

Chapter 14

Ongoing Research Into Barefoot Impression Evidence

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1. INTRODUCTION

Ongoing research in barefoot impression evidence will be discussed briefly. Further research is necessary to shed light on what constitutes a “unique” (individualizing) feature between barefoot and footwear evidence and to determine if these features are merely consistent with any individual or if they truly constitute an identification. Such research is critical because this evidence might not be accepted in some jurisdictions or may be at risk of not meeting the Daubert criteria in the United States and the Mohan standard in Canada.

In 1989, convicted murderer Alan Legere escaped from the Atlantic Institution in Renous, New Brunswick, Canada while being escorted to the hospital for an ear infection. During the next 6 months, he killed four people, spreading fear throughout the Miramichi region of New Brunswick. One of his victims, Father Smith, was found murdered in the rectory of a Catholic church in Chatham Head, New Brunswick. At the crime scene, bloody impressions from a pair of boots showed enough detail that they could be identified as the boots worn by the killer—if they could be found.

About a week after the murder, a pair of work boots that had been discarded was found behind a motel approx 60 mi from the murder scene and was subsequently matched to the crime scene by way of accidental characteristics on the outsole of the boots. The boots were cut apart in a search for any evidence that might link the owner of the boots to the scene. Barefoot weight-bearing impressions were evident on the insole of the boots, and it appeared that the impressions were of suitable quality for comparison with a suspect barefoot impression. Upon further examination of the inside

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Fig. 1. Nail in heel area of the footwear damaged the barefoot of Legere, as indicated by a dimple in the cast.

of the boot, a nail was found protruding through the heel area that appeared significant enough to cause damage to the foot.

When Legere was arrested in 1989, inked barefoot and molded impressions were taken of his feet. It appeared that a scar on the heel of Legere's foot was the same shape and in the same area as the nail protruding through the heel area of the boot (Fig. 1). The inked weight-bearing areas of Legere's bare foot were consistent with the weight-bearing barefoot impressions on the insole of the boot; this linked Legere to the boot and hence to the crime scene.

To get this barefoot morphology evidence introduced into a court of law, a detailed research project was undertaken by the Royal Canadian Mounted Police (RCMP) to prove that the inked weight-bearing areas of a human foot were unique to that person. A total of 1000 volunteers gave their inked barefoot impressions and all the relevant information was entered into a database. Each impression was searched through the database against all the others in the collection. No matches other than to that of the owner of the impression were found. The evidence was presented in court and Legere was found guilty.

2. OVERVIEW

Anyone committing a crime must walk around the crime scene, leaving footwear impressions and, at times, barefoot impressions, making the recovery of this type of evidence important. The human foot contains ridge detail similar to that found in a fingerprint. Forensic barefoot morphology involves the comparison of the weight-bearing areas of the bottom of a barefoot without such ridge detail, as in a fingerprint, to establish a link between the barefoot of an individual and an impression found in mud, blood, or some other medium at the crime scene or on the insole of a shoe that may have been linked to a crime scene. The elimination of an individual whose feet leave an impression that is not consistent with the crime scene impression is important to the judicial system.

2.1. History

The use of barefoot impression morphology in its current form by the RCMP had its origins in the Alan Legere case in 1989 (1). Although extensive research into the individuality (“uniqueness”) of barefoot impressions was not performed until last decade, barefoot comparisons were presented in court for many years.

2.2. Historical Cases

In 1948, two brothers—Donald and William Kett—were charged with a series of breaking-and-enterings in Canada. After Donald was convicted, William claimed he was innocent and that the shoes that were matched back to the crime scenes belonged to his brother. The shoes were cut open and the marks inside compared with the feet of the two brothers; it was determined that William, not Donald, had worn the shoes, and he was also convicted (2).

In 1953, New Scotland Yard had a case in which a burglar left a pair of shoes behind at the scene of the crime. The main suspect denied ownership of the shoes and volunteered an old pair of his own boots for comparison. The outsole of the boots and the shoes exhibited the same unusual wear patterns. To compare the impressions on the inside, a casting material was poured into the shoes and boots, the casts were shown to be very similar, and the suspect was convicted (3).

In 1962 in The Netherlands, a safecracker discarded the clothes he had worn while committing his crime by throwing them into a canal. The clothes, including a pair of shoes, were recovered and a prosecution expert compared the recovered shoes with the shoes from the suspect and concluded that they were worn by the same person. The defendant hired his own specialist, but was dismayed when his witness agreed with

the first expert. The defendant, who until this time had not agreed to have his feet photographed or printed, asked a third expert to examine his feet. Again to his dismay, this witness also agreed with the other two. The defendant was subsequently convicted (4).

In a case in New Jersey in 1981, a bloody socked footprint found at the scene of a homicide was compared with the foot impressions of two suspects. One suspect had left a bloody fingerprint at the crime scene but was eliminated as the person leaving the bloody footprint. The second suspect's foot impression was compared and was found to be very similar to the print at the crime scene, leaving the expert to declare that there was a high probability that the second suspect left the impression at the murder scene. Both were convicted (5).

3. ONGOING BAREFOOT RESEARCH

The purpose of the research described here is to study the outlines of footprints of persons walking and to determine whether one can prove that different people make verifiably distinct footprints. To support this hypothesis, a database of footprint outlines was compiled to provide a statistical basis for deciding whether the outlines of walking footprints of various people are distinguishable.

3.1. *Potential of Bare Feet to Present Individualizing Features*

In early casework, the individuality of human footprints was often assumed (2,4,6,7), i.e., no two prints, even from the same individual, would be identical. RCMP research has shown that barefoot impressions from the same individual may remain unchanged over several years. Impressions from the insole of several pairs of footwear worn over a 25-year period were examined and showed little change in the weight-bearing areas of the foot. Impressions taken from individuals walking a distance of 20 feet show little or no change in the weight-bearing areas imprinted on paper. Barefoot impressions taken from several identical twins show that their barefoot impressions are distinct one from the other (Fig. 2).

A great deal of early research and casework in barefoot impressions was performed in India, probably because there people are more often barefoot or in sandals. For example, in 1965, Puri described his work of classifying and measuring barefoot impressions for comparison purposes (8). In 1980, Qamra published the results of a preliminary study involving the measurement of the footprints of 725 individuals (9).

3.2. *Footprint Measurements*

At its inception, footprint research involved an examination of anatomic characteristics such as stature. For example, Topinard estimated that on average a person's footprint length was equal to 15% of a person's height (10). Gordon and Buikstra (11) analyzed the statures and foot lengths and widths of 867 soldiers in a combat boot-fitting study. Barker and Scheuer (12) investigated the Topinard estimate by collecting data from 105 seated and walking subjects.

Baba (13) studied 826 males and 1018 females to prove that there were significant differences in the ratios of breadth (i.e., ball width) to foot length and of ball girth to foot length between French and Japanese populations. The length of the foot was determined



Fig. 2. Barefoot impressions from identical twins show differences in placement of the toes and arch area.

to be the distance from the most posteriorly projecting point on the heel to the anterior tip of whichever toe gave the longest measurement. Hawes (14) studied ethnic differences between 513 Asian and 708 North American males. Their method of measurement was to have each subject place all of his weight on the right foot while the left foot was on a platform raised 25 cm higher than the one on the right. Calipers were used to measure the distance from the pternion to the tip of each toe, recording foot length as the maximum such measure. Breadth was measured between the first and fifth metatarsals in a plane perpendicular to the long axis of the foot. The reliability of foot measurements of

1197 Canadian subjects was studied, as well (15). Kouchi and Mochimaru undertook a thorough study of 5000 Japanese footprints (16,17) and proved that there was a significant distinctive out-flaring of the Japanese foot, with a mean flexion angle of 8.4°. The individuality of feet was studied by Qamra (9), Laskowski and Kyle (18), Kennedy (19–22), and Barker and Scheuer (12).

The Federal Bureau of Investigation, specifically Special Agent William Bodziak, has presented evidence on barefoot morphology and has conducted research to help establish the potential individuality of barefoot impressions (23). Bodziak's collection of impressions from 500 volunteers provided a starting point for studies of this nature. The RCMP has performed research regarding the individuality of barefoot impressions since 1989 and has extended this research considerably with the collection of samples from more than 12,000 volunteers who have given their barefoot impressions.

When the RCMP research began in 1989 (21,22), impressions were traced by hand and measured with a ruler to obtain the 19 measurements needed. These measurements were entered into the database for each foot (e.g., overall length of foot from heel to longest toe, width of ball of foot, distance of toe pads from edge of heel). The system was capable of accepting these data and searching them against data already in the system to determine whether any other foot matched this set of data. With 5000 impressions in this database, no false matches were found. Each time, only the person being entered was found if his or her impression was already in the database. In 1994, this manual system was changed to an automated system in which the foot was scanned and automatically traced and measured by the computer. The number of areas measured went from 19 to approx 120 per foot (Fig. 3).

Initial research (20,21) indicates that bare feet have characteristics that may form the basis for identification and that these characteristics can be compared to eliminate or link a suspect to the scene of a crime. This research is statistical in nature and based on anatomic measurements; however, the actual forensic examination involves a comparison of the contours, shapes, and placements of parts of the foot, and the bare feet from different people may show a degree of individuality. In a study (22) based on the population from which our samples come, barefoot impressions show a high degree of individuality. The probability of a chance match was estimated to be less than 1 in 10^8 . A subsequent analysis based on a larger sample size yielded a chance-match probability of 1 in 10^{11} (RB Kennedy et al., unpublished data). Of note, the mathematical database is used strictly for research purposes to establish the individuality of barefoot impressions.

The footprint impressions are collected from volunteers using a commercially available inkless pad and chemically treated paper. The pad is placed on the floor about one stride from the volunteer and the paper is placed approximately one stride ahead of the pad. The footprint impressions are taken in a one-step method not in a dynamic mode (i.e., walking mode). The volunteer walks toward the pad, steps on the inkless pad with one of his or her feet, and continues walking until that foot walks on the paper, creating a darkened impression. The process is repeated with the other foot so that we have a left and a right barefoot impression on each sheet of paper. The impressions are scanned and entered into a computer database. The computer program is capable of adding data to the

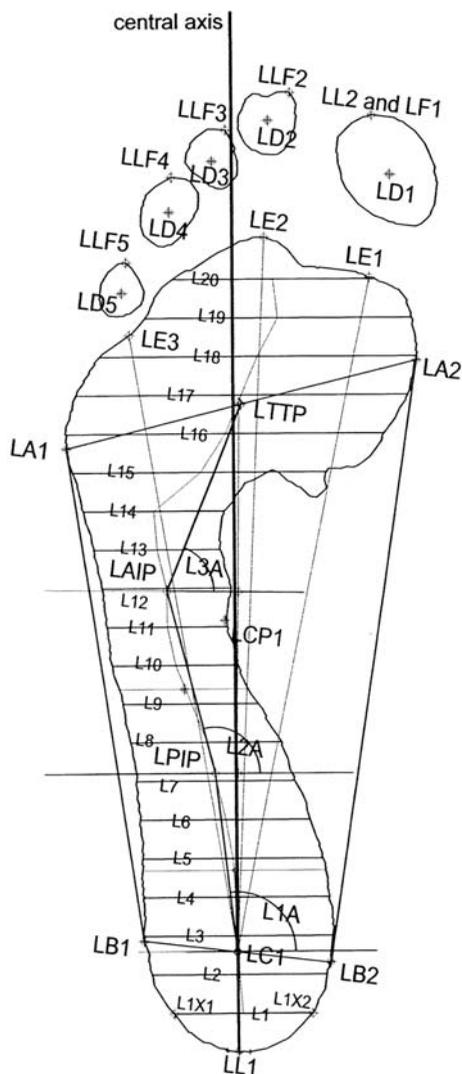


Fig. 3. Printout from the Royal Canadian Mounted Police database showing some of the areas measured during the processing of the barefoot impressions.

system and, as entry of new data takes place, it is searched against all the data presently in the system to determine whether a match exists. The system is capable of extracting data in any order for analysis by mathematicians and statisticians.

Damage or injury to the foot should be considered during the comparison process; it may explain a difference in impressions or produce an individualizing impression. Flexion creases on the foot can also be used to aid in the comparison and in sufficient number can be used to “individualize” the barefoot (24). While partial impressions may not contain sufficient information to individualize a barefoot, they may still be useful evidence in a court of law and for the possible elimination of a suspect.



Fig. 4. Crime scene barefoot impression in dust.

4. CASE STUDIES

4.1. Case Study 1

The investigation of a murder in Ontario, Canada, is an example of the comparison of a barefoot crime scene impression with a barefoot impression from a suspect.



Fig. 5. Inked barefoot impression from suspect.

The police received a report that a woman accidentally shot her husband as he tried to kill her. She contended that he went to the gun locker in the basement and returned to the bedroom carrying a rifle, with the intention of shooting her. She claimed that a struggle ensued and the rifle went off, killing him. The police found a set of barefoot impressions in dust on the concrete floor that led to the gun cabinet and then away. Barefoot

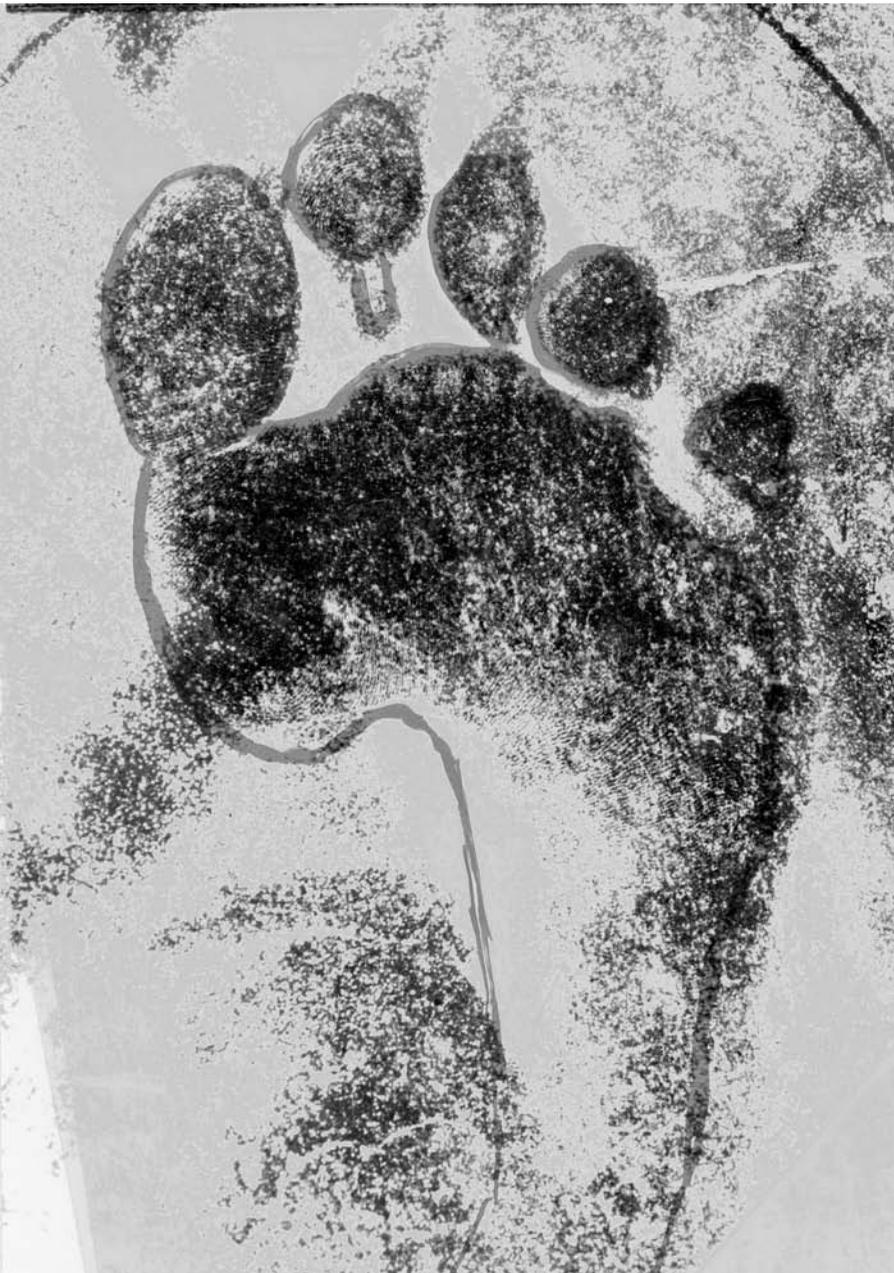


Fig. 6. Inked tracing of Fig. 6 overlaid on Fig. 5, the crime scene impression, showing consistency between the crime scene impression and the barefoot of the suspect.

impressions of the victim, his wife, and her sister were received and examined. It was determined that the barefoot impressions were too small to be the victim's and did not match the sister's, but did match the wife's barefoot impressions. These findings, along with other evidence gathered during the investigation, was presented in court, and she was subsequently found guilty of the murder (Figs. 4–6).



Fig. 7. Weight-bearing areas on the insole of two running shoes. Running shoes seized from the suspect with top removed (A) and running shoes (with the tops removed) found in the trash at the jail (B).

4.2. Case Study 2

A successful link between footwear from a crime scene and the accused was established in 1993, when an inmate in a prison in Quebec was found dead in his cell as a result of knife wounds in his neck and chest. Eighteen inmates lived in this section of the prison, providing a limited pool of suspects. Of the seventeen remaining prisoners, two brothers stood out as the prime suspects. The younger brother had only a short time left to serve, while the older brother, who then admitted to the killing, was serving a life sentence for murder.

A pair of blood-spattered running shoes, a pair of bloodstained jogging pants, and a nametag were found in the trash. The blood stains were eventually matched to the victim. Footwear and barefoot impressions were taken from both brothers and submitted, along with the running shoes found in the trash, to the Forensic Identification Research Services Section at RCMP Headquarters. The shoes were cut apart, and the impressions on the insoles were examined and compared with the barefoot impressions of the two suspects (Fig. 7). The older brother's impressions did not match those found in the running shoes, but the impressions of the younger brother were a good match. The case went to court, and the younger brother was found guilty and is presently serving a life sentence.

5. SUMMARY

Barefoot morphology has been used successfully in jurisdictions to exclude or include a suspect as having been at the scene of a crime. This evidence is based on an evaluation of the shapes and placement of various weight-bearing parts of the foot. Although statistical research has been performed to establish the potential individuality of barefoot impressions to meet the stringent jurisprudence standards in the United States, Canada and elsewhere (25), further studies may be necessary to help validate identification markers between the barefoot and shoe wear.

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