Forensic Review Paper on Various Methods Used in Forensic Podiatry

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Abstract

Forensic podiatry is the application of podiatric knowledge and experience in the legal investigation concerned with foot or footwear. In mass disasters like tsunami, earthquake, floods, road accidents, train accidents etc, feet are often found intact enclosed in shoes whereas deceased dismembered body parts are generally scattered and separated also in some criminal cases like homicide, rape, scuffle cases, foot is the potential evidence; hence it is imperative in identification of person. The paper discusses the four main areas of forensic podiatry as forensic podiatry record identification, Bare footprint identification and analysis, gait analysis and footwear identification and analysis. In addition, the various methods used by forensic podiatrist for the comparison and evaluation of unknown feet (questioned) with a known foot (suspect) also covers the limitations that bound pedal evidence to use in court of law.

Keywords: Forensic podiatry, Footprint, Footwear, Gait analysis, Personal identification

Introduction

Forensic podiatry is described as the "Use of sound and researched podiatric knowledge and experience in forensic investigations; to show the link of persons with the scene of crime, or to answer the other legal questions concerned with foot or footwear that needs the knowledge of functioning of foot"[1]. In other words, it does not restrict the forensic work completely to just foot but also requires the knowledge of functioning of foot. For example, in gait analysis the forensic podiatrist will take the entire view of the body and how the functioning of foot is affected by the movement, position, structure and function of more areas of a body and again vice - versa [2].

In forensic science, personal identification forms an extensive part. In the past, various body parts were used for forensic identification including head, vertebral column, face, thorax, extremities and their bones. In several instances, foot can also be used for personal identification. In mass disasters like tsunami, earthquake, floods, road accidents, train accidents etc, feet often found intact enclosed in shoes white the deceased dismembered body parts are generally separated and scattered [3][4][5]. The general identification may be based on types of shoes worn by the deceased. The deceased can be easily noticable from the foot by skin color, sex identification and general body size including the

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stature of the person. The identification becomes easier if unusual characteristics or deformities etc. reflects in a foot. In these conditions, to support identification, the antemortem podiatric records with pathological injuries or with deformities, moles, lesions, scars observed in the recovered feet [1][6].

In criminal investigation, the application of foot related evidence dates back to 1862 when Jessie McLachlan’s footprint was spotted her at women's murder scene for which she was later convicted [7]. In modern times, since 1970 law enforcement in investigation have assisted by forensic podiatrist [8]. ACE - V or ACE-V(R) stands for Analysis, Comparison, Evaluation, Verification and Reporting, which should be noted by forensic podiatrist in the investigation [9].

Forensic Podiatry has primarily focused on four main areas enlisted as follows:

1. Identification from podiatry records
2. Bare footprint analysis and identification
3. Forensic gait analysis
4. Footwear analysis and identification:

1. Identification from podiatry records:

Podiatry patient records comprise details of the patient to whom he has examined and/or treated. Personal information of patient, supervised medication, medical history, vascular or neurological status, treatment method undertaken, diagnostic foot and lower limb disorder etc. included in the details of patient [9].

Podiatrists are required to keep truthful information, created at the same time, up to date and legible details on consultation, diagnosis and administration and injuries provided to their patients. The podiatry records can be paper based or electronic and may also include items like letters, video files, photographs and other information. Podiatry records may have relevance in forensic and mass disaster identification suggested by other authors. [10-12]

It is most likely to be required in instances necessitating identification of deceased individuals. The pediatric patients record cards examined with the information piled in podiatry treatment records.[2][9]

Podiatrists keep records of the feet they have treated, during the span of their practice which comprises initial assessment of feet, brief treatment provided and diagnosis of foot conditions present [13]. To establish presumptive and positive identification, pediatric records have contained foot and ankle radiographs which provide supplementary sources of data to specify visual osseous pathology to possible effects on footwear[14][15].

The following approach is recommended to podiatric identification;
Assessment of questioned foot: Firstly, from the foot examination process, a proforma should be prepared for the precise recording of information which should be headed with place of assessment, time, date and label or coded reference of the foot or feet examined. The presence of podiatric lesions, skin blemishes or dermatological conditions and other marker markers should be accompanied by the type, size and if appropriate, the size of such lesions on the foot or feet under examination. Besides the use of performa, a diagrammatic representation of human foot, also it can further supplemented by various viewpoints of foot through digital photography [9].

Assessment of podiatric records: Without the availability of antemortem records, the foot evaluation will have limited use in the process of identification to equate it with the observation acquired from the examined feet or foot. On another clearly labeled proforma, the examiner should note all significant antemortem data and again notes can be supplemented through the utilisation of diagrammatic representation of human foot to document the type and site of any lesion detail clearly from these records.

Lastly, the comparison should be made between the unknown foot which details noticed and recorded with that of the acquired from a known podiatry record with the evaluating podiatrist reaching a conclusion as to the probability of a match.

Various foot features such as stability, mismatched features, resolution, new lesions, change in nature/severity of a lesion, record-keeping problems, incomplete records, inaccurate notes, incorrect diagnosis, mix-up of records, careless examination should be considered during matching [9].

Even though podiatry record card identification has recognised potential in the field of identification but there are drawbacks bound some with the approach including not limited to, as identification from podiatry records is possible, to test this theory only two studies have been published to date which are small scale in nature also to quantify the individuality of each feature or its combination, incident database were not available. so the work relied on the participating podiatrists subjective judgement.[16]

2. Bare footprint analysis and identification:

Bare footprint described as the prints left by barefoot. As the fingerprints, footprints are distinct to every individual and hence become a vital part of investigation. After committing a crime, one can consciously wipe off fingerprints but may forget to clear the print right after walking or standing. A sequence of footprints holds clues towards the modus operandi as it gives the movement of criminals. There is a strong probability of recovering them, seeing as all crime scenes are impregnated with footprints.

A comparison was made between the two dimensional print left at the crime scene to those of a known
person's prints, its size, orientation and shape of these features provides information which can help in the identification process. Forensic sequencing is the collection of multiple footprints from a person across their normal gait sequence. Sometimes casting may be taken of footprints which gives a three-dimensional imitation of foot and its impressions.[2][9]

The footprint analysis emphasises on a few geometric measurements comprising lengths, widths and angles of available evidence at the scene of crime. These measurements and distances are equated with the same measurements of the suspects in a specific case. The assessments and measurements may determine the inclusion and exclusion of suspects from the scene of crime [17].

**Footprint analysis techniques**

Traditionally, for evaluation of bare footprints, many researchers have been using various techniques such as technique for inked prints [18-23], prints which are acquired by a podtrack (a footprint mat used for measurement of plantar pressure) [24][25] or a three-dimensional cast which made up of dental plaster [26] or clay [27] etc. All such techniques have distinct approaches for the examination of linear and angular measurements.

For identification purposes, various modern approaches have been established to allow footprints to be objectively measured and equated. The most commonly used footprint methods are as follows [9][17] given in table 1.

<table>
<thead>
<tr>
<th>Author</th>
<th>Publishing year</th>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normann Gunn [28]</td>
<td>1970</td>
<td>Gunn method</td>
<td>Six lines were drawn, one line from each toe to the heel at a fixed point (i.e. 5 line) and one across the widest part of the ball of foot area. Measurement taken and compared.</td>
</tr>
<tr>
<td>Louise M. Robbins [29]</td>
<td>1978</td>
<td>Robbins diagonal and parallel axis method</td>
<td>Parallel and diagonal lines were used to determine length of different parts of footprints. Used for both 2D and 3D footprints.</td>
</tr>
<tr>
<td>Smerecki and Lovejoy [30]</td>
<td>1985</td>
<td>Overlay method</td>
<td>Various morphological features apparent on bare footprint outline was taken.it not includes the linear or</td>
</tr>
<tr>
<td>Method</td>
<td>Year</td>
<td>Description</td>
<td>Measurements</td>
</tr>
<tr>
<td>------------------</td>
<td>------</td>
<td>------------------------------------------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Rossi’s method</td>
<td>1992</td>
<td>Two tangents were drawn, one from lateral side of heel to the lateral side of ball and other from medial side of heel to the medial side of foot and intersect when traced backwardly gives secondary measurements.</td>
<td>angular measurements.</td>
</tr>
<tr>
<td>Optical centre</td>
<td>2003</td>
<td>Circle was drawn on the heel area and each toe that best fit to it and lines were drawn from circle's center of each toe to the circles center of heel, then measurements taken and compared.</td>
<td></td>
</tr>
<tr>
<td>Inkless shoe print kit used to achieve 2D footprint, both static and dynamic prints obtained is scanned and then digitised.</td>
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<td></td>
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</tr>
</tbody>
</table>

Table 1. Review of method used for footprint analysis.

1. Gunn Method

It is the first method invented by Canadian forensic podiatrist Norman Gunn which was used in assessment, comparison and evaluation of planter prints. Dr. Gunn authorized a method of footprint evaluation in which a total of six lines drawn, five lines from bottommost side of heel print to the tip of each toe print and one line is drawn across the widest part of the ball of foot. These lines are measured and compared between two separate footprints also the angles between the lines from point to point used as point of comparison. It is also probable to add multiple more measurements amongst numerous landmarks involved, this is imperative when dealing with partial footprints only.[16]

2. Robbins Method

It is an quantifiable method, developed in the 1980s by a forensic anthropologist Louise Robbins (1985). Visual anthropological measurements have been used in this method, some of which have
resemblance to those utilised in the gunn method. Additional measurement is involved. Despite that, it uses right angles lines drawn from the theoretical base line right through the end of the heel to the tips of each toe and between the tips of first toe to the fifth toe, an angle of inclination was drawn. It is used to determine the length of different parts of a foot using parallel and diagonal lines. It is utilised for the assessment of both two dimensional and three dimensional footprint leading to multiple measurements like length, width and angles.[16]

3. Overlay method:
It has been developed and utilised by forensic science service in the U.K. (Facey 2005) and portrays a radically distinctive approach to footprint comparison than those methods evolved in canada. Here, on a clear acetate sheet, the outline of known footprints is allocated and this image is placed over a questioned print. This method relies on morphological outline rather than point to point measurements and outlines the shape of features of the footprints being studied and equated with other footprint. The features in this method cannot be quantified, so it is a qualitative assessment process. Regardless, these feature demonstrate high degree of individuality suggested by Kennedy and others (Kennedy 1996, Kennedy et al. 2003).[16]

4. Rossi. 's method
In 1992, William Rossi, an American podiatrist, invented a method who focussing on the rear most side of heel yet measuring the footprint in order to retain the consistency of the method [31]. In this method, two tangents are drawn, one from medial side of the ball to the medial side of the heel and another from the lateral side of the heel of the lateral side of the ball of the foot. For the secondary linear measurement, these tangents are traced backwardly which intersect at a point and give a reference point for it. [9][16]

5. Optical center method
It is a development of a gunn approach to footprint evaluation and was improved by the Royal Canadian Mounted Police in a long-term project to validate the individuality of human footprint(Kennedy 1996, Kennedy et al. 2003). In this huge study a computer database has been produced of 24,000 human footprints (Kennedy 2005). With the aim of evaluating and comparing the footprint, an optical center approach is utilised. The optical centre is a focal point of morphological feature as described as center of circle when set in a position of best fit. The canadian database explains this position using the computer database while it can also be shown manually using devices with series of concentric circles and having marked central positions are present on a clear background.
This device can be used by placing the feature to be examined, e.g. toeprint, the best possible of the concentric circle matched with the print and the central position then identified and marked. The basic lines utilised in the optical center method begin from the described center of the heel print to the optical center of each toe print, and like in the Gunn method additional line is taken across the widest part of the ball of the foot area. The point to point measurement also the angles between each line taken for the comparison.[16]

6. Reel method

In 2012, Sarah Mai - Lin Reel invented and evaluated a more valid and consistent approach to measure footprints for forensic purposes. An inkless shoeprint kit is utilised to meet two dimensional static along with dynamic prints of the foot. The print acquired is scanned and had digitized using an Epson scanner and is additionally moved to ‘Freeware GNU Image Manipulation Program (GIMP) Version 2.2.17’ for examination. Using previous literature various length width and angular measurements taken on the scanned prints. From the medial and lateral margin of the footprint, a central axis is drawn by bisecting the inner and outer tangents. A grid is then superimposed on the print by the use of software and the central axis of the foot is adjusted with the vertical axis of the grid. When the print is adjusted properly, a horizontal line is noted at the posterior point of the foot and its intersection with the central axis represents a reference point for other measurements. The length, width and angular measurements that are derived from scanned prints includes linear measurements comprising length line from base of heel print to the tip of each toe width of widest section of forefoot print (Metatarsophalangeal joint), width of widest part of heel print. And in angular measurement, it includes footprint angle which is angle between the inner tangent, most medial point of the metatarsal area and the tip of concavity of the arch of the footprint, Distal metatarsal angle which is angle of declination of the metatarsal ridge that separates the ball of foot from the toe prints, 2-4 base angle which is the angle of declination from the base of the second toe print to the base of fourth toe print, 2-5 toe angle which is angle of declination from the apex of the second toe print to the apex of fourth toe print and 1-5 toe angle which is angle of toe declination from the apex of the first toe print to the apex of the fifth toe print is taken.[33]

Among the above techniques, the reel method produced mord reliable information compared to other methods. As other methods carried out manually or directly on inked print due to which, these methods may result in, inter or intra observer variability. But, the reel method used a scanned image of print for analysis due to which it holds high reliability and variability and also it is less time consuming.
## Comparison of footprint analysis techniques

<table>
<thead>
<tr>
<th></th>
<th>Gun</th>
<th>Robbins</th>
<th>Overlay</th>
<th>Rossi's</th>
<th>Optical center</th>
<th>Reel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>User friendly</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Beneficial for partial footprint</strong></td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Quantitative measurements</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Detailed comparison</strong></td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Devised for identification</strong></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Examine whole footprint</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table. 2. Comparison between the various techniques used for footprint analysis [16][17]

The comparison process should work accordingly through recorded and determined comparison of all measurements, shapes and features, using the following approaches and consideration:

- **Morphological comparisons:** The morphological resemblance and distinctness displayed by overlay method would be equate and noted feature by feature. It includes the compatibility of toe, heel, ball positions, the ball including the web ridgeline, outline shape formed by all toes, inner longitudinal arch, heel and foot.

- **Pathological feature comparisons:** The podiatrist is supremely specialized health professional competent in recognition and treatment of different pathologies of and foot comprising both structural and functional problems. When the appearance of such conditions has been probable from evaluation of bare footprint, these should be documented in table detailing to both known and unknown footprint to assess compatibility.
- **Detailed comparisons:** The evaluation process may have recorded the presence of a number of other details consisting of presence of skin lesions, close morphological details, position and shape of crease lines and friction ridge details. The significant podiatric information should be compared item by item from both known and unknown items, whether such a feature present or absent based on the that, the site and shape being recorded for all footprints evaluated with a view to examine it's compatibility.

- **Missing feature comparisons:** The footprint which has already been examined, it may be possible that some features may be missed in such case missed data from bare footprint should be equated point by point. During evaluation it will have two uses; firstly, it will point to the specific area of footprint that could not be made due to missing data and secondly, it indicates the presence of repeated features pertaining to repeated foot function or stance position.

- **Foot ratio comparisons:** The foot ratios should be equated side by side for resemblance and compatibility wherever it has been probable to calculate it.

- **Interpretative comparisons:** Where the forensic podiatrist has been capable of simplifying the various aspects of bare footprint and making a presumption in relation to causative foot from their examination, these should be correlated between known and unknown footprints feature by feature.

- **Functional aspect comparisons:** Function aspect comparison are also described. The bare footprint being examined and any features that have been noted within it and have functional relevance should also be compared.

Lastly, the examiner will necessitate to examine the evidence through careful notion of the detail that has been subject to examination and comparison [9].

3. **Forensic gait analysis:**

Gait is described as the pattern of movement adopted during locomotion [34]. Forensic gait analysis mostly taken into account when video footage does not contain strong biometric proof for identification. Based on the availability, non availability or size of gait features resulting from gait of culprit(s) and suspect(s) can then serve as evidence. Despite that, forensic gait analysis yet not capable of identification hence, gait is only practiced as a supportive evidence [35].

By persons gait or by features of their gait, usually from CCTV footage and comparison of footage of known individuals, identification of the person was done. It includes the analysis and comparison, for similarity and dissimilarity, of gait patterns shows on public or private CCTV footage. Depending upon the task and matter in the hand, the CCTV footage is analysed and the gait or gait features noted which compared to the other individuals or known suspect(s).[2][9]
The forensic gait analysis required the questioned footage i.e. the footage of unknown w.d n perpetrators also the known footage who is sdcc suspected of being in the questioned image. Both the recordings would be assessed by a podiatrist, who utilised their skills and knowledge to discriminate the gait related feature in recordings [9].

Forensic gait analysis may be human based and computer-based, discussed as follows [36]:

**Human-based approach:** It is also called an observer-based approach, and falls under three types as photo-anthropometry, morphometric analysis and superimposition. Photo-anthropometry estimates the measurements of set landmarks. In morphometric analysis, the morphological measurement taken from photographs. Then both the measurements are pooled and superimposed to signify a match between suspect and standard photographs [37]. In this approach, motion analysis is also practiced by running video in both pause and reverse mode. On the basis of observation, it also helps in identifying the suspects [38][39]. However, this approach is often disposed to error and bias. Most of the time the inter and intra variabilities are also over the acceptable limit. Furthermore, various measurements taken either directly on gait pattern or with use of photographs with a reference scale. Photogrammetry can also be used.

**Computer-based human -assisted:** Algorithms that can be either model based or appearance based comes under computer-based analysis. The former work on fixed landmarks for driving the feature of gait and is done by presumed landmarks utilising the human model. Later (appearance-based) model function by deriving silhouette sequence of walking individuals., here predefined human model is absent. In both cases, match score acquired between questioned and suspected gait [37][39].

Gait analysts specified realistic challenges like problems with playability of footage, low frame rates and incompletely visible individuals due to obstruction. As well they mention lack of solid scientific knowledge ground about intra and inter subject variability in gait features, also effect of various external and internal factors on gait. They take into account a gait database of features and their frequencies in population crucial for refining likelihood ratio estimation [35].

**4. Footwear analysis and identification:**

Footwear and its impression within the footwear, wear marks erosion on the outsole of footwear were taken into account[2] [9].

The science of footwear examination relies upon the rationale that a questioned shoe impression containing an adequate quality and quantity of detail may be individualized with complete certainty.
As the comparison and individualization of footwear impression can be practiced prolonged after it has been collected, it is essential that every impression, no matter what its condition, is processed very delicately (as it was the only impression found) [40].

To simplify the footwear impression examination some usual guidelines may be established. Based on Forensic Institute of Netherlands the examination may be splits up into four different phases as [41]:

**Phase I:** In this phase, the investigation of footwear and impressions in which the class and individual characteristics are located and detailed. The class characteristics include size, shape, design and outsole pattern that a shoe possesses etc.

**Phase II:** The similarity and differences are recognized by comparison of impression to footwear and test impressions. If it is recognized that is if similarities are present then move to the phase III else end it and draw a negative conclusion.

**Phase III:** The similarities and dissimilarities. First the identified similarities are evaluated and their characteristic value displayed, then the description for contingent dissimilarity are sought for.

**Phase IV:** Based on prevailing national standards a footwear examination report is processed. The conclusion may be described in terms of positive, negative or inconclusive.

For the footwear comparison and evaluation the details present over both known and questioned footwear items are examined. The direct comparison and evaluation includes features but not limited to, marked shoe size, sized shoe length, upper crease marks, upper distortion and inner lining wear, toe impressions etc[9].

Generally footwear impressions found in crime scenes. Still they are not regularly utilised as evidence due to the broad variability and quality of impressions and the multiple footwear outsole designs which makes manual comparison laborious and tough. Computational methods bear the scope of better use of footwear evidence in investigations and also in providing aid for court testimony.

However automatic classification of footwear prints is not yet usable, there are some published methods. A review of such retrieval methods is given in table 3.[42].

<table>
<thead>
<tr>
<th>Author</th>
<th>Year of publication</th>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>De Chazal et al. [43]</td>
<td>2005</td>
<td>Power spectral density</td>
<td>A fully automated shoe print classification system that utilised</td>
</tr>
<tr>
<td>Authors</td>
<td>Year</td>
<td>Feature</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------</td>
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</tr>
<tr>
<td>Zhang, Allinson [44]</td>
<td>2005</td>
<td>Edge direction histogram</td>
<td>An edge direction histogram is conditioned to represent the shape in shoes by an automated shoe print retrieval system.</td>
</tr>
<tr>
<td>Pavlou and Allinson [45]</td>
<td>2006</td>
<td>SIFT (Scale invariant feature transform)</td>
<td>In this, ShoeHash approach for classification that uses directional filter banks (DFB) to get local/global brief of shoe-prints with energy dominant blocks utilised as feature vector and normalized Euclidean-distance similarity.</td>
</tr>
<tr>
<td>Crookes, Bouridane, Su, Gueham [46]</td>
<td>2007</td>
<td>Local Image Features (LIF)</td>
<td>Shoeprint retrieval system grounded in topological and pattern spectra in which a pattern spectrum is assembled employing the area measure of granulometry, the topological spectrum constructed practicing the Euler number and a normalized hybrid measure of both utilised for matching.</td>
</tr>
<tr>
<td>Crookes, Bouridane, Su, Gueham [46]</td>
<td>2007</td>
<td>Phase Only Correlation (POC)</td>
<td>Described two ways to classify shoe-prints: First, in the spatial domain, modification of existing techniques: Harris-Laplace detectors and SIFT descriptors is introduced; the Harris corner detector is utilised to locate local</td>
</tr>
</tbody>
</table>
features; Laplace based automatic scale selection is liable to decide the final local features and a nearest neighbor similarity measure, and second in the transform domain, phase-only correlation (POC) is utilised to match shoe-prints.

<table>
<thead>
<tr>
<th>Name</th>
<th>Year</th>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patil, Kulkarni</td>
<td>2009</td>
<td>Gabor transform</td>
<td>Gabor transform used to elicit multi-resolution features after that Euclidean distance for matching. Rotation is determined by the Radon transform and equilibrated by rotating in the opposite direction.</td>
</tr>
<tr>
<td>Dardi, Cervelli, Carraro</td>
<td>2009</td>
<td>Texture</td>
<td>Described a texture based retrieval system in which a Mahalanobis map is utilised to capture texture and then equated using a correlation coefficient measure.</td>
</tr>
<tr>
<td>Tang, Srihari</td>
<td>2010</td>
<td>Shape attributed relational graph (ARG)</td>
<td>Shape features having lines, circles and ellipses are derived from database prints using</td>
</tr>
</tbody>
</table>
getsoned of the Hough transform. After that the attributed relational graph (ARG) is assembled for every known print, in which each node is an earliest feature and each edge depicts a spatial relationship within nodes. A footwear print distance (FPD) amid ARGs is utilised as a similarity measure. The FPD is computed amongst each known print and set patterns to form clusters. The utilisation of the methodology is signified with a large database of known prints.

Table 3: Review of retrieval method used for automatic footwear print.

Although footwear impressions are generally seen in crime scenes, they are not frequently practised in either the investigation or prosecution stage due to multiple practical complications. Infallible automated tools should allow more use of footwear impression evidence. A review of various methods brought to light the urge of computational solutions for different task: improving the quality of crime scene images, characterising outsole patterns to so as to be helpful for differentiation, evaluating resemblance between the evidence (unknown) and known, execution of algorithm to extract closest matches in reference database etc. [42].

Discussion

Forensic podiatry is described as the "Use of sound and researched podiatric knowledge and experience in forensic investigations; to show the link of persons with the scene of crime, or to answer the other legal questions concerned with foot or footwear that needs the knowledge of functioning of foot"[1]. It may crime cases like rape, homicides, sexual assaults and scuffle cases, as in these cases criminals left the crime scene in hurry also it is found in mass disaster cases.

The present paper discusses the four main areas of the forensic podiatry i.e. identification of podiatric
records, bare footprint analysis and identification gait analysis, footwear analysis and identification and various methods and approaches that can be used in forensic podiatry for evaluation of pedal evidences for comparison in the respective areas.

In western countries, forensic podiatrists offered consultation on multiple cases where analysis of foot played a vital role in identifying the criminals. In the USA and UK, there are various forensic podiatrists who may aid in the analysis of footprints recovered from the scene of crime and give consultancy to the police in assisting and identifying the culprit.

In India, forensic scientists assist in identification of the culprit by equating the unknown footprint or pedal evidence with that of known or suspects, whenever any cases related to foot reported by the police. However, no forensic podiatrist examination has been practised in India due to lack of training and specified qualifications, there is no footprint examiner or forensic podiatrist in India[17].

**Conclusion**

Although foot evidence is potential evidence as it is generally found at crime scenes in criminal cases also it has been found in the mass disaster cases. Podiatric evidence may play a vital role in identification of a person and also provides the lead for further investigation. The paper discussed the various forensic analysis techniques and approaches for the examination of bare footprint analysis and identification, gait analysis and footwear examination. But due to small scale published data on the methods and techniques used in forensic investigation also there is no established standard method and techniques that can be used by forensic experts for extracting the information from feet evidence recovered from mass disasters cases and crime scenes, its evidentiary value lags. The study suggests the need for further study, training and specific qualification in the area of forensic podiatry so that footprint examiner and forensic podiatrist can assist police and law enforcement in these cases. Forensic podiatry also raises the urge of an analysis method with the broad approach assisting the implementation of partial or impartial recovered footprint from the scene of crime.

**References**


