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Emergence of forensic podiatry—A novel sub-discipline of forensic sciences

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ABSTRACT

"Forensic podiatry is defined as the application of sound and researched podiatric knowledge and experience in forensic investigations; to show the association of an individual with a scene of crime, or to answer any other legal question concerned with the foot or footwear that requires knowledge of the functioning foot". Forensic podiatrists can contribute to forensic identification by associating the pedal evidence with the criminal or crime scene. The most common pedal evidence collected from the crime scene is in the form of footprints, shoeprints and their tracks and trails. Forensic podiatrists can establish identity of the individuals from the footprints in many ways. The analysis of bare footprints involves the identification based on the individualistic features like flat footedness, ridges, humps, creases, an extra toe, missing toe, corns, cuts, cracks, pits, deformities, and various features of the toe and heel region. All these individualistic features can link the criminal with the crime. In addition to these, parameters of body size like stature and body weight as well as sex can also be estimated by using anthropometric methods. If a series of footprints are recovered from the crime scene, then parameters of the gait analysis such as stride/step length and general movement of the criminal can be traced. Apart from these, a newly established biometric parameter of the footprints i.e. footprint ridge density can also be evaluated for personal identification. Careful analysis of the footprint ridge density can give an idea about the sex of the criminal whose footprints are recovered at the scene which can further help to reduce the burden of the investigating officer as the investigations then may be directed toward either a male suspect or a female suspect accordingly. This paper highlights various aspects of Forensic Podiatry and discusses the different methods of personal identification related to pedal evidence.

1. Introduction

Human foot has been studied for a variety of reasons in the past, be it the diabetic foot, or detailed study of foot for orthopedic or anatomical purposes, study of foot by shoe industries, and most importantly in the forensic research. It has been universally accepted that an adult foot and its impression are unique to an individual and provide highly valuable clues regarding personal identity. Forensic podiatry is a relatively new sub-discipline of Forensic Sciences concerned with the collection and examination of pedal evidence generally encountered at crime scenes. It is defined as "the application of sound and researched podiatric knowledge and experience in forensic investigations, to show the association of an individual with a scene of crime, or to answer any other legal question concerned with the foot or footwear that requires knowledge of the functioning foot" [1,2]. This sub-discipline has emerged from the experience and practice of podiatry or podiatric medicine which is a branch of medicine devoted to the study of diagnosis, medical and surgical treatment of disorders of the foot, ankle, and lower extremity. Whenever foot related evidence is recovered from a crime scene, the forensic podiatrists are called upon to give the opinion. They contribute to the personal identification by associating the pedal evidence with the criminal or crime scene. The evidence may be recovered in the form of partial or complete footprints or mutilated remains of the feet in case of mass fatality incidents. Forensic podiatrists can collect the evidence related to the foot and help in the identification of the individuals from the foot and its parts [3,4].

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2. Morphological and morphometric analysis of foot

2.1. Individualistic variations/uniqueness of foot

It has been a well observed fact universally that human foot is unique to an individual. Every foot is unique in itself because of the unique structure of each part of the foot from toes to heel. The alignment of foot bones to one another and the way they are held by connective tissues are the product of heredity and environment and differs from individual to individual and between left and right feel of an individual. This makes a human foot and a footprint unique to an individual [5]. The overall shape of the foot depends upon the structure of different bones comprising the foot and the joining together of these bones at the joints by tendons and ligaments. Both genetic and environmental factors are responsible for the general shape and size of the foot [6]. Environmental and acquired conditions like habitual barefoot walking, prior surgery and wearing of a particular type of footwear may influence the overall structure of the foot of a person. The morphological and anatomical variations in the feet and footprints thus, form the basis for their uniqueness [5]. Each foot is unique and left and right feet of a person show variations discernable by a naked eye. Commonly observed variations include variations observed in the toes e.g. pointed toes, flat toes, long and short toes, missing toes, Hallux valgus, riding toes, extra toe, interspaces between the toes and numerous other intermediate variations. The shape and size of the big toe may vary in different individuals; the ball region of the foot, arch region as well as heel may also show numerous types of variations in individuals and populations.

2.2. Landmarks and measurements on the human foot

For morphological, anthropological, and forensic studies of the foot, certain measurements and landmarks have been devised. These measurements and landmarks are useful in the measurement and analysis of the foot in forensic examinations.

2.2.1. Foot length measurements

Foot lengths are measured directly as the maximum distance from the most posterior point on the heel to the tip of the each toe (Fig. 1). The maximum length of the foot from the heel to each of the five toes (T-1 length, d1.t-pte; T-2 length, d2.t-pte; T-3 length, d3.t-pte; T-4 length, d4.t-pte; T-5 length, d5.t-pte) can be measured using the method described by Robbins [5]. The diagonal measurements as shown in Fig. 1 are the linear lengths from the pternion (pte.) landmark to the front tip of each toe (d1.t–d5.t). The measurement can be taken using an anthropometer.

2.2.2. Foot breadth at ball

This is the width across the bony metatarsal-phalangeal joint structure of the ball. The foot breadth at ball can be measured in diagonal orientation (Fig. 1) from the landmarks metatarsal medial (mt.m) to metatarsal lateral (mt.l) using a sliding caliper.

2.2.3. Foot breadth at heel

This measurement tends to encompass the widest part of the heel region. The foot breadth at heel can be measured in the diagonal orientation (Fig. 1). It uses the medial and lateral calcaneal landmarks i.e. calcaneal concavity medial (cc.m) and calcaneal tubercle lateral (ctu.l) that usually corresponds to the points of maximum heel width.

2.3. Foot in forensic identification processes

Personal identification forms a major part of forensic sciences. In this regard, various body parts including head, face, thorax, vertebral column, extremities and their bones have been used successfully in forensic identification in the past. Foot can also be used for personal identification in several instances. In mass disasters like train accidents, airplane crashes, road accidents, bomb blasts, earth quakes, floods, tsunami, etc., feet (often enclosed in shoes) are generally found separated from the dead body [7–9]. In such incidents, dismembered body parts of the deceased are usually found scattered, however, the feet can be found intact enclosed in the shoes. There are many such reported incidents in the UK and the USA in the recent past where feet are discovered in isolation [10]. In these incidents, the human remains/body parts are recovered in various stages of decomposition, the feet, however are found to be relatively less decomposed when compared to other body parts as they are protected by the footwear. In addition to the natural and manmade mass disasters, the postmortem disarticulation of the foot from the main body may occur in terrestrial or aqueous environments; scavenging behaviors of carnivorous fauna; and traumatic amputation etc. [10]. According to the experienced Disaster Victim Identification (DVI) experts [10] in the marine scenario, the presence of the foot within a shoe contains the pedal elements thus, preventing disassociation of the individual bones. In addition, the type of shoe in which the foot is enclosed may alter the buoyancy characteristics of the foot, and thereby affect the likelihood that the foot will become stranded on the tide line.

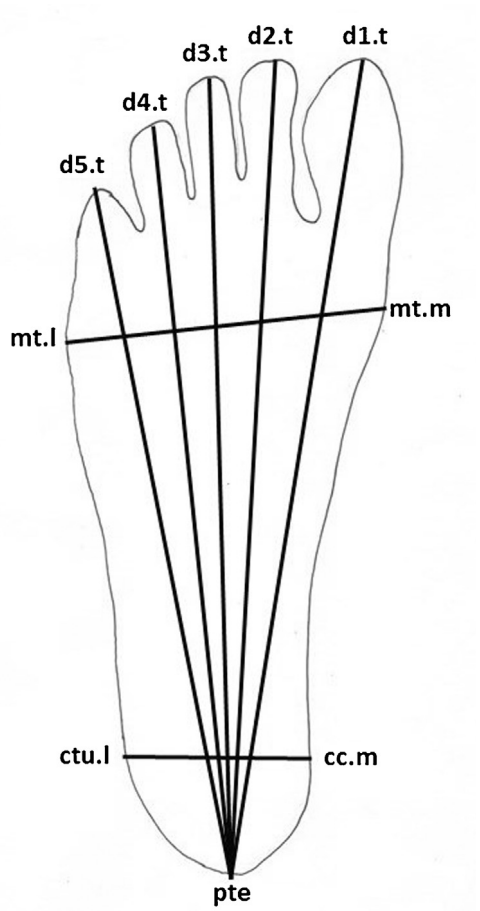

Fig. 1. Various landmarks and measurements on the human foot.

The general recognition may be based upon the kinds of shoes worn by the deceased. The skin color, sex identification, general body size including stature of the deceased can easily be discernable form the foot. Sometimes, if peculiar characteristics/deformities etc. are reflected in the foot, the identification becomes