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### **Gender Determination Using Fingerprint Ridge Density in Perambalur District of Tamil Nadu**

**Angeline Reshma M<sup>1</sup>, Shanmathi K<sup>1</sup>, Jeevapriyadarshini J<sup>1</sup>, Sweta Bharti<sup>1</sup> and Harsh Aniket<sup>2\*</sup>**

<sup>1</sup>Department of Forensic Science, Srinivasan College of Arts and Science (affiliated to Bharathidasan University), Perambalur, Tamil Nadu- 621212.

<sup>2</sup>Research Scholar, Department of Forensic Science, Punjabi University, Patiala, Punjab-147002.

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#### **ABSTRACT**

Fingerprints, renowned for their individuality, serve as pivotal evidence in the criminal justice system. It aids investigators in bolstering criminal and civil investigations, given the permanence and distinctiveness of fingerprints. Fingerprints are also helpful in determination of gender in such cases which helps in narrowing down the scope of search. Numerous studies have been conducted on determination gender determination using fingerprint ridge density but no such work was found for Perambalur district, Tamil Nadu. Hence, the present study aimed to explore correlation between fingerprints and gender in the young population of Perambalur district, Tamil Nadu. A total of 600 rolled fingerprints of index, middle, and ring fingers of both the hands were collected from 50 males and 50 females participants. Ridge density was calculated in an area of 25 mm<sup>2</sup>. It was observed that ridge density in a given specific area was higher in females than in males. The findings add to the existing literature and aims to help the forensic investigations.

**KEYWORDS:** Fingerprints, Gender Determination, Ridge Density, Tamil Nadu, Perambalur.

#### **\*Corresponding author:**

**Harsh Aniket**

Research Scholar,

Department of Forensic Science,

Punjabi University, Patiala, Punjab- 147002.

Email: [harshaniket17@gmail.com](mailto:harshaniket17@gmail.com). Mobile no: 8987492679.

## INTRODUCTION

During criminal investigations, determining the gender of the perpetrator is crucial for narrowing down the search area. This information is valuable in forensic investigations for providing crucial insights including vital data for identification and contributing to establish key facts about an individual's identity. Fingerprints are one of those evidences that have important break-through in the scientific investigation in criminal and civil cases. Fingerprint as science of personal identification has aided in solving many mysteries and yet continues to serve as an important tool in the criminal justice system.<sup>1</sup> A fingerprint is a unique pattern of ridges on the finger tips of the hand. They develop during the gestation and remain the same during the lifetime of an individual. They are classifiable and easily transferrable, thus, are easily encountered at any crime scene.<sup>2, 3</sup>

Fingerprints being readily available on crime scenes can aid the gender determination. Previous studies on gender determination from fingerprinted stated that more minutiae were present in the fingerprints of males when compared to females.<sup>4</sup> Males and females can also be differentiated on the basis of white lines or the skin folds on the friction skin suggesting higher number of white lines in women than men.<sup>5, 6</sup> Researchers found a correlation between dermatoglyphics and sexual orientation, rather than transsexualism itself.<sup>7</sup> Acree, 1990 investigated the ridge density for determination of gender through fingerprints.<sup>8</sup> Ridge density can be defined as the number of ridges within a defined fingerprint area.<sup>9</sup> Ridge density from the partial prints often encountered from the crime scene may also give relevant information regarding gender.<sup>10</sup> Investigation on gender determination through fingerprint ridge density was significantly conducted worldwide on people of various nationalities and ethnic groups.<sup>11-21</sup> However, the studies mostly included only a few fingers most commonly thumb and index fingers, though; it is possible to encounter the fingerprints of all the ten digits on the crime scene. Apart from thumb; index, middle and ring also fingers hold significant importance. Whenever individuals touch, hold, or manipulate objects like pens, paper, glass, firearms, or currency notes, their impressions are likely to transfer onto these objects. It was also suggested in previous studies to conduct on gender determination using ridge density method on all the ten digits.<sup>19</sup>

Past studies were mostly conducted on various communities and populations from different regions in India and around the world. However, a database on gender differentiation for a district population of Tamil Nadu could not be traced. The present study, however, was conducted on individuals of Perambalur district, Tamil Nadu including. In present study index, ring and middle finger

impressions of right and left hands were collected from the individuals to calculate the ridge density. Additionally, an attempt has been made to observe percentage distribution of types of pattern found in the population. The study mainly aims to add to the existing knowledge and to prepare a database based upon the aforementioned information.

## **MATERIALS AND METHODS**

### ***Sample Population***

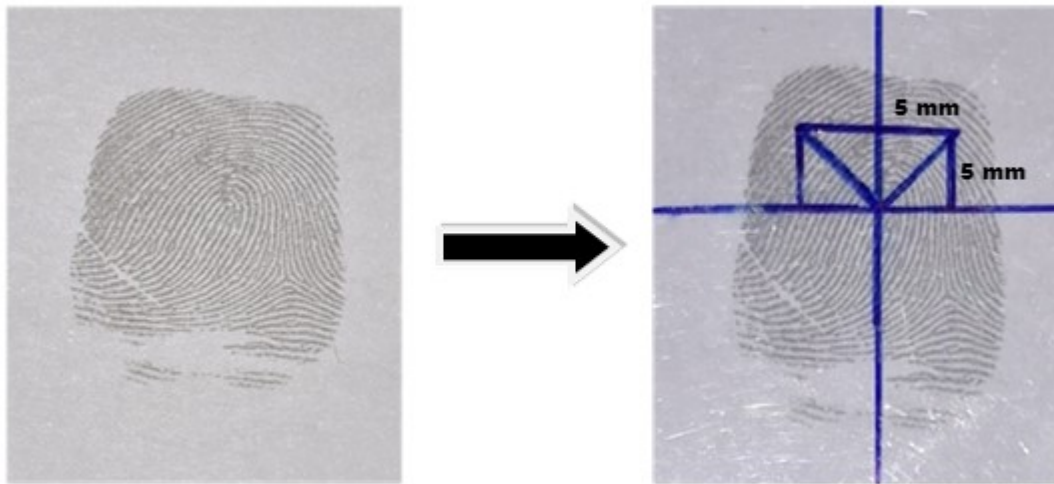
Samples were collected from 100 participants of Perambalur district of Tamil Nadu, India of which, 50 participants were male and 50 participants were female. Before collection of samples, all the participants were informed regarding the nature of study and were asked to sign a consent form. They were also informed regarding their participation and withdrawal rights. The participants belonged to the age group of 18-25 years. The fingerprint samples of index finger, middle finger and ring finger of both the hands were considered for the study. Participants having any types of diseases and injury on these fingers were excluded.

### ***Collection of samples***

The hands of the participants were cleaned and were allowed to dry. From each of the 100 participants, rolled impressions of the three fingers of both hands were collected making a total of 600 fingerprints samples. Rolled impressions were taken using a fingerprint inkless pad with model number: MSIP-ID35 marketed by Maruthi Scientific Investigation Products on white 70 GSM A4 sheet. The fingertip was rolled from the radial side to the ulnar side on the inkless pad and the same was transferred over the paper in the same direction applying appropriate pressure.

### ***Sample analysis***

Samples were analyzed using Acree's method.<sup>4</sup> A grid with two bisecting lines having a square of 25 mm<sup>2</sup> on both right and left side of the intersecting lines was prepared on a transparent sheet of paper. The intersection of the bisecting lines was placed on core of each sample. The ridges in the right of centre (ROC) and left of centre (LOC) were counted from one corner of the square to the centre and noted for each finger of both hands (Fig 1). In case of arch pattern having no core, the interesting point of the grid as placed lowest ridge flowing from one side of the print to the other.<sup>19</sup> The ridges actually cutting the diagonal lines of the squares were counted. Nascent and subsidiary ridges were excluded from the ridge count.



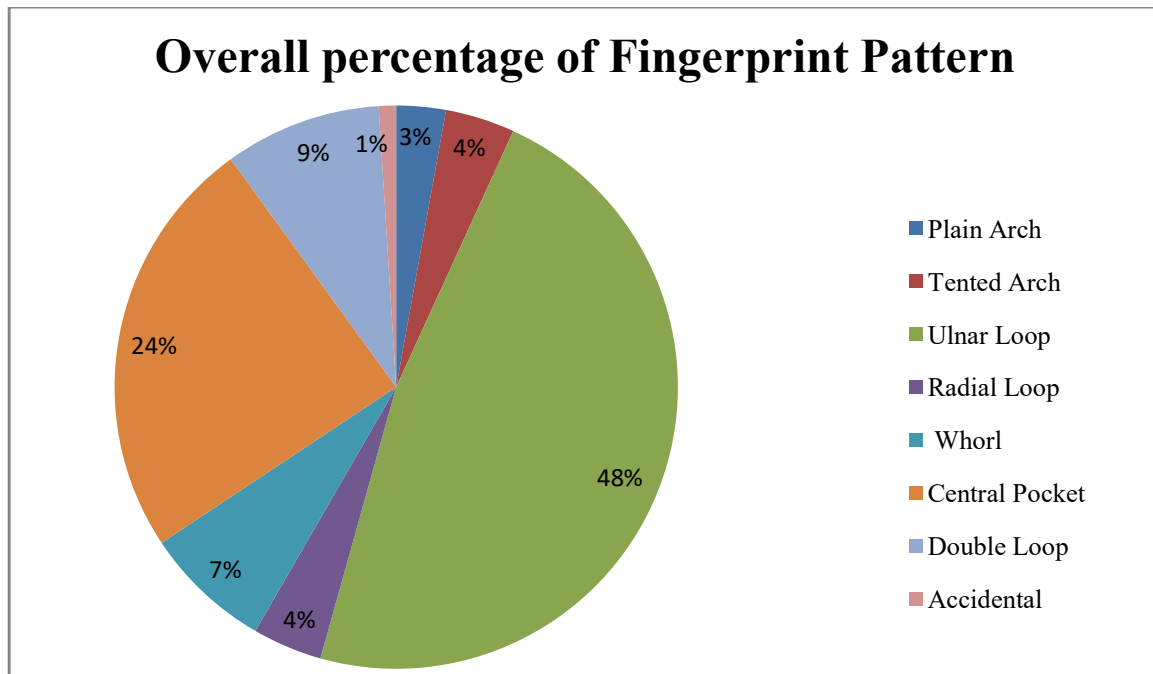
**Fig 1: Grid template placed over the fingerprint to determine the ridge density square of 25 mm<sup>2</sup> in both ROC and LOC.**

## RESULTS AND DISCUSSION

The first part of the study involved the identification of the first level details, that is, the pattern types on the index, middle and ring fingers of both left and right hand of the participants. Among the fingerprint samples, ulnar loop was the most encountered pattern type and was present on 285/600 samples. This was followed by the central pocket, double loops (both twin loop and lateral pocket) and whorl pattern. Radial loop, plain arch and tented arch were among the rare patterns found in the population sample. Gender wise distribution of the fingerprint patterns is mentioned in table 1. Fig 2 represents the pie- chart depicting the overall percentage of different fingerprint patterns found in the total subjects.

**Table 1: Gender wise distribution of the fingerprint patterns in the sample population**

S.No.	FINGERPRINT PATTERNS	FEMALE	MALE
1.	Plain Arch	13	4
2.	Tented Arch	12	12
3.	Ulnar Loop	159	126
4.	Radial Loop	12	12
5.	Whorl	20	24
6.	Central Pocket Loop	62	84
7.	Double Loop (Twin loop and Lateral Pocket)	20	34
8.	Accidental	2	4



**Fig 3: Overall percentage of fingerprint pattern present in total subject (both male and female).**

Further, the ridge density was analyzed in the collected fingerprint samples using Acree's method to determine the gender of the individuals. The number of ridges/ 25mm<sup>2</sup> in females was most likely in the range of 13- 22 ridges while for males it was 10- 16 ridges. The mean ridge density/25mm<sup>2</sup> in case of females for ROC and LOC of both hands in case of index finger, middle finger and ring finger was determined to be 17.44, 17.41 and 17.66 respectively. However, in males, the ridge density ROC and LOC for both hands in index, middle and ring finger was calculated as 12.44, 12.61 and 12.87 respectively. Thus, the mean ridge density in case of all the three fingers was found to be more in case of females than males. Similar observations were reported in majority of the previous studies.<sup>8- 21</sup> Females have thinner and narrower ridges creating more ridge density in a given area than the males.<sup>12, 13, 17</sup> The detailed mean ridge density and range of number of ridges of each finger (ROC and LOC) for females and males are tabulated in table 2 and table 3 respectively.

The study suggested that a mean ridge density of ~ 13 ridges/ 25 mm<sup>2</sup> or less can be said to belong to males and mean ridge density more than the aforesaid value may belong to females. However, for Caucasian and African American subjects, it was noted that fingerprint having ridge density of 11 ridges/25 mm<sup>2</sup> or less was of male origin and 12 ridges/25 mm<sup>2</sup> or greater was of female origin.<sup>8</sup> In the South Indian population, ridge density more than 14 ridges/25mm<sup>2</sup> most likely belonged to females and

less than that were of males.<sup>9</sup> Similarly, in Malaysian subjects, mean ridge density of 11 ridges/25 mm<sup>2</sup> or less was said to belong to males while 13 ridges/25 mm<sup>2</sup> or more was likely of female origin. While, in the same study, a ridge density of 12 ridges/ mm<sup>2</sup> or less were found to be of males while 13 ridges/ 25 mm<sup>2</sup> or more was found in females.<sup>12</sup> Similarly, in the central Indian population, a mean ridge density for LOC and ROC was found to be 11.58/25 mm<sup>2</sup> and 11.82/ 25mm<sup>2</sup> in males while, 14.6/ 25mm<sup>2</sup> and 14.56/ 25mm<sup>2</sup> for females.<sup>16</sup> Similar results were obtained for different north Indian population.<sup>13, 19</sup> It can be thus said that fingerprint ridge density is a sexual dimorphic characteristic; however the mean ridge density/25 mm<sup>2</sup> for both the genders varies by different population and places. No significant differences were noted in fingerprint ridge density of right and left index, middle and ring finger (table 2 and 3). Thus, gender determination using ridge density is not affected because of fingerprints of right or left hand.

The findings of the study remain relevant despite similar past studies on different sample population. Any relevant conclusion on the validity of results in the field of fingerprint examination relies upon results from a large number of samples. Thus, the present study adds to the knowledge of existing literature in drawing any conclusion from ridge density for gender determination through fingerprints. There yet remains scope for future studies in this area to be conducted over population samples of different regions in India and around the world.

**Table 2: Range of ridge density and mean ridge density in index, middle and ring fingers of female subjects.**

S.No.	Finger		Range of ridge density/ 25mm <sup>2</sup>	Mean ridge density/ 25mm <sup>2</sup>	
1.	Right Index	Right of center	12- 22	17.18	17.44
		Left of center	13-22	17.90	
2.	Left Index	Right of center	14-20	17.16	
		Left of center	14-23	17.52	
3.	Right Middle	Right of center	13-22	17.28	17.41
		Left of center	16-22	17.34	
4.	Left Middle	Right of center	13-21	16.96	
		Left of center	13-22	18.08	
5.	Right Ring	Right of center	15- 22	17.64	17.66
		Left of center	14-22	17.74	
6.	Left Ring	Right of center	15-22	17.24	
		Left of center	15-22	18.04	

**Table 3: Range of ridge density and mean ridge density in index, middle and ring fingers of male subjects.**

S.No.	Finger		Range of ridge density/ 25mm <sup>2</sup>	Mean ridge density/ 25mm <sup>2</sup>	
1.	Right Index	Right of center	10-16	12.06	12.44
		Left of center	10-18	12.62	
2.	Left Index	Right of center	10-16	12.96	
		Left of center	10-16	12.12	
3.	Right Middle	Right of center	09-16	12.38	12.61
		Left of center	10-17	12.56	
4.	Left Middle	Right of center	10-15	12.78	
		Left of center	10-16	12.72	
5.	Right Ring	Right of center	09-16	12.66	12.87
		Left of center	10-19	13.00	
6.	Left Ring	Right of center	10-17	12.96	
		Left of center	10-18	12.88	

## CONCLUSION

The current study involved gender determination through fingerprint ridge density in Perambalur district of Tamil Nadu. A total of 600 fingerprint samples of index, middle and ring finger from 50 males and 50 females were collected. The ridge density was evaluated in a square of 25 mm<sup>2</sup>. It was found that the ridge density of males were comparatively lesser than the females. This was because of the probable reason because females have narrow ridges causing more number of ridges in a given area. The results were similar to the results of previous studies. However, the means ridge density differed from population to population. Fingerprint ridge density was found to an accurate indicator for gender differentiation. It was suggested that more such studies should be conducted on various population to have more sets of database.

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