Forensic Podiatry

Podiatrists now play a key role in solving crimes.

BY BRYAN B. KAGAN, DPM

Introduction

Forensic science is the compilation of systematic methodologies to understand the physical world through observation and experimentation. It links people, places, and things that are involved in with criminal activities. It merges science and law and assists in the investigations and adjudications of criminal and civil cases. Criminal law cases deal with crime and the legal punishment of the offense. These can involve theft, assault, arson, robbery, murder, and trafficking of controlled substances. Civil law cases deal with disputes between individuals, organizations or between the two in which punitive fines/compensation is awarded to the victim. Examples of civil cases include landlord and tenant disputes, divorce proceedings, property disputes, and personal injury.

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Forensic podiatry falls under the main category of physical evidence.

Forensic podiatry is a subspecialty of podiatric medicine and offers an exciting new aspect of podiatric medical practice as an evolving discipline in the forensic sciences. “The discipline of forensic podiatry applies sound and researched podiatric knowledge and experience in forensic investigations. It shows linkage of an individual with a crime scene through pedal evidence and answers any legal questions concerning the foot or footwear that requires knowledge of the functioning foot.”

History

The history of American forensic podiatry began in September 2000 when the “First Annual Forensic Podiatry Seminar” was held in Scottsdale, Arizona. Eighteen podiatrists and several law enforcement personnel attended. For comparison, the first forensic conference held by the International Association for Identification almost 100 years ago in California attracted 22 law enforcement personnel. Membership now stands in the thousands. “In September 2003, the American Society of Forensic Podiatry (ASFP) was formed (Figure 2). By-laws were organized and accepted, and 22 individuals joined as charter members. In July 2007, a forensic podiatry sub-committee was established within the structure of the International Association for Identification (IAI) with the help of ASPF members.” The role and scope of forensic podiatry practice was delineated by the IAI; “forensic podiatrists assist in the identification of perpetrators of crime evaluating the static and dynamic foot and the footwear that housed it, to include barefoot prints (in blood, dirt, dust or in the sock liner), foot wear (outsole and upper wear patterns relative to foot pathology) and Closed Circuit Television (CCTV) Evidence.”

Figure 1A: Tire Impression. Tire Tread and Tire Track Evidence, Law Enforcement Training Network, p 13 ©2009

Figure 1B: Shoeprint. Personal photo file

Figure 1C: Reading the Soil. Galvin B, “Reading the Soil” Evidence Technology Magazine, July/August 2013, 18

Figure 2: Forensic Podiatry Discipline. Forensic Podiatry Discipline, International Association for Identification website.

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Impression. The forensic podiatrist’s expertise is therefore required
1) to assess the effects of the foot and lower limb function.
2) to evaluate the wear associated with a foot/shoe interface (Figures 3a-c).
3) to compare shoe size considerations (Figures 4a-b).
4) to compare the gait patterns of individuals captured on CCTV with those of suspected individuals (Figure 5).
5) to identify human remains from comparison of podiatry records and x-rays with the feet of deceased individuals.

Education and Training
A forensic podiatrist must attain a DPM degree or a BSc degree in podiatry. A level of expertise to practice in a medical-legal context must be developed. A Masters degree in forensic podiatry, forensic science, and/or forensic human identification is another pathway to pursue. The forensic podiatrist must continue his education in expert witness training programs, forensic podiatry, or related training workshops and/or seminars. He/she must continue his/her professional development with participation in research activities in forensic podiatry, and would be expected to publish in forensic journals or magazines, and/or present his research results at forensic conferences/seminars (Figure 6).

The Human Foot
The human foot is determined initially by its genetic code. The volar pads at approximately 8 embryological weeks develop into unique friction ridges, and foot and toe prints. Influenced during growth by the personal biomechanics of each individual, injuries and other physiological changes and pathologies, the foot develops into an adult structure that is highly individual in its form, size, and shape. Since no two feet are exactly the same, no two barefoot prints or barefoot impressions can be identical unless created by the same individual. “The forensic podiatrist’s evaluation of the evidence is often necessary because of the complexity of the human foot and the subtle variances inherent to such and the footwear housing it”. (John DiMaggio-2003 personal correspondence) In Crown vs. Chester-Nash 2006, it was necessary to determine if more than one individual could have worn a shoe that was linked to a murder and how much wear would be necessary before leaving a permanent impression. The forensic podiatrist’s expertise is therefore required

The volar pads at approximately 8 embryological weeks develop into unique friction ridges, and foot and toe prints.
can establish that a crime has been committed or that can link a crime and its victim or perpetrator.”” “In-
formation is whether in the form of personal testimony, the language of documents, or the production of ma-
terial objects, that is given in a legal investigation,” to establish the fact or point in question. Whenever two
objects come in contact, an exchange of matter or information occurs. This is the definition of the Locard Ex-
change Principle. That information may be too small to analyze or to detect, but that transfer has occurred nonetheless. It is those transfers that establish the links and associations between victims, suspects, weap-
ons, crime scenes, and/or anything involved in a crime. There are two
types of evidence in forensic scienc-
es. Real (physical) Evidence is recov-
ered from the crime scene or another location where the victim or suspect has been. Demonstrative Evidence
is not recovered at the crime scene but is created by an expert witness to help explain the real evidence that
is found (i.e. shooting scene recon-
struction, blood stain pattern analy-
sis, recreation of a crime scene).

Pedal evidence may be in the
form of footprints either bare (Figure 7) or in socks, in blood, dust, or dirt, (mud/dry) and can be patent (visible
to the naked eye), plastic (in clay,
gum), or latent (requiring additional processing to be viewed).

Footwear-related identification re-
garding sizing issues, ownership, and
assembling the footwear examiner, gait
pattern characteristics observed on
CCTV (Figure 8) and mass disaster
identification are also other forms of
pedal evidence.

ACE-V Methodology

A general methodology outline
for the identification process has
been developed to assist the podia-
trist in making and justifying deci-
sions. The acronym for the steps in
this process is the ACE-V Methodolo-
gy (Analysis, Compari-
son, Evaluation—Veri-
fication).

Analysis is the as-
se ssment of the foot-
print to determine if
the detail quality is
reasonably sufficient
to classify and evalu-
ate. In Bare Footprint/
Outline (Figure 9),
the foot length/width,
height approximation,
digital pattern, pressure
zones, morphology,
shoe size, gender, skin
creases, and papillary
ridge pattern are all ana-
lyzed. The basic foot
is comprised of three
zones: forefoot-40%,
mid-foot-30% and rear-
foot-30%. The percent-
ages are also useful
when a partial print is
presented for analysis
to determine approxi-
mate height. In addi-
tion, there are multi-
ple identification lines
(heel lines, arch line, lateral arch
line, web ridge line, and web space
outline) that are analyzed for further
identification.

Depending on the specifics of the
case, exemplars will be required for
comparison. These may be bare foot-
prints of known individuals, their
gait pattern, photographs, or foam
impressions.

At times, footprints and im-
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Amino acids that give a purple reaction. Another chemical, Luminol (Figure 11) "reacts by producing light, chemoluminescence, rather than color when applied at a crime scene to detect latent blood." Many other newer chemicals are being developed currently to enhance visualization of impressions.

During the Comparison stage of investigation, the "unknown" evidence is analyzed side-to-side, superimposing and measuring with the known entity. After comparing the two, the forensic podiatrist must come to a conclusion. There are several possibilities, Non-Identification (to include also probable non-identification), Identification (to include probable and very probable).
and Inconclusive. To address the confusion with different terminology such as probable, possible, etc., and to increase the comprehension by juries, judiciary, and attorneys. Dr. John DiMaggio devised a logical methodology in 2005 to confirm the Evaluation findings in a stepwise manner.

“Levels of Certainty” are conclusions for pedal evidence. The findings are expressed in the affirmative, ranging from Level I (least) to Level V (most) that can be adapted to other disciplines in forensic sciences as well. Verification is the final step where a colleague with an understanding of the process will perform the ACE steps on the same “unknown” evidence. The outcome of the first forensic podiatrist’s comparison should not be known to the second until after he has completed the process. They should both agree on the conclusion. It is a quality check of the work undertaken. It is especially important because of the subjective element involved in reaching forensic conclusions. Verification confirms that the work is replicable by other competent examiners.

Levels of Certainty (DiMaggio 2005)

Level I: Is it a footprint? If the answer is in the affirmative, subsequent questions will follow. Is it a partial or full footprint (Figure 12)? Is it a dynamic or static impression? Is there sufficient quality to continue? If the answer is still in the affirmative, then the examiner proceeds to the next level. If there is no affirmation, hand, when a foot is determined not to have made the impression based on confirmable and significant differences, it is excluded.

Level II: (Foot Zones) Is there an agreement in the size, shape, and position of the digits and foot zones (Figure 13)? If the answer is in the affirmative, then the examiner proceeds to the next level.

Level III: (Lines of Identification) Is there an agreement of the identification lines, specifically the web ridge line, the arch line and lateral foot line, the heel line, and web space outline? If the answer is in the affirmative, then the examiner proceeds to the next level.

Level IV: This is the level where the forensic podiatrist’s clinical experience and knowledge of pathological, morphological, and biomechanical imbalances are drawn upon. This is the level of Class characteristics (Figure 15). “Physical evidence can express different levels of individuality; from those features that a large proportion of the population demonstrates, and from those features that the probability of a chance match is so remote as to be considered impossible.

Class level characteristics are not unique but demonstrate incontrovertible compatibility between similar items, i.e. bunions, hammertoes. There is no evidence considered and utilized by forensic podiatrists that has been demonstrated to exhibit unique individual identification; however, the evidential weight of evidence differs considerably. A condition present in 20% of the population is weaker than one that is present in 0.1% of the population. The task in forensic podiatry is to identify relevant features in the questioned and known items during comparison for identification purposes. The individuality of the features is determined by considering the prevalence in the population.”

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Luminol reacts by producing light, chemo-luminescence, rather than color when applied at a crime scene to detect latent blood.

then an inconclusive identification or non-identification and exclusion will result. Inclusion is based on the agreement of general features; the larger the number of similar size and shape features, the less likely the impression was made by others in the general population. On the other
Forensic Gait Analysis

Forensic gait analysis "involves the recognition and comparison of gait features to assist in the identification process. Captured on closed circuit television (CCTV), the characteristics of gait need to be examined in depth and, as in other identification processes, the unknown footage of an individual of interest in relation to a crime scene is compared against known footage that has been made of a known individual. Assessment of the quality of the images is imperative. CCTV images are usually of much lower quality and resolution than those in clinical settings.

CCTV images contain variables that need to be taken into account. Was the picture sharp or blurred, with good or poor contrast? Was the picture too bright or too dark? Was the lighting good or bad? Was there shadow or reflection interference? Was the direction of the light source good or poor? The frame rate needs to be evaluated; was there a continuous flow of image or were there series of still images? From which direction was the image taken, side, front, or back? Was the subject viewed via only the upper body or lower body? Was the subject moving too fast or too slow? Were ten steps or more in the shot or less than two steps? Was the clothing worn good for gait analysis?"

Also, the examiner must consider if the gait pattern could have been amended or altered in the recordings. The gait analysis performed in a clinical or laboratory setting is more controlled and ideal, thus allowing gait features and anomalies to be more readily recognized and identified than those observed on CCTV footage. Gait analysis is class level identification. Although not unique, "gait analysis is class level identification, demonstrating compatibility between similar items."10

Expert Testimony

The forensic podiatrist is an "expert witness and as such is qualified to analyze and compare sets of facts and then render an opinion based on those facts."

"The credible expert must be thoroughly prepared to demonstrate a command of the scientific knowledge in their field of expertise, to understand the procedures of the court and the evidence admissibility standard in their jurisdiction. They must be open in their dealings with good or poor contrast. Was the picture too bright or too dark? Was the lighting good or bad? Was there shadow or reflection interference? Was the direction of the light source good or poor? The frame rate needs to be evaluated; was there a continuous flow of image or were there series of still images? From which direction was the image taken, side, front, or back? Was the subject viewed via only the upper body or lower body? Was the subject moving too fast or too slow? Were ten steps or more in the shot or less than two steps? Was the clothing worn good for gait analysis?"

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Figure 16A: Expert Testimony. Personal Photo File


Analysis in ACE-V is to determine if quality of evidence is reasonable to classify and evaluate.

The Federal Rules of Evidence helps to ensure that juries only consider admissible material and relevant evidence. The rules secure fairness in administration, eliminate unjustifiable expenses and delays, and promote growth and development of the law of evidence so that in the end, truth may be ascertained and the proceedings justly determined. Rule 702 of the FRE delineates the testimony of experts. If scientific, technical, or specialized knowledge will assist to help understand the evidence, an expert may testify an opinion. The testimony must be based on sufficient facts or data, and be the product of reliable methods and principles. The witness must apply the principles and methods to the facts of the case."

The landmark Supreme Court decision that involved the admissibility of scientific evidence was Frye v United States (1923). The case involved a polygraph test in a murder crime. The test was considered a new science that had not been accepted by the relevant scientific community. The evidence presented was therefore not admitted. This became the standard known as the Frye rule or test of general acceptance. The United States Supreme Court case that changed the rules of evidence was Daubert v Merrell-Dow Pharmaceuticals, Inc (1993). Daubert deals with the admissibility of expert witness testimony during legal proceedings. The testimony must be relevant and reliable. The Daubert Factors is a non-exclusive checklist that was created to assess the reliability of scientific expert testimony:

1) The theory or technique must be refutable, testable and falsifiable;
2) The theory or technique has to be subjected to publication and peer review;

3) There must be a known or potential error rate of the theory or technique;

4) Standards and controls of the theory or technique must exist and be maintained.

Forensic practitioners must operate at the highest standards. They must comply with the codes of conduct of the professional body(ies) with which they are members with honesty and integrity. They must be non-discriminatory against people and groups. Their primary duty is to the court. Work must be carried out fairly and impartially and any conflicts of interest must be declared at the first opportunity. “It is the responsibility of the forensic podiatrist to ensure professional competence. This can be accomplished by continuing professional development with formal educational instruction, professional reading, mentorship, attendance at conferences and seminars, and the preparation of conference presentation materials which should all be documented in a learning diary or log.”

There are standards of practice that the forensic podiatrist must maintain. He/she must “inform others where there is potential for a miscarriage of justice. He/she must provide quality assurance and accept full responsibility for all the work undertaken or participated in. He/she must be prepared to change their opinion in the presence of new developments, information or research findings. It is imperative that confidentiality be maintained.”

There are ten essentials when writing a report on your conclusions.

1) Understanding the task requested.

2) Describing the exhibits, items, and material examined. What exactly was it that was examined?

3) Establishing that the exhibits, items, and material submitted were of suitable quality to be examined.

4) Confirming that the correct types of examinations and procedures were selected.

5) Confirming that the examinations and procedures were performed competently.

6) Recording and interpreting the evidence and making a reasoned and sound objective conclusion.

7) Referring to others involved in the investigation and recommending other specialities, where and when appropriate.

8) Presenting a clear, methodical and logical report.

9) Ensuring that the report is fit for the purpose requested.

10) Providing evidence of continuing education and expertise.

Conclusion

Forensic podiatry is an exciting, evolving discipline in forensic sciences and a growing subspecialty in podiatric medicine. Membership in the American Society of Forensic Podiatry has also been increasing, according to Dr. John DiMaggio, president of the ASPF. Forensic clubs have already been established at Temple University School of Podiatric Medicine and the New York College of Podiatric Medicine, and interest in establishing a club at the Dr. William M Scholl College of Podiatric Medicine has also been expressed. An elective forensic podiatry course was introduced at the New York College of Podiatric Medicine in 2013. The expanding awareness of forensic podiatry in the forensic and legal worlds through education, research and scientific participation, and collaboration with national and international organizations will afford greater opportunities and increase the need for qualified individuals to provide these services. PM

References

1 Forensic Science Online Course, West Virginia University Forensic Science Initiative 2009.


5 American Society of Forensic Podiatry website, http://www.theasfp.org

6 Vernon W. Chairman Forensic Podiatry Sub-Committee, “Forensic Podiatry: Role and Scope of Practice (In the Context of Forensic Human Identification)”, International Association for Identification, 2009.


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Continuing Medical Education

CME Examination

1) Examples of civil cases include:
   A) landlord and tenant disputes
   B) divorce proceedings
   C) property disputes
   D) all of the above.

2) An example of trace evidence is:
   A) serology
   B) DNA
   C) glass
   D) blood stain

3) Lines of identification are agreed upon in which Level of Certainty?
   A) III
   B) II
   C) I
   D) IV

4) Foot zones are agreed upon in which Level of Certainty?
   A) III
   B) II
   C) I
   D) IV

5) 3-Dimensional impressions are NOT found in:
   A) sand
   B) dust
   C) snow
   D) soil

6) Which chemical reagent causes a light change instead of a color change?
   A) DFO
   B) Ninhydrin
   C) Cyanoacrylate
   D) Luminol

7) Cyanoacrylate fuming can further enhance visualization of foot prints with all of the following except:
   A) Gentian violet
   B) Ninhydrin
   C) Rhodamine 6G
   D) Ardrox 970-P10

8) When do foot/toe prints first appear?
   A) at two years of age
   B) at embryological 8th week
   C) at embryological 20th week
   D) at one year of age

9) To address the confusion in terminology such as possible, probable, etc., which methodology was devised?
   A) Standards of Practice
   B) Federal Rules of Evidence
   C) Levels of Certainty
   D) ACE-V

10) What is NOT in the Standards of Practice?
    A) Primary duty is to the court
    B) Maintain confidentiality
    C) Must provide quality assurance of your work.
    D) Must not change your opinion in the presence of new information.

11) Foot print impressions can be:
    A) latent
    B) plastic
    C) visible
    D) all of the above

12) The foot zone percentages that help to determine the height of the “unknown” individual:
    A) Forefoot 40%
    B) Forefoot 30%
    C) Rearfoot 40%
    D) Midfoot 40%

13) Which are different types of evidence in forensic sciences?
    A) Real
    B) Physical
    C) Demonstrative
    D) All of the above

14) What is the methodology (ACE-V) to evaluate evidence?
    A) Assessment-Comparison-Examination-Verification
    B) Analysis-Comparison-Examination-Veracity
    C) Analysis-Comparison-Evaluation-Verification
    D) Assessment-Contrast-Evaluation-Verification

15) Analysis in ACE-V is:
    A) to determine similarities of evidence with known
    B) to determine dissimilarities of evidence with known
    C) to analyze random sampling
    D) to determine if quality of evidence is reasonable to classify and evaluate.

16) Forensic podiatry falls under the main category of
    A) Biology
    B) Trace evidence
    C) Physical evidence
    D) Demonstrative evidence

See Answer Sheet on page 151.
17) Level of class characteristics is based on the forensic podiatrist’s clinical knowledge and experience of:
   A) Morphology
   B) Biomechanics
   C) Pathology
   D) All of the above

18) Forensic podiatry
   A) Shows linkage of an individual to a crime
   B) Answers legal questions concerning foot function
   C) Identifies victims of mass disasters
   D) All of the above

19) Daubert Factors are applied to assess the reliability of testimony. Which is incorrect?
   A) The theory must be testable.
   B) The theory has to be peer reviewed and published.
   C) There may be an unknown error rate of the theory.
   D) There must exist standards and controls.

20) In forensic gait analysis what is to be taken into account from visualization of CCTV footage?
    A) The lighting
    B) The clothing of the individual
    C) The image flow
    D) All of the above

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