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Review on Sex Determination from Fingerprints

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Abstract:

Fingerprints are unique characteristics which helps in positive personal identification. Two fingerprints are never alike, thus one of the best technique for individualization. Fingerprint has been the most commonly encountered trace evidence in scene of crime in the form of latent, patent and plastic prints. Dermatoglyphics is the branch of science related to patterns of ridges on skin. Dermatoglyphics is further divided into qualitative and quantitative. Qualitative Dermatoglyphics encompasses difference in fingerprints patterns and minutiae; whereas, ridge density (RD) and Ridge Count (RC) are incorporated with quantitative study of fingerprints. Epidermal ridge density is determined by means of following: (1) Distance between the ridges and (2) Width of Ridges. Thickness/Width of the epidermal ridges varies among individuals, generally women possess ridges which are fine in contrary to men and, thus, ridge density per given unit of space is greater for female. This form basis for determination of sex from Fingerprints. Researches have conducted the studies among Caucasian–American, Spanish, African–American, Southern Indian and Central Indian populations and similar trend of women having ridge density greater over men is observed. From studies of various researches over the decades, it is proved that ridge density will help the investigators to identify the sex of the perpetrators and thereby eliminate least significant possibilities.

Keywords: *Fingerprints, Dermatoglyphics, Ridge Density, Sex Determination, Personal Identification, Ridge Width*

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Introduction

Dermatoglyphics deals with a branch of science related to configurations of dermal ridges on hand and feet **(Tikare *et. al.*, 2010).** Positive personal identification can be often established from fingerprint, face, teeth, hair, DNA, iris, gait patterns, bones etc. **(Karki and Singh, 2014)**. Identification can be complete (absolute) with complete fixation of the individual or Partial identification which involves ascertainment of specific facts like sex, stature, age etc. regarding an individual **(Kapoor and Badiye, 2015)**. Fingerprints are best to establish the identity owing to its non-invasive and cost effective characteristics. Two fingers will never have identical prints, even monozygotic twins. (**Kapoor, 2015; Nayak *et al*., 2010; Tandon *et al*., 2017)**. Fingerprints involves the unique arrangement of furrows and grooves in distal phalanges of fingers **(Nabar, 46–52)**. The science of identification through the examination of fingerprints - Dactyloscopy is devised by Harold Cummins in 1926 **(Tandon *et al*., 2017; Kapoor and Badiye, 2015)**. Dermal ridges and craniofacial structures are both formed during 5–7th week of intra-uterine life and are completed by 21-24th week (6-month foetal life) **(Tikare *et. al*., 2010; Sharma *et al*., 2018; Kapoor and Badiye, 2015)**. The ridges are thus permanent and are lost through decomposition after death **(Sharma *et al*., 2018)**. The overall fingerprint characteristic is affected by genetics and environmental factors; thus useful for the diagnosis of congenital malformations **(Sharma *et al*., 2018; Maltoni, 512–13)**. The genetic code in DNA gives general instructions on the way skin should form in a developing foetus and the specific way it forms is a result of random, influenced by the flow of amniotic fluid, the position of the foetus in the uterus etc **(Maltoni, 512–13)**. This result in uniqueness of the fingerprints. The fingerprints remain permanent and unaltered except in scenarios of injuries of cuts, bruises and burns, however, it is restored once healed **(Karki and Singh, 2014; Soanboon *et al*., 2015)**.

Dactyloscopy has developed over time. Initially, it was used in ancient Babylonia to mark business transactions. Today fingerprints are the most preferred to biometric security devices and an important scientific evidence in courts throughout the world **(Gunas *et al*., 2018)**. The foundations for Modern Fingerprint Identification were established by the studies of Sir Francis Galton (Father of Fingerprint) and Sir Edward Henry at the end of the 19th century. F. Galton put forth Dalton details or minutiae and minimum minutiae required to establish a perfect match. Sir E. Henry contributed to the formation of the "Primary classification of fingerprints" **(Rao *et al*., 2008; MHA, Government of India, 2016)**.

Characteristics of Fingerprints

All the fingerprints have common characteristics known as pattern area, type lines, triradius (delta) and core etc.

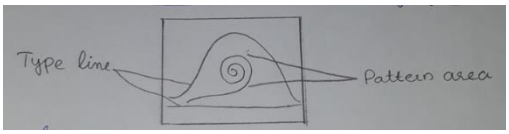

Figure No. 1: Type line and Pattern Area

Type lines: These are the 2 ridges (innermost) which initiate as parallel, diverge and surround or seem to surround over the pattern area. It helps to discriminate among whorl, loop and composite sub types patterns. However, arches are devoid of type lines **(Sehgal, 129–45)**.

Pattern area: The region of fingerprint where core, delta and ridges are enclosed enabling to classify them to respective patterns. It is indefinable in arches and in loops & whorl (including composite) pattern area is accompanied with typelines **(Sehgal, 129–45)**.

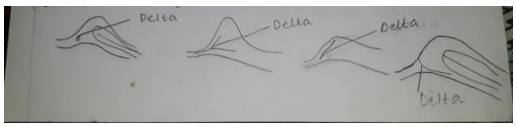

Figure No. 2: Types of Deltas

Delta (triradius): It is formed when a ridge bifurcates and two arms of the bifurcating ridge diverge or when two adjacent ridges running side by side diverge causing an interspace within the parallel lies, the triangular thus formed is called triradius **(Nabar, 46–52; Sehgal, 12–45)**.

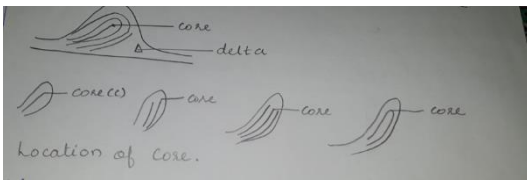

Figure No. 3: Types of Cores

Core: Core is the centre of the pattern. Core is present is loop, composite and whorl. It is absent in arches **(Nabar, 46–52; Sehgal, 12–45)**.

The presence or absence and frequency of core and delta form the basis of the classification of fingerprints **(Nabar, 46–52; Sehgal, 12–45)**.

Fingerprint Patterns

Fingerprint patterns are classified based in accordance with configuration of ridge on the distal phalanges of fingers. The shape, direction of ridges, type line, delta, and core constitute fingerprint patterns. There are 4 basic patterns and 9 subtypes **(Nabar, 46–52; Sehgal, 12–45)**.

Table 1: Classification of Fingerprints (Nabar, 46–52; Sehgal, 12–45)

BASIC PATTERN	SUB PATTERN TYPE	SYMBOL	NO OF DELTA	NO OF CORE
ARCH	PLAIN ARCH	A	NIL	NIL
ARCH	TENTED ARCH	T	NIL	NIL
LOOP	RADIAL LOOP	R	ONE	ONE
LOOP	ULNAR LOOP	U	ONE	ONE
WHORL	PLAIN WHORL	W	TWO	ONE
COMPOSITE	CENTRAL POCKET	C OR CP	TWO	ONE
COMPOSITE	DOUBLE LOOP PATTERN: LATERAL POCKET LOOP	S OR LP	TWO	TWO
COMPOSITE	DOUBLE LOOP PATTERN: TWINNED LOOP	S OR TL	TWO	TWO
COMPOSITE	ACCIDENTAL	X OR AC	TWO OR MORE	TWO OR MORE

Location of Fingerprints:

Fingerprints are seen on porous, semi porous and non-porous surfaces. Surface textures interfere with the quality of prints. Fingerprints are detected with ease in smooth, non-textured dry surfaces on contrary to rough or more porous material. The chance prints obtained from crime scenes are more of latent in nature and require development/ enhancement either by means of physical or chemical methods. Latent fingerprints are frequently encountered especially in cases of murder, homicide, robbery, theft, forgery, sexual assault, child abuse, etc. Fingerprints are helpful to identify criminals, amnesia victims and unidentified corpses if antemortem fingerprints are documented **(Kapoor and Badiye, 2015)**.

Determination of Sex from Fingerprints

Dermatoglyphics studies can be qualitative and quantitative. Qualitative Dermatoglyphics deals with the difference in fingerprint patterns and minutiae; whereas quantitative analysis is more concerned with finger ridge density (RD) and ridge count (RC) **(Soanboon *et al*., 2015))**. Ridge density denotes the number of ridges within a defined space. Epidermal ridge density is influenced by: (1) distance between ridges and (2) width of the ridge. If the sex of the individual is identified, it would give positive leads to the Investigating Officer and thereby ease the task. Thus, differences in ridge density based on sex are relevant **(Nayak *et al*., 2010)**. R.D could act as presumptive indicators of the sex, especially when an unknown chance print is present at the scene of crime. It is a better supportive aid for forensic experts and law enforcement agencies **(Kapoor and Badiye, 2015)**. Data from RD can act as an aid in identification of mutilated remains when dismembered parts such as hand is brought for medico-legal examination **(Kapoor and Badiye, 2015)**.

Okajima (1970), concluded from his research studies that the fork index was higher in female fingerprints in comparison to males **(Nayak *et al*., 2010; Okajima, 1970)**. The results showed that forks (a type of minutiae) occur more frequent in ulnar loops and in females.

Jantz (1977), analyzed 11 samples on the ten fingers representing Negroes and Caucasians. He obtained correlations between the sex and race differences in finger ridge count. Even though the samples of European decent did not show any consistent sex difference in mean correlation, the female White Americas significantly exceeded males in Ridge Density. In 3 of the 6 Negroid and in the Parsis of India samples, males exhibited significantly greater average correlations than the females **(Nayak *et al*., 2010; Jantz, 1977)**. However, the sample size was very small.

Moore (1994), another researcher mentioned that females possess epidermal ridge detail that are fine in nature in comparison to males **(Nayak *et al*., 2010)**.

Acree (1999), put forth that thickness/width of the dermal ridges varies among individuals. Women, in general, possess fine ridges on contrary to men and,

thus, ridge density was higher within a given unit of space **(Acree, 1999; Gutiérrez-Redomero, Esperanza *et al*., 2008)**.

In order to calculate ridge density, researches followed the method given by Acree. The prints were collected either by rolled impression through the ink **(Acree, 1999)**, tape transfer method **(Gutiérrez-Redomero, Esperanza *et al*., 2008)**. Ridges of both men and women from fingerprint samples were counted within 5mm X 5mm square drawn on transparent film. It gave the number of the ridges /25 mm and would be taken as the ridge density. If the fingerprints were from the right hand, this square placed directly to the region upper left of the central core. Likewise, for the fingerprints from the left hand the square was placed to the region upper right of the central core **(Nayak et al., 2010; Acree, 1999)**. Area usually chosen for analysis of all the fingerprint pattern types were upper portion of the radial border due to similarity in ridge flow in this area **(Nayak *et al*., 2010),** The epidermal ridges were counted between the diagonally opposite corners of a square. Dots were excluded from counting. Forks and lake were taken as 2 ridges, excluding the handle of fork. This value indicated the number of ridges in 25 mm square area i.e. Ridge Density **(Kapoor and Badiye, 2015; Nayak et al., 2010)**.

Acree (1999), based on his research on the population of Caucasian and African American races suggested that a ridge count of about 11 or less ridges/25 mm2 was highly probable to of a male whereas, a ridge count about 12 ridges or high/25 mm2 was highly probable to be a female in both the races **(Acree, 1999)**.

Gutiérrez-Redomero, Esperanza *et al*. (2008), carried out research on Spanish-Caucasian population. They extended analysis two further fingerprint areas: the ulnar side and on the lower part along with the radial region. With regard to sex differences, they concluded that women exhibited very high ridge density than men in the radial and ulnar areas for all fingers. However, no significant differences were observed in the lower area. The ridge count of 16 ridges or less per 25 mm2 was highly probable to be a male, while a ridge count of 17 ridges or more per 25 mm2 was highly probable to be a woman. Similar trend was observed in ulnar area of analysis **(Gutiérrez-Redomero, Esperanza *et al*., 2008)**.

Nayak et al. (2010), tried to identify the sex of an individual using fingerprint ridge density among the Indian population and they found that for fingerprints with mean ridge density of 12 ridges/25 mm2 or less was highly probable to be a male and a mean ridge count of more the 12 ridges/25 mm2 was highly probable to be a female **(Nayak *et al*., 2010)**.

Karki and Singh (2014), conducted a study on 200 medical students of Kathmandu University School of Medical Sciences and the result concluded that a fingerprint ridge of <12ridges/25mm2 was highly probable to be a male and fingerprint ridge of> 14ridges/25mm2 was highly probable female origin **(Karki and Singh, 2014)**.

Soanboon *et al*., (2015) conducted similar study on Thai teenagers and observed that females exhibited very high RD (narrower ridges) than males. A trend of decrease in R.D (ridge density) with the increase in age was detected in both the radial and ulnar areas of the fingerprints. The study was carried on three set of sample group as group A (total subjects), group B (14–18 years old) and group C (18–24 years old) and they suggested that in the ulnar area; for group A: a ridge count of fewer than 20/25 mm2 was highly probable to be male origin, and greater than or equal to 20 ridges/25 mm2 of female, for group B: R.D of 15 ridges/ 25 mm2 highly probable to be male while 20 ridges per 25 mm2 for female and for group C: R.D of 13 ridges/25 mm2 highly probable to be a male while RD 16 ridges/25 mm2 for female. In the radial area, group B shows 15 ridges/25 mm2 to be of a male while RD 18-19 ridges/2 5 mm2 to be most likely female group C also shows a pattern similar to that of group B that the RD of 14 ridges/25 mm2 highly probable to be male while RD 18 to 19 ridges/25 mm2 for being highly probable female **(Soanboon *et al*., 2015)**.

Kapoor and Badiye (2015) devised a new improvised approach for calculation of thumbprints ridge density. It consisted of two straight lines bisecting lines with the bisecting point was placed at the core or centre of the print. 5mm above the bisecting point, a transverse line was drawn. Two squares with dimension 25 mm each were drawn on left and right sides. The analysis was extended to the Left of Centre (LoC), the Right of Centre (RoC) and combined. The study was conducted on the Marathi population of Central India and suggested that women possess significantly higher thumb ridge density in comparison to men at LoC, RoC and Combined. At LoC, R.D (Ridge Density) of lesser or equal to 12 ridges/25 mm2 was highly probable to be the male origin, whereas, a R.D of greater or equal to 13 ridges/25 mm2 was highly probable to be a female origin at RoC, a R.D of lesser or equal to 12 ridges/25 mm2 was highly probable to be a male origin, whereas ridge density of greater or equal to 13 ridges/25 mm2 was highly probable to be a female origin. For the Combined ridge density (LoC +RoC), a ridge density of lesser than or equal to 25 ridges per mm2 was highly probable to be a male

origin whereas a ridge density of greater or equal to 26 ridges per mm2 was highly probable to be female origin. They supported the reasons proposed by **Krishan *et al*., (2010)** on the account of the difference between the ridge density of fingers in males and females as to difference in average body proportions of males. Males possess larger average body proportions in comparison to females. Thus, same number of dermal ridges are present within the males in a larger surface area and thus, lower ridge density in males **(Kapoor and Badiye, 2015; Krishan *et al*., 2010)**.

The result of the research suggested that combining the ridge densities at the LoC and RoC regions will improvise the result in scenarios of sex differentiation using thumbprints **(Kapoor and Badiye, 2015)**.

Thakar *et al*., (2018) conducted similar study in the Punjabi population of India on index and middle fingers. They concluded that mean R.D in men were 12.32 ridges/25mm2, whereas in women it were 13.94 ridges/25mm2 on index finger.

The mean R.D in men were 12.7 ridges/25mm2 and in women were 13.22 ridges/25mm2 on middle fingers. Men seemed to have very high number of minutiae over the females in loop and whorl as general pattern type. For the Arch pattern, females exhibited a high number of minutiae on contrary to males **(Thakar *et al*., 2018)**. The samples were analysed using the methodology given by Acree. Adobe Photoshop cs5 was used to analyse ridge details by superimposing the scale on fingerprint **(Thakar, 2018)**.

Conclusion

Fingerprints are frequently encountered evidence in crime scene. If the sex of the individual is identified, it would give positive leads to the Investigating Officer and thereby ease the task of investigations. The studies within India and various parts of the world support and confirmed that female exhibited very high ridge density in a given area over men and RD can be successfully used as a presumptive aid to discriminate between the sexes. Researches also suggested that men exhibited a very high number of minutiae over women in loop and whorl pattern, whereas in arch women possessed very high number of minutiae over men. Thus, RD is one among the genetically quantitative traits in human populations which exhibit sexual dimorphism. More studies is anticipated to incorporate third genders as well.

References:

Acree, Mark A. “Is There a Gender Difference in Fingerprint Ridge Density?” *Forensic Science International*, vol. 102, no. 1, 1999, pp. 35–44. *Crossref*, doi:10.1016/s0379-0738(99)00037-7.

Gunas, V. I., et al. “Palmar Dermatoglyphics of Modern Ukrainians: Regional Trends.” *Biomedical and Biosocial Anthropology*, no. 31, 2018, pp. 11–17. *Crossref*, doi:10.31393/bba31-2018-02.

Gutiérrez-Redomero, Esperanza, et al. “Variability of Fingerprint Ridge Density in a Sample of Spanish Caucasians and Its Application to Sex Determination.” *Forensic Science International*, vol. 180, no. 1, 2008, pp. 17–22. *Crossref*, doi:10.1016/j.forsciint.2008.06.014.

Jantz, Richard L. “Sex and Race Differences in Finger Ridge-Count Correlations.” *American Journal of Physical Anthropology*, vol. 46, no. 1, 1977, pp. 171–76. *Crossref*, doi:10.1002/ajpa.1330460122.

Kapoor, Neeti, and Ashish Badiye. “Digital Dermatoglyphics: A Study on Muslim Population from India.” *Egyptian Journal of Forensic Sciences*, vol. 5, no. 3, 2015, pp. 90–95. *Crossref*, doi:10.1016/j.ejfs.2014.08.001.

Kapoor, Neeti, and Ashish Badiye. "Sex Differences in the Thumbprint Ridge Density in a Central Indian Population." *Egyptian Journal of Forensic Sciences*, vol. 5, no. 1, 2015, pp. 23–29. *Crossref*, doi:10.1016/j.ejfs.2014.05.001.

Karki, RK, and PK Singh. "Gender Determination from Fingerprints." *Journal of Universal College of Medical Sciences*, vol. 2, no. 1, 2014, pp. 12–15. *Crossref*, doi:10.3126/jucms.v2i1.10484.

Krishan, Kewal, et al. "Sex Differences in Fingerprint Ridge Density – Causes and Further Observations." *Journal of Forensic and Legal Medicine*, vol. 17, no. 3, 2010, pp. 172–73. *Crossref*, doi:10.1016/j.jflm.2009.12.003.

Maltoni, Davide. "Fingerprint Recognition, Overview." *Encyclopedia of Biometrics*, 2009, pp. 510–13. *Crossref*, doi:10.1007/978-0-387-73003-5_47.

MHA, Government of India, "Finger Prints in India- 2016 Pdf." *NCRB New Delhi*, 2016.

Nabar, BS. *Forensic Science in Criminal Investigation*, 2nd ed., Asia Law House, 2015, pp. 46–52.

Nayak, Vinod C., et al. "Sex Differences from Fingerprint Ridge Density in the Indian Population." *Journal of Forensic and Legal Medicine*, vol. 17, no. 2, 2010, pp. 84–86. *Crossref*, doi:10.1016/j.jflm.2009.09.002.

Okajima, M. "Frequency of Forks in Epidermal-Ridge Minutiae in the Finger Print." *American Journal of Physical Anthropology*, vol. 32, no. 1, 1970, pp. 41–48. *Crossref*, doi:10.1002/ajpa.1330320106.

Rao GS et al, "A Novel Fingerprints Identification System Based on The Edge Detection." *International Journal of Computer Science and Network Security*, vol. 8, no. 12, 2008, pp 394-397.

Sharma, Anu, et al. "Dermatoglyphics: A Review on Fingerprints and Their Changing Trends of Use." *Chrismed Journal of Health and Research*, vol. 5, no. 3, 2018, pp. 167–72, doi:10.4103/cjhr.cjhr_112_17.

Sehgal, V. N. "Forensic Science & Its Related Issues." *A*, 2011, Selective & Scientific Books, 2012, pp. 129–45.

Soanboon, Pattanawit, et al. "Determination of Sex Difference from Fingerprint Ridge Density in Northeastern Thai Teenagers." *Egyptian Journal of Forensic Sciences*, vol. 6, no. 2, 2016, pp. 185–93. *Crossref*, doi:10.1016/j.ejfs.2015.08.001.

Tandon, Aanchal, et al. "Estimation of Gender Using Cheiloscopy and Dermatoglyphics." *National Journal of Maxillofacial Surgery*, vol. 8, no. 2, 2017, p. 102. *Crossref*, doi:10.4103/njms.njms_2_17.

Thakar, Mukesh Kumar, et al. "Validation Studies on Gender Determination from Fingerprints with Special Emphasis on Ridge Characteristics." *Egyptian Journal of Forensic Sciences*, vol. 8, no. 1, 2018. *Crossref*, doi:10.1186/s41935-018-0049-7.

Tikare, S et al. "Dermatoglyphics--a Marker for Malocclusion?." *International Dental Journal* vol. 60,4 (2010): 300-4.