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Correlation of Fingerprint and Footprint in Individual Identification

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Abstract:

Aim: Fingerprints are unique patterns, made by friction ridges (raised) and furrows (recessed), which appear on the pads of the fingers and thumbs, prints from palms, toes and feet are also unique; started in 1892 by Sir Francis Galton. Dermatoglyphics is the study of ridge patterns of the skin which naturally occur on certain body parts, like palms, fingers, soles, and toes. Fingerprints are permanent and are not the same even in monozygotic twins and are used in identification in case of mass disaster. The present study aims to correlation fingerprints and footprints of the same individual for forensic identification.

Materials and methods: Thumb fingerprint and thumb toe print of both right and left hand and leg were collected from the participants; n=50. Participants were asked to wash their hands and legs and were asked to roll their fingers and toe then examined for uniformity of ink spread. The resultant ridge patterns were analyzed by manual method and studied for patterns of plain whorls, plain arches and loops and statistically analyzed using SPSS software.

Results: Lesser variation of prints were observed in fingers than that of foot, more frequent fingerprints were 51.7% of loop patterns followed by 48.3% of plain whorls. Toe print most common patterns of loop were observed with 48.2% in left and 49.9% in right toe. Same distribution pattern for both fingers and toe showed 95% correlation while 5% discrepancy was observed.

Conclusion: Various patterns in finger and footprints were observed, more common patterns reported were loop pattern followed by whorls in fingerprint; but in toeprint reported loops more common followed by arches and least reported were whorls. This pattern correlation of fingerprints and footprints might be useful for individual identification

Keywords: Fingerprints, Footprints, Forensic identification, Dermatoglyphics

Introductions:

Fingerprints are unique patterns, made by friction ridges (raised) and furrows (recessed), which appear on the pads of the fingers and thumbs, prints from palms, toes and feet are also unique. This started in 1892 when one of the biologists, Sir Francis Galton, a cousin of Charles Darwin published his work on fingerprints; later the term dermatoglyphics was given by Dr. Harold Cummins, the father of American fingerprint analysis [1]. Dermatoglyphics is a Greek word, derma means skin and glyph means carving [2]. Dermatoglyphics is the study of ridge patterns of the skin which naturally occur on certain body parts, like palms, fingers, soles, and toes [3][4]; otherwise simply defined as the scientific study of fingerprints or toe prints. Toeprints can be classified using the same classifications as fingerprints because they have similar characteristics [5]. The ridge patterns are formed in the human fetus before birth and remain the same throughout a person's life except in the case of accidents, such as bruises and cuts on the fingertip; but fingerprints are same even in case of small cuts or abrasion due to regeneration of original dermis [6].

Any evidence can be a source of information that assists the investigator in reconstructing the sequence of crime. The number of individuals and the direction in which individuals were moving in a crime scene is often difficult; can be determined by footprint and footwear analysis [7]. These evidences are also used in estimation of stature, weight, sex, holding weight, number of individuals present, the direction in which an individual was moving, the speed at which an individual was moving and whether the individual was carrying anything heavy [8][7][9]. In cases of disaster victim identification (DVI) of individuals in mass fatality, the use of postmortem friction ridge prints (fingerprints, palm prints or footprints) for victim identification is often the fastest primary method of identification [10]. Dactylography is the process of taking the impressions of papillary ridges of the finger tips for the purpose of identification of a person [12] [13].

Fingerprints are permanent and are not the same even in monozygotic twins. Identification of fingerprint and footprint patterns show the most commonly occurring patterns are Loops followed by whorls, composites and finally arches [14]. Various studies have been done to identify individuals by footprint and fingerprint analysis in forensics. There are no specific studies that have been done in correlation of both fingerprint and footprint of an individual in identification. The

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present study aims to correlation fingerprints and footprints of the same individual for forensic identification.

Materials and methods:

This pilot study is conducted in the department of Oral and Maxillofacial Pathology, Saveetha dental college and hospital, chennai. This study was approved by the Institutional review board (IRB) with Institutional Human Ethical Committee number: IHEC/SDC/OPATH-1905/21/12.

Sample collection:

Total participants in present study n=50 whose thumb fingerprint and thumb toe print (*Hallux* in latin*)* of both right and left hand and leg were collected. Participants were asked to wash their hands and legs using soap and water; asked to pat dry leavin some moisture. Ink was spread uniformly in stamp pads and participants were asked to roll their fingers and toe then examined for uniformity of ink spread. Fingers and toes are placed on the sheet of paper kept over the firm board with gentle press; but toe prints are better taken with the individual seated on the chair.

Analysis:

The resultant ridge patterns were analyzed by manual method and studied for patterns of plain whorls, plain arches and loops patterns like right and left loop, radial loop, ulnar loop, double loop, accidental loop, central pocket loop and tented arches according to Cummins et al. (1961) and Penrose (1973) [1].

Inclusion Criteria

Population of young adults, age group 20 – 35

Clear prints

Exclusion criteria

Population below 20 and above 35 not included

Blurred prints

Statistics:

Demographic data and patterns were tabulated using Microsoft Excel; then exported to IBM SPSS (Software Package for Social Science), version 23. Descriptive statistics and Chi square test done for correlation of left and right finger and footprint; correlation of foot and fingerprint.

Results:

Present study shows populations with equal gender distribution were selected with 48.3% of 21-25 age groups and 48.3% of 26-30 years with least participants of 3.4% among 31-35 years, (Table-1). Various patterns reported are summarized in Table-2; (Figure-1). Lesser variation of printswas observed in fingers than that of foot, more frequent fingerprints were 51.7% of loop patterns distributed as 48.3% right loop in right fingers and 46.7% left loop in left fingers followed by least observed patterns were double loop with 5% in the left and 3.3% in the right finger. 48.3% of plain whorls in left and right fingers. More variations in patterns were reported in foot with the most common pattern of loops with 48.2% in left and 49.9% in right toe distributed as right and left loop with 18.2%, 16.6% respectively; 11.6% of double loop pattern in right and 10% in left toe. Other patterns reported less frequently are radial loop 6.7% in both right and left toe, ulnar loop 6.7% in right and 5% in left, accidental loop 5% in left and 3.3% in right. Left loop with 1.7% in left toe and right loop with 1.7% in right toe. Plain arch with 30% occurrence in left and 26.6% in right, tented arch with 15% occurrence in both right and left toe. Least variations of patterns were reported with a plain whorl with 1.7% only in the right toe. There are patterns like plain arch with combination of central pocket loop, tented arch and with right loop reported with 6.8% in right and 5.1% in left toe. Same distribution pattern for both fingers and toe showed 95% correlation while 5% showed no correlation.

Correlation between variations of fingerprint and toe prints has been analyzed, reported with no significant association found; also, no association found in right fingerprints and footprints; and with left fingerprint and footprint, summarized in Table-3.

Discussion:

Dermatoglyphic patterns are uniquely varying among individuals and statistically differ between the genders, ethnic groups and age categories [2][8][13]. The science of fingerprint has been used generally for the identification or verification of persons and for official documentation [14]. Ridge patterns exhibit many properties like fingerprint ridge count, ridge density, ridge thickness to valley thickness ratio and ridge width reflects the biology of individuals. There is connection between the ridge pattern and anatomical structures known as volar pads; temporary eminences found around 7th week of intrauterine life, become less prominent in 10th week and disappear in human embryos [15]. At this time the volar pad has fibrous dermis with epidermis; the interface between the

innermost layer of epidermis with dermis is known as the basal layer. By 10th to 13th week this layer becomes undulated and further becomes more prominent and called as primary ridges and further established by 16th week. Ridge formation on fingers and the palm precedes ridge formation on toes and the sole [14][16]. These patterns are encoded at the interface between dermis and epidermis; hence are not by the superficial injuries [17].

Present study shows equal gender distribution; where these ridge patterns and density may vary among females and males, which also shows statistical significance in literature [18][19].Another study reported whorl fingerprint pattern was common in the male (51.5%) while the loop and arches patterns were more common in the female (52.0% and 51.0% respectively)[20]; but showed no significant association with gender distribution.

Present study shows plain whorls more common followed by loops and plain arch type of fingerprint pattern was not reported; in concordance with the literature, among three basic pattern whorls, loops and arches; arches are least common [21]; and similar to Allu and Chakrabarti in 2020; the arch pattern was not observed in the thumb [22]. Gan Shyang Heng et al in 2018 studied fingerprint patterns among the Malaysians, Chinese and Indian population reported that Indians showed different distribution patterns when compared with Malays and Chinese. Extremely frequent loop patterns followed by whorls and least was arch pattern; arch patterns were reported more in Indians than other populations; in concordance with present study; there is no significant association with left or right-side fingerprint patterns [6]. Distribution among Caucasian as reported by the FBI (USA) indicates that loops are more common 65.5% with no double loop recorded; whorls 27.9% and arches 6.6% [23].

In the present study we observed right and left thumb toe showed loops patterns more common with 49.9% but variation in types of patterns among right and left loop, radial loop, accidental loop, central pocket loop and double loop. Plain arches (30% in left and 26.6% in right); tented arches (15% in left and right) and plain whorls not reported in left toe but right toe showed least percentage; with no significant association with left or right-side footprint patterns. There are less or no databases for toe prints available for researchers to study with; Enemakwu OS, 2019 study done on comparison of Caucasian (USA) fingerprint distribution and lepers toe print distribution (9 Colonies in Nigeria); reported loops pattern with 73.5% like left and right loop, double loop as more common pattern and whorls were 10.8% among lepers' toe. They also reported least variants of arches like tented arches [24]. In present study there is no significant correlation found between

fingerprints and footprints.

According to Holt, 1964; there is asymmetry in dactyl graphics [24]; similarly in present study there are deviations in percentage observed due to variations like different patterns in right and left finger and toe; (Figure-2). Fingerprint analysis showed the same distribution pattern in left and right with plain whorls but 5% discrepancy was observed with loop patterns; double loop followed by right and left loop. Toe print showed no discrepancy in radial loop and central pocket loop; small percentage discrepancy was present in plain whorls, plain arch, left and right loop, accidental loop. There are combinations of patterns associated with toe print; plain arch with central pocket loop, tented arch and with right loop reported. Literature reported with asymmetry in patterns are suspected to due to genetic control; but may also be due to environmental factors [25].

Limitations of present study are lesser sample size; pattern of foot and fingerprints were not studied according to the segments. Further studies can be done with digital software support and correlation with lip prints and ameloglyphics pattern.

Conclusion:

Various patterns in finger and footprints were observed in our study, more common patterns reported were loop pattern followed by whorls in fingerprint; but in toeprint reported loops more common followed by arches and least reported were whorls. There is variation in distribution of patterns among the left and right side with 5% of discrepancy. This pattern correlation of fingerprints and footprints might be useful for individual identification

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Legends:

Tables:

Table-1: Demographic data of included study population.

Table-2: Percentage of occurrence of patterns in fingerprint and toe print

Table-3: Comparison between right and left side fingerprint and toe print using Chi-square test.

Figures:

Figure-1: Image shows different patterns in the right and left thumb finger of the same individual, left image shows **Whorl** pattern in left thumb finger (a) and right image shows **Loop** pattern in right thumb finger (b).

Tables:

Table-1: Demographic data of included study population.

s. no	Parameters		Percentage
1	Gender	Male	50
		Female	50
2	Age group	21-25	48.3
		26-30	48.3
		31-35	3.4

Table-2: Percentage of occurrence of patterns in fingerprint and toe print

Pattern - Fingerprint		Left	Right
1	Plain whorl	48.3%	48.3%
2	Loop	51.7%	51.7%
	Left loop	46.7	0
	Right loop	0	48.4

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	Double loop whorl	5	3.3
Pattern - Toe print			
1	Plain arch	30%	26.6%
2	Tented arch	15%	15%
3	Plain whorl	0%	1.7%
4	Loop	48.2%	49.9%
	Left loop	18.2	0
	Right loop	0	16.6
	Left radial loop	1.7	0
	Right radial loop	0	1.7
	Double loop whorl	10	11.6
	Radial loop	6.7	6.7
	Ulnar loop	5	6.7
	Central pocket loop	3.3	3.3
	Accidental loop	5	3.3
5	Others - Combination of patterns	5.1%	6.8%

Table-3: Comparison between right and left side fingerprint and toe print using Chi-square test.

s.no	Features	Chi-square test
1	Right side fingerprint and toe print	0.237
2	Left side fingerprint and toe print	0.132
3	Correlation of fingerprint with toe print	0.684

Figure-1: Image shows different patterns in the right and left thumb finger of the same individual, left image shows **Whorl** pattern in left thumb finger (a) and right image shows **Loop** pattern in right thumb finger (b).