate planting of evidence on the shoes. Such situations can involve quite complex processes of footwear analysis in order to produce conclusions that would either support or refute such claims.

It is important to recognize that the forensic examination of footwear is a multidisciplinary activity and it would not be usual for podiatrists to become involved in linking the shoe to the scene of crime, as the knowledge base required for this task is solely that of the forensic footwear or marks examiner. The forensic podiatrist usually becomes involved in cases involving footwear where the task is to link the footwear to the suspected wearer, or where a complex question concerning ownership

Fig. 5.1 Podiatrists positioning in relation to footwear investigations

[1]The term unique here is used in its formal sense, meaning that the feature or features are so individual that they represent the only example anywhere in the natural world.

has arisen (Fig. 5.1). Work undertaken within the International Association for Identification has clarified this situation, listing precisely what a forensic podiatrist does and does not do in this context (Vernon et al. 2009). The forensic podiatrists' involvement centers around the relationship between the foot and the shoe as represented by wear features of that footwear.

To date, assisting in identification from footwear has represented the most frequent involvement of podiatrists in forensic human identification. The process of footwear examination and identification in such scenarios will now be considered.

5.2 Footwear Assessment: Initial Considerations

Initially, there is a need for personal protection to be considered prior to the footwear examination being carried out. Footwear items that have been associated with a crime scene can potentially represent a biohazard, and it is even possible for sharp items to be deliberately placed within the shoe (e.g., needles) to cause harm to anyone examining that shoe. The forensic podiatrist must take reasonable precautions in this respect – ensuring that protective gloves, face masks, and general protective clothing are available, if required. Having made arrangements to ensure personal protection, the examining podiatrist would verify the parameters allowed on each particular case in relation to examination of the footwear evidence. Clarification should be specifically obtained over whether the shoes may be cut open and if access to the suspect for examination purposes will be possible. The equipment required for the examination will then be selected and in addition to protective clothing, should include the following:

- Digital photography equipment (see Chap. 3)
- Shoe sizing device
- Locking steel tape
- Sharp knives (multi-tools are particularly useful in this respect)
- Strong scissors
- Stiff card stock of square dimensions larger than the shoe outsole
- Impression foam box
- Inkless paper kit
- Clear acetate sheets
- Fine indelible marker pens
- Inspection mirror
- Adhesive tape
- Small frame (to support the shoe for photography purposes)
- General adjustable lighting source (e.g., angle poise lighting)
- Bright flashlight/torch
- Forensic lighting kit with filters
- Portable computer with digital photography software available
- Adhesive labels
- Adhesive tape

- Masking tape
- Notepaper and writing implements
- Large carrying case

The examination itself should be carried out in a suitable area – typically a workbench, such as one found in a laboratory. This area should be secure so that unauthorized access throughout the examination is not possible. Having prepared for the footwear examination, the examining podiatrist must finally consider the chain of custody requirements in the evidence-handling process. The footwear evidence will usually have been sealed within heavy-duty labeled brown paper evidence bags, fastened securely with a locking cable tie. The cable tie should initially be cut away and the contained brown paper evidence bags removed. Before opening the evidence bags, labels should be read carefully to verify that the contents are in fact the evidence to be examined. It is essential to deal with only one item of evidence at a time – opening, dealing with, and sealing each bag separately before moving to another item of evidence. When ready to deal with a footwear item, the time of examination should be recorded in the examiner's notes and the detail on the label should be carefully recorded at the same time. The examiner should put their own name on the label, sign the label, and record the date and time of opening. The evidence bag itself should be opened with care to avoid damaging the contents within, preferably with scissors. Where the bag has been opened and sealed previously, if possible, the bag should be accessed along the original opening with the contained footwear article finally being removed for examination. Following the examination, the article should be replaced and the bag carefully resealed and returned to the retaining authority. It is good practice to photograph the shoe before proceeding.

5.3 Footwear Assessment Phase 1

The examiner should initially observe the footwear item from all angles. Detail of the style, indicated make (if known), shoe type, color, and marked size should be recorded as well as a subjective assessment of the general condition of the shoe. Descriptors of any wear, distortions, and crease lines of the upper should be made in the examiner's notes, as should the presence of any unusual features such as areas of deliberate damage and style of lacing. The outsole is then examined for signs of wear and where such wear is present, this should be recorded. While a written description of the outsole wear pattern is appropriate, a principle is available to assist with this task. The focal point "instrument" is a tool that considers the areas of the outsole from which each anatomically referenced component of wear spreads (Vernon et al. 1999). Each such area is described as a focal point (Fig. 5.2). The focal point instrument is not a tool as such, but a means by which the examiner can describe the outsole wear for later comparison purposes. Figure 5.3 shows how the focal point approach would work in practice, with the examiner considering which focal point would be ascribed to each component of wear, leading to a combination of focal point code numbers that describe the wear pattern in its totality.

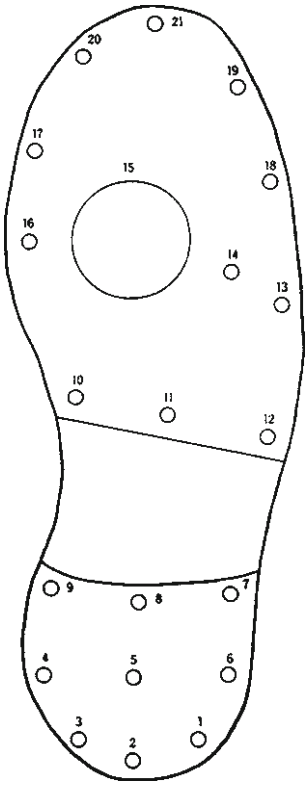

Fig. 5.2 Focal point concepts for the assessment of outsole wear patterns

Shoe sizes vary in the footwear industry, with variations in the actual length of marked sizes occurring between shoe style and between manufacturers, which can lead to apparent discrepancies in shoe sizing. Size alone is therefore not an indication of correct shoe fit, with sizes being used instead to assist shoe fitters and the purchaser of shoes by providing an initial guide with a primary indication and not a definitive gauge of fit. In shoe fitting, this means that, although the foot will be measured to give an indication of the correct shoe size for that foot, this does not automatically mean that a shoe marked with the size sought will fit appropriately. Additionally, footwear is often purchased subjectively with many people selecting and wearing shoes incorrectly sized for their feet. Footwear marked or measured as being of a particular size will therefore not necessarily correlate with the owner's required shoe size. At best, shoe fitting is an ideal compromise in which the required length size will differ and where many other fitting variables serve to compound the problem of correct fitting. For this reason, when examining a shoe as a forensic podiatrist, the marked shoe size should always be verified.

The usual method of verifying the length of a shoe involves the use of an internal shoe size gauge. Two types of gauge are available – those that give an indicated shoe size and those that give the internal length of the shoe in millimeters. Because of the lack of standardization in the footwear industry, the millimeter scale device is

Fig. 5.3 Focal point concepts in practice

preferred. With this version of the device, the indicated length can be checked where possible against each manufacturers' standards to give a more specific shoe size indication. Shoe-sizing systems also vary internationally and the use of a millimeter scale will allow meaningful comparison with shoes from any country through the sensitivity to change offered by the millimeter scale.

Prior to inserting the gauge into the shoe, it is advisable to check the inside of the shoe as far as possible for the presence of any potentially harmful item within the interior of the shoe. In use, the internal shoe size gauge is inserted into the shoes of interest, with the anterior edge of the device being placed carefully against the furthest aspect of the shoe toe box. With the anterior aspect of the device held securely in place, the rear component of the device is then slid backwards until it just contacts with the internal heel area of the shoe and the indicated internal size of the shoe is then read off from a scale (Fig. 5.4). In this way, the internal length of the shoe from front to rear (toe box to heel) of the shoes can be confirmed (Lucock 1980). Where the examined shoes have a styled toe box, allowances need to be made for the greater internal length cause by that styling (Fig. 5.5).

As an alternative to this specialist device, shoe length can also be indicated through the use of a locking steel tape measure. In this, the front end of the measure is slid to the end of the toe box inside the shoe and the body of the tape measure extended

Fig. 5.4 Internal size gauge to indicate shoe size

Fig. 5.5 Compensating for shoe styling when using an internal size gauge

Fig. 5.6 Locking steel tape measure to indicate shoe size

until it makes a snug contact with the rear of the shoe. The tape is then locked, carefully removed and the total internal length is then given by the locked tape distance plus tape case length, which is often marked by the tape manufacturer on the side of the tape casing (Fig. 5.6). The indicated shoe length is then checked against manufacturers' or other tables to allow this length to be converted into an indicative shoe size with the measurements being recorded in the examiners notes.

Having provided a written description and confirmation of the internal length of the footwear item to be examined, the footwear should be photographed from the upper, medial, lateral, anterior, posterior, and outsole aspects, following the principles advocated in Chap. 3. In addition to this, simple records of the upper crease marks and distortions of the shoe upper can also be made. This can be done by placing the shoe onto a sheet of stiff card stock, tracing the outsole periphery, and marking the crease mark and upper distortion positions on the card stock and carefully cutting out this outline to make a template. This can be useful later for preliminary comparison purposes. The card template should be carefully labeled to include the evidence code, shoe description, date, and an indication as to whether this template is of the right or left shoe. A more accurate template can be prepared later from a life-size print out of the photograph of the shoe upper; however, the cardboard template will allow simple early physical comparisons to be undertaken prior to that stage.

5.4 Footwear Assessment Phase 2

The next phase of the footwear examination requires the shoe to be examined internally. Here, the use of an inspection mirror and hand light will allow a simple inspection of the shoe interior to be undertaken with a particular focus on signs of wear. Where the shoe cannot be cut apart, the examiner will need to rely on the mirror in conjunction with the simple palpation of wear (while wearing protective gloves as necessary), to determine the sites of wear within the shoe. In this scenario, it is also possible to photograph the images of reflected wear in the mirror with simple, qualitative descriptions being provided to describe these internal wear observations. It must be stressed, however, that this approach is far from ideal and permission to cut open the footwear should be sought wherever possible. Whether or not the shoe can be cut open, it is at this stage the examiner would determine whether the shoe insole/sock liner can be detached. In some footwear items, this is a simple task with the insole/sock liner simply being placed and not adhered into position. In other cases, the insole/sock liner may have been fastened into position with an adhesive. It is worth attempting to gently remove the insole/sock liner, even if it has been glued into place, as in some cases, the insole/sock liner can be detached from the adhesive within the shoe relatively easily. Care is required at this stage, however, not to tear the upper surface of the insole/sock liner and at the first signs of potential damage, the examiner should cease the attempt at removal and proceed if possible to opening the shoe.

Whether or not the attempt to remove the insole has been successful, if permission has been granted and closer inspection is required, the shoe should now be opened carefully. The task is to separate most of the upper from the sole unit leaving a section of material intact, which will act as a hinge on completion of the task (Fig. 5.7). A sharp, strong knife is essential and this is often easiest to use on the sides of the shoe, where, because of the design of the shoe, the material tends to be relatively soft, pliable, and not reinforced. To separate the heel and toe box areas, which may be reinforced, a strong pair of scissors may be more appropriate and also safer to use at this stage of the separation. Once the shoe has been opened, if the insole/sock liner is still in place, a further attempt can made to separate this from the body of the sole unit, taking advantage of the improved access. Here, the use of a blunt instrument can useful to aid the separation process, but again at the first indication of potential damage, the examiner should end the removal attempt and photograph the insole in situ instead. If the insole has been removed, it should be photographed separately using the techniques of lighting and photography advocated in Chap. 3. The purpose of making a recorded image of the outsole is to capture the foot impression on that insole in a manner that will show optimal detail of that impression for later comparison purposes. At the same time, it can also be useful to make a simple tracing of the outline of the insole/sock liner to show the position of the foot impression on the material surface. Here, an acetate sheet is placed into secure, close contact with the insole/sock liner with the examiner palpating the impressions carefully to determine the extent and shape of the impression, tracing the outline carefully at

Fig. 5.7 Preparation of footwear for internal examination

the same time. The acetate sheet can then later be used to make a preliminary comparison of this foot impression with that present within other footwear items. A written description of the wear impression can also be provided, with particular emphasis on the presence/absence of particular toe impressions, unusual features of the imprint, and a preliminary assessment of their positions relative to the periphery of the shoe as an early indication of shoe fit.

Having examined the shoe insole/sock liner as described, the next task is to consider the lining of the internal upper surface of the shoe. Here, all sites of wear, distortion, and damage should be recorded using digital photography. Notes should also be made of the site and level of deformation/damage caused by the related anatomical features (e.g., the apex of the second toe, lateral aspect of the fifth metatarso–phalangeal joint, etc.). Further comment can be made on any foot/shoe size match implications and any unusual features that may be apparent.

At this stage, the examination of the single footwear item is complete. A final check should be taken to ensure that all required notes have been made, that all digital photographic images have been taken, and that these images appear to be of the required quality. When the examiner is satisfied that this is the case, the footwear evidence that has been the subject of the examination should be put back

together again as far as practicable and returned to the relevant evidence bag, which should be immediately resealed. The time of the resealing should be recorded and the evidence bag returned to its keeper. The described process is then repeated for all questioned and known items to be examined.

5.5 Shoe Owner Assessment

It can also be advantageous to examine the suspected owner of any of the footwear items involved in the investigation and, in the case of possible multiple wearers of shoes, the known wearer of any shoes that may have found their way into the suspected wearers' possession. This may not always be possible, however, particularly in the face of a refusal on the part of the person concerned to be examined. In this case, the comparison phase would proceed on the basis of footwear item comparisons alone. Where the owner or suspected wearer of any of the shoes is available and willing to be examined, inkless footprints should initially be taken using the protocols advocated in Chap. 4. A full clinical examination of the person (or persons) involved should then be undertaken and the presence of any foot pathologies recorded. Finally, a template of the suspects foot outline should be made using the following technique:

- A standard box of foot impression foam is placed on a firm surface.
- The subject is asked to stand with the respective foot adjacent to the impression material, supporting him or herself gently, if required.
- The subject is instructed to place the foot carefully in position over and just resting on the foam impression material.
- When the foot is positioned within the confines of the material, the subject is asked to force his or her foot vertically into the material. The examiner can gently press any of the dorsal aspects of the foot further into the material to ensure that an impression of adequate depth has been left of the foot.
- The subject is asked to carefully lift his or her foot vertically out of the impression material.
- The material and the contained box is both labeled with the subject's name, the date and time that the impression was taken and a code is ascribed to identify the item within the notes.
- The process is then repeated for the subject's alternate foot.

At a later stage, the impression taken in this way can be used to create an exact template of the peripheral border of the subject's foot. This template can be made by placing a scale on the upper surface of the impression material and taking a digital image of the impression using the photographic techniques described in Chap. 3. The scale image is then printed out life size and the peripheral template cut out carefully to give the required template.

5.6 Footwear Assessment Phase 3

Following processes detailed above, the foot impressions and other wear features from the examined footwear items and features of interest noted from the subject need to be considered further. At this stage, life-size foot impression images need to be created for comparison purposes using the techniques described in Chap. 3. These life-size images can then be printed out to allow the outlines of foot impressions within the shoes to be traced accurately onto clear acetate sheets for outline comparison. A second copy should then be made of the life-size electronic digital image. This can then be used in electronic format to give accurate measurements of the foot impression using the Gunn method (see Chap. 4 on bare footprint examination). Such measurements can be made as follows (these instructions are based on the basic Adobe Elements software programme but can be adapted to other software packages):

- Use the zoom tool to enlarge the image on screen to the maximum practical working size
- Verify that the electronic image has been converted to life size
- Select the pencil tool from the toolbox menu
- Select an appropriate size for the pencil mark to be utilized (typically 10 px)
- In order to facilitate the accurate placing of the marks to follow, the grid function should be used on the software program and the image rotated so that the most posterior aspect of the heel print just contact the adjacent horizontal line of the grid and the most lateral aspects of the footprint just touch an adjacent vertical line of the grid
- Place pencil dots on the foot impression points to be used in the Gunn approach (basic measurements including rearmost aspect of the heel, tips of all toes and medial and lateral aspects of the ball of foot areas)
- Select the line tool from the software menu
- Select an appropriate color for the line to be drawn from the Swatch menu (red is often particularly suitable, depending on the background color of the foot impression)
- Select an appropriate weight for the line width (typically 5 px)
- Using the line tool, place the cursor on the first foot impression point to be used in the measurement and drag and hold to the second point to be used
- Continue until all required lines have been drawn
- Flatten the image using the function – layer/flatten image (this is essential in order to "lock" lines to be put in later with the foot impression image when the image is rotated later)
- Place a grid across the image checking the function – view/grid
- Select the function – image/rotate/free rotate layer
- Placing the cursor on one of the rotation points, rotate the image until the first measurement is parallel with any of the grid lines
- Select the rectangular marquee tool from the toolbox menu
- Carefully place the cursor on one end of the first line to be considered, then drag and release to the opposite end of that line
- Select info from the menu

- Read off and record the length (or for the cross ball of foot measurement, the width) of the line in centimeters to two decimal places
- De-select the rectangular marquee tool and go back to the function – image/rotate/free rotate layer
- Complete the process for the measurement of all other lines involved

The above approach will give quantitative measurements taken from the footprint dimensions for later comparison using the Gunn method. If the optical center method is preferred (see Chap. 4, Bare Footprints), most examiners will need to use manual approaches involving life-size printouts to determine and measure from the optical centers unless access to software that allows the creation and use of optical centers is available. In this manual approach, which was devised by Kennedy,[2] an acetate-based "target" with a central pin hole is placed in the position of best fit over the morphological feature from which the measurement is to be taken and a mark made through that center onto the foot impression image. Lines are then drawn as in the Gunn method to connect these marked points.

At this stage, the examiner will have measurements taken by either the Gunn or optical center approaches along with traced outlines of the foot impressions under consideration taken from the insole or sock liner, which would be used in the comparison process to follow. The next task is to undertake these comparisons.

5.7 Footwear Comparison and Evaluation

Having examined all relevant footwear items including the collection of descriptive and quantitative measurements, the next requirement is comparison of the detail present on both known and questioned footwear items. The comparison process can be considered as two separate but related phases – direct comparison and evaluation.

5.7.1 Direct Comparisons

5.7.1.1 Marked Shoe Size

The first direct comparison to be undertaken is that of the marked and sized shoe lengths. Here, the marked length is used to check for compatibility where the usual wearer of a shoe is being considered.

5.7.1.2 Sized Shoe Length

In the comparison of shoe length as confirmed by the use of an internal measuring device, the measured internal length would need to be compared with the information

[2] Kennedy R., personal communication, 1996.

provided by the manufacturer of that shoe to verify the shoe's size. This can be undertaken in two ways. Firstly, the shoe may contain labeling that clearly states the internal length for that particular shoe in centimeters and also in size according to the length system used in various countries (e.g., UK, US, or European size). Secondly, tables are produced by many manufacturers and these can be used to show the internal lengths used by that manufacturer for shoes of given sizes; these tables, where available, can be used to confirm the size of that particular shoe.

When a suspected wearer of the shoes is also available for examination, the overall length of that person's foot can also be compared with the marked and sized length of all shoes considered.

5.7.1.3 Upper Crease Marks

Next, the position and angle of the upper crease marks apparent between both known and questioned footwear items should be considered. Here, the examiner is looking for similarities and differences in the placing and the measured angles of such marks (Fig. 5.8).

Fig. 5.8 Position and angle of creasing of the shoe upper

Where a suspected wearer of these shoes is also available for examination, the heel-to-ball length of the foot and any pathological features that may have influenced the placing and angle of the upper crease marks can also be compared with these marks.

5.7.1.4 Upper Distortions and Inner Lining Wear

The upper surface of the examined shoes may show a number of distortions. These can include a general medial or lateral displacement of the upper (Fig. 5.9), bulging of the medial and/or lateral aspects of the shoe in the shoe flex line region, and bulging of the toe box area, corresponding to the contained toes. The examined shoes can be compared for the presence or absence of such distortions. While considering distortions of the shoe upper, wear within the shoe or the lining surface should also be taken into account. Here, the examiner is looking for similarities and dissimilarities of wear features relating to the fit of the medial and lateral aspects of the ball of foot area and around the heel.

Where a suspected wearer of these shoes is also available for examination, the overall shape and function of the foot can be compared with any distortions apparent. To assist this comparison, a template can be prepared of the outline of that persons' foot structure and the features apparent within that outline can be compared to the wear features apparent within the shoe upper and lining. This foot outline template can be used to compare the ball of foot and toe positions with distortions and wear in the shoe upper surface (Fig. 5.10).

Fig. 5.9 Upper shoe distortions

Fig. 5.10 Toe impression wear features

5.7.1.5 Toe Impressions

Inside the shoe, staining, impressions within the upper, or a wearing through of the lining of the upper may be found (Fig. 5.10), which would correspond with the positioning of the toes that have been contained within these shoes. These wear features can be directly compared between the examined known and unknown shoes with a view to determining similar and dissimilar placing of these particular features.

Again, where a suspected wearer of these shoes is also available for examination, the position, morphology, and any pathological states of the toes can also be compared with impressions and wear caused by the wearer's toes within the shoes. The creation of an outline template as suggested above will also facilitate the comparison between the persons outline foot shape and toe impressions apparent within the shoe.

5.7.1.6 Foot Impressions

Central to comparisons involving footwear is the use of the plantar impressions taken from known and questioned footwear items. Here the comparisons undertaken follow the procedures detailed under bare footprint identification as considered

in Chap. 4, however, greater attention will be needed when considering the additional variables brought about through the relationship between the foot and the containing footwear. These need to be considered carefully in the evaluation phase of the process.

Where a suspected wearer of these shoes is also available for examination, foot impressions can also be taken and compared with foot impressions present within the examined shoes. This may not, however, always be desirable. The bare footprint is in effect a snapshot in time, in which the foot has briefly contacted the ground at the moment that the impression was created. Conversely, the foot impression within a shoe is in effect a history of the relationship between the contained foot and the shoe's sock liner or insole within which that foot has been in contact. As such, the form of the foot impression within the shoe may have been influenced by a whole range of activities together – walking, standing, running, turning, sliding, etc. – and may therefore become quite different in shape and character. For this reason, the preferred comparison would be between separate footwear items, which should also be "like-with-like" items where possible (i.e., training shoes should be compared with training shoes, dress shoes with dress shoes, etc.). The bare footprint could, however, be a useful addition to this comparison process where unusual features of the foot impressions within the shoes are apparent.

5.7.1.7 Outsole Wear Patterns

Finally, the outsole wear patterns of footwear items that have been examined can also be compared. The practical difficulty in this comparison is that of comparing the wear of older shoes with that of quite new shoes, when the wear patterns can appear quite different in their spread across the outsole surface. The focal point concept mentioned earlier in this chapter (Fig. 5.2) can assist with this comparison as it considers and compares the central positions from which each component of outsole wear spreads as opposed to considering the outer periphery of that wear. This allows worn new and old footwear items to be compared together irrespective of the amount of wear. In the comparison of outsole wear patterns, the examiner would again look for similarities and dissimilarities between the wear patterns of the outsoles being compared.

5.8 Evaluation (Interpretation)

Evaluation of the comparisons made as detailed above will require interpretation of the comparison data. Here, the significance of any apparent matches or mismatches in terms of identity will be considered in the particular context created by the wearing of shoes. These shoes will not only demonstrate wear features caused by the contained functioning foot, but also will have served to introduce variable

influences, which may have affected the contained foot. The wear features in their own right and the effect of those external variable influences will demand interpretation by the forensic podiatrist – a task that can be complex because of the many variables potentially involved.

5.8.1 Marked Shoe Size

Lucock (1980) considered that while differences in the sizes of shoes belonging to a single person commonly vary by a half or full size, a person would be highly unlikely to wear footwear with length differences greater than 1½ sizes and the author's personal observation supports this belief. Close matching of shoe size could therefore be considered as a compatible class characteristic in footwear comparisons. It must be remembered, however, that this consideration centers on the usual wearers of shoes and would not necessarily apply to situations in which footwear has been worn for a period of time by a second wearer for reasons of convenience, ignorance, socio-economics, or a deliberate attempt to deceive. Here, quite major mismatches in shoe size are possible as factors other than normal purchasing habit may then come into play. It should be noted, however, that such mismatches would still usually be within the ±2 shoe sizes for the wearer, although anecdotally. There is, however, strong potential for shoes that are short for the wearer to show clear wear features demonstrating that an over-long foot has been contained within that shoe.

5.8.2 Sized Shoe Length

The comparison of sized length is important for two reasons. Firstly, confirming the marked size can be especially important where "fake" designer shoes are widely available and where such fakes may be incorrectly sized according to the true manufacturer's specifications. Secondly, where mismatches have occurred between foot length and shoe length, confirming the actual shoe length will help to determine the magnitude of such differences in terms of that manufacturer's shoe size and, in turn, will help the examiner to produce conclusions over the minimum length of the foot that has been contained within that shoe.

5.8.3 Upper Crease Marks

In shoes of approximately the same length, with common ownership, it would be expected to find that the upper crease marks would share approximately the same position and angle. Where the position differs between known and unknown shoes

being compared, further consideration would need to be given to the possibility of the shoe structure and design itself having influenced the position of the crease mark. Here, for example, it is possible for the leading edge of the eyestay of the shoe to have influenced the upper crease mark position, requiring the crease to pass in front of as opposed to through this feature. It is also possible for the toe cap of the shoe to amend the crease position. Where such factors are believed to be present, they should be carefully documented as a confounding factor. Where no influencing design features of the shoe are apparent, with common ownership, the crease marks would be expected in approximately the same position and conversely, different crease positions without any apparent footwear influence may indicate different wearers of the shoes being compared.

Similarly, upper crease marks would be expected to be positioned at similar angles where they share common ownership. Again, this would be dependent on the crease marks not having been influenced by the shoe design. Where no such design feature can be found that may have affected the crease mark angle, and the crease marks of the compared shoes are found to be situated at different angles, then this may suggested that the examined shoes have different wearers. The angle of the crease mark may relate to the presence of foot pathologies that could have led to the creation of a more extreme angle than would normally be anticipated. This can particularly relate to a foot that has supinated towards the end of the stance phase of the gait cycle, such as typically seen in a foot that exhibits hallux rigidus or hallux limitus. The presence of such an angled crease mark without apparent influence from the structure of the shoe may therefore indicate the presence of such a condition. If it has been possible to examine the suspected wearer of the shoe and such a condition has also been observed in that person and brought into the comparison process, then that would be a further compatible class feature indicating possible common ownership.

The crease mark also has a role to play in considering the implications of the shoe fit in terms of length. One of the most important foot measurements is the heel-to-ball measurement – the distance from the rearmost aspect of the heel to the inner ball joint of the foot (Rossi 1992). The ball of the normal foot should flex during motion and, at the same time, the shoe is designed to flex at a position related to this position as represented by the heel-to-ball measurement of the foot. The shoe is designed to accommodate this function just anterior to the front edge of the shank of the shoe (Council of the Society of Shoefitters 1991). For a shoe to fit correctly, the ball flex positions of foot and shoe should match. Where there is a mismatch between the foot position and the shoe ball flex position and/or angle, this can lead to friction in this area through the foot and shoe attempting to flex at different positions relative to each other. Where this occurs, the shoe may crease away from the point at which it was designed to flex. In the evaluation phase, the presence of such wear features at this point of the shoe can indicate a mismatch of the foot versus shoe heel-to-ball length and can provide further evidence of a shoe having been worn by someone of either a larger or smaller foot size than the marked size of the shoe.

Fig. 5.11 Additional anterior crease mark associated with a shoe that was too long for the wearer

Also in relation to shoe length is the potential for an over-long shoe to show an additional crease mark towards the end of the shoe, where the foot has prepared for toe-off during walking, with an additional length of shoe extending further forward than the shoe designer intended had the shoe been correctly fitted (Fig. 5.11). The shoe is then forced to bend as the toe-off function takes place, leading to an additional anterior crease mark, which is an indicator of a short foot being placed within that shoe. This can in turn, suggest size parameters for the contained foot, especially when considering additional wear features within the shoe (e.g., the foot impression, etc.).

Crease marks can also indicate that the shoe has been worn by more than one wearer. In reaching such a conclusion, the crease marks would need to be considered in conjunction with other wear features of the shoe, particularly those relating to ball-of-foot positioning. A crease mark situated well behind the impressions caused by the ball of a foot that has been placed within a shoe that has been fitted reasonably correctly would indicate the strong possibility that the shoe has experienced two different wearers, as the crease mark would then correspond with the metatarsal shaft positioning of the wearer who had created the ball-of-foot impressions (Fig. 5.12).

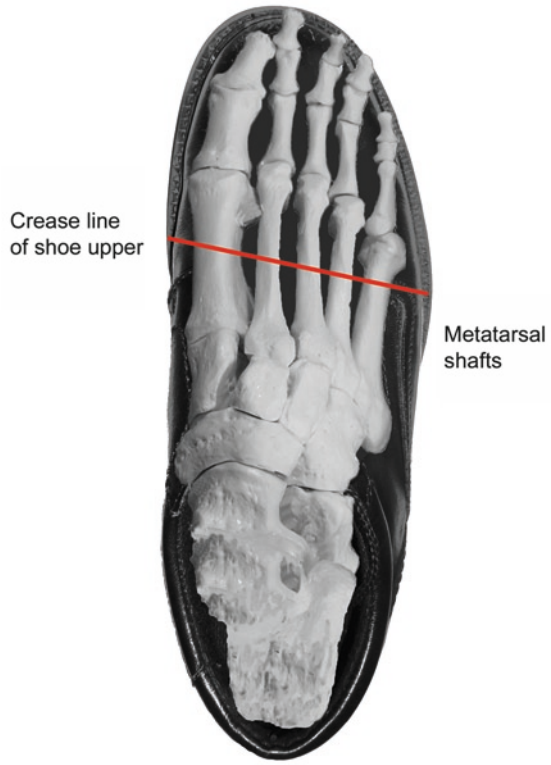

Fig. 5.12 Conflicts between upper creasing of the shoe and the functional anatomy of the foot seen in cases of multiple wearers of shoes

5.8.4 Upper Distortions

Upper distortions involving a general medial or lateral displacement of the upper can either be related to function or to the fit of the foot that has been contained within that shoe. Where these features have been noted in known and unknown footwear, further consideration will need to be given as to whether these features have arisen from common functional causes, or from shoe-fitting problems. Where differences as opposed to similarities are found to exist between known and questioned shoes, further consideration should be given to whether these differences can be justified through factors such as different shoe fit, age, and design. Distortions that may be notable in soft upper material may not, for example, be apparent in comparison with a shoe manufactured to a much stiffer material specification.

The examiner may be able to determine the cause or causes of such distortions relating to features suggesting common ownership. They could also be due to unrelated fitting problems. When assessing such features, it should always be borne in mind that upper distortions of footwear may possibly relate to other external causes, such as the placement of heavy weights on the top of the shoe while in storage.

Where the suspected wearer of the shoes is available for examination, features from that person and/or templates created from that person's foot outline can be brought into the evaluative considerations, further strengthening the evidential opinion.

5.8.5 Toe Impressions

Toe impressions formed within the shoe upper can indicate problems with the fit of the shoe or, alternately, the presence of toe pathologies that have affected the wearer of that shoe. Where the toe positions are situated on, or in close proximity to, the point at which the shoe upper meets the periphery of the sock liner or insole, this can indicate that the shoe has not correctly fitted the wearer, either in terms of available length or toe box style. This can be an important fact to know when comparing shoes of different lengths. Where a shorter and longer shoe are being compared together and it is found that the shorter shoe has been too short for the wearer and the longer shoe has been the correct length for the wearer, this can mean that despite the apparent length differences, the shoes could still have the shared same common wearer. Where toe impressions are apparent within the upper of the shoe, this can indicate the presence of pathologies such as hammer or mallet toes, or hyperextension of the toes. Referral to the prevalence data for these conditions will show the evidential value of determining the presence of such conditions across both known and unknown footwear items examined.

If it has been possible to examine the suspected wearer of the shoe and the recognized conditions have also been observed in that person and brought into the comparison process, this would be a further compatible class feature indicating possible common ownership of the shoes in question.

5.8.6 Foot Impressions

The same features and considerations involved in the evaluation of bare footprints also come into play when considering foot impressions within footwear being examined. In dealing with a foot impression present within a footwear item as opposed to the impression created by the bare foot, additional considerations needw to be taken into account, other than the effects of function on that impression. These include the potential for the plantar impression to have been modified from its natural position by the interaction taking place between the foot and the containing shoe, the effect of shoe fitting and shoe sizing on the impression, and the implications of additional wear features apparent in other areas of the examined footwear, when the shoe is considered in its entirety. The effects of function on the plantar impression have been dealt with in the earlier chapter on footprint identification. The additional factors to be considered in the evaluation will now be considered additionally and in turn.

It is possible the plantar impression will be modified from its natural position by the interaction between the foot and the shoe. This factor is the main reason

why like-with-like comparisons are highly preferable in footwear comparisons. There are many ways that a shoe can amend the form of a foot impression and a like-with-like comparison can go a long way to eliminating many of these variables. One of the most dramatic variations that can occur between compared foot impressions of the same person relates to the effect of the toe box shape on the contained foot, where a styled shoe can channel the toes into a position that they would not have naturally adopted (Fig. 5.13).

Fig. 5.13 Clockwise from lower left (all standing): barefoot; running shoe (size 10); cross trainer (size 10); casual dress 2 in. heel (size 10)

An extreme manifestations of this variable can be seen in the effect that a court shoe has on the plantar impression. The possibility of a shoe channeling the toes away from their natural position in this way should be considered in plantar impression comparisons where measurements fall outside the ±5 mm variation, and where the overlay approach demonstrates that toes fall out of line in their positioning. A careful evaluation may find that the toe box shape is the responsible factor. It should be noted, however, that while this factor may affect the general positioning of the toes through the forcing of the toes into close proximity with each other, it may also mask the general morphology of the toes. This effect would be unlikely in itself to affect the heel-to-toe length of any impressions under consideration. In some examples of the effect of such restrictions, the positions of just one, two, or three toes may have been amended – typically, the fourth or fifth toes. Again, where this is apparent through the shoe design and toe impression positions, this should be documented as a possible cause of any variation noted. Indications that this may be a factor come from the shape of the toe box itself, distortions that are apparent in the toe box area of the upper surface of the shoe that relate to the toe positions and wear and/or impressions within the shoe that correspond to toes that are believed to have been forced out of line.

Similarly, awareness should be maintained for the possibility and effects of a shoe having been of inadequate width for its wearer, when considering the cross-ball impression measurement. Here, the ball of the foot could have been compressed laterally, giving the impression that the cross-ball length is less wide then it would be if allowed to adopt a more natural position. Again, consideration of the shoe in its entirety would provide support for this conclusion, particularly where corresponding distortions of the shoe upper have been apparent.

Where the suspected owner of the shoe is available for examination, prints from that person can again be used in the comparison as can an pathological features that may have manifested themselves in the formation of the foot impressions being considered. Such features could include, for example, those that have amended the morphology of the foot (e.g., hallux valgus) and those that have had an effect on foot function (e.g., hyperpronation). The significance of the presence of these features across all items examined can be shown by referral to known prevalence data for these conditions.

5.8.7 Outsole Wear Patterns

The outsole wear patterns of footwear items that have been examined and compared should also be evaluated. Great caution is required when evaluating the comparisons between outsole wear patterns. Such patterns are not necessarily stable features and they can be influenced by a multitude of variable factors (Vernon 2000; Vernon et al. 2004). It has previously been considered that characteristic outsole wear patterns would be created by known foot pathologies (Lucock 1980; Charlesworth 1961; Gibbard 1958a, b; Hanby and Walker 1949; Lake 1943;

Gottlieb 1939); however, it is now known that this is not the case (Vernon 2000; Vernon et al. 2003, 2004). A hierarchy of influence has been constructed to show the factors that compete together to influence the form of the outsole wear pattern of footwear (Vernon 2000; Vernon et al. 2004). This means that footwear belonging to the same person can, depending on circumstances, show quite different outsole wear patterns. While this model is of clinical interest, its purpose in terms of identification involving shoe outsole wear patterns is to show that these features can be amended by three classes of variables, meaning that wear pattern differences observed between known and questioned footwear items do not necessarily mean that these shoes have different usual wearers. This can be problematic when attempting to use outsole wear patterns in human identification. They can however, be used as another class indicator, when identical patterns are observed across known and questioned footwear and where unusual wear patterns are repeated across known and questioned shoes this can be of greater value, especially where a reason for such unusual wear patterns has been observed in a postulated wearer of these shoes. It is not possible, as previously thought, to examine the outsole wear pattern of a shoe in isolation and name the causative pathology. In order to make such interpretations, a context is needed, such as may be provided by considering other wear features of the shoe and/or the history of that shoe and the clinical features exhibited by the postulated wearer. If this context is available, then the evaluation of such wear features can become meaningful.

5.9 Conclusions

Footwear identification is a multidisciplinary activity and often the need to involve the podiatrist in this process is superfluous, particularly where the task is simply to link a shoe to a scene of crime. Where the task is to associate or disassociate a person with shoes already linked to that crime (e.g., where there is denial of ownership of shoes already linked to the crime scene), or where there are differences between the wear features of compared shoes, then the very specialized knowledge of the podiatrist can be useful. For the process to work smoothly, however, it is essential for each discipline involved to understand and respect the contribution of other specialties to the footwear identification process and for podiatrists to recognize the strengths and limitations of their own highly specialized role in this task.

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Chapter 6
Forensic Gait Analysis

Keywords Gait cycle • CCTV • Forensic gait analysis • Recognizable features • Analysis and evaluation

Forensic gait analysis is the most recent subspecialty of forensic podiatry. The work of forensic gait analysis involves the recognition and comparison of gait and features of gait, to assist the process of identification. The gait patterns and features of gait used in this process are usually those captured on closed circuit television (CCTV) footage, which needs to be examined in depth by the forensic podiatrist. As in other forensic identification processes, unknown or questioned footage of the person of interest in relation to a crime scene is compared against known footage that has been made of a known person. Conclusions are then made as to the value of the features that are seen to either match or mismatch in this comparison. This chapter defines forensic gait analysis, describes the processes involved, and comments on cautions that should be adopted while performing this work.

6.1 Basic Principles

Historically, practice in this area began in July 2000 when UK-based podiatrist Haydn Kelly first presented forensic gait analysis evidence in a trial at the Central Criminal Court (Buncombe 2000). In this particular case, using his clinical expertise, Kelly was able to recognize certain features of the gait of the perpetrator of a crime and relating these features to the published literature, was able to state that only 5% or less of the UK population would be expected to exhibit the gait features recognized (Buncombe 2000).

Forensic gait analysis has since continued to develop, mainly in the UK. The techniques are, however, increasingly being used in a number of other countries, where they are being developed within different legal systems. There are several definitions of forensic gait analysis, but in order to fully appreciate these, it is first necessary to remember what is precisely meant by "gait" and "gait analysis" in their clinical context.

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Gait itself is simply the manner of walking or stepping, bearing or carriage while moving and is intended to propel the body in the desired direction – usually forwards. Gait represents the most fundamental form of human movement (Watkins 2006). In order to achieve gait, a series of repetitive movements occur, producing sequences of steps and strides, which cause forward motion and in their totality are described as the gait cycle. The gait cycle has two main phases – the stance phase, which is that period in the gait cycle where the foot is in contact with the ground, and the swing phase, where the foot is being swung forward and is not in contact with the ground (Decker and Albert 2002). During these activities, there is what is described as single- and double-support phases, where either one or both feet are in contact with the ground at a particular moment in the gait cycle. The swing phase, by definition, represents the single-support phase of the gait cycle, however, there is also a point within the gait cycle during which both feet together are in stance and this is the period known as the double-support phrase, which lasts for just 10% of the gait cycle (Watkins 2006). These phases in the gait cycle can be broken down into considerably more detail, to understand what is happening precisely at each and every point of the cycle.

The gait cycle as described in the literature (Watkins 2006; Nixon et al. 2006; Decker and Albert 2002) is usually considered from an ideal perspective, where normal gait has been explained as "A method of locomotion involving the use of the two legs, alternately, to provide both support and propulsion" (Whittle 2007). Where deviations occur from the norm, problems can occur, which are well known to podiatrists, physiotherapists, orthotists, orthopedic surgeons, and other professionals who are concerned with problems of the functioning foot and lower limb. These deviations can be considered as functional anomalies within the gait cycle in which the anomalies themselves may be the direct cause of symptoms observed by the clinician, or of functional compensations that can be seen to be taking place in the presence of underlying pathologies. The work of podiatrists and some other clinicians involved in problems relating to the foot, the lower limb, and human movement is very much concerned with the recognition and management of such anomalies. The first phase of this work – that of recognition – involves the process of gait analysis.

Gait analysis is the process of quantification and/or interpretation of human movement. There are two methods of gait analysis – qualitative and quantitative (Bartlett 1997).

Qualitative gait analysis is a non-numerical evaluation of a movement and usually consists of a visual assessment of gait undertaken from the sides, front, and rear of the subject during walking (Perry 1990). The approach is routinely used by clinicians, particularly podiatrists who are taught first-level evaluation of gait within their program of undergraduate and postgraduate education. In this clinical gait analysis, an examination of the subject's gait is made during walking and considered against a theoretical norm, thereby enabling any deviations from this norm to become apparent through observation. Subjective gait analysis is an experience-based skill that can be learned and improved with practice. Cautions are required, however, in that, as highlighted by Vernon (2000), such subjectivity can be prone

to error. However, keeping these cautions in mind, qualitative gait analysis is a valuable tool for clinicians to use in their evaluation of patients.

Quantitative gait analysis, on the other hand, is a more in-depth form of gait analysis involving the collection and analysis of numerical data relating to the complex forces, pressures, and movements involved in gait. Such data are usually collected in order to allow movement to be studied and may include information such as linear and angular displacement, velocities, accelerations, forces, torques, energies, and powers (Bartlett 1997). This process is facilitated through the use of technology, such as computer-interfaced video cameras to measure patient motion, electrodes placed on the surface of the skin to appreciate muscle activity, and force platforms imbedded in a walkway to monitor the forces produced between the ambulatory patient and the ground.

Forensic gait analysis from the perspective of the podiatrist currently involves the recognition and comparison of nominal and some ordinal data and not the numerical (interval) forms of data that would be involved in objective or quantitative gait analysis. Kelly does, however, report that "forensic gait analysis is undergoing quantitative development," which he is using in case work and in the development of an automated method of recognition,[1] although details are not available at the time of writing.

6.1.1 Definition

Forensic gait analysis was first defined by Kelly (2000) as "The identification of a person or persons by their gait or features of their gait, usually from closed circuit television (CCTV) footage and comparison to footage of a known individual." Forensic gait recognition was later defined by Grant (2006) as "The process of identifying people by the unique characteristics of their manner of walking," where "features are extracted from a person's gait in order to recognize them." This definition is currently somewhat optimistic, as to date, the characteristics of walking and the features of a person's gait, as evaluated qualitatively, have not been demonstrated to be unique, although there is certainly class-level distinction. The work has been used not only to provide evidence when required, but has also been used by a number of security agencies as an investigational (intelligence) tool.[2]

The practice of forensic gait analysis has been the exclusive domain of forensic podiatrists (Vernon et al. 2009:11). Some other medical and medically related disciplines do have the background knowledge to be able to undertake this form of work; however, with limited exceptions from a few particularly interested professionals, none of these other disciplines have developed expertise in this area of

[1] Kelly H.D., personal communication, 23rd Jan 2010.

[2] Kelly H.D., personal communication, 23rd Jan 2010.

practice. Academics in other specialized areas have, however, been considering the potential for the automated recognition of gait and, to this effect, have been attempting to develop biometric approaches to forensic gait analysis, with this work being particularly investigated by computer engineers (Nixon et al. 2006; Grant 2006). At the time of writing, considerably more work appears to be required before this can be used outside the laboratory situation – although a considerable amount of research has been put into this task, the computational tasks required are immense. As noted above, however, Kelly has also reported that he is furthering the development of automatic gait recognition and publication of further detail is anticipated.

Forensic gait analysis as developed and practiced by podiatrists and the general biometric approach to automatic gait recognition both essentially look at an individual's gait, although the methods employed differ.

6.2 Method of Comparison

One published biometric approach is an attempt to recognize gait by comparing repetitive patterns of a subject's gait cycle, with variations in this cycle being used to distinguish one gait pattern from another (Grant 2006). The biometric gait signature being worked on by Kelly[1] is reported to be considering numerous aspects of gait in the gait recognition process. Forensic gait analysis as currently practiced by podiatrists is the recognition and comparison of particular forms or classes of gait, or of different class characteristics of the components of gait, using known prevalence data to show how distinct the recognized features would be in the population.

In practice, forensic podiatrists usually become involved in forensic gait analysis when the perpetrators of a crime have been captured on CCTV recordings and their more obvious features, particularly facial identity, are obstructed or unclear. This is of particular use where perpetrators of crime either make deliberate attempts to cover up identity, for example, by the wearing of hooded clothing or masks, or when their features are unclear because of image quality, shadow, or angle of view. Where such individuals are ambulant, this raises the potential for the analysis of individuals gait and/or features of gait to assist in the identification process, where such features can be recognized. The focus for this work is on factors of podiatric importance, that is, foot and lower limb functional anomalies recognizable within the specialty of podiatric biomechanics.

6.3 Methodology

The methods involved in forensic gait analysis are relatively simple. The requirements are for questioned (also described as incident or unknown) footage to be available – that is footage of the unknown perpetrator of the event in question as

well as known footage – recordings made of a person suspected of being present in the questioned images. Both recordings would be examined by the podiatrist, who would use their knowledge and skills in gait analysis in viewing and examining for the presence of common discriminating gait-related features in both recordings, which would show compatibility and conversely for features in the recordings that would demonstrate incompatibility. Although this may appear to be a simple process, care is required in determining whether the images allow such comparisons to be made.

6.3.1 Collection of Known Footage

While pre-existing known footage is often already available for comparison with the questioned recording, if this has not already been undertaken, it may be necessary to advise the instructing agencies as to how to collect this appropriately for comparative purposes. Here, recommendations may need to be given as to the camera angle and detail required in the known footage, with the intention being to try to match known and unknown recording variables as closely as possible. While forensic podiatrists can provide advice regarding the collection of such recordings, it would be unusual for the podiatrist to become directly involved with this process and it is usually left to those with expertise in carrying out covert recordings. Once this known footage has been collected and forwarded to the examining podiatrist, the recordings are subjected to the same quality checks as detailed above.

6.4 Assessment

6.4.1 Quality Requirements

The key difference in dealing with CCTV images as opposed to image analysis in the clinical setting lies in the quality of the images available, the additional variables and the significance of these variables, which the examiner has to deal with in the analysis. In clinical settings, high-quality, high-resolution, detailed images from standardized perspectives are utilized, whereas CCTV images are usually of much lower quality and resolution. CCTV images may also contain a significant number of variables that need to be taken into account through differences in the positioning and context of the CCTV scenarios. For this reason, the initial tasks of the examining podiatrist are to prepare for the appropriate examination of the images concerned and to determine whether or not the images are of sufficient quality to allow meaningful analysis to be performed.

Suitable equipment will be required in order to allow meaningful examination of the recordings. Previously, in the UK, the Home Office listed recommended equipment for the examination and comparison of video recordings as evidence. However,

with the wide availability and increasing quality of recording playback equipment, this list is no longer produced. The examiner should, however, ensure that there is either direct or indirect access to appropriate equipment, including:

- Computer and high-quality DVD player with playback, pause, slow motion, and fast forward capabilities.
- High-quality videotape player (e.g. Super VHS) with playback, pause, slow motion, and fast forward capabilities. (This is becoming less of a requirement with the increasing use of digital recordings.)
- High resolution screen or monitor
- Video editing software
- CCTV video demultiplexing, recording, and enhancement software capable of extracting and displaying camera numbers, time, and date information on the examined images.

Having selected the equipment to be used in the examination process and having also obtained any known footage for comparison purposes, the next task is to ensure that the original/master recordings are available for viewing, whether DVD-based recordings or videotape. This is to ensure that originals and not copies are viewed in order to verify that any copies that are worked with are consistent with the original. Having viewed the original/master recordings and compared any copies provided against these for compatibility, it is acceptable to use the copies for analysis. With the continued advent of technology and digital storage devices, copies in their original format (and copies where there is no data loss on transfer or conversion of the original format) taken from computer hard drives do not show loss of data. For forensic gait analysis, it is important that detail is not "lost" if compression of the data has been performed when copying from the original material. This is more likely to occur when the copying or conversion of original time-lapsed footage involves compression of the images. Copying onto portable storage devices such as digital video display (DVD) is a convenient way to receive the material for analysis and the availability of high-speed connections allows for video footage to be transferred more rapidly. An analysis should then be made of the material provided to determine whether it is of suitable quality to allow meaningful analysis to take place. This is essential in order to help prevent errors being made that will not stand up to later scrutiny.

At the time of writing, work has been undertaken at the University of Brighton to prepare and test a template for objectively assessing the quality of a recording in the context of evidence provision (Birch 2009) (Table 6.1). Such a template has the potential to be applied at the initial quality assessment stage of the examination. In working through the quality assessment, the examiner would initially consider the picture itself. Factors worked through would be how the image varies between being very sharp or very blurred. The contrast in relation to the detail of interest would next be evaluated, as would the brightness of the image – whether it is too bright, or too dark, or indeed where it would lie on a continuum between these two extremes.

Having considered the picture overall, considerations over the suitability of the image would be made, and these would be limited to factors such as whether or not

Table 6.1 Draft template for objectively assessing the quality of a recording in the context of evidence provision

Picture		
Very sharp	⟷	Very blurred
Very good contrast	⟷	Very poor contrast
Too bright	⟷	Too dark
Lighting		
Very good lighting	⟷	Very bad lighting
No shadow interference	⟷	Significant shadow interference
No reflection interference	⟷	Significant reflection interference
Direction of light source good	⟷	Direction of light source poor
Direction		
Directly from the side	⟷	Directly from the front or back
Frame rate		
Continuous flow of image	⟷	Series of still images
Subject		
Whole of upper body in shot	⟷	None of upper body in shot
Whole of lower body in shot	⟷	None of the lower body in shot
Moving very fast	⟷	Moving very slowly
Ten steps or more in shot	⟷	Two steps or less in shot
Clothing good for gait analysis	⟷	Clothing poor for gait analysis

Adapted from Birch (2009)

the lighting within the image is suitable and whether or not there is interference from shadows or reflections.

The direction from which the person within the recording is being viewed is also an important factor in considering and assessing the quality of the image from a forensic podiatrists' standpoint. The person within the image could have been recorded from the side, front, or back, or from the same plane, above, or below. Depending on what is of interest in the image, the positioning may or may not be detrimental to the quality of the recording in relation to the features of concern. The question that should also be considered is that of what information can be extracted from the footage or image(s) under examination?

Also in relation to the person of interest within the recording, another quality requirement is the detail of that person present within the recorded images. In podiatric gait analysis whole body analysis should be considered as part of the evaluation. In forensic gait analysis, all aspects of the upper and lower body may not necessarily be available for viewing. The examiner must therefore consider whether all or part of the upper and lower bodies, respectively, are in view and whether or not the detail available for upper and lower bodies, respectively, and in their totality is adequate for forensic gait analysis to take place.

Similarly, the effects of clothing need to be taken into account. In podiatric gait analysis, podiatrists are interested in the movement of the body, and the type of clothing worn can facilitate, impede, or not affect such examinations. If tight clothing is worn, the gait and features of gait may be more easily accessible to the observer

Fig. 6.1 Comparison of clothing types that can affect the ability to perform forensic gait analysis

than they would be, perhaps, in the case of loose or flowing clothing, which may potentially hide the features of interest (Fig. 6.1).

The speed of motion must also be taken into account when determining whether or not the quality of image is adequate for forensic analysis purposes. If the subject is moving very quickly, this may prevent meaningful analysis from taking place, both from the perspective of lost detail and also from changed gait form, – i.e. from walking to running, whereby like-for-like gait comparisons are not so easy to undertake and in many cases are simply not possible to obtain.

Consideration must also be given to frame rate when assessing the suitability of the recording for gait analysis purposes. The greater the frequency of the recording measured in Hertz (Hz), the greater the detail that is able to be seen. Recordings may, however, vary considerably, with digital video recordings typically being recorded at 50 Hz, while many CCTV images are commonly recorded at 2 Hz or less. In the interests of economy and practicality, time-lapsed recordings are suitable for analysis, but when the lapses are more than 1s between images, this may be unreliable and subject to the amount of material available for examination. For example, a single frame being taken every 30 s would make true forensic gait analysis impossible, as this requires assessment of the kinetic flow of gait as opposed to single, disconnected images many seconds apart. In such circumstances, it may be possible to recognize single features of the foot/lower limb that contribute to the gait form; however, these would need to be very obvious and seen to be repeated in the footage to guard against the possibility of these being an isolated variation from the normal repetitive gait cycle for the person under observation. The quality assessment as detailed above should be undertaken for both questioned (unknown) and known recordings.

Where the quality of the image is deemed unsuitable for analysis, consideration should be given as to whether the image can be enhanced in order to improve the detail available within the image. Here, an appropriate laboratory specializing in digital technology assessment could consider the quality issue and, where possible, adjust various aspects of the image to attempt to enable more meaningful analysis

to take place. Such adjustments would typically cover minor adjustments to lighting and contrast. It must be recognized, however, that many problems cannot be corrected by such laboratories, particularly those relating to sampling rate, angle of view, clothing restrictions. etc., however, where any non-correctable problems exist with the known recordings, a request can be made for a further attempt to collect improved recordings.

Once the examiner is satisfied that the images are of such quality as to allow meaningful forensic gait analysis to take place, assessment to consider the gait and features of gait is then undertaken. Here, the examiner makes an in-depth assessment of the questioned and known recordings with a view to determining and documenting any characteristic gaits or features of gait recognized in the footage. In making this assessment, the recordings would initially be viewed in their totality at normal and slowed speed, with the sections of interest being noted. The focus would then be on these particular sections, which would again be viewed repeatedly at normal speed, in slow motion, and frame by frame. Observations made should initially describe the overall context of the recordings, such as noted in the following example:

Recording AB/1 consisted of one daytime color video recording of a male in a small yard. This person is seen to undergo a range of activities including standing, interrupted walking and push-up exercises in one corner of the enclosure.

The examiner would then comment on the sections of the recording that are of further interest, for example, as follows:

In the first recording, much of the time lapse frames were of poor quality with the feet being obscured, and therefore did not allow meaningful assessment to be made. However, in one section of the recording designated 15:30:16 to 15:30:24, the right foot of the male present within the image could be clearly viewed.

The examiner would then proceed to detail meaningful gait observations made for each frame, which is to be considered further, as noted in the following examples:

Frame 15:30:16: Despite the image being somewhat poor, the right foot is forward, seen at heel strike and is abducted.
Frame 15:30:22: The right foot is forward and again abducted when compared to the pavement edge with the forefoot being situated much nearer to the pavement than the rear foot.

Such observations should be made for both questioned and known recordings with for later comparison and evaluation.

6.4.2 Recognizable Features

Gait analysis performed under clinical or laboratory conditions allows a wide range of gait anomalies and characteristics to be more easily recognized and identified

Table 6.2 Examples of gait/features of gait recognizable in forensic gait analysis

Feature	Classification
Abduction (out-toed gait)	Gait feature
Adduction (intoed gait)	Gait feature
Ankle equinus	Gait feature
Ataxic gait	Gait form
Calcaneal gait	Gait form
Chorea	Gait form
Drop foot	Gait feature
Excessive ankle dorsiflexion	Gait feature
Genu valgum	Gait feature
Genu varum (bow legs)	Gait feature
Hemiplegic gait	Gait form
High stepping gait	Gait form
Limping	Gait form
Paraplegic gait	Gait form
Pronated foot	Gait feature
Scissor gait	Gait form
Shuffling gait	Gait form
Tibial varum	Gait feature
Toe walking	Gait form
Waddling gait	Gait form

than those presently seen on CCTV footage. Some of the features and conditions that are apparent through such analysis tend to be the more obvious states, such as those listed in Table 6.2. The task of the examiner is to recognize and record the presence of these features where their presence is incontrovertible. Where there is the possibility of such features having been affected by a known variable (e.g., standing or running as opposed to walking positions being viewed), other reasons for the identified features must be considered as appropriate in order to prevent erroneous conclusions from being made.

6.5 Comparison and Evaluation

Having worked through known and unknown recordings, the forensic podiatrist must then compare the detail recorded as being present in both sets of recordings. As in all forensic comparisons, the examiner must not only look for compatible features, but also must look with equal rigor for those features that would suggest incompatibility – i.e., that the recordings could not have been of the same person. At the same time, it is also important to take into account those features noted, which may represent the same class of condition, but that may not necessarily relate to that particular persons usual gait form.

Having compared the gait and features of gait from both known and questioned recordings, the examiner must evaluate the significance of his or her findings. Here,

it is usual to consider compatible features from all compared recordings and to then determine their prevalence in the population of interest in order to judge what level of individuality is demonstrated by that particular feature. The prevalence can be obtained from pre-existing literature, databases, or unpublished data. Where this does not exist, the examiner may need to undertake an additional item of work in order to quantify the prevalence within a given population for the purpose of the particular exercise. In this way, a numerical conclusion as to the significance of isolating the same feature or features in both known and questioned recordings can be elicited.

6.6 Cautions

While the process of forensic gait analysis is often relatively straightforward, it is often time consuming. There are, nevertheless, a number of cautions that the examiner must be aware of during case work. These include:

Could the usual gait pattern have been amended in either or both of the recordings used for comparison? It must be remembered that the examiner is interested in the compatibility of usual gait forms or features of gait and whether it is likely these have been significantly affected to visibly alter the persons' gait and/or feature of gait. It is possible for these features to be affected through the effects of external variables. These can include the immediate effects of alcohol or drugs, temporary antalgic gait forms from the effects of short-term injury, and perhaps deliberate attempts to alter gait in the forensically aware. Without maintaining an awareness of such possibilities, such affectations of the gait may potentially lead to either an incorrect conclusion of incompatibility, where a temporary state is present in one recording alone, or alternately, an incorrect conclusion of compatibility through the presence of a temporary class of gait/gait feature in one of the recordings, suggesting a compatibility that is not normally present.

Forensic gait analysis is a class-level identification technique: The features that can be recognized and used in forensic gait analysis are class-level features (features that demonstrate incontrovertible compatibility between similar items[3]). This means that the conclusions that can be reached do not represent the unique levels of individuality afforded by true identifying characteristics. They do, however, afford a degree of discrimination that can either be used to discriminate between persons within a closed population, or alternately in conjunction with other evidential features in order to strengthen conclusions in relation to individuality.

The forensic podiatrist undertaking forensic gait analysis must not comment on matters outside their expertise: While this appears to be an obvious point, it can

[3] See earlier section on Principles of Forensic Podiatry for a detailed explanation of the formal term "class characteristic".

nevertheless be misleadingly easy to deviate from areas requiring forensic podiatry expertise into those more appropriately covered by other disciplines. Examples of pitfalls to be avoided in this respect include not commenting on the particular characteristics of clothing (other than the fact that clothing has or has not impaired the ability to comment on specific aspects of the gait) and not providing an estimate of a person's height from the footage examined. A forensic podiatrist should only provide an opinion on such matters within their expertise and where they have received adequate training and experience in these specialty areas. An understanding of the fact that such factors can affect the gait is required (Vernon et al. 2009), but the forensic podiatrist should not extend their opinion to anything beyond that level of understanding.

The forensic podiatrist should not extend the opinion expressed in their reports beyond the point at which any competent forensic podiatrist would agree with their findings: Here, the only safe way to practice forensic gait analysis is to adhere to agreed levels of understanding. Podiatric gait analysis has an abundance of competing "theories" and differences of opinion, few of which are truly research based. As with all areas of forensic expertise, the forensic podiatrist should confine the opinion within their reports to the facts, which by definition will be that level which is at that moment beyond dispute. This would avoid adopting any of the debated and disputed podiatric biomechanics theories, which are yet to be validated. It is, however, also important to note that when acting as an expert witness in court, any expert witness can be asked to give an opinion based on their expertise and experience. The point being made here, however, is when reporting a case, this report should be mindful of the scientific basis of the profession.

6.7 Conclusions

Forensic gait analysis is the most recent and fastest growing subspecialty of forensic podiatry. Because its use is relatively new, the potential of forensic gait analysis has yet to be fully developed and applied. With further, supportive research, improvements in technology and developments in practice, this should become one of the most valuable tools that forensic podiatry can offer to the field of identification.

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Chapter 7
Identification from Podiatry Records

Keywords Records review • Mass disaster investigations • Foot uniqueness • Matched features • Pedal lesions

As a routine aspect of their practice, podiatrists are required to keep accurate and relevant records of their patients, their foot condition, associated diagnoses, and subsequent treatment. This recorded information has previously been demonstrated to have value in person identification. This chapter considers identification from podiatry records, presents an overview of the approaches that would be taken in this work, and considers potential sources of error that forensic podiatrists may encounter.

7.1 Introduction

As a clinical governance requirement, podiatrists must keep records of their professional work and such records include those pertaining to patient management – the patient records. Podiatry patient records contain details of the patient whom the podiatrist has examined and/or treated. These details include personal information, medical history, supervised medication, diagnosed foot and lower limb disorders, vascular and neurological status, foot lesions present, clinical investigation results, and any treatment methods undertaken. It has previously been suggested that these podiatry records may have value in forensic and mass disaster identification (Doney and Harris 1984; Vernon 1994; Sanger and Vernon 1997). There are a wide range of techniques used in investigations pertaining to identification, some of which are more commonly used than others. Circumstances such as trauma, loss of body tissue, and decomposition can, however, limit the usefulness of all of these approaches, and in doing so, the need to widen the "armory" of available identification techniques can be justified, even with the availability of the powerful DNA identification techniques now being used as evidence of identity.

Such records are available through public-funded podiatry services (such as the National Health Service in the UK), practices in the private and independent

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sectors, and schools of podiatry. While it has been believed that the standards of such record keeping have been variable in the past (Idris-Evans and Pooke 1985; Vernon 1994), the higher demands of improved clinical governance arrangements now require higher record keeping standards, and failure to keep appropriate records may lead to disciplinary action through the professional regulatory arrangements (such as the Health Professions Council in the UK), or the professional bodies with which podiatrists may be affiliated.

The possibility of podiatry card identification was first raised in 1984 by Dr. Ivor Doney, a police surgeon (Doney and Harris 1984). Dr. Doney highlighted the work of podiatrists and the potential of their records in identifying individuals from features of their lower limbs following disasters. Podiatry records were seen by Doney as having particular value in situations in which only the foot is recognizable, and also in dealing with the problem of the identification of headless murder victims. In disaster situations, the feet are well placed to survive trauma through being encased by shoes and socks, and they are often the last body part to be destroyed in fires, leaving them in such circumstances as the final possible means of identification. Doney noted that podiatrists keep fine details that are not recorded by any other medical practitioners. At the time, podiatrists' work predominantly focused on treatment of the elderly population and Doney also argued that there was a preponderance of elderly persons at risk in disaster situations, adding further justification to the consideration of podiatry record card use in the identification process. It was postulated that such identifications could be assisted through recognizing the use of individual styles of podiatry treatment, and through the antemortem recording of distinctive lesions (e.g., hemangioma, cysts, and pigmented nevi) that would be expected to be recorded in the podiatry records. The possibility of orthotic devices (such as those fitted by podiatrists into footwear) being marked with details such as the source of manufacture and/or a patients personal details was also considered by Doney as an aid to identification. The American Navy were later reported to be charting the feet of their crews for identification purposes in line with Doney's suggestions. This was because it was known that in deaths due to fire, very often, the lower limbs protected by thick boots would be the last part of the body to be destroyed, leaving foot parts as the only means of identification (Filer 1983).

In the UK, research was later undertaken to consider the potential and the efficacy of podiatry record use in human identification (Vernon 1990, 1994). In this work, Doney's ideas were widened to consider all aspects of recorded detail in podiatry records, which would additionally include foot type, local deformities (both major and minor), and the form, size, and pattern of podiatric lesions present. In the early stage of this research, using a stratified random selection of 300 podiatry record cards, patterns represented by combinations of foot lesions alone were considered and in this sample, only 18 distinct lesion patterns were found to have occurred more than once (Vernon 1990). The repeated patterns of lesions all represented the presence of very simple podiatric conditions and did not take both feet or nonpodiatric identifying features recorded on the podiatry records into consideration. Tests were also conducted to determine the value of podiatrists' clinical judgment in identifying an individual from details recorded in their podiatry notes alone

(Vernon 1994). Early testing required the participating podiatrists to compare the feet of an unknown individual with the details recorded on an anonymous record card and to conclude simply whether the record card selected was that pertaining to that individual or not. The judgments expressed were based on consideration of the features examined and their expected frequency of occurrence. The test was crudely performed and simply required podiatrists to state whether or not the records under consideration related to a particular individual under examination or not. As such, there was minimal potential within the test to deal with matters of uncertainty, such as the podiatrist believing that it was possible that the card belonged to the individual, but with no strong evidence present to suggest that this was the case. Despite this, 85.65% of all judgments made by the participating podiatrists who had considered whether a record card related to an unidentified individual or not were found to be correct. In later tests, a simple strength scale was introduced, in which the participating podiatrists were allowed to state different levels of certainty in relation to their identification judgments (Sanger and Vernon 1997). Here, it was found that when podiatrists expressed an opinion that they were absolutely certain of a match between detail listed in the patient record card and that observed on the feet of the unidentified patient, 100% of these judgments were correct. It was also noted that 56% of all judgments made by the participating podiatrists were made with such absolute certainty. When considering the individuality of the human foot as expressed in podiatric records and the success demonstrated by podiatrists in testing their judgments in identification from such records, it was concluded that there was strong potential for the use of such records in human identification.

7.2 Method of Identification

Identification from podiatry records is most likely to be required in situations requiring identification of deceased individuals. This may be in cases where a single missing person is known to have received podiatry treatment and upon recovery of a body, more conventional identification approaches be compromised or impossible to perform through the results of trauma, or loss with the foot or feet being found relatively intact. Anecdotally, it is known that a number of podiatry departments in the UK have occasionally assisted the police in such identification tasks. Other situations requiring podiatry record card identification include those of mass disasters, where multiple victim identification may be required, again, where more traditional identification techniques may have been compromised as detailed above. It is likely that the identifying podiatrist in both circumstances would undertake such work in the mortuary environment. In mass disaster situations, this may be the emergency field mortuary facility, which will require the podiatrist to have knowledge of and adherence to disaster team working protocols and a general prior understanding of the required procedures and working practices would also be required. Such contextual understandings are beyond the scope of this text, and it is recommended that anyone working in this field gain familiarity with the working protocols involved,

which will inevitably include considerations of accountability, procedure, recording, storage, cross-contamination, and infection control.

As part of the research undertaken to consider the potential of podiatry records in human identification, a protocol for the approach to be adopted was devised. Based on this protocol, the following approach to podiatric identification is recommended.

7.2.1 Assessment of the Questioned Foot

Initially, a proforma should be prepared for the appropriate recording of information obtained from the foot examination process. This should be headed with the date, time, and place of assessment and the coded reference (label) of the foot or feet to be examined. Following this preparation, it is important to verify that the coding references (labels) of the foot and/or feet to be identified are those listed for this particular examination and it should be recorded whether this is the examination of one foot or two feet. The condition of the foot or feet to be examined should be stated and then the following information should be recorded as part of the examination process:

- The overall length of the foot from the rearmost aspect of the heel, to the tip of the longest toe (using a foot measuring device)
- The heel-to-ball length of the foot being examined (using a foot measuring device)
- The width of the foot across the widest aspect of the ball (using a foot measuring device)
- The foot type if apparent
- The presence of minor structural toe deformities
- The presence of structural forefoot deformities
- The presence of mid-foot/arch area deformities
- The presence of heel area deformities
- The presence of deformities at the rear of the heel/tendon – Achilles insertion

For each toe, the status of all nails should be recorded, including reference to any deformity, fungal affectation, discoloration, and length. Comments on the quality of nail care if apparent should also be made.

The presence of podiatric lesions (e.g., corns, callus), dermatological conditions or skin blemishes (e.g., scars, nevi, pigmentation), and other marks should be recorded along with the site, type, and, if relevant, the size of such lesions on the foot/feet under examination. In doing this, the following situational order should be followed:

- Dorsal surfaces (toes/other areas)
- Apices of toes
- Interdigital areas
- Medial and lateral aspects of the foot
- Plantar metatarsal area
- Plantar mid-foot area (inner longitudinal arch/lateral surface)

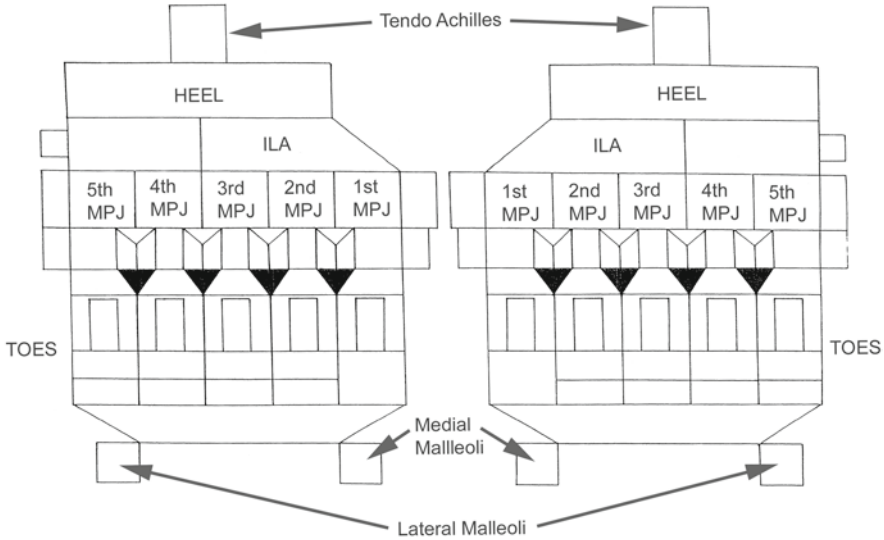

Fig. 7.1 Diagrammatic representation of human feet designed for podiatry record card identification purposes

- Plantar calcaneal area
- Posterior heel area
- Medial and lateral malleoli

In addition to the use of a proforma, a diagrammatic representation of the human foot indicating its various anatomical areas has been created on which the exact location of lesions present on the foot can be marked (Fig. 7.1). This can usefully supplement the written information on the proforma and create a more detailed record of the findings of the examination. The proforma can be further supplemented by the use of digital photography to show the foot from its various viewpoints (anterior, posterior, plantar, dorsal, medial, and lateral) and to provide close up detail of any deformities or lesions present on the foot or feet in question. As in all photography of this nature, this should always include a scale situated in the same plane as the feature being recorded and parallel to the camera lens. Finally, if possible, a print of the plantar surface of the foot should be taken preferably using an inkless paper system, however, in the case of the deceased; this is rarely successful because of the changed, nondynamic nature of the postmortem foot.

7.2.2 Assessment of Podiatric Records

The foot examination will have little value in the identification process without the availability of antemortem records with which to compare the observational data obtained from the examined foot/feet. At this stage, podiatric records pertaining to

missing persons should have been obtained for comparison and these records should be carefully examined using the same category headings as in the foot examination process detailed above. The examiner should note all relevant antemortem data on another clearly labeled proforma. In labeling the proforma, it is especially important to clearly distinguish between the ante and postmortem records and also to note the personal details of the subject to whom these records belong. It is possible that many such records will be considered in the identification process and because of this; the potential for confusion can arise. Again, the notes can be supplemented through the use of the diagrammatic representation of the human foot (Fig. 7.1) to record the site and type of any lesion detail apparent from these records.

7.3 Comparison

Finally, comparison should be made between the detail observed and recorded from the unknown foot or feet and that obtained from the known podiatry records with the examining podiatrist reaching a conclusion as to the likelihood of a match. Here, the podiatrist should compare the features observed in turn under each category heading. Note should be taken of features that match and those which do not.

7.3.1 Matched Features

Where features match, consideration should be given to the following:

Stability: Here, stability refers to the potential permanence of the features noted and stability of a feature is an important prerequisite for bodily features used in the identification process (Bernstein 1997). In reference to the foot, bony features such as hallux valgus (bunion) and hammer toes (Fig. 7.2) are examples of permanent features, as are conditions such as onychogryphosis and the presence of nevi or other growths (Fig. 7.3). Simple skin lesions (e.g., areas of minor callus) would not have such a degree of stability, being potentially able to resolve through podiatric intervention and changes of function, footwear, or habit. Despite this however, podiatry records may show that such lesions have been present over a period of many years, suggesting a reasonable degree of stability for the feature being considered in the assessment process, thereby improving their value in identification. Consideration of the longevity of such lesions may therefore be an important factor in their assessment during the identification process.

Individuality: Some features can represent higher degrees of individuality than others. Scar tissue, especially when caused through trauma, would represent a highly individual "accidental" feature and could be of great value in the identification process (Fig. 7.4). Conversely, a single individual pressure point with a minor build-up

Fig. 7.2 Bunion and hammertoe deformity

Fig. 7.3 Skin "tag" growth

Fig. 7.4 Residual keratosis after puncture wound

of callus, for example, on the dorsum of a fifth toe, would not represent such a high level of individuality, but would instead suggest compatibility as opposed to uniqueness. Complications present within more common lesion forms can, however, increase the individuality represented by that lesion. Here, a multinucleate, fibrous, or vascular corn would be of greater identification value than, for example, a common heloma, however, it would be essential for these complications to have been recorded accurately in the antemortem records of the individual concerned. Although a lesion may be a very common type (e.g., heloma durum), the site of the lesion can be relevant to the level of individuality represented by that lesion. In the example given above, a low level of individuality would be expressed by a single heloma durum corn situated on the dorsum of a fifth toe, as this such lesions can be commonly found at this particular site (Fig. 7.5). Conversely, a heloma durum lesion found to be present on the lateral aspect of the fifth styloid process, for example, would represent much stronger individuality because this is a much less common position for such a lesion. In judging the level of individuality represented by any feature found to be present on the foot, the examining podiatrist will use both personal experience and theoretical understanding based on published knowledge. In this respect, familiarization with any papers on research topography would be recommended.

Mismatched features: Mismatches between the detail observed on the foot or feet under examination and the detail written in the individual's record card may also be apparent during comparison. Depending on the nature of the mismatch, this may or may not preclude the possibility of a match between examined foot or feet and the records under consideration. Various situations that could lead to a mismatch and their implications in the identification process are considered below.

Fig. 7.5 Heloma durum (corn) fifth toe

Resolution: A prerecorded foot type listed in the antemortem records would be a strong feature, which would not be expected to have resolved. If, for example, the examined foot is of a pes cavus type and the records describe a pes planus type foot, then subject to the absence of recording errors, a mismatch would be certain (Fig. 7.6). Other permanent bony features such as hallux valgus and hammer toe can be corrected by surgery, and where such features have been listed in the antemortem records, yet are not present on the foot or feet being examined, the examiner should look for indications of surgery in order to preclude that possibility (Fig. 7.7). Similarly, skin lesions (e.g., nevi) can also be removed through surgery and, while surgery to remove minor examples of such lesions from the foot for cosmetic purposes is very unlikely, it is possible that this could have taken place for other reasons (e.g., biopsy). Where such a difference is apparent, the possibility of past surgical removal (i.e., the presence of scar tissue) on the foot in question should again be considered by the examiner. Where postsurgical features are not present within the feet that are being examined, this would suggest incompatibility, subject to the limits of antemortem record keeping accuracy.

As noted above, there is also the possibility that podiatric lesions may have resolved through treatment, functional change, and change of footwear or habit. Here, information present in podiatric records can be used to give an indication of the potential effectiveness of treatment that has taken place previously. If, for example, physical or chemical cautery has taken place, then this may suggest the potential for the lesion to have been successfully removed. Indications may also be given through the recording of footwear advice being given and acted upon, which may suggest a positive change of footwear habit and anticipated improvement through such action. The notes may also record the use of orthotic devices or long-term functional changes that have been previously observed by the treating podiatrist. If this is the case, then it may in turn indicate functional change and the potential for improvement and resolution of the associated lesions. When considering the potential for lesions having

Fig. 7.6 Pes cavus (high arch) on left and pes planus (low arch) foot types

Fig. 7.7 Scar indicating prior surgery

resolved, the form of lesion should also be taken into account. A prerecorded fibrous heloma, for example, would be unlikely to resolve with routine conservative treatment approaches alone and even if such treatment had lead to localized improvements, complete resolution without leaving any trace of such a lesion being present is unlikely. The absence of long-standing significant lesions or of several less significant lesions would suggest incompatibility between ante and postmortem states, where the presence of such lesions has been previously recorded. Such conclusions would again require the availability of up-to-date and accurate podiatric records.

New lesions: In addition to the possibility of podiatric lesions having resolved, there is also the potential for new lesions to have developed since the last record entered on the antemortem records. Examples would include the formation of new pressure points, areas of callus, and helomas. Where such lesions are encountered on the foot or feet being examined, the nature and severity of these lesions should be taken into account by the examining podiatrist. Here, consideration should be given to the past lesion stability as shown on the antemortem records. The likelihood of the individual having developed a new lesion to the level found within the time period since the last premortem record entry should also be considered, as should any contextual information indicated in the antemortem records relating to the overall foot condition and potential to develop new lesions such as those observed. Such information may, for example, be contained in a record card entry noting the purchase of new shoes with a particular identified issue (such as a toe box restriction). The presence of multiple lesions not recorded in the premortem records would suggest a mismatch, however, the addition of single additional non-recorded lesions should be considered cautiously in the comparison process and not necessarily lead to rejection of the potential for a match.

Change in nature/severity of a lesion: In the comparison phase of the examination process, lesions can be found to be present on the foot in places recorded in the antemortem records, but these may be of a different nature or level of severity. For example, the records may note the presence of an area of callus, while the foot being examined demonstrates a heloma durum on that particular area. Again, consideration should be given to the potential for the recorded lesion to have improved, and this would be indicated by lesion stability, severity, treatment carried out, and time period elapsing since the last premortem record was made, as indicated by those records. In this case, a subjective judgment will need to be made by the examining podiatrist, which may impact on the strength of the resulting probability statement produced in the identification report produced by that examiner.

Record-keeping problems: Previous tests of podiatrist's judgments in human identification from podiatry records showed the potential for recording errors and other record-keeping problems to impair the identification process with resulting failures of accurate identification/elimination (Vernon 1994). In a number of cases, notes used in the identification process were found to be illegible (Fig. 7.8). Where this is the case, unless the podiatrist who made the notes is available and can provide an explanation of them, the antemortem records may be useless and help with identification will then not be possible. Where partial illegibility is found, then the notes

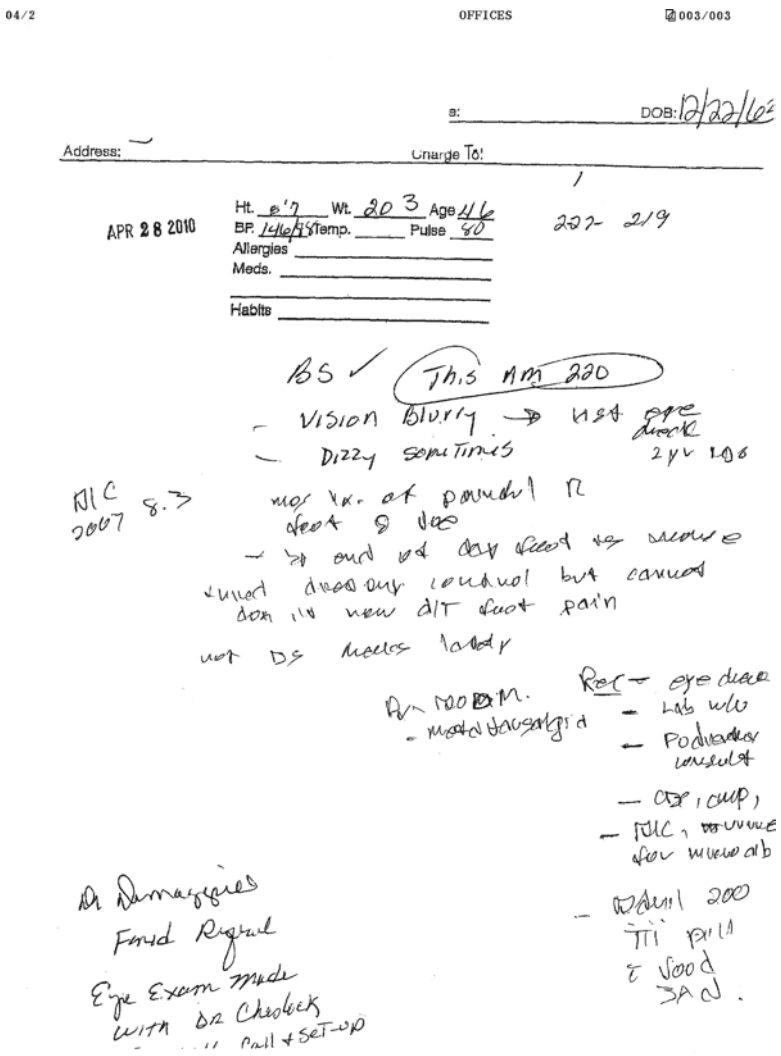

Fig. 7.8 Illegible notes

may still be of value, depending on the level of detail still apparent. Another problem noted in the previous research related to the use of personal shorthand in clinical note-keeping. A wide range of abbreviations have been used by podiatrists in their records over many years. Previously, different schools of podiatry have taught different systems of notation (Vernon 1990) and this has been complicated further by podiatrists developing their own personal forms of shorthand, which may not be easily deciphered by other podiatrists. Although current recommendations are for note-keeping to be made in full, the presence of multiple taught systems in the past means that shorthand records can still be found and may cause problems in ante-mortem record card interpretation. Where this is the case, the podiatrist who made

the original records should be contacted for an explanation, if possible, and, failing that, other colleagues of that podiatrist may have knowledge of the shorthand system that has been used. Should such contact not be possible and should the system used be unclear, then the records in that case would be useless in the identification process.

Incomplete records: Another problem encountered has been where records required in the identification process are legible and accurate as far as they go, but are incomplete. One example of such a problem is in the failure to record a podiatric diagnosis. The results of such failure can be catastrophic. For example, when the task of the examiner is to identify the owner of a lower limb where a gross feature such as pes cavus or hallux valgus has not been recorded. Where the records have inadvertently been left blank in the section pertaining to the presence of that feature, then the question arises as to whether that feature has not been present on the person believed to be deceased or whether it was present, but had not been recorded. In such a case, the recording omission could leave the examiner unable to reach a conclusion in respect of either compatibility or exclusion. Where the features of the foot being examined are of a less obvious nature (e.g., the presence of a very mild example of hallux valgus or a partially overlapping toe) and have not been recorded, then this would not be as serious an omission, with the examiner being able to work with the other recorded information available. In all cases of absent diagnoses, the examiner would be advised to contact the practitioner or podiatry service from where the records had been obtained. This would be to determine whether any further information was available to confirm the presence or absence of the feature in question (e.g., older records, computer entries, referral letters that may inadvertently have not been attached to the case notes), or to seek knowledge of the involvement of any other agency in that individuals care, who may be able to provide additional information. In the case of podiatric lesions, such agencies may typically include the patients' general practitioner, orthopedic surgeons, radiographers/radiologists, orthotists, and physiotherapists.

Similarly, the records of the known person being considered may have omissions in relation to the recorded treatment, or such treatments could have been recorded with detail that is inadequate for the purpose of assisting in the identification process. This situation can arise where the records have been made in busy clinical situations and the recording practitioner has rushed the note-taking process. Changes in clinical governance standards have improved the situation in recent years. Previously, however, it was not uncommon to find whole treatment events written up as "B/F/op (representing both feet general podiatric operating procedures)," with no detail whatsoever to be found of the treatment process, the site and nature of lesions attended to, and other pertinent details (Idris-Evans and Pooke 1985). While problems at this level are unlikely to be encountered now, it is still probable that rushed notation may be encountered, containing examples of omissions and/or inadequate details of the current status of the feet being treated. In identification situations, when this occurs, the examiner should check back in earlier records for information made on previous occasions, which may be of value. At the same time, the examiner needs to bear in mind that over the longer period of

time, soft tissue lesions could have improved or deteriorated, and new lesions could have formed and old ones could have resolved, especially where detailed and accurate continuous records are not available. Omissions in the treatment notes create additional problems for the examiner, who is likely to be unaware of the omission, unlike the problem of inadequate note-keeping, which would be obvious on first reading. The possibility of an omission of detail is only likely to become apparent when a range of features have been noted as compatible on assessment, yet one or two additional features have been identified on the examined person that are not recorded in the patient notes. The level of problem that this causes to the examiner will vary from situation to situation and may very well decrease the strength of certainty as to a match. Where the apparently missing data relates to one small and insignificant lesion in the presence of several other compatible and possibly unusual features, then the problem to the examiner is a minor one. If, however, the missing feature are unusual and possibly one of few apparent features present on the examined foot, then this situation would be unknown to the examiner and could therefore lead to erroneous conclusions. It is therefore important for the identification examiner to be aware of this possibility and, where possible, look for other features within the record-based information, which may indicate that such a situation is possible (e.g., errors or incomplete recording of personal details, signs that the records have been rushed, missing signatures from the recording practitioner, etc.). Again, recording omissions or inadequacies may ultimately require the identification examiner to form the opinion that no conclusions can be reached over whether the records belong to the examined individual or not. It is also possible that this type of recording error could lead the examiner to arrive at erroneous conclusions where the records have contained major omissions.

Inaccurate notes: The presence of inaccuracies within patient notes is one of the most frequent problems that may be encountered when using podiatry records in the identification process. Such errors in record keeping most commonly relate to inadvertently mixing up right and left feet in the notes, or mistakenly recording a lesion observed or treated on the wrong toe. As in the above consideration of recording omissions, the errors would not necessarily be apparent to the examining podiatrist in an identification situation and again could lead to erroneous conclusions being made. If, for example, a unilateral hallux valgus with nail involution (incurvatus) and the presence of heloma durum on the medial side of the first metatarso-phalangeal joint has been inadvertently recorded as being present on a right foot as opposed to a left foot and a single right foot being considered for identification purposes does not show these features, then the derived conclusions will be wrong. If such an error has been made within the records, this will be more problematic where there has only been one clinical attendance recorded for the individual, or where the error has been copied through to subsequent appointments. Often, however, the mistake within the records can be of a one-off nature, which becomes obvious when looking back through previous recording entries. Sometimes, looking through the sequence of treatment notes made, it can be seen that reference to right and left sides changes on a number of occasions through this error. Alternately, references can be made to,

for example a particular toe being affected by a named deformity or lesion and the affected toe changes in the patients notes, suggesting that this error has occurred on a number of occasions. In maintaining an awareness of the possibility of this error, the examining podiatrist should pay particular attention to patterns of lesions and other pathological features that are present on the examined foot, yet recorded on the opposite side in record cards. Again, when this situation is encountered, further work should be undertaken to seek confirmation of which side has been affected. This additional information could be elicited through notes and correspondence that could be available through other sources, such as related professional groups who may have also been involved in that same individuals care.

Incorrect diagnosis: The problem of incorrect diagnosis can arise in podiatry records used in the identification process. In this situation, the podiatry records may present a diagnosis of a foot condition that is simply wrong, or disputable. Common examples of this type of error can include the recording of hallux rigidus as opposed to hallux valgus, hammer toe as opposed to retracted toe, or excessive functional pronation as opposed to pes planus, although these are just a few simple examples of the many possibilities. The examining podiatrist should be aware of the possibility of this error occurring. In the comparison process, where all other features have been found to be identical, and there remains just one source of incompatibility with the recorded lesions being similar in nature, this should suggest the potential for such a situation and, where possible, work should be undertaken to investigate this further. As in previous examples of dealing with the possibility of erroneous podiatry records, the involvement of other disciplines in the care of this person should be determined and the availability of other records, which may be used to verify the exact nature of the lesion encountered, should be pursued. It may also be possible to obtain footwear known to belong to the missing person, and the wear features of such footwear items may also be useful in determining the exact nature of the feature noted within the treatment records. It is again likely that such recording errors will compromise the level of certainty of any conclusion derived in the identification comparison process.

Mix-up of records: Occasionally, situations can occur in which the podiatry patient records have been inadvertently confused with those of another patient. In the identification situation, this would simply be where records of an individual other than the person under consideration have been forwarded incorrectly. This situation occurs commonly in clinical situations and it was an occurrence in a real-life patient appointment situation that led to the research undertaken in the UK on identification from podiatry records. Although potentially disastrous in identification situations, this possibility can be guarded against by the examining podiatrist through a protocol-based approach to this work, which would demand careful checks of personal details on the record card, to verify that these are indeed the notes required for the exercise to take place.

Careless examination: A final source of error that could occur in identification from podiatry records is one that is entirely in the hands of the identifying podiatrist, and

this is the possibility of errors resulting from careless examination of the records or feet in question. While not the most commonly encountered error in the research undertaken on identification from podiatry records, this situation did occur on four separate occasions, being responsible for 4 out of the 199 failures in identification judgment that were encountered. These errors related to simple nonadherence to the protocols involved, forgetting to check through retrospective treatment records, and carelessness in not observing lesions present on the persons foot on examination. On another occasion, the information within the record card involved was misread and on one other case, the examining podiatrist mixed up the treatment notes and subsequently undertook the examination and comparison process with notes other than those that had been allocated. All of these sources of error can be minimized through the strict adherence to working protocols, through a verification process in which a second examiner checks the work of the primary examiner, and through the adoption of a methodological and careful approach to the work required.

7.4 Strength Scale

In the research undertaken previously in identification from podiatry records, the use of a strength scale was introduced in order to allow examining podiatrists to express degrees of certainty as to their strength of opinion in relation to a match/mismatch between examined records and the questioned feet. The strength scale used in this case was based on one in use within forensic odontology at the time and allowed the following levels of certainty (Dailey 1987):

- Absolute certainty
- Most likely
- Possible
- Most unlikely

Work has since taken place in Europe to standardize the approaches to expressing degrees of certainty in dealing with forensic evidence, with the result that the continued use of the above scale used in earlier research on identification from podiatry records would not be recommended. Instead, the podiatry record card examiner would be advised to adopt the current conventions when reaching conclusions in relation to their evidence. More detailed consideration of these approaches have been given in Chap. 2.

7.5 Conclusions

The examination of podiatry record cards should be within the capability of all working podiatrists because, by definition, podiatrists read and consider records relating to all the patients whom they treat in the course of their normal clinical work. As such, they will be highly familiar with the problems encountered in the recording of patient

diagnoses and treatment and in the management of these records. The main difference in considering such records for the alternative purpose of human identification is in the need to consider these records carefully within a different framework of rules. Gaining familiarity with this different context in a supervised environment would be highly recommended before pursuing work of this nature in order to develop the necessary expertise required prior to undertaking case work involving identification from podiatry records.

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Part III
Pedal Case Work

Chapter 8
Case Studies in Forensic Podiatry

Keywords Luminol enhancement • Bare footprint evidence • Footwear evidence • Chain of custody • ACE-V

The previous chapters have covered the theory and methods employed in forensic podiatry practice. This chapter presents a number of forensic podiatry case studies to illustrate how the methods presented and discussed in the earlier chapters may work in practice. Obviously, these only cover a limited range of scenarios, but it is hoped that the reader will gain enough of an understanding from these to see how podiatric knowledge would "typically" be employed in forensic podiatry situations.

8.1 Footprint Case Study (Crown *vs.* Clarke 2005)

The suspect in this case, Michael Clarke, was a young man of 21 years, who lived with his parents. One evening, he went out with friends to attend a rock concert. His friends had called for him that day and on leaving his home, he asked his friends to wait because he had forgotten something, returning to his home for a few minutes to collect the item he had left behind. Upon returning home that evening after the music concert, the young man telephoned the police to advise that he on arriving at his home, he had found both his parents dead. On attending the scene, the police found that Clarke's parents had been stabbed to death in what appeared to be a very expert manner. Suspicion soon fell on Clarke, who was known to be a practitioner of Eskrima, a Filipino stick and knife fighting form of martial art. Although there had been a period of less than 10 min when Clarke had returned home on his way out for the evening, the police believed that his expertise and fitness were such that he could have had time to slay his parents, change, and return to his friends within that window of opportunity.

Circumstantial evidence mounted against Clarke and consisted of material on Clarke's computer indicating that he had been developing a forensic awareness and closed circuit television (CCTV) film at the concert venue Clarke had attended. It appeared to show Clarke entering a gentlemen's' toilet with what appeared to be a

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full sports bag and later, leaving with the same bag now looking apparently empty. The suggestion here was that Clarke may have been disposing of incriminating evidence such as bloodstained clothing and the murder weapon. During the investigation of the crime scene, a number of bare footprints were found using luminol enhancement, and the situation of these prints indicated they were in fact associated with the crime. A request was received from the police to collect footprints from Clarke and compare these with the luminol footprints captured at the crime scene, with a view to determining whether the known and unknown sets of prints has been formed by the same person.

An appointment was made to examine Clarke who was being held in police custody. Because the exact circumstances under which the prints had been left were not known, at this appointment, footprints were collected from the suspect under a variety of conditions – barefoot, socked, standing, walking, light running, and on both hard surface and carpet. Inked prints were made by Clarke on the carpet and the inkless paper method was used to collect all other prints from him. During

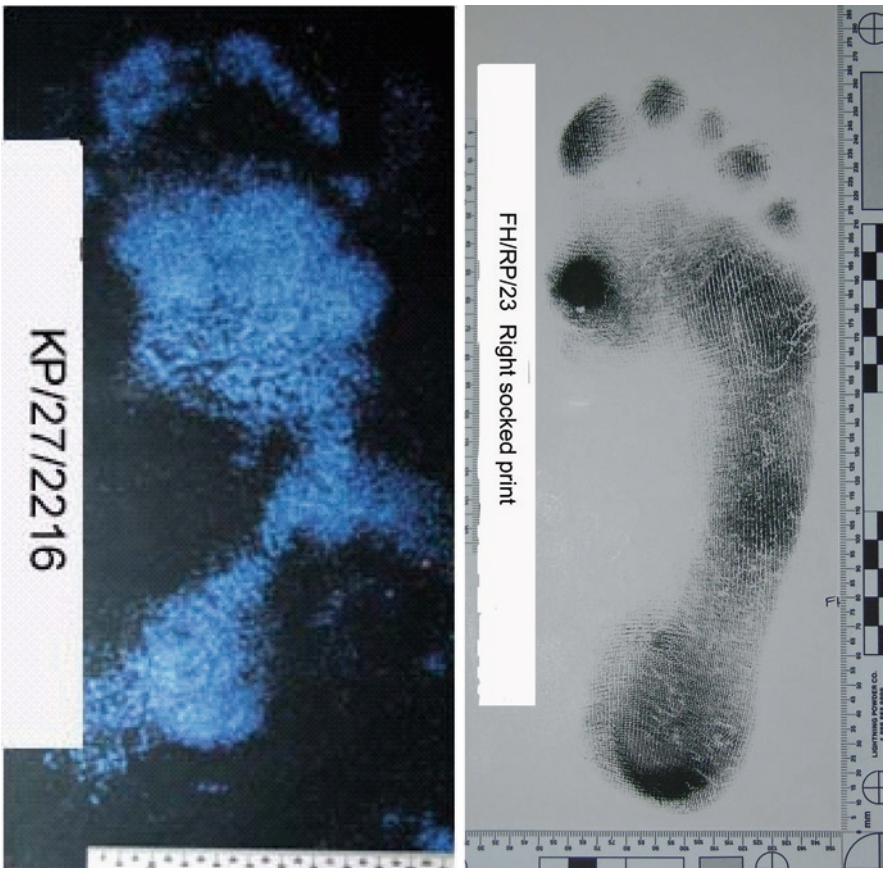
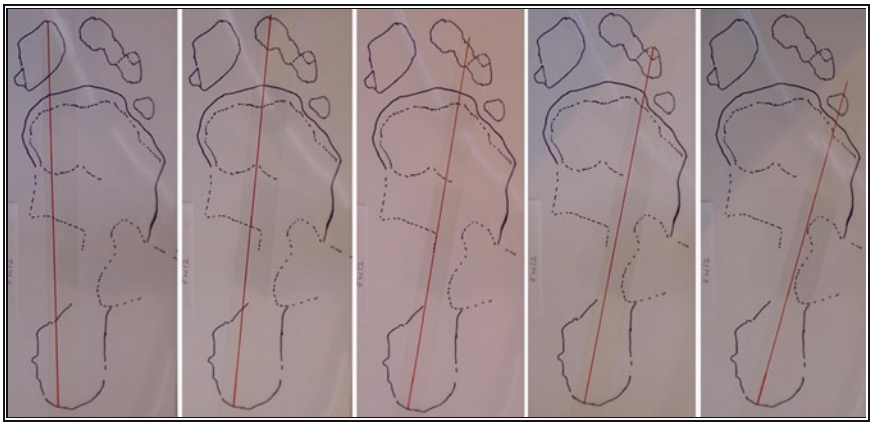


Fig. 8.1 Known and questioned footprints in the Crown *vs*. Clarke 2005

collection of the prints, paired observations were made by two observing podiatrists as well as video recordings being made from posterior and lateral viewpoints of every step which left a print. This was with a view to ensuring that no attempts were being made to purposely amend each print formed. The best-quality known prints, collected from the suspect, were compared with the best-quality questioned prints found at the crime scene (Fig. 8.1). The methods used for this comparison were the Gunn and the overlay methods as described in Chap. 4.

In the comparison between known and questioned footprints, the Gunn lines closely matched all but one of the measurements taken (Fig. 8.2). Additionally, the morphological outlines of known and questioned prints closely matched in terms of both position and form. Considering the Gunn lines, the heel to third toe measurements between known and unknown prints was 4 mm different in length, but from close examination of the unknown print, it was apparent that this was a partial toe print only, hence there was an explanation for this difference. A difference of 10 mm was, however, apparent between the heel to fifth toe measurements of known and questioned prints. Closer examination revealed that on the questioned print, the fifth toe print was partial and also that the position of this toe print was in line with the fourth metatarso-phalangeal joint position, suggesting that some torsional



Measurement	Known Footprint	Questioned Footprint	+/- mm
Heel to 1st Toe	250mm	250mm	0mm
Heel to 2nd Toe	255mm	253mm	2mm
Heel to 3rd Toe	244mm	240mm	4mm
Heel to 4th Toe	233mm	232mm	1mm
Heel to 5th Toe	216mm	206mm	10mm
Cross Ball	97mm	95mm	2mm

Black outline = questioned bare footprint

Red lines indicate Guinn line measurements taken from known bare footprint

Fig. 8.2 Crown *vs.* Clarke 2005: comparison of known and questioned bare footprints

Fig. 8.3 Greek ideal toe prints in case comparators

movement had taken place, which would further have amended the placement of this toe. Again, an explanation for this difference was apparent.

The close matching of measurements as described above also suggested that the known and questioned prints had been made by feet requiring the same size shoe. It was also apparent that both known and unknown prints had been formed by someone who exhibited a "Greek Ideal" – a state in which the second toe is the longest toe of the foot (Fig. 8.3).

The known and questioned prints were also examined for the presence of features that would have suggested that the prints had been made by different persons and no such differences could be found for which an explanation could be provided as to these differences.

In the evaluation, the common features of known and questioned prints suggested that in European convention terms, there was at the time "moderately strong support" for the proposition that the known and questioned prints had been produced by the same person. "Moderately strong support" represented a likelihood ratio of between 1–100 and 1–1,000. The report was verified by another podiatrist competent in this work and duly submitted in statement form.

A number of weeks later, an additional report was requested. The luminol testing had been repeated to a higher standard and the request made that photographs of the clearer footprints be examined and a further report be provided regarding the

likelihood of a match between these prints and the known prints that had been taken from Clarke. Although the new luminol test had produced obviously clearer images for examination, it was also apparent that these images had been taken without the use of a scale within the image. Such a scale had been provided with the images of the original tested prints and it is essential for the assessment process, as it is only by the use of a scale that the size and overall dimensions of the print can be determined. In the absence of such a scale, the possible conclusions that could be derived were limited and were in fact restricted to the presence of the Greek Ideal – the only feature apparent that was not dependant on the overall dimensions of the print being known for a conclusion to be made. Due to the absence of a scale, in this second report it was only possible to produce conclusions at the "moderate level of support" for the proposition that both known and clearer questioned prints had been formed by the same person; therefore, the findings of the original report remained stronger. The fact that a lower level of certainty was derived from the clearer prints demonstrated the need to use a scale in all evidence quality images.

The footprint evidence was presented in court and having chosen not to use a defense report, which considered the footprint evidence, in oral evidence Clarke accepted that the footprints were his and changed his evidence in an attempt to provide a new explanation as to how the prints had been left in the position in which they were found, without being responsible for his parents' murder.

Clarke was found guilty of the murder of his parents and was sentenced to 29 years in prison.

8.2 Footwear Case Study (Crown *vs*. Chester-Nash 2006)

A woman was found murdered in her home and later that day, transport police arrested a man who was about to board a train after stealing sandwiches from a sandwich shop at the railway station. Police noticed spots of blood on this person's shoes and investigated further, finding that the person that they had arrested, one Gary Chester-Nash, was well known to the criminal justice system. When the bloodstained shoes being worn by Chester-Nash were later examined, they were linked through DNA to the murder victim. Chester-Nash provided an explanation as to how the blood had found its way onto his shoes. He stated that he had been living in a squat with a Russian gentleman, who had a complicated name he could not remember. On the morning in question, the Russian had borrowed Chester-Nash's clothing, including his shoes, left and returned one and a half hours later, leaving the clothing with Chester-Nash, before departing. Chester-Nash then commented that, under these circumstances, it must have been the Russian gentleman and not himself that had committed the murder and that this was how the blood had found its way onto his shoes.

The police were concerned because, implausible as it was, the story provided by Chester-Nash could have adversely affected the need to prove guilt beyond all reasonable doubt by introducing an element of doubt to their case, which potentially

could have resulted in Chester-Nash's acquittal. Contact was made by the police, who asked if the questioned footwear could be examined for signs of multiple wearers as claimed by Chester-Nash or whether the shoes did really appear to have been worn by only one person. An additional piece of work was also suggested to the police, namely the testing of identical shoes to those questioned to determine their susceptibility of wear and the effect of a second wearer. This latter item of work was suggested in view of the known different susceptibilities of shoes to wear. While Kennedy has presented images showing footwear containing a clear foot impression after just 15 min of wear (Kennedy 1996) and the author had personal experiencing of footwear showing clear wear after just 2h, experiences reported in the Nike project (Keereweer 1998) were that the training shoes used in that project needed to be worn for at least 44h before foot impressions were exhibited and, in some cases, required up to 155h. This variation suggested that the propensity of the shoes in question to demonstrate wear should be investigated to determine whether these shoes could in fact show wear within a period of just 1.5h.

An appointment was initially arranged to examine the questioned footwear (Fig. 8.4) and a comparator pair of shoes that had been seized from the suspect. On examination, the questioned and known footwear items were found to exhibit a clear foot impression of the same form and size. The questioned footwear items were examined in much closer detail in order to seek any signs that these shoes had been worn by more than one wearer. These shoes were examined using the Crime-lite® 80S with various filters followed by a multiple waveband forensic light source to maximize contrast and highlight the wear features apparent within the shoe (Fig. 8.5). Throughout the examination, no wear features were apparent to suggest that the shoes had been worn by anything other than one wearer. From the experience of the investigating podiatrist, where footwear has been worn by more than one person, it would be expected that some wear features of the different wearers should be apparent. The conclusions reached at this stage of the investigation were that there was "limited support" for the proposition that the questioned footwear items had only been worn by one wearer.

Fig. 8.4 Footwear in Chester-Nash case

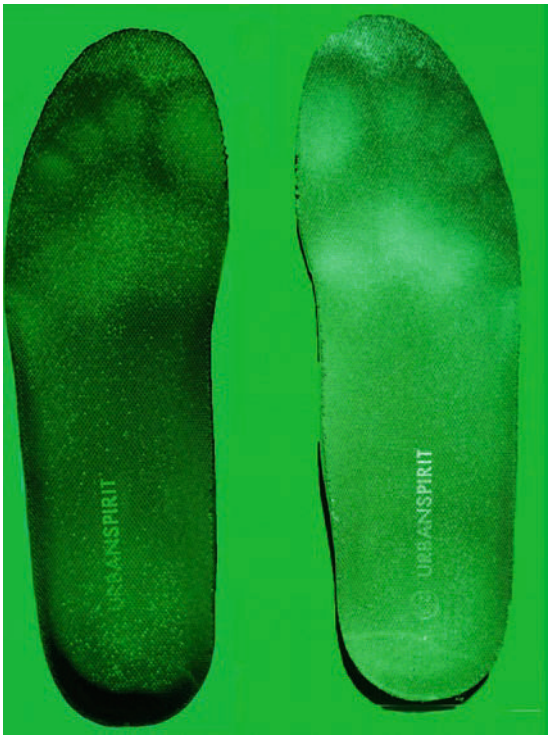


Fig. 8.5 Contrasted foot impressions in questioned shoes

Two separate and new pairs of the same make, type, and size (nine UK) of the questioned footwear items were then obtained and forwarded for wear testing. In this task, the shoes were subject to wear that would have closely matched that of the questioned shoes that were known to have been worn for 1 week by the suspect, who had then claimed that they had been worn by the Russian gentleman for 1.5h. Each pair of shoes was first worn for 1 week by separate people and the shoes were photographed at intervals of 30 min, 1h, 1.5h, 2h, and then daily to determine their susceptibility to wear form a single wearer. After 1 week, separate and different wearers were found for each shoe and these wearers wore the shoes for 1.5h – the time that Chester-Nash claimed that the shoes had been worn by the Russian gentleman. Because little was known of the claimed missing Russian gentleman, the test of these shoes was made as difficult as possible. The shoes were therefore worn by size nine wearers for the first week, followed by size nine wearers for the second week. This would have prevented any explicitly obvious differences from becoming apparent in the shoe wear through mismatches in sizing between the feet involved and through the shoes being worn by someone with an incorrect foot length for that shoe. It was, however, probable that size differences would have occurred in a situation in which footwear was being borrowed and without proper fitting.

For the first wearer of each pair of shoes, a clear and permanent foot impression was apparent at the first photographing of the shoe after just 30 min wear (with the

shoes being left overnight after being worn for 16h prior to the photograph being taken) (Fig. 8.6). This impression became more and more pronounced throughout the week of wear. The conclusions derived at this point were that the shoes were capable of demonstrating permanent wear features after just 30 min of wear.

The second wearer then wore the shoes for the required 1.5h and the shoes were then left overnight and photographed once more 16h later. At this point all shoes exhibited clear additional toe impressions from the second wearer – impressions that could not have been created by a single wearer of the shoes (Fig. 8.7). The conclusions derived at this stage were that the shoes were capable of clearly showing the effects of a second wearer within just 1.5h of wear from that additional wearer.

The report stating the conclusions derived at each stage of this work was then shown to Chester-Nash. At this point, Chester-Nash changed his story, advising that the shoes had not in fact been worn by the Russian gentleman, that he had actually been at the scene of crime hence the blood being present on this shoes, however, he held out that it was still the Russian who had committed the murder and that he had simply been present.

Because Chester-Nash had now admitted that he had been the only wearer of the questioned shoes, this evidence was not required to be presented in court, however, the fact that the story had changed in the manner described contributed to the jury

Fig. 8.6 Foot impressions in test shoes after 30 min of wear

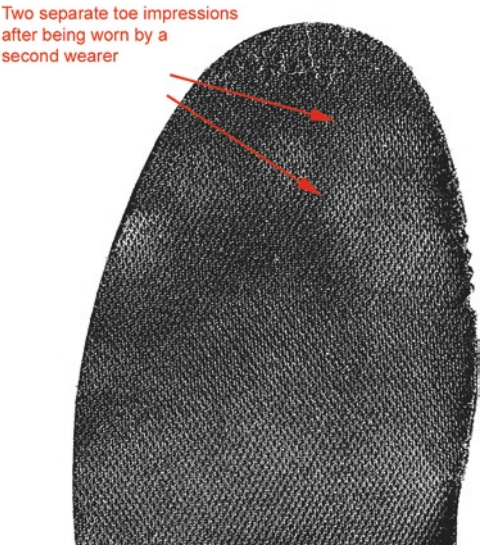


Fig. 8.7 The effects of a second wearer on the foot impression present on the shoe insole after 1.5h

being convinced that Chester-Nash was guilty of murder, and he was sentenced to serve a minimum of 30 years in prison.

8.3 Footwear Case Study (2002)

A murder had been committed in which a man had been kicked to death and the following day, police recovered a pair of bloodstained training shoes from elsewhere in the district in which the crime had been committed. Forensic examination of the training shoes determined that the blood staining the shoes was that of the victim. The police already had a suspect and seized another pair of training shoes from this person for direct comparison with the questioned training shoes associated with the crime scene. The questioned training shoes were of the Reebok brand, and the training shoes seized from the suspect were Adidas. Both pairs of shoes were marked as UK size eight. The shoes were duly examined by a forensic marks examiner, who focused on the foot impressions within both pairs of shoes. The forensic marks examiner noted a number of closely matched features between the foot impressions of both shoes, particularly the shape of the anterior ball of foot area and the shape of the individual toes. The examiner did, however, note that despite the close matching of these features, the foot impression present within the questioned Reebok training shoes was noticeably longer than that present within the known Adidas footwear items. Because of this difference, which the marks examiner did not have an immediate explanation for, the report provided noted, in European convention terms, that there was "moderate mupport" for the proposition that both known and questioned footwear items had been worn regularly by the

same person. A podiatric opinion was sought and it was believed that the podiatrist's viewpoint might be able to introduce additional factors in order to improve the strength of the evidence and to provide an explanation for the differences apparent between the lengths of two sets of foot impressions.

An appointment was arranged to view the shoes at the laboratory. At the assessment it was noted that both footwear items were indeed marked as size eight UK. The sizes were checked in both pairs of shoes using an internal sizing device. This checked indicated that the questioned Reebok training shoes were indeed an indicative size eight in length, however, the known Adidas training shoes were an indicative size seven, with a difference of one less shoe size in available length between them and the Reebok shoes.

Examination of the wear features of the questioned Reebok training shoes indicated that these shoes had been too long for their usual wearer. Features of note in this respect were a turning up of the leading edge of the insoles where the foot had not been in contact with the insole during walking, causing the leading edge to curl upwards during toe-off and creating an additional anterior crease mark of the shoe upper, where toe-off had taken place during walking in a more posterior position than the design of the shoe allowed (Fig. 8.8).

Examination of the wear features of the known Adidas training shoes did not elicit any wear features that suggested that these shoes has been similarly over-long for their usual wearer, but to the contrary, appeared from those wear features present to have fitted the owner reasonably well in length terms.

When the foot impressions present in both known and questioned training shoes were examined, it was noted that those impressions present within the questioned Reebok training shoes were longer than those present within the Adidas shoes. Both sets of impressions were measured and it was found that the heel to toe measurements

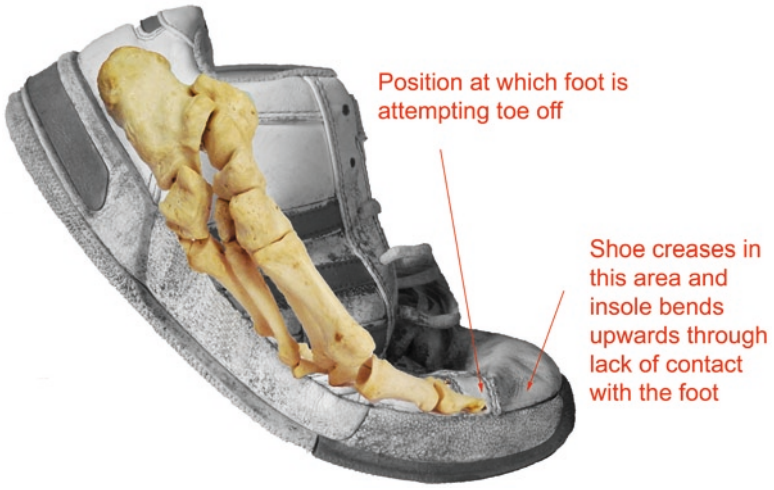


Fig. 8.8 The effects of the contained foot being shorter than the shoe being worn

(measuring from the rearmost aspect of the insole to the anterior aspect of each toe) were exactly 1/3 in. longer in the Reebok shoes than in the Adidas for each and every toe impression; 1/3 in. is the exact difference between UK shoe sizes.

The scenario thus determined was one in which the foot of the usual wearer of the longer Reebok shoes had been able to slide forward during gait because of the excessive length of these shoes. In sliding forward, the toes would have reached the anterior position in relation to the shoe that they would have adopted if the owner had been wearing the correctly sized shoes for his foot length (Fig. 8.9).

Given the close similarity of the other wear features of the foot impression, having provided an explanation for the foot impression length differences based on the intra-shoe function that would have taken place when wearing a shoe of excessive length, it was then possible to increase to strength of the conclusion to that of moderately strong support for the proposition that both footwear items had the same usual wearer. The case illustrated the value of multidisciplinary working in the forensic examination of footwear.

Fig. 8.9 Lengthening of the foot impression in shoes that have been too long for the wearer

8.4 Footwear Case Study (2007)

A series of burglaries had taken place, and shoe impressions had been found at each scene. Forensic marks examiners determined that these shoe impressions were all made by the same pair of shoes, being of the same make and type and with the same accidental damage features present on the outsole impressions. The police arrested a suspect and seized two a pair of shoes from his home for comparison with the outsole prints found at the crime scenes. The marks examiners determined that these were the same shoes that had produced the foot impressions found at the crime scenes. The suspect, however, denied ownership of the shoes, stating that many people visited and stayed at his home and that these shoes must have been left there by one of these many visitors. This presented the need to determine whether the suspect could be linked with these shoes in any way, or whether the story was genuine and the suspect had not in fact worn the questioned footwear items. A second pair of training shoes was taken from the suspect with a view to comparing the wear features of these with wear features of the questioned training shoes. This comparison was to determine whether any of the wear features would associate or disassociate the suspected wearer and the questioned shoes. Both pairs of shoes were collected from the police headquarters, where the shoes were being held for examination.

Both known and questioned training shoes were of the Nike brand and of the Airmax style. In the known training shoes, the Nike insole had been replaced with a Reebok brand insole and the insole present within the left questioned training shoe has missing upper covering material. This left a firm closed cell rubber construction that did not present a foot impression of the wearer, meaning that comparison of the left foot impressions was not possible. The focus of the comparison was therefore on the right training shoes, although factors relating to the left were also considered as far as possible.

In the comparison process, it was noted that the known training shoes was size seven (UK) and the questioned training shoe was size eight (UK). While one size different, this difference fell within the observations noted by Lucock, and supported by the author, that people commonly purchase and wear shoes of a full size length difference, although would be highly unlikely to purchase shoes with length differences greater than 1.5 sizes (Lucock 1980). The two pairs of shoes examined therefore fell within the expected tolerance for common ownership. Known and questioned footwear items also exhibited some common wear features. In relation to wear of the outsole, unusually heavy wear was noted at the posterior-lateral aspect of the heel and also at sites corresponding with the medial and lateral aspects of the ball of foot area. The uppers of both shoes demonstrated wear corresponding with the apex of the first toe, whereby the toe had worn completely through the lining at that point, due to the shoes being too short for the wearer at that position. Because of the missing left insole, foot impression comparisons were restricted to the right insoles only (Fig. 8.10). The right foot impressions were closely matched in terms of overall length (measured from the rearmost aspect of the insoles, toe position and shape, and the contour of the anterior ball of foot impression).

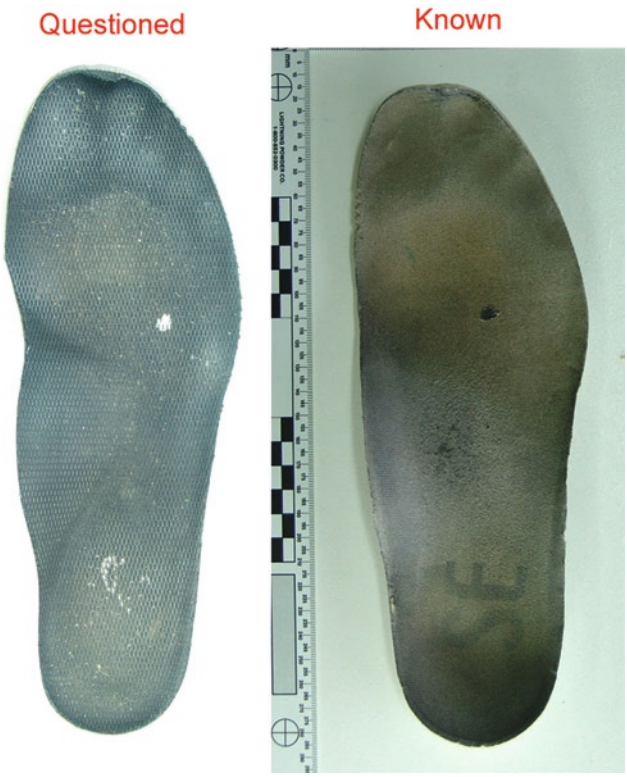


Fig. 8.10 Known and questioned insoles for comparison

The similarities could be demonstrated clearly by taking a series of cross-sections of each impression and matching them together, showing that irrespective of where the cross-section was taken, the features being compared between questioned and known shoes lined up perfectly (Fig. 8.11).

An additional feature was, however, apparent on the right insole of the questioned shoes, namely an additional set of toe prints, situated some way behind the first set. The overall wear features of the shoes did not suggest any reason relating to function, fit, or habit, as to how these additional set of toe prints could have belonged to the wearer of that right shoe whose foot impression had lined up so well with that of the right known shoe. No features could be found suggesting that the shoes had not been worn by the same wearer. It was therefore concluded that (1) there was moderately strong support for the proposition that both shoes had been worn by the same person (using the European scale of convention); and (2) there was strong support for the proposition that the questioned trainer had also been worn by another person with a shorter foot length than the other wearer.

The recommendation was made that an examination be carried out of the wearer of the known shoes in order to tighten the conclusions reached above and also to confirm whether or not there were in fact any functional reasons for the same person to have

Fig. 8.11 Known and unknown foot impressions superimposed

created two different sets of toe impressions in this particular case. This recommendation was not, however, taken up because of time and resource restrictions.

Upon being shown the report, the suspect then remembered that he did in fact own the shoes in question. Although the defense expert agreed with the findings of the report, a conviction did not result from the trial. This was because in the presence of strong support for the proposition that there had been two wearers of the shoe, it could not be proved that the suspect was the actual wearer of the shoes when the burglaries in question had been carried out.

8.5 Phoenix Homicide Case

Crime-Homicide

Date of Incident – November 19, 1996, Phoenix, Arizona

Case Facts:

In the early morning hours four young friends took a drive around Caesar Chavez Park in Phoenix, Arizona, that ended in murder.

One of the girls is on trial for the murder facing charges that she twice tried to strangle her 19-year-old roommate. CM took one of the other girls' purses and started to strangle DB, who was driving, when the strap broke. The car started to swerve, and DB pulled on the emergency brake. When the car stopped, DB got out and started to run but CM caught her. CM started choking DB again, but the strap broke a second time. All the time DB was screaming for help. That's when CM grabbed a large rock that required two hands to hold and repeatedly crushed DB's head with it. These are the facts as described by the other two suspects who agreed to testify against CM to avoid murder charges.

Autopsy findings included stab wounds and bite marks on the body. The girls put DB's body in the trunk then drove to the West Valley and dumped it in a pond at a sand and gravel pit.

CM is accused of ordering her roommate from their apartment to kill her and forcing the other two girls who were 14 and 16 into helping her dump the body. CM was 18 and pregnant at the time of the incident. If she is found guilty she could get the death penalty.

The victim was DB, an Ahwatukee (residential area of Phoenix) girl who graduated from Mountain Pointe High School and was living in her own apartment and owned a car.

Two different footwear impressions were discovered and photographed at the crime scene.

The three females were arrested driving the victim's vehicle on November 20, 1996, and the shoes (500K, 501K, 502K) they were wearing were recovered.

On November 21, 1996, four pairs of shoes (304K, 305K, 306K, and 313K) were recovered from the victim's apartment.

On November 22, 1996, two pairs of shoes (419Q and 420Q) were recovered from the trunk of the victim's vehicle with other clothing items. The outsoles of the shoes were similar to the impressions discovered at the scene, but could not be positively identified or excluded by the crime laboratory.

Subsequently, two pairs (914K and 915K) of the victim's shoes were given to the police by her parents to be used for purposes of the evaluation.

What was the Forensic Podiatrist's Objective?

Can it be determined if (1) the suspects most likely wore the questioned shoes and (2) who was the predominant wearer of each.

Initial contact was by the case detective stating that they were interested in retaining me for a case involving footprint evidence. They advised they had discovered footwear impression(s) at the crime scene. The laboratory evaluated them but could not reach a definitive conclusion. They wanted forensic podiatry input relative to examining some questioned footwear. Several photographs and the two pairs of questioned shoes were examined. At an early stage, it was apparent that there was adequate quality and quantity of data to make a determination in this case. By

the podiatrists own request, no details of the crime were provided. The initial facts are transcribed to a case determination form (Fig. 8.12).

(Case work comments: It is very important to isolate oneself from the emotions of a case. One's opinion whose intent is to be totally objective will always have some subjective component, albeit very small. For example, knowledge that a 3-year-old was brutally murdered and aware of all the facts of that gruesome act before the trial

FORENSIC PODIATRY CASE DETERMINATION FORM:

CONTACT:

AGENCY:

DATE:

TIME:

REQUEST:

PHONE NUM:

BRIEF SYNOPSIS:

TYPE OF CRIME:

CASE NUMBER:

DATE OF OCCURRENCE:

SUSPECT(S):

STATUS: ____in custody ____other

PHYSICAL EVIDENCE RECOVERED:

COURT STATUS:

EVIDENCE REQUESTED FOR REVIEW:

____PHOTOGRAPHS
____FOOTWEAR
____BARE FOOTPRINTS
____OTHER

REFERRAL SOURCE:

DISPOSITION:

Fig. 8.12 Example of a case determination form

can affect one's opinion. On the other hand, having no prior knowledge does not allow anyone to imply that you had made up your mind because of this and may possibly use this against one, at times, in their testimony.)

The evidence was hand delivered to the podiatrists' office.

(Case work comment: Your laboratory or, in many cases a room in your house or office dedicated to case work, should have a door that can be secured and restricted to entry).

Footwear Inventory

ID#	Questioned (Q)/ Known (K)	Make	Size	Description
419	Q	Nike®	5 ½	canvas off court casual sneaker *black*
420	Q	Kani®	5L 5 ½ R	designer athletic thick outsole *white*
500	K	Ellemenno®	8	canvas lace fashion sneaker *white*
501	K	Fila®	9	canvas off court casual sneaker *blue*
502	K	Nike®	8	Air running shoe Pegasus *white*
304	K	Highlights®	10	dress lace slip-on mule *tan*
305	K	Reebok®	7	cross trainer *black*
306	K	TFL®	5	lace up ankle boot *black*
313	K	Nike®	9	canvas off court casual sneaker *white*
914	K	Fila®	10	high top court shoe *white*
915	K	Asics®	9 ½	running shoe gel *white*

Fig. 8.13 Inventory of footwear

Fig. 8.14 #419Q

The shoes were received appropriately sealed with evidence tape in paper bags and identified as to its content. The evidence was removed from the paper bags, logging each item with appropriate identifiers (Fig. 8.13).

(Case work comment: It is a good idea to photograph everything as received initially and after removing from packages, etc. It is also important to confirm that the lab has examined, for example, a pair of shoes, for trace evidence so there is no concern of contamination or loss of evidence if there is a need to cut the shoe open).

The questioned evidence is examined first.

Questioned footwear (unknown) #419Q was a pair of canvas sneakers (Fig. 8.14) size 5.5 U.S.

Questioned footwear (unknown) #420 was a pair of designer athletic shoes size 5.0 left and size 5.5 right (Fig. 8.15).

Each shoe is analyzed including the upper, outsole, and sock liner/insole (refer to Chap. 5).

At the time of the arrest of the three suspects their shoes were removed and placed into evidence. Suspect #1 (CM) was wearing item #500, which was a pair fashion canvas sneakers size eight. Suspect #2 (YE) was only wearing a left shoe, item # 501, which was a canvas casual sneaker size nine. She had injured her right foot/ankle a couple of weeks before and wore a cast on her right side. Suspect #3 (TS) was wearing a pair of running shoes item #502 size eight. Several other shoes, item #s 304,305,306, and 313, were recovered from the victim's apartment. It might be assumed theses were the victims shoes, but suspect #1 (CM) was also residing there at the time. Items #914 (Size 10) and #915 (Size 10.5) were supplied by the victim's parents of known shoes that the victim had worn.

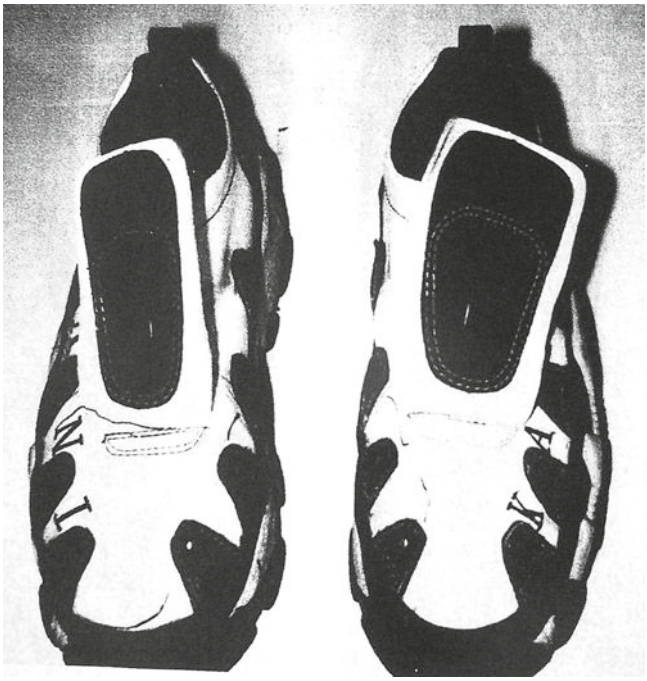


Fig. 8.15 #420Q

The suspects' were examined at the jail infirmary. Each suspect was evaluatedm including photographs, inked footprints in a weight-bearing position, foam impressions, and a biomechanical evaluation both static and dynamic. Foot measurements were also taken utilizing two separate devices to equate them to shoe size. The data was then transferred onto a forensic foot evaluation sheets for further study.

Appropriate standards (exemplars) (refer to Chap. 4) were constructed including dental stone cast molds of each foot as well as appropriate transparencies from the inked footprints and photographs. The laboratory supplied examination-quality photographs of the sock liners of each shoe as requested (Figs. 8.16 and 8.17).

All standards were verified for accuracy prior to any comparison evaluation.

(Case work comment: if the original photographs were not received then it must be verified that what was received was accurate. This also includes photocopies of bare footprints, for example for accurate size reproduction.)

The methodology utilized is the ACE-V paradigm.

The analysis entails dissecting each piece of evidence item into its basic components (refer to Chap. 4). The next step is to compare the known to questioned item. The modified overlay technique (DiMaggio 2005) (Fig. 8.18) was utilized. The Gunn method can be utilized to back up or corroborate the findings. Direct overlay of the sock liner is performed as well as using the foot casts for same. At this time suspect number #2 (YE) was excluded because of a considerable size differential. She had a larger foot size than the two other suspects and would not have been an

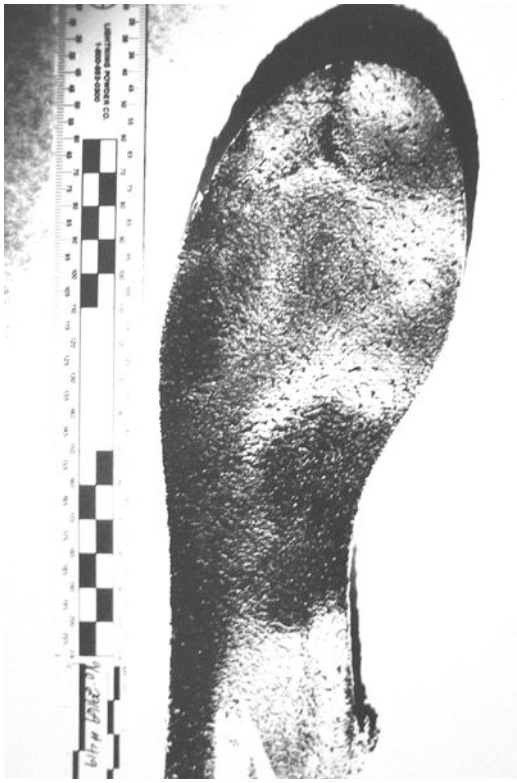


Fig. 8.16 Sock liner image 419Q

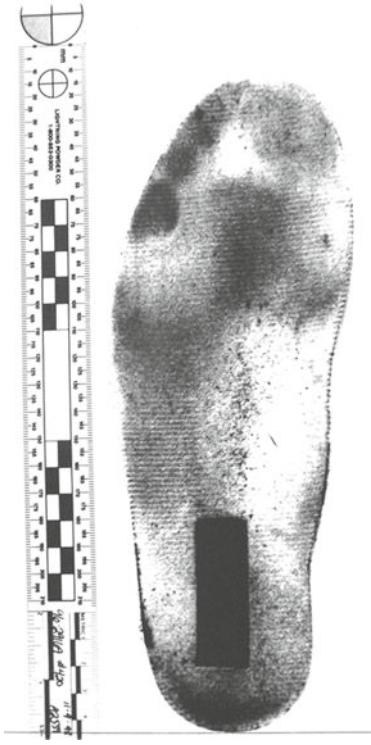


Fig. 8.17 Sock liner image 420Q

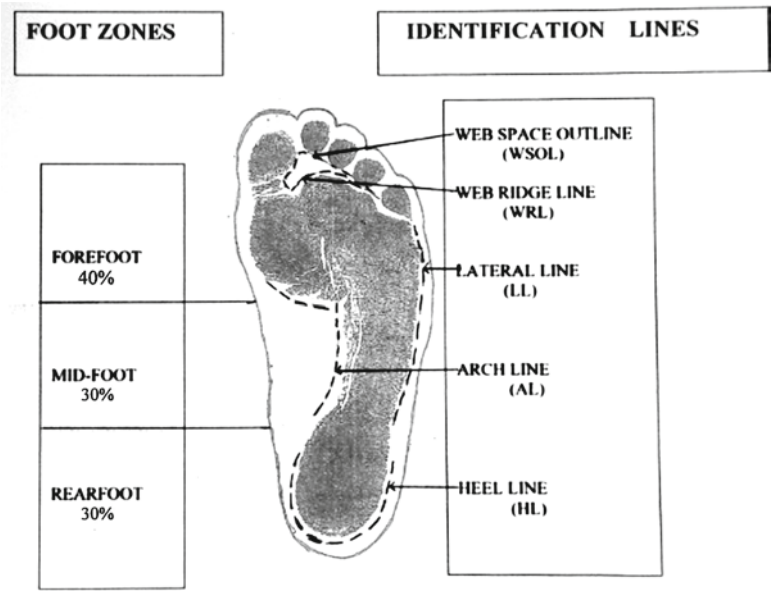


Fig. 8.18 Foot identification lines and foot zones

appropriate wearer of either of the questioned footwear. Suspect #1 (CM) (Figs. 8.19 and 8.20) and suspect #3 (TS) were then utilized for comparison purposes against the questioned shoes and the known shoes.

The examination stage consists of correlating findings to determine the strength of the evidentiary findings on the affirmative side or the negative side.

Another component of the ACE –V methodology is the V (verification) component. This is like a "second" opinion in medicine and is always a good idea.

The bases of opinions are the cumulative findings from each phase of the case study.

Because of the large number of footwear and suspects there were some interesting components that needed investigation.

A footwear examiner was consulted for information on the questioned shoes. A query was made to a computer database that is available to research a particular shoe. In this case, however, shoes #420 were somewhat unique and required, as in some cases, personal investigation. It was determined these were part of a new African-American line of designer clothes and shoes. Shoes #500K were determined to be a popular brand of shoes sold by a mid-level department store common to the Phoenix area.

The sock liners in the questioned shoes #419Q posed a minor problem. Because of the black nylon cover, it was difficult to see a good shadow image of the foot. The crime laboratory of the Maricopa County Sheriffs Office spent considerable time to test different wavelengths, etc., using a Forensic Light Source to enhance the image to a more usable form (Fig. 8.16).

One of the most important components of the sock liner analysis includes the Web Space Outline (WSOL) (Fig. 8.21). This usually exhibits the best clarity and

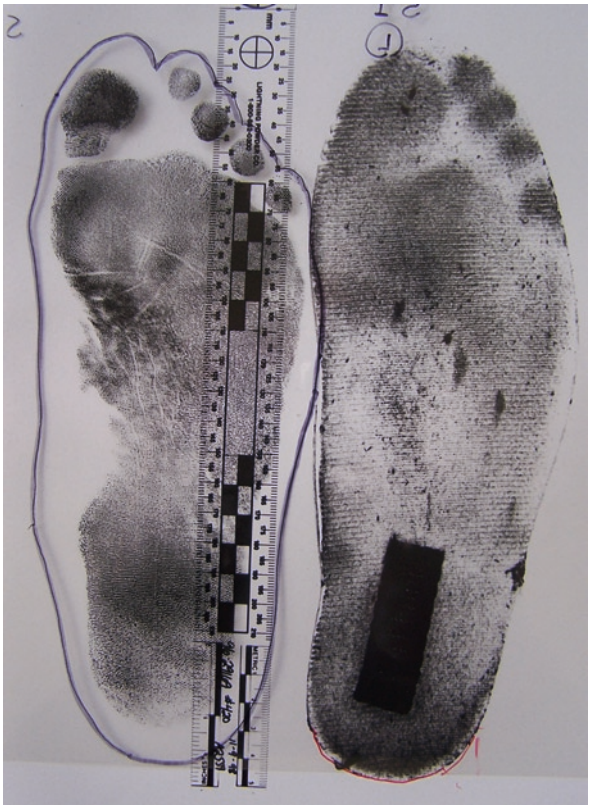


Fig. 8.19 Side by side CM to 420Q

detail for comparison and appears to be fairly constant for one person although other lines may exhibit similar findings.

The sheer number of shoes involved made this case interesting as well as the size variations. #420Q was in different sizes per foot? Were they mismatched at the time of purchase?

Suspect#1 (CM) when arrested was wearing a size eight fashion (dress) style shoe but her size measured 5–6. The questioned shoes #419 (size 5.5) sock liner was the same length as that in the size eight dress shoe.

(Case work comment: The knowledge of how feet actually fit shoes properly is something that still needs clarification and, for the most part in this author's opinion, is at best highly inaccurate. An appraisal of the foot to sock liner can be more accurate and these are things the podiatrist is trained to understand. The foot/shoe combination is evaluated from a static point of view, but one must consider and be aware of dynamic influences that may affect the foot placement. Considering this evaluation, a "simple" physical comparison does not consider the knowledge acquired from evaluating and treating many hundreds of thousands of feet. The end

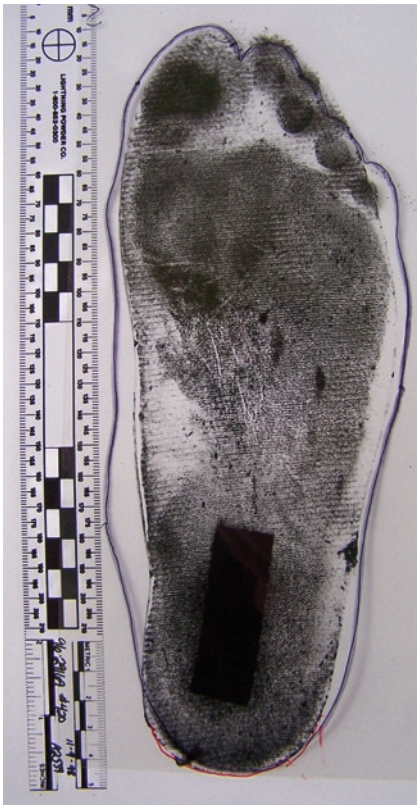


Fig. 8.20 Overlay CM to 420Q

result to these cases, often involving someone's life, is too important to allow less qualified individuals from making such determinations).

It was also interesting considering they left their shoes in the trunk and two of the suspects (YE and TS) appeared to be wearing the victim's shoes.

The apparent ploy to confuse the issues was by planning or just happenstance?

A challenging part to this case was the morphologic similarity of the suspect's feet. CM had, however, a developing bunion deformity and a long second toe with hammertoe deformity. Podiatric interpretation of the pathologies and their influence on certain factors proved highly significant to the final outcome.

The final determination was:

Note: the terminology used for "conclusions" was accepted as such at the time of this case.

It was very probable that Suspect #1 wore footwear #419Q. It was also felt she was probably wearing her own shoes when arrested.

It was very probable that suspect #3 was wearing footwear #420Q. The shoes she was wearing at the time of arrest were probably the victims.

Fig. 8.21 Web space area depicte

Two pairs of shoes recovered from the victim's apartment were the victims. One was inconclusive because of severe wear and obliteration of any detail and the other was probably suspect #1's shoes.

Results: The shoe #419Q was considered by the police before the trial to be the shoe worn by the actual murderer.

The jury deliberated on all the evidence and came back with a guilty verdict.

8.6 Forensic Gait Analysis: Case History (Crown *vs*. Saunders 2000)

An armed robber entered a jeweler's shop which he intended to rob, believing that he had taken all the necessary precautions to avoid recognition. He wore two pairs of trousers, a mask, and gloves. He could not, however, disguise the way he walked and in examining a recording of the crime which had been captured on CCTV footage

from a camera in the jeweler's shop, an image analyst subsequently noted that there was "something unusual" about the robber's walk in the recording being examined. Footage of a known suspect was also taken and made available for comparison purposes. The Metropolitan Police Officers involved in the case subsequently contacted Mr. Haydn Kelly, a podiatrist who specialized in gait analysis, to seek assistance in identifying the gait anomaly and determining whether this was in fact present in known and questioned recordings.

The specific instruction given to Kelly was a request to view and examine CCTV footage of a series of robberies as well as footage of a known suspect and to provide a report outlining and comparing the person's gait in both the known and questioned footage.

The first important test faced by Kelly was to determine whether each item of CCTV footage provided was of the appropriate quality and suitability for gait analysis. Once this had been ascertained, the next task was to view and examine the questioned CCTV footage looking for unusual gait patterns or features of gait that were apparent. The same process was then performed for the surveillance (known/control) footage of the suspect. Finally, comparisons were made with the questioned CCTV footage and a conclusion made in relation to common features apparent on both. At the same time, the footage was also examined for any features that might indicate a mismatch and would therefore suggest that the known and unknown footage could not have been of the same person.

Kelly subsequently worked frame by frame through a large volume of video footage to determine whether there was any match between the gait of the robber on the jeweler's CCTV security video and that of the known suspect on police surveillance recordings. Over 12 h was spent going over the CCTV footage and the police video surveillance recordings (Expert Witness institute, 2001). While surveillance footage was used as the known or control footage for comparison purposes in this particular case, this could equally have been custody or other known footage.

For the forensic gait analysis work, the original surveillance video was examined (in this case analogue tapes). This was because distortions or loss of images found on copies may have reduced the reliability. With the introduction of digital technology, this consideration has now become much less of a concern, but nevertheless was an important consideration then. The material was examined in fine detail, and each phase of the suspect's walking cycle was compared with that of the robber captured on the questioned CCTV recording. In this comparison process, the recordings of the known suspect and the robber were compared and viewed in the same or similar body planes: front, rear, and side views, as well as views from above, where available. Still images of the footage were found to be a useful supplement for illustrative purposes, though still images alone may not always clearly show the relevant feature of gait being referred to. Hence the work necessarily concentrated on the actual footage sequences of the full view of the person walking. Kelly determined that both the robber and suspect displayed the condition known as genu varum. This feature was clearly visible on the questioned recordings, despite the robber having worn two pairs of trousers. Kelly determined that no more

than 5% of the relevant population would be expected to exhibit this same feature as observed in known and questioned recordings. At the same time, no features could be observed on the recordings which would have suggested that the suspect could not have been the person filmed on the jeweler's CCTV footage of the crime.

As required, the concluding report was written from a neutral perspective and also without knowledge of any of the characters involved in the case.

The trial was subsequently held at the Old Bailey Central Criminal Court in London, with the suspect being found guilty. Various recommendations were made on the conclusion of this case in relation to this form of evidence. It was suggested that investigators need to be aware of the experts' needs when obtaining footage for gait comparison and analysis purposes. At the same time, consideration must be given to the positioning of surveillance cameras so that their installed position would help and not hinder forensic gait analysis, should this ever be required. It was also suggested that training in the expert processes involved in this work would be beneficial.

This particular aspect of the case made legal history, being the first time that forensic gait analysis and biomechanics became admissible evidence in criminal law (The Independent 2000, Guinness 2009) and subsequently led to the further use of forensic gait analysis in criminal investigations.

In Fig. 8.22, the two images on the left are of the CCTV footage showing a front (sagittal plane) view of the robber in the doorway and inside the jeweler's premises.

The image on the right is of surveillance footage which shows a rear (sagittal plane) view of known persons, that on the right being the suspect.

Fig. 8.22 CCTV and surveillance footage

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Part IV
Medicolegal Concerns

Chapter 9
Expert Witness Considerations and Standards of Practice

Keywords Frye standard • Daubert standard • F.R.E. 702 • Crown prosecution rules • Professional standards

The forensic podiatrist is an expert witness whose overriding duties are to the court. In performing these duties, the podiatrist must live and work to high professional standards and during practice, should work to defined protocols. This chapter covers this area and provides an explanation of these standards and protocols, adherence to which will go a long way to preventing errors from occurring while working as a forensic podiatrist.

9.1 The Expert Witness

The forensic podiatrist's role is that of the expert witness. Definitions exist in both the USA and the UK to state what it is that expert witnesses do. In the USA, the Federal Rules of Evidence (F.R.E.) Rule 702 states:

"If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case" (US Govt 2009).

The Frye standard relates to the admissibility of expert testimony and was established by Frye *v* United States, 293 F. 1023 (D.C. Cir. 1923). The Frye standard requires expert testimony be based on science that has gained "general acceptance" in the relevant field. The Frye standard was utilized in federal courts until 1993 (Sacks, 1995).

J.A. DiMaggio and W. Vernon, *Forensic Podiatry: Principles and Methods*,
DOI 10.1007/978-1-61737-976-5_9,

In 1993 US Supreme Court case *Daubert v Merrell Dow Pharmaceutical, Inc*., 509 U.S.579 (1993), established the Daubert standard. In December of 2000 Federal Rule of Evidence 702 was formally amended to reflect the implications of the Daubert standard. In order to be admitted the testimony must be based on sufficient facts or data, the product of reliable principles and methods, and the witness must apply the principles and methods reliably to the facts of the case (Written communication Arizona Identification Council, 2009). Many states are now utilizing Daubert; however, some still recognize the Frye standard.

In the UK, the Crown Prosecution Rules (CPR) apply to the expert witness. Here, an "expert" is described as being:

> "a person who is required to give or prepare expert evidence for the purpose of criminal proceedings, including evidence required to determine fitness to plead or for the purpose of sentencing" (Ministry of Justice 2010: Section 33.1).

The rules continue to describe such an expert's duty to the court as follows:

1. "An expert must help the court to achieve the overriding objective by giving objective, unbiased opinion on matters within their expertise.
2. This duty overrides any obligation to the person from whom they receive instructions or by whom they are paid.
3. This duty includes an obligation to inform all parties and the court if the expert's opinion changes from that contained in a report served as evidence or given in a statement."

(Ministry of Justice 2010: Section 33.2)

Although these rules are stated differently, they share many similarities and it is within these rules that the forensic podiatrist must operate. These rules are, however, basic and they can be further supported and enhanced by more detailed standards of practice for experts from any background including forensic podiatry.

9.2 Standards of Practice

In the UK, the standards for forensic practice for all subspecialties of forensic podiatry were defined by the Council for the Registration of Forensic Practitioners (CRFP) in October 2006 (Vernon and Kelly 2006). Three forensic podiatrists, Vernon, Kelly, and Walker, worked closely with the CRFP to develop these standards, which were later formally used to regulate the practice of those podiatrists who wished to voluntarily register with the CRFP. This would allow registered podiatrists to benchmark the quality of their work and demonstrate that their standards complied with a broad generic framework used across all registered specialities, yet tailored to the needs of the forensic podiatry profession. The CRFP is no longer in existence as a regulatory body in the UK and, at the time of writing, a vacuum exists in the formal regulatory arrangements for sole forensic traders, including forensic podiatrists in that country although the Forensic Science Society have recently attempted to fill this vacuum by piloting a competency testing scheme

for forensic podiatrists.. Nevertheless, the standards written for forensic podiatry practice are recently created and still apply.

Also at the time of writing, the USA does not have an equivalent organization to the CRFP that could formally regulate practice in forensic podiatry. With the inclusion of a forensic podiatry section within the International Association for Identification, the scope of practice for forensic podiatrists and other relevant information is now established and is expected to act as the benchmark for practicing podiatrists in the USA. The author from the USA does, however, ascribe to the standards of practice developed within the CRFP and the considerations described in this chapter are relative to such.

The standards of practice as developed within CRFP therefore form the basis of considerations described in this chapter. Although created in the UK, these standards represent reasonable expectations of forensic practitioners working in this field and should therefore be applicable to practice in other countries. The framework described in this section is that developed within the CRFP, some of this on an organization-wide basis, which was later translated to the requirements applicable to forensic podiatrists by Vernon, Kelly and Walker. As such, this section is mainly reporting the standards developed within that organization, which believed that not only was it "undesirable to try to protect these legally," but that it was also "fine to promulgate the guidance" with due reference being given to this having been created within the CRFP[1] As the CRFP has now ceased to operate as a regulatory body, the source of reference to the work (the CRFP web site) no longer exists, however what is being reported are those standards which were in place within the CRFP and were being utilized for the regulation of those disciplines which fell under the auspices of the CRFP until 1st April 2009.

As with all branches of forensic science, the professional status of forensic podiatrists carries with it a range of professional responsibilities. In forensic podiatry practice, these cover conduct in personal and professional life, maintaining fitness to practice, safeguarding confidentiality where required, and working to the high standards required of this discipline, which includes not extending professional opinions beyond those that the individual practitioner is qualified to provide. These standards are now considered in more detail below.

9.2.1 Personal and Professional Conduct

Forensic practice requires practitioners to operate to the highest standards at all times, whether this is while acting in a professional working capacity, or in one's personal life. The practitioner must act with honesty and integrity and comply with the code of conduct of the professional body or bodies with which they enjoy membership. To do otherwise would compromise the personal integrity required in this area of work and would additionally have the potential to bring the specialty

[1]Personal communication with Dr. Kate Horne, 28th January 2010, past Chief Executive of CRFP.

into disrepute. Practitioners are also expected not to discriminate against people or groups who enjoy legal protection against such discrimination.

9.2.2 Professional Practice

The primary duty of the forensic podiatrist is to the court: When working as a forensic podiatrist in the UK, the first principle of professional practice is that the podiatrist's overriding duty is to the court and not to the agency which has asked for their expert opinion. This means that work must be carried out fairly and impartially and presented at all times in that same fair and impartial manner. In this respect, if the forensic podiatrist is aware of anything that may be seen as a conflict of interest when working on a particular case. This should be declared at the first opportunity and, where this has been an issue, should only act further with the explicit written consent of those who asked for their involvement.

9.2.3 Professional Competence

Forensic podiatrists also have a responsibility to ensure their professional competence in the area or areas within which they specialize. This would include participating in continuing professional development (CPD) activity, which will allow competence to be maintained in line with developments in that particular field, thereby ensuring that their practice remains of high quality and up to date. CPD activity does not need to be formal education and could include professional reading, mentorship, conference or seminar attendance, the preparation of conference presentation material, and the like. What is essential, however, is a learning diary or log that is kept by the practitioner as evidence of such development.

Linked to the need to ensure professional competence in the area of practice is a need to work exclusively within the areas of professional competence within which the forensic podiatrist has been properly trained to do. For example, within the International Association for Identification (IAI), it has been formally stated that any podiatrist who wishes to undertake identification from wear marks (e.g., outsole identification based on accidental characteristics) as opposed to the wear patterns, of footwear would be required to undertake the full range of training required to become a forensic marks examiner (UK)/certified footwear examiner (USA) (Vernon et al. 2009), which if undertaken would in effect qualify the podiatrist to operate in another specialist field other than forensic podiatry.

The other element that relates to ensuring professional competence is that of fitness to practice on health grounds. It is possible to be unable to practice safely as a result of illness and in line with medical practice, it is incumbent on the practitioner to not practice when medically unfit to do so.

9.2.4 Informing Others Where There Is the Potential for Miscarriages of Justice

When providing expert witness reports in a legal that, if it remains undeclared, may potentially lead to a miscarriage of justice. These can be in situations where reports have been provided that are clearly erroneous, or alternately where an error has later come to light in one's own work. While the latter should not happen if appropriate care has been taken in case work, it is nevertheless possible. Whenever such errors come to light, they should be reported confidentially, if appropriate, to what was described by the CRFP as "a suitable person or authority" – in most cases, this being the authority that has approved or requested the expert's involvement.

9.2.5 Providing Quality Assurance

Quality assurance processes are expected to be followed by large forensic laboratories and it has been stated that similar standards should be practiced by all providers of forensic science services "regardless of their size or the scope of their examinations" (Rennison 2009). There is, however, the practical problem of large laboratories having the greater financial means to operate such quality assurance processes, while individual practitioners are unlikely to have access to such resources, therefore, in the UK, competency testing if being developed for "sole trader" practitioners, who work outside the large laboratory system. Whether working in or outside a large laboratory, there is a clear obligation to provide an acceptable level of quality assurance in the approach to and outcomes of the work provided. To this effect, forensic podiatrists are advised to work to strict protocols and to ensure where possible that their work is checked and verified by a peer practitioner.

9.2.6 Accept Full Responsibility for All Work You Have Either Undertaken or Participated in

Here, the forensic podiatrist must recognize that by undertaking forensic podiatry work and subsequently providing a legal report for the court, they are accepting full responsibility for everything within that report. There is, however, a level of responsibility on the part of those verifying such reports and by signing the report, the verifier must be prepared to answer questions related to their verification of that report. This does not, however, remove the fact that the report author has full ownership of, and responsibility for, the report produced.

9.2.7 Being Prepared to Change an Opinion in the Presence of New Developments, Information, or Research Findings

The task of all forensic practitioners including the forensic podiatrist is to enable the courts to come to a truthful conclusion. In this sense, the practitioner should adopt and maintain a mature, reflective, open, and unbiased approach at all times. This means that if new information comes to light at any time that suggests that the conclusions of the report provided may be incorrect in light of such information, the practitioner must be prepared to declare this and if necessary amend those conclusions provided. The authority who requested the work should then be informed of such reinterpretation at the earliest opportunity.

9.2.8 Confidentiality Should Be Appropriately Preserved

While podiatrists are used to working in situations of confidentiality, there is a major difference between working in clinical situations and the work of a forensic podiatrist who is also obliged to work confidentially. That difference relates to the fact that when a forensic podiatry report has been prepared, it is entirely possible that this will need to be exchanged with the other party involved in the case (either the defense or prosecution side). Once this exchange has take place, it is also possible that the exchanged information will be presented and challenged in an open court of law. As such, any aspect of the report that has been covered in court will therefore normally be available within the public domain from that point onwards. Nevertheless, confidentiality should be preserved until that point that authorization has been given to disclose the information, which may arise from the client requesting this, court orders, legal obligations, or where this is demanded by the overriding duty to the court or the administration of justice.

In relation to confidentiality, the issue of preserving legal privilege must also be considered. Legal privilege is in effect "an enforceable duty of confidence" in a legal context (Gillhams 2010). Such a duty applies to all communications between professional legal advisers and their clients and also between those advisers and expert witnesses involved in the case. Forensic practitioners are obliged to preserve these privileges unless this right is waived by the client.

9.3 Ten Essentials for Forensic Podiatry Practice

CRFP identified ten essential elements for the competent practice of forensic podiatry, irrespective of subspecialty. The essential elements are (CRFP 2006):

- Understanding the requested instruction or task
- Describing the exhibits, items, and the material examined

- Establishing that the exhibits, items, or materials submitted were of suitable quality for the requirements of the case
- Confirming that the correct type of examinations and procedures have been selected
- Confirming that the correct type of examinations and procedures selected have been carried out competently
- Recording and interpreting of the evidence and findings, the range of opinion (where relevant), and making reasoned objective conclusions
- Referring to others involved in the investigation and what they performed and recommending other specialties where appropriate
- Presenting a clear, methodical, and logical report, the details of which should be within the applicant's area of expertise for which they are applying to be registered, and where required, presenting this orally in court
- Ensuring that the report is fit for purpose
- Providing evidence of keeping up to date within the applicants area of podiatry practice and expertise

These elements will now be considered separately and in more detail.

Understanding the requested instruction or task

In providing a written case report, the forensic podiatrist will, in this report, need to provide evidence that they have understood their given instruction or task. To do this, it is important to obtain clear and precise instructions from the party requesting forensic podiatry assistance. These instructions should then be carefully stated in the subsequent written report for the benefit of other parties. At the same time, in addition to stating these questions, it is necessary for the forensic podiatrist to also show that they understand the critical questions required in the context of the situation they are asked to become involved in. Having established that the task has been understood, the reason for the examinations to be undertaken in order to address the questions posed should also be made apparent within the report.

Describing the exhibits, items, and the material examined

Having demonstrated a full understanding of the task required, the forensic podiatrist will then need to describe in their report the evidential items made available for examination. Here, the report should contain a full list of these items including any designator codes as well as a brief physical description of each item.

Establishing that the exhibits, items, or materials submitted were of suitable quality for the requirements of the case

Following the clarification of the questions to be addressed and itemizing of the materials available for examination, the next requirement is to establish that each exhibit, item, or material submitted is of suitable quality for the requirements of the case. This is in effect a preliminary quality check to determine whether examination and evaluation of the material is going to be possible. The conclusions arising from these considerations should be carefully documented in the case notes and in the final report, with any reasons for rejecting items as unsuitable also being recorded. This process is used to determine what evidential material is available that is critical to the case in question. As well as considering the physical quality of the evidence

made available, this check should also take care to confirm that all available evidential materials have been forwarded for examination and also to determine "as far as is reasonably practicable" whether there has been any potential for the evidence to have been compromised before receipt (CRFP 2006). An example of such a problem could be problems apparent with the maintenance of a chain of custody for the evidence in question.

Confirming that the correct type of examinations and procedures have been selected
With the evidential items of central interest having being determined, the next task is to select the correct type of examination and procedures with which to assess and compare the selected items. In the subsequent report, this will usually require some background information to be given indicating the justification for the chosen method in the context of the particular case and providing a brief explanation of the methods themselves. The methods involved should have proven validity. They would also be those appropriately required in the podiatric assessment of records, the foot, bare footprints, footwear, and images of gait, covering the assessment and comparison of both unknown (questioned) and known (comparator/standard) material. In justifying the selected approach, the forensic podiatrist must show in the report that they understand the type of information available from each different type of examination. In addition to showing that the correct method has been selected, the work should also be carried out using appropriate equipment and materials and details of this should be available within the case notes.

Confirming that the correct types of examinations and procedures selected have been carried out competently
The selection of the correct type of examinations and procedures is not in itself enough to ensure their appropriate handling as the examination and procedures once selected also need to be carried out competently. To this effect, the forensic podiatrist must be able to show in their case work how their work has been done, to enable others to determine whether they believe that the work has been appropriately and correctly carried out. In practice, this should be made apparent through a combination of information written into the subsequent report, supplemented by detail available within the supporting case notes. Confirmation of the competent working of the case material can be indicated by making notes on the handling and recording of evidential material made available. Where any established professional principles are relevant to the handling of the case, these should be followed faithfully and documented as required. Forensic podiatry differs from the practice of a number of forensic disciplines in that the work may require a comprehensive podiatric clinical examination of the subject. These examinations should only be carried out where they are deemed to be required and if when undertaken a clinical problem becomes apparent, then appropriate clinical advice should be given to the subject as required. The provision and detail of that advice should be carefully documented within the case notes, as would be undertaken in a clinical situation. The examinations and procedures should also be carried out efficiently and competently, and while it may be difficult to determine this exactly from the case notes, this will be indicated by the presence of clear and detailed supporting records.

Recording and interpreting of the evidence and findings, the range of opinion (where relevant), and making reasoned objective conclusions

In the assessment, comparison, and evaluation process, fully detailed contemporaneous notes are required at all stages in order to demonstrate to others, if required, exactly what was undertaken and how. Such notes must be clear, accurate, legible, and comprehensible. They should also report all findings comprehensively and in an unbiased and impartial manner. The purpose of the notes is to provide a record that would allow "another forensic practitioner competent in the same area of work to review your work independently" (CRFP 2006), should this be required.

The critical area of the forensic case report is that of the evaluation phase, where the examining practitioner has completed the assessment and comparison of evidential items and must now use reasoned and informed judgment in order to reach a conclusion. The process of reaching this judgment should be demonstrated in the case notes and report combined, where the objective and critical assessment process leading to a balanced judgment should be apparent to the reader. This process should also clearly relate to the examined evidence.

In reaching the conclusions of the report, due consideration should be given to preexisting research reports. Where a range of opinion is required, "all relevant explanations should be listed" within the report (CRFP 2006). These should be considered in turn, with reasons being given for rejecting alternative explanations, Everything should be logically explained, and sound justification should being given for the selection of the most acceptable explanation, where a range of opinion has been apparent.

Referring to others involved in the investigation and what they performed and recommending other specialties where appropriate.

This requirement recognizes the responsibility of the forensic podiatrist to work within the boundaries of their own specific role and scope of practice at all time. These boundaries have been clearly defined by the International Association for Identification (Vernon et al. 2009). They were produced in recognition of the very close multidisciplinary interests and involvement required of some of the evidential areas that forensic podiatrists work with. Of particular reference here is that of footwear. While podiatrists have a particular interest in footwear as an item of evidence, so do forensic footwear (marks) examiners, DNA analysts, fiber analysts, and the like. Forensic podiatrists' primary concern in this area centers around the functionally induced wear of shoes, while forensic footwear (marks) examiners are interested in the manufacturing and accidental damage characteristics of shoes in an identification context. Forensic podiatrists should not extend their work into the realms of these other disciplines (and vice versa) without having first undertaken the training required for proper qualification to work in this area. In any case report in which items of potential interest to other forensic specialties are apparent, the report should note the apparent presence of such items and recommend referring these to the appropriate specialty as required. In no circumstances should the report continue to present an analysis of such an item unless the author of the report possesses and has received the necessary training and development to do so competently.

Where a referral has been made or recommended to other specialties, the forensic podiatrist must make it clear in his/her report which specialties should become involved, what they are being asked to do, and if later known, what these people actually did following this request having been made.

Presenting a clear, methodical and logical report, the details of which should be within the applicant's area of expertise and where required, presenting this orally in court

The final report on the case should be well structured and written, and clear, concise yet comprehensive, and impartial. While case notes do not form part of the submitted report, these can be requested in relation to the work and, as such, should also be legible, accurate, clear, and impartial. The structure of the final report should cover the following areas:

- Information about the reporting expert. This should include the name and title of the expert and a summary of their relevant qualifications and experience. An up-to-date curriculum vitae (CV) should be appended to the report. If the reporting expert or verifier has any conflicting interests that should be declared, this should also be included in this section of the report. Examples of such interests could include relationships or previous involvement with anyone involved in the case, no matter how limited.
- The terms of reference and the source of the instructions given. Here, the instructions, detail and facts of the case over which an opinion is being sought should be clearly stated.
- The material upon which the author's investigation and conclusions have been based. Here, it may be relevant to provide a list of such material with designated code numbers where these apply.
- A summary of the report, including the results and conclusions.
- Limitations of the report. This requirement would cover areas that may have affected the quality of the conclusions. These could include access restrictions (e.g., refusal, or limited time allowed to examine a subject, any refusal for a request to cut footwear apart, financial limitations and the like).
- Reference to any required standards or protocols that have applied to the work being reported. These can include the professional standards of the forensic podiatrist, or alternately, requirements stated by the requesting party, or by the court.
- The expert's' opinion/conclusions. Here, the opinion expressed should be grounded in any available relevant research, known literature, and, where relevant, personal experience. The conclusions of the report should carefully balance together the findings of the assessment, comparison, and evaluation, in order to produce an evidential statement in which the strength of conclusion is shown.
- A declaration of truth. The declaration of truth is in effect a statement of integrity, with the reporting expert confirming that the report is a genuine attempt to be truthful and that the responsibilities of producing such a report are fully understood and accepted by the author.
- Relevant reference list as required. In producing a scientifically grounded report, it is probable that references will be required. While a number of mainstream disciplines would assume that their science is accepted, because forensic podiatry

is relatively new, that assumption cannot be made; therefore, the use of appropriate references should be carefully considered.
- Appendices. In addition to the need to reference the report appropriately, other appendixes also may be required. This could include relevant tables, diagrams and any photographic images deemed appropriate.

Ensuring that the report is fit for purpose
The report along with any associated notes should provide evidence that the work is fit for purpose, meaning that all aspects of the report have contributed towards achieving what has been requested, namely competently addressing the question posed using acceptable methods and techniques, without bias, and in a manner that can be understood by the intended audience. Following the approach and structure advocated will go a long way towards achieving this requirement.

Providing evidence of keeping up to date within the applicant's area of podiatry practice and expertise
Within the report (specifically through the CV), the expert should demonstrate that they have undertaken appropriate and timely continuing professional development (CPD) relevant to their area of podiatry practice. CPD can cover a wide range of activities in addition to those presented by formal learning experiences. Alternative forms of CPD can include for example professional reading, research, publication and presentation, conference, seminar and workshop attendance, and mentoring or being mentored.

These then are the basic standards required in the working and reporting process of forensic podiatrists. In the UK, a detailed range of relevant National Occupational Standards (NOS) have been created by the Sector Skills Council and Standards Setting Body for the Justice sector. Such standards "describe competent performance in terms of outcomes of an individual's work and the knowledge and skills they need to perform effectively. They allow a clear assessment of competence against nationally agreed standards of performance, across a range of workplace circumstances" (Skills for Justice 2008). A number of these NOS standards are directly relevant to general forensic practice. It is recommended that forensic podiatrists, particularly those based in the UK, read through those NOS standards relevant to their work in order to verify that they are able to meet those requirements, where applicable. These standards may be subject to revision from time to time, therefore regular scrutiny is recommended.

9.4 Summary

Much of the information presented in this chapter has been based on guidelines developed and implemented in the UK. Other podiatrists outside the UK, however, also ascribe to the standards set forth in the UK relative to forensic podiatry practice. It is also inherent for the expert to continue to strive for excellence in this field, continually learning and ensuring that they are as knowledgeable as possible in all pertinent areas prior to undertaking case work.

In addition, working protocols and guidelines should be created and followed, with detail of these being provided in the underpinning case notes. Finally, it should be remembered that having undertaken this work, the expert may also be required to have the work "tested" in the adversarial courtroom situation, and they should be aware of the requirement and responsibilities in this context, should this be required.

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Glossary of Podiatric Terms

Foot

Abduction	Movement of the foot away from the midline of the body.
Adduction	Movement of the foot towards the midline of the body.
Ball (foot)	The part of the foot beneath the five metatarsal heads.
Biomechanics	The application of mechanical laws to living structures, specifically to the locomotor system of the human body.
Bunion/hallux abducto-valgus	An enlargement of the first metatarsal head with rotation and lateral deviation of the big toe.
Calcaneum	The heel bone.
Callus/callous	A hardening and thickening of the skin usually associated with a boney influence.
Contracted/retracted toes	A condition in which the toes are pulled back and may not contact the ground properly during stance.
Corn/clavus	A discrete hard and painful area often associated with a hammertoe. It usually has a deep "core" that presses on a subdermal nerve.
Distal	Farthest away from the central location of the body or part in question, such as the toes are distal to the heel.
Dorsal/dorsum	Upper surface of the foot.
Dorsiflexion	Upward movement of the foot.
Eversion	The plantar surface tilts away from the midline of the body; lowering the inner border of the foot.
Fibrous corn	A corn usually of very long standing duration that shows the presence of fibrous tissue.
Foot zones	The sectioning of the foot into three sections (rearfoot – 30%; midfoot – 30% and forefoot – 40%) that can be used in the comparison process.
Gait	Any form of locomotion. For example, walking, running, etc.

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Genu varum	Bow leggedness, or bandiness so called because of an outward bowing of the lower leg, when compared to the thigh.
Greek ideal	Refers to a foot with a long second toe length versus the big toe.
Hallux limitus	A condition in which the movement of the joint of the big toe is limited restricting its ability to bend during walking.
Hallux rigidus	A condition in which the joint of the big toe is immobile leading to a stiff toe and inability to bend during walking.
Hallux valgus	A condition in which the big toe is deviated away from the midline of the body towards the midline of the foot.
Hammertoe	A common toe deformity with prominence of one of the toe bones where a painful corn often develops.
Hyperextended toes	A condition in which the toes are excessively extended beyond the normal range of movement.
Hyperpronation	An excessive pronatory movement of the foot.
ID lines	Morphological descriptors (arch line, heel line, web ridge line, etc.) that are used in the comparison process.
Interdigital	The area between the toes.
Inversion	The plantar surface tilts toward the midline of the body; elevation of the inner border of the foot.
Involution	A condition in which the nail curves inwards at the edges.
IPK (intractable plantar keratosis)	A deeply nucleated keratotic lesion on the bottom of the foot that may leave its mark as an area of increased pressure on a receiving surface.
Lateral	Farther from the midline.
Malleoli	The bones which can be seen as medial and lateral protrusions of the ankle.
Mallet toe	A form of a hammertoe with a deformity at the end of the toe creating a downward pressure that may be useful in the examination process.
Medial	Nearer to the midline.
Metatarsal formula (parabola)	The order in which the metatarso-phalangeal joints of the ball of the foot are encountered when approaching these from a distal position.
Metatarsalgia	A term denoting pain in the metatarsal area secondary to different etiologies.
Metatarso-phalangeal joint	Joints situated within the ball of the foot, where the metatarsals join with the proximal phalanges.
Midfoot	Section of the foot situated between the forefoot and heel.
Multi-nucleate corn	A corn that shows the presence of more than one white nucleus as a result of pressure in the area.

Nevi	Small benign pigmented lesions of the skin – often described as "moles."
Onychogryphosis	Grossly thickened and deformed toe nail that, when neglected, takes on the appearance of a ram's horn.
Pedal evidence	Physical evidence related in some form to the human foot. For example, bloody footprints, foot impressions in dirt, etc. It may also include associated deformation of the shoe upper or an image on the sock liner secondary to the foot that housed it that can also be used in the comparison process.
PES cavus	A foot type in which the arch is markedly accentuated and the toes are retracted with the forefoot usually being situated lower than the heel when viewed in a relaxed position from the side.
PES planus	A true flat foot.
Phalanges	Toe bones.
Plantar	Pertaining to the sole of the foot.
Plantarflexion	Downward movement of the foot.
Plantar verruca (E) (plantar wart(s))	One or more lesions on the bottom of the foot that may leave their mark by an area of increased pressure or break in continuity on a receiving surface.
Podometrics	The science of foot measurements.
Pressure point	Area of the foot (usually a toe) that shows minor signs of having rubbed against an enclosing shoe.
Pronation	A tri-plane motion of the foot consisting of abduction, dorsiflexion, and eversion of the calcaneous which is often labeled as the valgus (flat) foot type.
Proximal	Nearest to the central location of the body or part in question, such as the heel is proximal to the toes.
Running	Double float phasic gait.
Supination	A tri-plane motion of the foot consisting of adduction, plantar flexion, and inversion of the calcaneous, which is often labeled as the cavus (high arch) foot type.
Step length	The distance between one foot plant and the next, e.g., right foot to left foot.
Stride length	The distance between one foot plant and the next of the same foot, e.g., right foot to the next right foot plant.
Tailor's bunion	An enlargement of the joint situated on the outer aspect of the ball of the foot.
Toe formula	The order in which the toes are encountered when approaching these from a distal position.
Toe-off	That phase of gait just prior to the foot leaving the ground, whereby the foot is now acting as a rigid lever.

Valgus	An abnormality or deformity in which the foot is turned or forced outward; used to describe a pronatory attitude (flat foot).
Varus	An abnormality or deformity in which the foot is turned or forced inward; used to describe a supinatory attitude (high arch).
Vascular corn	A corn that has been complicated by the presence of blood vessels within the affected area.
Walking	Double stance phasic gait.

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