
**“DETERMINATION OF SEX FROM FINGERPRINT RIDGE DENSITY AMONG
SOUTH INDIAN POPULATION-A ONE YEAR CROSS SECTIONAL STUDY”**

by

REGISTRATION NUMBER-BF 0110001

Dissertation

Submitted to the

KLE UNIVERSITY, Belgaum, Karnataka,

In partial fulfillment

of the requirements for the degree of

M.D. (DOCTOR OF MEDICINE)

in

FORENSIC MEDICINE & TOXICOLOGY

**DEPARTMENT OF FORENSIC MEDICINE & TOXICOLOGY
JAWAHARLAL NEHRU MEDICAL COLLEGE**

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**KLE UNIVERSITY
BELGAUM.**

**ENDORSEMENT BY THE HEAD OF DEPARTMENT,
PRINCIPAL OF THE INSTITUTION**

This is to certify that the dissertation entitled “**DETERMINATION OF SEX FROM FINGERPRINT RIDGE DENSITY AMONG SOUTH INDIAN POPULATION - A ONE YEAR CROSS SECTIONAL STUDY**” is a bonafide research work done by **THE CANDIDATE REG.NO. BF0010001.**

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LIST OF ABBREVIATIONS USED

A.D : Anno Domini

B.C : Before Christ

CCD : Charge Coupled Device

DF : Degree of freedom

LR : Likelihood Ratio

P : Probability

SD : Standard Deviation

SE : Standard Error

ABSTRACT

Objectives and Background

Fingerprints appeared to be permanent features of each person's body and personal identification through fingerprints has long been recognized because of its uniqueness. Criminals often leave their fingerprint at the site of crime unknowingly which though not apparently visible can be subsequently developed and studied successfully. Identification of sex by fingerprint ridge density will be helpful to the investigating officer which would save time in nabbing the suspects. The present study was undertaken to determine the sex from fingerprint ridge density.

Materials and Methods

The present study was conducted in the year 2010-11 consisting of 200 subjects (100 males and 100 females) of South Indian origin of J.N.Medical College, Belgaum, by simple random technique. After taking fingerprints, the ridges of upper portion of the radial border of each print in an area of 25 mm² counted. The mean value is calculated for all the ten fingers. This value represents the approximate number of ridges for the particular individual. The significance of this value is determined.

Results

In our present study females were found to have significantly higher ridge density than males ($p < 0.001$). Study showed that 95% of the males have a mean ridge density of 15 ridges/25 mm² and 87% of the females have a mean ridge density of 16 ridges/25 mm². It is observed that none of the males have a mean ridge density of more than 18 ridges/25 mm² and there are no females who have a

mean ridge density below 13 ridges/25 mm². It is found that thumb finger tends to have less ridge count compared to other finger. Ring finger and Little finger showed higher ridge density compared to other fingers. It is found that thumb finger tends to have less ridge count compared to other fingers and Ring finger and Little finger showed higher ridge density compared to other fingers. Study also showed that average ridge count doesn't differ in all the four blood groups but the percentage of distribution of gender into two categories is significantly different in all the blood groups.

Conclusion

The present study has shown that a fingerprint with ridge density of 15 ridges/25 mm² is more likely to be of male and fingerprint with ridge density of 16 ridges/25 mm² goes in favour of female.

Key words: Male, Female, Fingerprint, Ridge, Density.

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In ancient days, the lines on the palm and fingers were basic source of study of palmistry in India as well as in the western countries. Even today these lines, ridges on the palm and finger tips are connected at best for their mystic significance, a fortune or misfortune.

The skin of palm and fingers, sole of the feet and toes is a special type in relation to the skin of the other parts of the body. The skin of these areas contains numerous ridges (lines). They are present in various patterns.

The Chinese were the first culture known to have used friction ridge impressions as a means of identification. Earthenware estimated to be 6000 years old was discovered at an archaeological site in northwest China and found to bear clearly discernible friction ridge impressions. These prints are considered the oldest friction ridge skin impressions found to date¹. The study of fingerprints and its use can be traced back to the earliest forms of civilization. Archeologist are of the view that thousands of years before the B.C era fingerprints were used on pottery to indicate the maker and the brand of pottery. Clay slabs with fingerprints nearly 3000 years old have been found in Tutankhamen's Tomb in Egypt. Thumbprints were used as official seal on documents by Chinese emperors since 240.B.C. Emperor Ts-in-she (240-210 B.C.) was the first imperial authority to use fingerprint seals in China².

Since 700 A.D. dactylography, study of dermal ridges has been used for the purpose of identification³. At that time though it was not known that finger ridge patterns are unique for each and every individual, people accepted its authenticity as they thought that it cannot be altered or falsified.

But the scientific study of fingerprint was done by Prof. M Mulpighi. He classified fingerprints systematically for the first time and in 1858, W.J. Herschel,

began the first known official use of fingerprints in India on a large scale². Dr Henry Fauld (1880)⁴ in Tokyo published an article on the individuality of fingerprints. But the first mentionable study on fingerprint was done by Sir Francis Galton (1892). He studied the patterns and classified fingerprints. Edward Henry partly modified the Galton's system of fingerprint study; in 1901 fingerprint study was officially introduced in the process of investigation in England and Wales. This system of fingerprint study is still in effect in most of the countries of the world and is popularly known as Henry-Galton system⁵.

Many scientific research and studies have been done on the finger ridges, starting from its types, classification (Henry-Galton), methods of lifting prints, and methods of recording and different materials used to get a clear fingerprint which can be easily deciphered.

Determination of individuality is one of the prime concerns in forensic investigation. Fingerprint is considered to be the most accurate and reliable indicator in identification. Identification means determination of the individuality of a person. It may be complete (absolute) or incomplete (partial). Complete identification means the absolute fixation of a person. Partial identification implies ascertainment of only small facts about the identity while others still remain unknown. The most successful approach utilizes a combination of more than one method. Fingerprints are the impressions of patterns formed by the papillary or epidermal ridges of the fingertip.

Fingerprints have been used for civil as well as criminal cases because of their unique pattern of absolute identity. No two persons, even uniovular identical twins would have similar fingerprint pattern. In case of missing person or disaster victims, if along with fingerprint any other trace evidence such as blood, saliva, pus, seminal

stains and hair are available, then the study of fingerprint is the simple method used for identification rather using technique such as DNA analysis.

Recently more research and studies are done on the method of storing fingerprint in computers for rapid search and matching of fingerprints around the globe.

Personal identification through fingerprints has long been recognized and is regarded as the greatest contribution to the law enforcement. Through its important characteristics, the science of fingerprint provides a unique service in the administration of justice and also in other areas where positive identification is of paramount importance. Fingerprints are commonly used in the identification of criminals, whose fingerprints are found at the scene of crime, identification of unknown deceased, missing persons, persons who are suffering from amnesia, establishing correct identity in cases of kidnapping and in detection of bank forgeries. It also helps in prevention of either accidental or purposeful exchange of newborn infants in hospitals

With the rise in the number of criminal cases like robbery, rape and assault, fingerprint is increasingly becoming an indispensable tool in the hands of investigating officers to apprehend the culprits. Criminals often leave their fingerprint at the site of crime unknowingly which though not apparently visible can be subsequently developed and studied successfully. Identification of gender by fingerprint ridge density will be helpful to the investigating officer which would save time in nabbing the suspects. The fingerprint ridge density has shown a real significant difference as far as sex is concerned. Study on fingerprint density was done in 1961⁶ and later on by many others. They found significant fingerprint ridge density difference between male and female. In a study done in 1999 on 400 subjects

consisting of 100 Caucasian males, 100 African American males, 100 Caucasian females and 100 African American females. Study showed significant fingerprint ridge density difference between male and female. Author recommended the study on other races⁷.

We did a pilot study in this region and it showed encouraging results. Which further led us to take up this study.

- A. To establish association between sex and fingerprint ridge density.

Since ancient times, people have been aware of the patterns on their fingers and their possible uniqueness. Thousands of years before the B.C era archeologists are of the view that, fingerprints were used on pottery to indicate the maker and the brand of the pottery². The Chinese were the first culture known to have used friction ridge impressions as a means of identification. Earthenware estimated to be 6000 years old was discovered at an archaeological site in northwest China and found to bear clearly discernible friction ridge impressions. These prints are considered the oldest friction ridge skin impressions found to date¹.

Clay slabs with fingerprints nearly 3000 years old have been found in Tutankhamen's Tomb in Egypt. Thumbprints were used as official seal on documents by Chinese emperors since 240.B.C.² In one of the Chinese document entitled "The Volume of Crime Scene Investigation—Burglary", from the Qin Dynasty (221 to 206 B.C.) contains a description of how handprints were used as a type of evidence and also the individualization using friction ridges on the clay seal¹.

Emperor Ts-in-she (240-210 B.C.) was the first imperial authority to use fingerprint seals in China and these seals remained in use till the times of Emperor WU (187-156.B.C). Chinese documents of Tang Dynasty (618-906 A.D) refer to fingerprints being impressed upon business contracts².

In ancient Assyria³ the science of fingerprint was known, and was used for the purpose of identification in 700 A.D and in A.D. 1637 the letters written by Shahuji to Khan Bahadur bears the stamped impression of his hand. This is an example of the nobility's use of palm prints in India to demonstrate authenticity of authorship when writing an important document¹.

In the late 17th century, European scientists began publishing their observations of human skin. Friction ridge skin was first described in detail by Dr. Nehemiah Grew in the 1684. In 1685, Govard Bidloo, a Dutch anatomist, published 'Anatomy of the Human Body' which included details of the skin and the papillary ridges of the thumb but failed to address individualization or permanence¹.

But the Marcello Malphigi of Italy was the first to make scientific study of ridge patterns of finger and first mention of fingerprints (pattern of fingertips) in his researches in 1686. Many anatomical works appeared mentioning about the dermatoglyphics during eighteenth century. Among them, the contribution of Hintze (1747), Albinus (1764) and Mayer (1788) received more attention. Mayer in his anatomical atlas described that although the arrangement of skin ridges is never duplicated in two persons yet the similarities may be closer among some individuals² and he was the first to write that friction ridge skin is unique¹.

In 1814 Schroter explained about the arrangement of ridges and pores while discussing the morphology of palmar skin². The first regular classification of was done by Johannes Evangelista Purkinje⁸ in his thesis (1823) and also he classified finger prints into nine principal configuration groups.

Sir William J Herchel was the first known officer who used fingerprints in Bengal (India) on a large scale in 1858. He has not classified fingerprints for general use, but he used fingerprints to prevent fraudulent collection of army pay accounts and also for the purposes of identity on other documents² and in 1880, Dr. Henry Faulds, published an article in "Nature" mentioning that the ridges are extremely divergent in

different individuals and patterns remain unchanged throughout life time and the fingerprint pattern can help in identification⁹.

Meanwhile another scientist Alphonse Bertillon devised an alternate identification method called Bertillon's anthropometric method and was first put to use in 1882. This system includes various body measurements like height, reach (middle finger to middle finger of outstretched arms), trunk, length of head, width of head, length of right ear, width of right ear, length of left foot, length of left middle finger, length of left little finger, and length of left forearm for identification purposes¹.

In 1882, Gilbert Thomson of United States Geological survey used his own thumb print on commissary orders to prevent forgery and in 1883 Mark Twain, in his episodes relates an incident of the identification of a murderer by his thumbprint. He further developed this theme in his novel based on a dramatic fingerprint identification demonstrated during a court trial, and pointed out the infallibility of fingerprint identification in 1894².

The first mentionable study of fingerprint was done by Sir Francis Galton in 1892 and he observed that ridge patterns of any two fingers differ and the patterns are never identical. He also mentioned that the ridge patterns in an individual never change⁵.

The first fingerprint Bureau in the world was officially established in Kolkata in 1897² and in 1898 in Bengal the first criminal case in which fingerprint evidence was used to secure a conviction¹. Edward Henry partly modified Galton's system of fingerprint study and was officially introduced in the process of investigations in

England and Wales in 1901. That is popularly known as Henry-Galton system or simply Galton's system of identification⁵.

In 1902 Dr. Henry P. de Forest of the New York Civil Service Commission was first to use fingerprints in the United States. In 1903, Captain James H. Parke of New York State developed the American Classification System. The use of the American Classification System and subsequent fingerprinting of all criminals in the state of New York was the first systematic use of fingerprinting for criminal record purposes in the United States¹.

In 1904, Leavenworth penitentiary at Kansas together with St. Louis Police Department inaugurated fingerprint Bureaus, which were followed by adoption of fingerprint system by the U. S. Army in 1905, the U. S. Navy in 1907 and U. S. Marine Corps in 1908².

In 1926, Harold Cummins, coined the term 'Dermatoglyphics'¹⁰. In 1929, he together with others, including Midlo and the Wilders, published one of the most widely referenced papers on dermatoglyphic methodology to date¹¹.

In 1929 K. Bonnevie had speculated that fingerprint patterns were dependent upon the underlying arrangement of peripheral nerves¹². Harold Cummins, alone and with collaborators, published numerous studies in the field as well as his now famous 1943 book, "Finger Prints, Palms and Soles", a bible in the field of dermatoglyphics, which he dedicated to the pioneer Harris Hawthorne Wilder¹³.

In 1952, Dr. Alfred R. Hale published a thesis titled "Morphogenesis of the Volar Skin in the Human Fetus", in which he described the formation of friction

ridges during fetal development and the differential growth of friction ridges, which is the major premise of friction ridge identification¹.

After this many workers have contributed on new methods of recording latent finger prints and advances in fingerprinting. Computer can scan and digitally encode fingerprints nowadays. The computer uses the scanning system for search¹⁴. The (AFIS) Automatic Fingerprint Identification Systems have drastically reduced the time for matching and issuing reports by fingerprint experts.

Many researches are being done on fingerprint pattern, ridge characteristics and ridge count and their pattern of distribution among males and females.

In the year 1941, a study was conducted on 200 subjects and observed that men have coarser epidermal ridges than women and also concluded that the breadth of ridges tend to vary directly with bodily dimensions¹⁵.

In another study in 1961, showed that females generally have smaller body than males and it might be expected that their ridges would be narrower than the males. It also showed that the number of ridges per centimeter in males is less compared to females¹⁶.

A study done on the frequency of minutiae types in fingerprint of 77 males and 82 female Japanese (aged between 14 and 16 years) in 1970. It was noticed that the fork index, which represents the frequency of forks in minutiae, is higher in female than in male for each finger¹⁷.

In a study conducted in 1973, summarized the opinion and pointed out the arrangement of blood vessels and nerve pairs under the smooth epidermis. Study also

speculated that the folds were induced by the blood vessel-nerve pairs and also it was noticed that the neuro epithelium plays an important part in the development of the dermatoglyphic patterns¹⁸.

A study done in 1974, on the ridge count on human palm to determine the inheritance of ridges and he found that some major genes govern the ridge count in the palm and in the interdigital area¹⁹.

In a another study done on the index of pattern intensity in 432 whites and 654 blacks and also the total ridge count in the year 1974 in Identification Institute of the State Police in Porto Alegre. Study showed that no sexual difference in gradient but in general the females showed higher values than males and the females in blacks showed lower pattern intensity than males²⁰.

In the year 1975, a study was done in Johns Hopkins University, on digital and palmar dermatoglyphics of 408 Negros Americans (184 males and 224 females) and observed mean ridge counts are significantly higher on the right hands of males than females but there was no difference for left hand comparisons. Study revealed that the total mean ridge count on both hands is significantly different between males and females²¹.

A study done on the Digital and palmar dermatoglyphics of 360 male and 360 female American Caucasians from the greater Boston area, with individuals having I.Q. scores more than 70 and who are free of minor anomalies or chronic diseases in the year 1975 and observed that bilateral ridge counts are significantly different in the female while in the male no difference was seen. This study denotes males have significantly higher ridge counts than females²².

In 1975 a study on tribal population of Araku Valley in Andhra Pradesh (India) consisting of 470 subjects (235males and 235 females). It is observed that there was significant mean ridge count difference between the sex and the mean ridge count in males was 13.41 and that in females 12.04²³.

A study done in 1988 is noteworthy, as it is the first study to describe the distribution of epidermal ridge minutiae within the ridge structure and his results support possible sources of error²⁴.

In 1991, a study on “Advances in the finger print technology” also showed that the finger print from females have smaller features than those from males, accounting for their high ridge density²⁵.

An another study done in 1999 in USA analyzed Fingerprint samples of 400 randomly picked ten-print cards representing 400 individuals (i.e. 200 Caucasian males and females, 200 Africa American males and females) all within the age range of 18–67. Result showed that women tend to have a significantly higher ridge density than men and he found that fingerprint possessing a ridge density of 11 ridges/25mm² or less is most likely to be of male origin. Likewise a fingerprint having ridge density of 12 ridges/25mm² or greater is most likely to be of female origin. Authors suggested that further studies should be done on other races⁷.

A study conducted in 2007, on 500 subjects (250 males and 250 females) in the age group of 18-60 years from the state of Karnataka (Southern part of India) and it showed that fingerprint ridge count of less than 13 ridges/25mm² is more likely to be

of male sex and ridge density of more than 14 ridges/25mm² is likely to be of female sex²⁶.

According to one another study conducted in 2008 on 200 subjects (100 males and 100 females) of Spanish Caucasian population and results showed that women tend to have significantly higher ridge density in distal region of all 10 fingers and also have finer ridges(radial and ulnar area)²⁷.

In a similar study conducted on 130 males and 130 females of Thai region in 2010. Study showed that fingerprint ridge density is the indicator to establish the gender and fingerprint ridge characteristics may be used to predict the gender. It is observed that the fingerprint ridge density of 16 ridges/25mm² and 17 ridges/25mm² were more likely to be of male and female origin respectively²⁸.

In a study done in 2010 on 100 male and 100 female healthy Indian students aged between 18 and 25 years studying in various educational institutions in Manipal, India showed that ridge density range from 12 to 15.9 ridges/25 mm² for females with a mean of 14.198 ridges/25 mm² and from 9.6 to 12.5 ridges/25 mm² for males with a mean of 11.049 ridges/25 mm². It is observed that fingerprint ridge density of 12 ridges/25mm² or less is more likely to be of male origin and a mean ridge count of more than 12 ridges/25mm² is more likely to be of female origin. This study confirmed that females have finer ridge details because of greater ridge density, than men²⁹.

In another study conducted in 2010 on 200 Chinese (100 males and 100 females) and 100 Malaysian (50 males and 50 females) subjects aged between 18 and

25 years on students studying in various institutions of Manipal, India. They noticed that fingerprint mean ridge density of 12 ridges/25 mm² or less is found to be more likely to be of males and a mean ridge count of more the 13 ridges/25 mm² is more likely of female origin in Chinese subjects. Likewise fingerprint mean ridge density of 11 ridges/25 mm² or less is found to be more likely to be of males and a mean ridge count of more the 13 ridges/25 mm² is more likely of female origin in Malaysian subjects³⁰.

In a recent study conducted in 2011 in the department of Forensic Medicine and Toxicology, J.S.S. Medical College, Mysore, India on 550 subjects (275 men and 275 women) belonging to South Indian population all within the age range of 18 to 65 years. Study showed that a fingerprint possessing ridge density <13 ridges/25 mm² is most likely to be of male origin and a fingerprint having ridge count >14 ridges/25 mm² are most likely to be of female origin³¹.

Table No.01: CHRONOLOGY OF FINGERPRINTS ^{1, 2, 32, 33}

6000 years Old	The Chinese were the first culture known to have used friction ridge impressions as a means of identification
3000 years Old	Clay slabs with fingerprint have been found in Tutankhamen's Tomb in Egypt
2000 years ago	Chinese begin using fingerprints as signatures on contracts

240-210 B.C.	Emperor Ts-in-she was the first imperial authority to use fingerprint seals in China
618-906 A.D.	Chinese documents of Tang Dynasty refer to fingerprints being impressed upon business contracts
1684	Nehemiah Grew – An English Botanist, first person to document his finding about ridges. He described the ridges and pores of the hands and feet in his report, which was published and read before the Royal Society of London
1685	G. Bidloo published a treatise about the description of sweat pores and ridges
1686	Marcello Malpighi, an Italian Anatomy Professor, published a book on study of ridges and pores
1751	Hintz, studied the ridges and wrote about ridge formation. He dealt with anatomical point of view of ridges
1764	Albinus, another anatomist studied and described the ridges
1770	Thomas Bewick, an English Wood engraver, author, engraved some of his own finger prints and used them to ornament three of his books
1788	Mayer, in his Human Anatomical Atlas, described that although the arrangement of skin ridges is never duplicated in two persons, yet similarities may be closer among some individuals
1788	J.C.A. Yayer was the first to state in his book (<i>Anatomische Kupfertafeln Nebst Dazu Gehorigen</i>) that the prints of two different

	persons are never alike
1814	Schroter – while discussing morphology of palmar skin, explains the arrangement of ridges and pores
1823	Johannes E. Purkinje, Professor of Physiology in his thesis (in Latin) described the ridges; established certain rules for classification and identified nine different patterns
1833	Bell pointed that there are minute spiral ridges on cuticle
1856	Herman Welcher took the prints of right palm, and forty one years later, i.e. in 1897 he printed the same palm to prove the print do not change
1858	Sir William Herschel – Magistrate of Hoogly district in Bengal (India) printed the palms of the labourers, pensioners and prisoners to avoid impersonation among the labourers, pensioners and prisoners. Instead of signatures, here the prints of entire palm were used
1878	Henry Faulds, Scottish physician and missionary in Japan, begins collecting and studying fingerprints
1880	Mr. Gabor the eminent photographer of San-Francisco, noticing the lineation of a print made by him accidentally on the blotting paper by his inked fingers, used fingerprints for identification of Chinese labourers
1880	Henry Faulds of Tsukiji Hospital in Japan wrote on the subject of fingerprints entitled “On the skin-furrows of the hand” which was

	published in “Nature” on 28 th October 1880
1882	Mr. Gilbert Thompson and American Geologist, on Government duty, when paying the members of his party used finger impression along with their signature
1883	Kollman, an anthropologist wrote in his book on ridges and pores
1883	Mark Twain (Samuel Langhorne Clemens) – In one story published in his book “Life on the Mississippi: tells of a fortune teller who made use of thumb prints
1888	Sir Edward Richard Henry was interested in fingerprints and he devised a method for classification of fingerprints with the help of his two Indian assistants – Khan Azizul Haque and Rai Bahadur Hem Chandra Bose. He read the paper before the British Association for advancement of science in 1889 detailing about his system
1891	Jaun Vucetich developed his own system of classification. This was Officially adopted in Argentina and now also used in most of Spanish speaking countries
1892	Sir Francis Galton, an English biologist, wrote his first text book titled “Fingerprints” explaining about system of classification and filing, in his book. His report of fingerprints as identification was read at Asquith committee of London on 1894
1893	Galton published a supplement to his book entitled “Decipherment of Blurred Finger Tips”

1895	Galton publishes Finger Print Directories, which includes an improved Classification System
1896–9	With Azizul (Azial) Haque and Hemchandra Bose, Henry develops the Henry system of fingerprint classification
1897	On the 12 th of June 1897 a resolution signed by the Govenor General in Council directed that the system of identification of criminals by finger impression be adopted generally in British India
1897	In June 1897 the first Fingerprint Bureau in world was officially established in Calcutta (INDIA)
1897	Wilder Harris and his wife Inez Whipel studied comparative dermatoglyphics
1900	Henry published his system in book form entitled “Classification and uses of Fingerprints”
1901	Henry became the first man to successfully apply fingerprints for identification
1902	CID fingerprint bureau identifies 1,722 repeat criminals Fingerprint evidence convicts first criminal (a burglar) in a British court case
1903	New York becomes first U.S. state to use fingerprints for identification of prisoners
1905	Fingerprint evidence convicts brothers Alfred and Albert Stratton of murder, the first time such evidence is used in a British murder case
1905	In the case of Emperor v Abdul Hamid, a court in India decided that no Expert was required to testify to the individualization of prints

1904	Inez Whipple published the paper, “The Ventral Surface of the Mammalian Chiridium”. Whipple’s survey into mammalian palm and sole configurations formed an important part of the modern scientific knowledge on the subject and is considered a landmark in the fields of genetics and ridgeology
1903–10	Fingerprinting (usually classified by Henry system) replaces anthropometry for identifying criminals in most European countries, Canada, and U.S. states
1910	Murder suspect Thomas Jennings was convicted after testimony by four experts who individualized Jennings’ fingerprints from a porch railing at the crime scene
1910	Frederick A Brayley published a book titled “Fingerprints, their Identification and Uses”
1911	Lieutenant Joseph Faurot, a New York Police Department fingerprint Expert presented testimony in a burglary case
1911	People v Crispi (1911) is considered to be the first conviction obtained with fingerprint evidence alone in the United States
1914	Dr. Edmond Locard published “The Legal Evidence by the Fingerprints” which explained the theory of poroscopy
1916	Frederick Kuhne published “The Fingerprint Instructor”
1918	Harris Hawthorne Wilder and Bert Wentworth (Police Commissioner of Dover, NH) published Personal Identification: Methods for the Identification of Individuals, Living or Dead

1919	The first fingerprint magazine was published
1924	Dr Henry Faulds published his book entitled “Manual of Practical Dactylography”
1926	Harold Cummins, with Midlo introduced for the first time, the word “Dermatoglyphics”
1926	Cummins – Dermatoglyphics pattern in Mongolism
1939	The Supreme Court of Washington convicted a habitual offender using certified copies of fingerprints as proof of identity
1939	The first United States disaster in which fingerprint individualization played a major role was when the USS Squalus sank
1940	A court in Hamilton, TX, declared the fingerprint method of identification to be valid
1940	The FBI participated in disaster identification for the first time, when a Pan Am Central Airliner crashed in Lovettsville, VA
1943	Cummins’s book Fingerprints, Palms, and Soles—An Introduction to Dermatoglyphics describes the formation and development of volar pads on the human fetus
1952	Dr. Alfred R. Hale, published a thesis titled “Morphogenesis of the Volar Skin in the Human Fetus”
1953	Salil Kumar Chatterjee of Calcutta, India, published the book Finger, Palm, and Sole Prints
1961	Sara B. Holt – Devised a method of ridge counting in the study of fingerprints

1962	Article by Chatterjee, “Edgeoscopy” in which he described his theory of using specific ridge-edge shapes to supplement fingerprint individualization
1963	Sara B. Holt – Studied dermatoglyphics abnormality in sex chromosomal disorders
1967	Penrose “Memorandum on Dermatoglyphics – Nomenclature”
1973	I.C.Fuller studied dermatoglyphics as tool of diagnostic aid to various diseases
1975	J Mavalwala – studied genetic background of ridges
1975	C. C. Plato and W. Wertelecki have devised a method of subclassifying the pattern types of the II, III and IV interdigital areas
1976	Dr. Michio Okajima published the paper “Dermal and Epidermal Structures of the Volar Skin”
1984	Brigitte Lacroix, Marie-Josephe Wolff-Quenot, and Katy Haffen of Strasbourg, France, published “Early Human Hand Morphology: An Estimation of Fetal Age”
1991	Dr.William Babler of Marquette University, published “Embryological Development of Epidermal Ridges and Their Configurations”
1999	U.S. Federal Bureau of Investigation establishes Integrated Automatic Fingerprint Identification System (IAFIS)

Dermatoglyphics has been used in clinical medicine as a diagnostic tool in various diseases of congenital or acquired nature:-

Table N0.02: Dermatoglyphics used in clinical medicine as a diagnostic tool

Rubella embryopathy	Achs, Harper, and Siegal, 1966 ³⁴
Schizophrenia	Mellor, 1968 ³⁴
Leukaemia	Verbov, 1970 ³⁴
Mental retardation, Diabetes Mellitus	Hirsch, 1978 ³⁵
Trisomy 21, Trisomy 13 and Trisomy 18	Blanka Schaumann, 1983 ³⁶
Spinabifida, Cleft lip & Cleft palate	Danuta Z. Loesch ³⁶
Schizophrenia	Amrita Bagga, 1989 ³⁷
Congenital heart diseases	Brigendra 1996 ³⁸
Lung Tuberculosis	Nechava 1996 ³⁸
Diabetes	Roopa Rabindranath 1990 ³⁸
Leprosy	Nagar KS et al 1981, Natekar P E. 1996 ³⁸
Bronchial Asthma	M. Gupta et al 1993; Ozkaragoz 1971 ³⁸
Carcinoma Cervix	Inamdar VV, 2006 ³⁹
Breast Cancer	Natekar PE, 2006 ⁴⁰
Idiopathic (primary) dilated Cardiomyopathy	Oladipo GS, 2007 ⁴¹
Bronchial asthma	Mahajan AA, 2011 ⁴²
Pulmonary Tuberculosis	Khairnar KB, 2012 ⁴³

The Indians who have contributed to the science of Fingerprint^{44, 45, 46}

1. Azizul Haque and Hem Chandra Bose - Played a key role in the advancement of the science of fingerprints and so called Henry's System of Fingerprint Classification was actually worked out by them.
2. Bose - Invented the telegraphic code system for fingerprints. Bose described the system in a book entitled, Hints on Finger-Prints with a Telegraphic Code for Finger Impressions.
3. Azizul Haque - Who helped Edward Henry in creating a mathematical formula to supplement Henry's idea of sorting 10 digit fingerprint forms into a 'pigeon hole' cabinet system based on fingerprint patterns.
4. Salil Chatterjee – Who presented article on Edgeoscopy in 1962. He envisioned an identification process where characteristics along the ridge edge would be compared and evaluated for comparison purposes. These characteristics are the result of the alignment and shape of the individual ridge units as well as the pores close to the edge of the ridge. However, these shapes are only of use when the friction ridges are clearly reproduced in both the latent and the exemplar prints.
5. Sri. N. K. Lahiri - invented a new type of powder with silicon and iodine for developing latent prints on paper.

EMBRYOLOGY OF DERMAL RIDGES

Numerous descriptive studies of epidermal ridge morphogenesis have been reported. Classical descriptions have been reported by Kolliker and others. Additional studies on the origin of epidermal ridges have established that the critical period of primary ridge differentiation is between 11 and 17 weeks. These findings on ridge development have been confirmed more recently by Blechschmidt, Penrose and O'Hara, Okijima, and Babler⁴⁷.

Other scientific studies related dermatological marking developments to the first four months of gestation, according to Dr. Eugene Scheimann⁴⁸ or in the second trimester according to Dr. Theodore J. Berry⁴⁹, Schaumann and Alter⁵⁰ describe the process more accurately and in detail as taking place early in fetal development and being genetically determined while being modified by environmental forces as exemplified by exposure to Rubella⁵¹ and Thalidomide⁵².

According to Schaumann and Alter, the process of dermal ridge formation begins with the formation of fetal volar pads. These are mound-shaped formations of mesenchymal tissue elevated over the end of the most distal metacarpal bone on each finger, in the interdigital areas just below the fingers, and on the hypothenar and thenar areas of the palms and soles. Secondary pads are found in other areas such as in the center of the palm and on the proximal phalanges. The fingertip formations of volar pads are first visible in the sixth to seventh week of development. William J. Babler indicates the epidermal ridges first appear as localized cell proliferation in the basal layer of epidermis around 10th to 11th week of gestation. These proliferations form shallow primary ridges that project into the superficial layer of the dermis. The

number of primary ridges continues to increase, being formed either between or adjacent to existing ridges⁵³. At about 14 weeks the primary ridge formation ceases and secondary ridges begin to form as sweat gland anlagen begin to develop along the apices of the primary ridges at uniform intervals. At this time the epidermal ridges first begin to appear on the volar surfaces. The dermal papillae are reported to develop in the valleys between the ridges on the deep surface of the epidermis around the 24th week. Until then the morphology of primary and secondary ridges appears as a smooth ridge of tissue and thereafter peg like structures, the dermal papillae, characteristic of the definitive dermal ridges are progressively formed⁵⁴.

Babler reports that there is a relationship between the volar pad shape and the epidermal ridge configuration, specifically narrow volar pads related to whorl patterns. There was also a suggestion of association between the shape of the distal phalanx and the pattern type and significant correlations between the bony skeleton of the hand and the epidermal ridge dimensions. It had been believed that the critical period of development of ridge formation began in the fetus of approximately 70-mm crown-rump length, or about 12 weeks of age⁵⁵. The volar pads become visible around the 6th to 7th week of gestation⁵⁶. In addition, clinical evidence supports the finding of arch patterns with shortened distal phalanges or short fingers because of the shortening of their bony parts (brachytactyly)⁵⁷.

ANATOMY OF DERMAL RIDGES⁵⁸

Use skin covers the entire external surface of the body, Skin forms 8% of the total body mass. Its thickness ranges from 13-4.0 mm, according to its state of maturation, ageing and regional specializations. Depending on these features skin is of two types, thin, hairy skin which covers greater part of the body and thick, hairless skin, forming the surface of the palms of the hand, soles of the feet and flexor surface of digits.

FUNCTIONS OF THE SKIN

1. The skin forms a self-renewing interface between the body and its environment, and is a major site of intercommunication between the two.
2. Within limits, it forms an effective barrier against microbial invasion.
3. It has properties which can protect against mechanical, chemical, osmotic, thermal and UV radiation damage.
4. It is an important site of immune surveillance against the entry of pathogens and the initiation of primary immune responses.
5. Skin carries out many biochemical synthetic processes, including the formation of vitamin D under the influence of ultraviolet B (UVB) radiation and synthesis of cytokines and growth factors.
6. Skin is the target of a variety of hormones.
7. These activities can affect the appearance and function of individual skin components, such as the sebaceous glands, the hairs and the pigment-producing cells.
8. Control of body temperature is an important function of skin, and is affected mainly by regulation of heat loss from the cutaneous circulation through the rapid

increase or reduction in the flow of blood to an extensive external surface area; this process is assisted by sweating.

9. Skin is involved in socio-sexual communication and, in the case of facial skin, can signal emotional states by means of muscular and vascular responses.

10. It is a major sense organ, richly supplied by nerve terminals and specialized receptors for touch, temperature, pain and other stimuli. Skin has good frictional properties, assisting locomotion and manipulation by its texture.

11. Skin contains specialized cells which produce the pigment melanin. Melanin has a protective role against ultraviolet radiation, and acts as a scavenger of harmful free radicals.

HISTOLOGY OF THE SKIN^{59, 60}

Skin is composed of epidermis, an epithelial layer of ectodermal origin and the dermis, a layer of connective tissue of mesodermal origin. The junction of dermis and epidermis is irregular, and projections of the dermis called papillae interdigitate with evaginations of epidermis known as epidermal ridges.

EPIDERMIS:-

The epidermis consists mainly of a stratified squamous keratinized epithelium. The keratinizing epidermal cells are called keratinocytes. The thick and thin skin refers to the thickness of the epidermal layer. Thick skin found on the palms and soles. Thin skin found elsewhere on the body. Total skin thickness also varies according to site. The epidermis consists of 5 layers of keratin-producing cells (keratinocytes).

1) Stratum Basale (Stratum Germinativum): Consist of single layer of columnar or cuboidal cells, resting on the basement membrane at dermo-epidermal junction. The stratum basale, consisting of stem cells, is characterized by intense mitotic activity and is responsible, in conjunction with the initial portion of the next layer.

2) Stratum Spinosum: Stratum Spinosum consists of cuboidal, or slightly flattened, cells with a central nucleus and a cytoplasm whose processes are filled with bundles of keratin filaments. Filament filled cytoplasmic spines and desmosomes that punctuate the cell surface, giving a spine-studded appearance.

3) Stratum Granulosum: Stratum Granulosum consists of three to five layers of flattened polygonal cells whose cytoplasm is filled with coarse basophilic granules called keratohyalin granules. This layer acts as a barrier of penetration by foreign materials and provides a very important sealing effect in the skin.

4) Stratum Lucidum: Is present between Stratum Granulosum and Stratum Corneum. It is a translucent, thin layer of flattened eosinophilic epidermal cells and the cytoplasm consists of densely packed keratin filaments embedded in an electron-dense matrix.

5) Stratum Corneum: Stratum Corneum consists of 15-20 layers of flattened non nucleated keratinized cells whose cytoplasm is filled with a birefringent filamentous scleroprotein, keratin. Keratin consist at least 6 different polypeptides.

DERMIS

The dermis is an irregular, moderately dense connective tissue. It has a matrix composed of an interwoven collagenous and elastic network in an amorphous ground substance of glycosaminoglycans, glycoproteins and bound water which

accommodates nerves, vessels and lymphatics. Mechanically, the dermis provides considerable strength to the skin by virtue of the number and arrangement of its collagen fibres and its elastic fibres.

Layers of the dermis:

- 1. Papillary layer (superficial)**
- 2. Reticular layer (deep)**
- 3. Hypodermis**

1. Papillary layer: The papillary layer is immediately deep to the epidermis. The superficial surface of the dermis is shaped into numerous papillae or rete ridges, which interdigitate with rete pegs in the base of the epidermis. In thin skin, especially in regions with little mechanical stress and minimal sensitivity, papillae are few and very small, while in the thick skin of the palm and sole of the foot they are much larger, closely aggregated, and arranged in curved parallel lines following the pattern of ridges and grooves on these surfaces. Lying under each epidermal surface ridge are two longitudinal rows of papillae, one on either side of the epidermal rete pegs through which the sweat ducts pass on the way to the surface.

2. Reticular layer: The reticular layer merges with the deep aspect of the papillary layer. Its bundles of collagen fibres are thicker than those in the papillary layer. The predominant orientation of the collagen fibres may be related to the local mechanical forces on the dermis and thus may be involved in the development of skin lines.

3. Hypodermis: The hypodermis is a layer of loose connective tissue of variable thickness which merges with the deep aspect of the dermis. It is often adipose, particularly between the dermis and musculature of the body wall. It mediates the increased mobility of the skin, and the adipose component contributes to thermal insulation, acts as a shock absorber and constitutes a store of metabolic energy. Subcutaneous nerves, vessels and lymphatics travel in the hypodermis.

THE FUNDAMENTAL PRINCIPLES OF FINGERPRINTS^{61, 62}

1. First principle: Fingerprinting is an individual characteristic: no two fingers have been observed to possess identical ridge characteristic. Even the fingerprints of the twins are not similar. It has been estimated that the chances of two persons having identical fingerprints is about one in sixty four thousand millions.
2. Second principle: A fingerprint will remain unchanged during an individual's lifetime. Though it is not possible to change one's fingerprint, there has been no lack of effort on the part of criminals to obliterate them. If an injury reaches deeply enough in to the skin and damages dermal papillae, a permanent scar will form. For this to happen, such a wound would have to penetrate 1-2 mm beneath the skin's surface. Presence of such permanent scars would serve as a new and additional characteristic for the purpose of identification.
3. Third principle: Fingerprinting has general ridge characteristics that permit them to be systemically classified. Quetelet's rule says that every nature made objects shows infinite variations of forms and in the world's crime records no identical fingerprint patterns have been reported.

CHARACTERISTIC FEATURES OF FINGERPRINTS⁶³

Although it is true that each fingerprint is different from the other, yet it is also true that all fingerprints have common characteristics among themselves. These common characteristics make fingerprint classification possible. Pattern area is that part of a loop or a whorl in which appear the cores (core is the central point of the pattern), deltas (Delta or triradius, the triangular plot formed by the two diverging ridges and the first ridge in front of them within the interspaces as the base.) and ridges which are concerned in classifying.

Dr.Jan Evanjelist Purkinje, a professor of Physiology in the University of Breslau (Germany), in 1823, has classified all fingerprints into nine standard types⁶.

- 1) The Transverse curves.
- 2) The central longitudinal stria.
- 3) The oblique stripe.
- 4) The oblique loop.
- 5) The almond whorl.
- 6) The spiral whorl.
- 7) The ellipse.
- 8) The circle.
- 9) The whorl.

Sir Francis Galton sorted out nine patterns classified by Dr Jan Evangelist Purkinje into three classes namely

- **Arch.**
- **Loop.**
- **Whorl.**

Sir Edward Richard Henry modified Galton's classification and classified into four main groups according to the percentage of their distribution in the whole population of the world (Shown in Fig No.1), these are:-

- **Loop** - **65%**
- **Whorl** - **25%**
- **Arch** - **7%**
- **Composite** - **2-3%**

This method is known as "**Henry Galton method**" or "**Henry method**", its name being derived from its originators Sir Francis Galton and Sir Edward Richard Henry. This Henry system of classification is most efficient and in used universally.

FINGERPRINT PATTERNS⁶³

Fingerprint patterns are determined by the configuration of the ridges appearing on the distal phalange of the finger. It is the shape and direction of the ridges, along with a consideration of type line, delta and core, which constitute a fingerprint pattern.

Table No.03: Different types of fingerprint patterns

Basic Pattern	Pattern Type	Symbol	No of Deltas Present
Arch	Plain Arch	A	Nil
	Tented Arch	T	Nil
Loop	Radial Loop	R	One
	Ulnar Loop	U	One
Whorl	Plain Whorl	W	Two
Composites	Central Pocket Loop	C	Two
	Double Loop		
	Later Pocket Loop	S	Two
	Twinned Loop	S	Two
	Accidentals	X	Two or more than Two

ARCHES

These are characterized by a slight rise (elevation) in the ridges which enter on one side of the fingerprint pattern and exit on the opposite side. The arches are of two types

- 1. Plain arch.**
- 2. Tented arch.**

Plain Arch: This is most simple of all the forms of fingerprint pattern. In plain arches the ridges enter on one side of the impression and flow or tend to flow out on the other side with a rise or wave in the center.

Tented Arch: Tented Arch is the one in which most of the ridges enter upon one side of the impression and flow or tend to flow out upon the other side as in the plain arch type, however, the ridge or ridges exhibit a sufficient upward movement. There are three types of tented arches.

1. In the first type of tented arch, the ridges at the center form a definite angle of 90° or less.
2. In the second type, one or more ridges at the center form an upthrust. An upthrust is an ending ridge of any length rising at a sufficient degree from the horizontal plain, i.e. 45° or more
3. In third type, there are two of the basic or essential characteristics of the loops but lacks the third characteristic.

LOOPS

In terms of fingerprints, as well as in general application of the word loop, there cannot be a loop unless there is sufficient recurve or retrieval of one or more of the ridges along with the other pre-requisites. A pattern must possess several requisites before it may be properly classified as a loop. A loop is that type of fingerprint pattern in which one or more ridges enter on either side of the impression, recurve, touch or pass an imaginary line drawn from delta to core, and terminates on or tend to terminate on or towards the same side of the impression from where such ridge or

ridges entered. A loop has one and only one delta. A pattern is identified as a loop provided it possess the following characteristics:

1. A sufficient recurve.
2. A Delta.
3. A ridge count across a looping ridge.

Loops are subdivided into two main types according to the position and flow of the ridges:

- 1. Radial loop.**
- 2. Ulnar loop.**

Radial loop is so called because the ridges flow or terminate in the direction of Radius bone of the forearm. In case of right hand fingers, the ridges slant towards left and in the left hand fingers, the slant is towards right side.

Ulnar loop is so called because the ridges flow or terminate in the direction of Ulna bone of forearm. In case of right hand fingers, the ridges slant towards right and in the left hand fingers, the slant is towards left side.

WHORLS

A whorl is characterized by a circular pattern having one or more ridges revolve around the core making a complete circle. The whorl is that pattern in which at least two deltas are present with a recurve in front of each delta. This pattern, however, may be subdivided for extension purposes in large groups where whorls are predominant. The subdivisions of whorl pattern are as follows:

- **Plain Whorl.**
- **Central Pocket Loop.**
- **Double Loop.**
 - (1) **Lateral Pocket Loop.**
 - (2) **Twinned Loop.**
- **Accidentals.**

Plain Whorl consists of the simplest form of whorl construction and is the most common of the whorl subdivisions. It has two deltas and at least one ridge making a complete circuit, which may be spiral, oval, circular or any variant of circle. An imaginary line drawn between the two deltas must touch or cross at least one of recurving ridges within the inner pattern area.

Central Pocket Loop is a composite pattern in which most of the ridges take the form of loop. However, one or more ridges recurve around the core to form a center pocket. The circuit may be spiral, oval, circular, or any variant of circle. The central pocket loop has two deltas and falls within the whorl group for the purpose of classification. An imaginary line drawn between the two deltas must not touch or cross any of the recurving ridges within the inner pattern area. In central pocket loop, one or more of the simple recurves of the plain loop type usually recurve a second time to form a pocket within the loop. The second recurve, however, need not be a continuation of, or even connected with the first. It may be an independent ridge altogether.

Double Loops are composite patterns and fall within the whorl group of patterns for the purpose of classification. The double loop consists of two separate and

distinct set of shoulders, and two deltas. The fact that there must be two independent loop formations eliminates from consideration as a double loop the 's' type core, the inter-locking type of core, and the formation with one loop inside another. The two loops of a double loop pattern do not have to confirm the essential requirements of a loop, in other words, no ridge count is necessary. It is not essential that both sides of the loop be of equal length, nor that two loops be of the same size. Neither is it material from which side loop enters. The double loops are of two types- lateral pocket loops and twinned loops.

In Lateral Pocket Loop, one loop serves as side pocket to the other loop. This pocket is formed by the downward bending on one side of the ridges of the other loop before they recurve. The ridges about the centre, the one containing the point of core of the loops have their exit on the same side or delta.

In Twinned loop, there are two distinct loops, one resting upon or encircling the other and their ridges, containing the point of core have their exit towards different deltas.

Accidentals are certain composite patterns within the whorl group as they occur very rarely and are formulated purely by chance. The accidental whorl is a pattern consisting of a combination of two different types of patterns, excepting plain arch, possessing two or more delta formation; or a pattern which possess some of the requirements for two or more different types; or a pattern which confirms to none of the definitions.

RIDGE CHARACTERISTICS⁶⁴

Permanency of the ridge characteristics and their unique distribution by shape, location and direction provides the basis for the premise that no two fingerprints are same except when obtained from the same finger of the same person. In connection with the number of characteristics essential for establishing complete identity, the first All India Forensic Science Congress (1973) held in Srinagar (India) recommended the following resolution regarding the minimum number of ridge characteristics to be considered for establishing positive identity:

“The minimum number of points for establishing the identity beyond doubt in case of fingerprint examination has been fixed as **Eight**. However, where there are six or seven points of identity a qualified opinion can be offered by the expert on his responsibility”.

A single fingerprint may possess as many as hundred and fifty or more characteristic features in the form of fine minute details of the ridges in the complete print area of a finger impression. Each of the characteristic feature or the minutiae is identified through the specific label attached to it according to its construction and alignment in the pattern. Following are the main characteristics of ridge formation commonly found in a fingerprint impression.

- 1. Ridge ending or termination:** This is a ridge placed between two other more or less parallel ridges. It ends abruptly and does not reappear.
- 2. Bifurcation:** It is formed when ridge emerging from one side of the pattern divides for a certain length into two parallel ridges.

3. **Convergence:** It is the mirror image of bifurcation and is formulated when two more or less parallel ridges emerging from one side of the pattern fuse or converge to form a single ridge.
4. **Fork Rightward:** It is formulated when a ridge emerging from the left side of the pattern divide into two and the divided ridges do not continue ahead.
5. **Fork Leftward:** It is mirror image of the fork rightward and is formulated when a ridge starting from the right side of the pattern divides into two and the divided ridges do not continue ahead.
6. **Spur or Hook formation:** It is formulated when a ridge starting from any margin of the print divides into two and only one of the divided ridges continues ahead. The formation of the spur may be rightward up or down and leftward up or down.
7. **Enclosure:** It is formed when a ridge starting from any margin of the print divides into two and the two divided ridges almost immediately converge to form a single ridge leaving a blank space within the ridge.
8. **Lake formation:** A lake formation is a prolonged or elongated enclosure.
9. **Deviated break:** It is an interruption formed by two ridges which, instead of stopping just before they meet suddenly deviate, forming two ridge endings with a furrow between them.
10. **Natural break:** It is formed by the interruption in a ridge. It is in its formation similar to two ridge endings facing each other.
11. **Interjunction:** It is formulated by the junction of two parallel ridges by a short diagonal ridge which meets the parallel ridges at a very acute angle.

- 12. Ridge fragment:** It is a ridge with ends which finishes abruptly. The fragment may be small or large in size and ridge between two parallel ridges or within the same ridge between two ridge endings.
- 13. Point or Dot:** It is a very small fragment of a ridge. Ridge length which is as long as it is wide. It is usually found in the middle of an interruption or delta or between two ridges.
- 14. Intersection:** It is formed when two parallel ridges suddenly intersect each other and continue further.
- 15. Changeover:** It is formed when two parallel ridges change their places. One ridge is interrupted while the other takes its place by passing through the break.
- 16. Ridge return:** It is formed when a ridge starting from one margin of the print suddenly turns upon itself and returns the way it has come, forming a rounded loop without a core.
- 17. Angle formation:** It is a rare character which is sometimes observed close to delta where two ridges join each other at a specific angle or they assume a T-shape.
- 18. Trifurcation:** It is formulated when a ridge starting from any margin of the print trifurcate.

These ridge characteristics have been identified and located by several fingerprint experts. The identification of an individual is possible on the basis of location of these ridge characteristics in the fingerprint. A complete rolled impression of a finger may have as many as 100 to 150 ridge characteristics appearing in variable frequency all

over the print area. Thus, it may be mentioned that even if fragment of a fingerprint is found at the crime scene, it is likely to have sufficient number of ridge characteristics present to establish complete identity.

CLASSIFICATION OF FINGERPRINTS⁶⁵

The fingerprints are of immense help to the law enforcement agencies for the purpose of general identification by means of records (prints) of large number of individuals and for specific identification by means of latent prints (chance prints) left at the crime scene, on weapon or on other objects at the location of crime. The complexity of ridges has led to many complications in developing a proper classification system, as each major feature will be found so greatly diversified as to merge gradually any abrupt transition into another major feature. This ambiguity of definition of a feature has given rise to the major complication in the classification of fingerprints. There are over fifty classification systems in use in different countries, which are based on Galton, Henry and Vucetich systems. The most commonly used system is the Galton-Henry system which is employed in many countries with minor regional changes.

Broadly, classification of fingerprints is of two types:

- 1. Ten Digit Classification.**
- 2. Single Digit Classification.**

TEN DIGIT CLASSIFICATION

Ten Digit Classification are based on the recognition of certain fundamental structures like Arch, Loop, Whorl and Composites. Besides this, the secondary factors, which are of importance, include, the direction of slope of the ridges, the distance between the right and left delta and the core. The ten digit classification is analyzed under the following seven systems.

- 1. Primary Classification System.**
- 2. Major Divisions System.**
- 3. Secondary Classification System.**
- 4. Sub-Secondary Classification System.**
- 5. Second Sub-Secondary Classification System.**
- 6. Final Classification System.**
- 7. Key Classification System.**

PRIMARY CLASSIFICATION SYSTEM

The percentage of plain arches, tented arches and composite patterns is of relatively low in comparison to the frequency of loop and whorl patterns. Thus, for the purpose of primary classification system, plain arch and tented arch have been grouped under loop types and composite patterns under whorl types.

The ten fingers of the two hands are grouped in five pairs in the following manner.

Pair includes Right Thumb and Right Index (RT & RI).

Pair includes Right Middle and Right Ring (RM & RR).

Pair includes Right Little and Left Thumb (RL & LT).

Pair V includes Left Index and Left Middle (LI & LM).

Pair V includes Left Ring and Left Little (LR & LL).

For arriving at the primary formula, the second part of each pair is taken for the numerator while the first of each pair is taken for denominator. On taking the second of each pair as numerator and first of each pair as denominator the arrangement of the digits will be as under:

RI+RR+LT+LM+LL

RT+RM+RL+LI+LR

For practical purposes, different numerical values have been assigned to the patterns according to their occurrence in different pairs. The loops (including arches) have zero value in the primary classification system. Whereas whorl along with composite are assigned certain numerical values according to their occurrence in different pairs.

In first pair they are assigned numerical value 16, in second pair 8, in third pair 4, in fourth pair 2 and fifth pair 1.

In numerator and denominator positions, 1 score is added for convenience of calculation. Thus, if whorl or composite is present in all the ten fingers then counting will be as follows:

$$\begin{array}{r} 16+8+4+2+1+1 \\ \hline \end{array} = \begin{array}{r} 32 \\ \hline \end{array}$$
$$\begin{array}{r} 16+8+4+2+1+1 \\ \hline \end{array} = \begin{array}{r} 32 \\ \hline \end{array}$$

At the next stage the total score at the numerator is multiplied by the total score at the denominator. This gives a maximum of $32 \times 32 = 1,024$ score.

If no whorl is present in any of the fingers, then the score distribution will be:

$$\begin{array}{r} 0+0+0+0+0+1 \\ \hline \end{array} = \begin{array}{r} 1 \\ \hline \end{array}$$
$$\begin{array}{r} 0+0+0+0+0+1 \\ \hline \end{array} = \begin{array}{r} 1 \\ \hline \end{array}$$

This gives a minimum of $1 \times 1 = 1$ score.

This way, due to presence or absence of whorl in fingers any number from 1 to 1,024 can be the total score. On the basis of this scoring, a total of 1,024 boxes are made which are termed “pigeon holes”. According to the total score of a person his fingerprint is preserved in the box, bearing the same number.

In 60% of the world population, there is no whorl in any finger. For all of them the score on primary classification is 1. But there are other subsequent classifications

which distribute the fingerprint efficiently, so that, when necessary for comparative study with another, the desired fingerprint can be very easily and quickly searched.

When any particular finger is so deformed that the pattern cannot be identified at all or missing altogether and no impression can be recorded for such a finger, the space is left blank. While classifying such impression for primary classification, the following regulations are followed:

1. When one finger is damaged or missing, the pattern of such a finger is labeled according to the type of pattern occurring on the corresponding finger of the other hand and classification is made.
2. If same digits of both the hands are missing or damaged, the pattern for such fingers is taken as whorl type for the purpose of primary classification.

MAJOR DIVISIONS SYSTEM

The major divisions are created by counting the ridges in loop patterns and by tracing the whorl patterns on the thumbs only for both the right and left hands. The loop patterns on the thumb have been subdivided into three categories (or groups) according to the number of ridges counted between the delta and the core of a loop. The categorization of loops on thumb is made in the following manner:

1. All loops on thumbs with ridge count between 1-12 are identified as 'I' type.
2. All loops on thumbs with ridge count between 13-19 are identified as 'M' type.
3. All loops on thumbs with ridge count 20 and above are identified as 'O' type.

Depending upon the ridge tracing (Once the deltas are identified and located, the procedure of ridge tracing involves the tracing of the ridge that emanates from the lower side of the left delta until the point nearest or opposite the extreme right delta is reached), the whorl and composite patterns are grouped as ‘I’ (if the ridge traced passes inside or above the right delta and three or more ridges intervene between the tracing ridge and delta, tracing is said to be inner, designated as ‘I’), ‘M’ (if the tracing ridge beginning with the left delta exactly meets the right delta or passes within the two ridges above or below the right delta, the whorl is said to be meeting, designated as ‘M’) and ‘O’ (if the ridge traced beginning with left delta passes outside or below the right delta and three or more ridges intervene between the tracing ridge and the right delta, the tracing is said to be outer, designated as ‘O’).

For major divisions, the type of pattern on the right thumb is taken as numerator and left thumb for denominator. Thus, with three types we obtain the following nine combinations.

Table No.04: Showing Loop patterns on the thumb subdivided into 3 categories

RT/LT	RT/LT	RT/LT
I/I	M/I	O/I
I/M	M/M	O/M
I/O	M/O	O/O

Thus, the value of major divisions would fluctuate between I/I to O/O types.

SECONDARY CLASSIFICATION SYSTEM

For the secondary classification system, the patterns appearing on “Index Fingers” of the right and the left hand are considered. The nine pattern types- PLAIN ARCH, TENTED ARCH, RADIAL LOOP, ULNAR LOOP, WHORL, CENTRAL POCKET LOOP, LATERAL POCKET LOOP (DOUBLE LOOP), TWINED LOOP (DOUBLE LOOP) and ACCIDENTALS—are represented by the following eight symbols: A, T, R, U, W, C, S, S and X. For arriving at secondary classification the patterns occurring on the Right Index finger are taken as numerator and the Left Index finger for denominator. These eight types of pattern symbols would provide 64 possible combinations of Right Index/Left Index.

Thus, the secondary formula for any individual would fluctuate between A/A type to X/X type. For representing this formula capital symbols are used.

SUB-SECONDARY CLASSIFICATION SYSTEM

Classification of prints under Sub-Secondary system can be made under following headings:

- 1. Lettered Group Method.**
- 2. New Method of Ridge Counting and Ridge Tracing.**

These subdivisions are based on the occurrence of patterns on the Index, Middle and Ring fingers of the right and left hands.

Lettered Group Method:

Whenever plain arches, tented arches and radial loops occur on any finger other than the Index finger the prints are classified under Lettered Group. The type of the pattern is recorded by employing small alphabetic symbols in the sequence of their appearance.

Table No.05: Showing Lettered Group Method

Thumb	Index	Middle	Ring	Little	Main Number
a	A	-	-	-	I
a	A	a	-	-	II
a	A	a	a	-	III
a	A	a	-	a	IV
a	A	a	a	a	V
a	A	-	a	-	VI
a	A	-	a	a	VII
a	A	-	-	a	VIII
-	A	-	-	-	IX
-	A	a	-	-	X
-	A	a	a	-	XI
-	A	a	-	a	XII
-	A	a	a	a	XIII
-	A	-	a	-	XIV
-	A	-	a	a	XV
-	A	-	-	a	XVI

The Roman numbers are noted in addition to the lettered formula to avoid any kind of confusion in recording and for quick searching. Taking 16 groups each for the right and the left hand the total number of possible combinations would be $16 \times 16 = 256$, when the pattern on the index finger (as fulcrum) is identified as A. Thus on taking T and R patterns on the index fingers as fulcrum, we would get 256 possible combinations for each T and R respectively. For arriving at the lettered formula the patterns on the right hand fingers are taken as numerator and the left hand fingers as denominator.

New Method of Ridge Counting and Ridge Tracing

Index Finger

1. All loops with ridge count between 1-5 are identified as 'I' type.
2. All loops with ridge count between 6-12 are identified as 'M' type.
3. All loops with ridge count 13 and above are identified as 'O' type.

Middle Finger

1. All loops with ridge count between 1-6 are identified as 'I' type.
2. All loops with ridge count between 7-13 are identified as 'M' type.
3. All loops with ridge count 14 and above are identified as 'O' type.

Ring Finger

1. All loops with ridge count between 1-7 are identified as 'I' type.
2. All loops with ridge count between 8-14 are identified as 'M' type.

3. All loops with ridge count 15 and above are identified as ‘O’ type.

The whorls are grouped into I, M and O type according to their tracing. Plain arches and tented arches existing on Index Finger are taken as ‘I’ type loops for the purpose of classification.

The whorl and loop patterns existing on the Index, Middle and Ring fingers would provide the following eight combinations:

Table No.06: The eight combinations of whorl and loop patterns existing on the Index, Middle and Ring fingers

Groups	Index	Middle	Ring
1	L	L	L
2	L	L	W
3	L	W	L
4	L	W	W
5	W	L	L
6	W	L	W
7	W	W	L
8	W	W	W

As both the pattern types i.e. loops and whorls are subdivided into I,M and O types, each of the eight groups would provide twenty seven possible combinations

SECOND SUB-SECONDARY CLASSIFICATION SYSTEM

In a huge collection of fingerprints under a specific sub-secondary system, it is essential to incorporate the use of second sub-secondary system to split them into smaller groups so as to save time in searching a particular fingerprint slip. The value of second sub-secondary is achieved by identifying the patterns on the Middle and the Ring fingers only by representing them through symbolic small alphabets (letters) in the following manner.

Table No.07: Showing second sub-secondary system

Pattern type	Alphabetic symbol
1. Invaded or Crested Ulnar Loop	k
2. Nutant Ulnar Loop	n
3. Plain Ulnar Loop	u
4. Whorl	w
5. Central Pocket Loop	c
6. Double Loops	s
7. Accidentals	x

For arriving at the formula of second sub-secondary system, the pattern types occurring on the right hand Middle and Ring fingers are taken for numerator and the left ones for denominator.

The invaded loop, the crested loop and the nutant loop patterns which are utilized in the second sub- secondary system may be identified as follows:

An Invaded Ulnar Loop is a pattern which represents an appearance as though a series of ridges were swarming (passing) over the pattern coming from the direction of delta and trying to engulf the loop.

A Crested Ulnar Loop is a pattern in which the ridges swarms over the pattern and merge there to form a sort of crest over the pattern area.

A Nutant Loop (or Indented Loop) is a pattern in which a loop assumes the appearance of a sickle, or the core line exhibits a bent near the point of core. Such loops are identified as Nutant loops.

FINAL CLASSIFICATION SYSTEM

The final classification system of the Ten Digit Classification is made by recording the ridge count of loop and whorl patterns on the little fingers exclusively.

The ridges of a whorl are to be counted from Left delta to the core in case of Right little finger and from Right delta to the core in case of Left Little finger.

In case of Double loop patterns the ridges are to be counted between the Left delta and the core of the ascending loop for right little finger and between right delta and the core of the ascending loop for left little finger.

In case of loop patterns the ridges are counted in the usual manner, i.e. between the core and the delta.

KEY CLASSIFICATION SYSTEM

Key classification system involves the ridge counting of loop or whorl patterns appearing on the Right Thumb only. For the purpose of recording the value of the key system the ridge count is specified followed by the pattern type in small alphabetic symbols which were used under the second sub-secondary system, i.e. k, n, u, w, c, s and x.

The value of the key system is placed at the extreme left of the complete classification formula in line with numerator.

The system of ridge count in case of whorl and double loop pattern is the same as that followed in the final system, i.e. for whorls between left delta and core, and for double loops between the left delta and the core of ascending loop.

SINGLE DIGIT CLASSIFICATION SYSTEM

The Single Digit Classification System was felt necessary because of the availability of chance prints at the crime scene, where many a time only part of print is left. In case of one or two chance prints which may be partial or complete, it is extremely difficult to utilize the Ten Digit Classification System for establishing identity of a criminal. Therefore, a strong need to have such a system developed was felt through which the chance prints could, without much complications, help in establishing the identity. As a result a new system of classification was developed on the basis of certain characteristics for individual digits. This new system was named as Single Digit Classification System.

In most countries, the different systems in use were replaced by Battley's system which was found to be most effective one. Under this system single digit impressions are classified with the help of special magnifying lens having a fixed focus and a window at the base. The center of the window is marked by a spot around which seven concentric circle of 3, 5, 7, 9, 11, 13, and 15mm radius are inscribed respectively. For analyzing a chance print, different pattern, position of delta in relation to the center, which is placed about the core, ridge tracing and other peculiarities are noticed for sub classification.

Circle Reading of Delta

This is obtained with the center spot of the glass placed on the summit (top) of the first recurving ridge constituting the core, and by noting the circle in which the left hand or the right hand delta appears. If the delta does not appear in any of the seven circles A to G, it belongs to H group. In practical the center spot should be placed so that it is not superimposed on but in contact with the first recurving ridge.

Circle Reading of Cores in Whorls and Central Pockets

The center spot of the lined glass should be placed on the summit (top) of the first recurving ridge constituting the core and classify the prints as A, B, C, D, E, F, G or H according to the circle in which the bottom of the first recurving ridge of the core appears.

AUTOMATED FINGERPRINT IDENTIFICATION SYSTEM (AFIS)

The Henry system and its sub classifications have proven to be a cumbersome system for storing, retrieving and searching for fingerprints, particularly as fingerprint collection enlarges. The manual approach was the only viable approach to the maintenance of fingerprint collection till the emergence of fingerprint technology. Since 1970, technology advances have made possible the classification and retrieval of the fingerprints by computers.

The heart of AFIS technology is the ability of a computer to scan and digitally encode fingerprints so that they can be subjected to high speed computer processing. The AFIS uses automatic scanning devices that convert the image of a fingerprint into digital minutiae that contains data showing ridges at their points of termination (ridge ending) and the branching of ridges into two ridges (bifurcations). The relative position and the orientation of the minutiae are also determined, allowing the computer to store each fingerprint in the form of a digitally recorded geometric pattern. The computer search determines the degree of correlation between the location and relationship of the minutiae for both the search and the file prints. In this manner, a computer can make thousands of fingerprint comparisons in a second. During the search for a match, the computer uses scanning system that assigns prints to each of the criteria set by an operator. When the search is complete, the computer then produces a list of file prints that have the closest correlation to the search prints. The final verification is made by trained fingerprint expert who will examine all the selected prints. Prior to the AFIS, police were usually restricted to searching crime scene fingerprints against those of known suspects. Now with the speed and accuracy

of ten fingerprints processing by AFIS it is possible to search latent crime scene fingerprints against an entire file's print collection database.

AFIS has brought a fundamental change in the way criminal investigators operate, allowing them to spend less time in developing suspect lists and more time in investigating the suspects generated by the computer.

METHODS OF DETECTING FINGERPRINT^{66, 67, 68, 69}

Fingerprints from a crime scene are crucial in determining a possible suspect. All the objects at the crime scene should be considered as possible sources of fingerprints.

There are three types of prints found at a crime scene:

1. **Visible Prints**, while visible prints are made by fingers touching a surface after the ridges have been in contact with a colored material such as blood, grease, ink or paint.
2. **Plastic Prints**, are ridge impressions left on a soft material such as wax, putty, soap or dust.
3. **Latent Prints**, are impressions caused by the transfer of body perspiration or oils present on finger ridges to the surface of an object.

Finally locating a plastic or visible print at the crime scene is usually a simple task because it is usually visible to the eye. However, finding latent or invisible prints is much harder and requires the utilization of techniques that will help visualize the print.

There are several different methods for visualizing a latent print; the one of choice depends on the surface that is to be examined.

A. Fingerprint Development from nonporous Surfaces:

Fingerprints on nonporous surfaces like glass, gloss-painted surfaces, metal and plastic can be very easily damaged as most of the trace residues deposited from the fingerprint ridges usually remain on the surface. Development techniques includes

1. Visual examination: Visual examination of any article may sometimes reveal latent fingerprints, particularly if the surface is smooth and dean. A variety of light sources should be used, e.g. oblique illumination. Any fingerprints should be photographed before proceeding with other techniques.

2. Fluorescence examination: Examination of surfaces with a high intensity tight source or laser, usually working in the near UV, blue or green parts of the spectrum and using barrier filters in front of the eyes, will sometimes reveal fingerprints either by die rarely observed fluorecence of naturally occurring components of the latent fingerprint, or more often by the florescence of some contamination which may have been on the finger such as oil or grease.

3. Vacuum metal deposition (VMD): This is the most sensitive, being capable of detecting monolayers of fat by sequential deposition of a very thin coating of thermally evaporated gold followed by zinc. Plastic wrapping materials up to about 1000mm x 1000mm and other small solid objects may be treated in specially modified industrial vacuum coating systems. VMD has the great advantage that it can develop fingerprints on surfaces that have previously been wet or even submerged in water for

extended periods of time. If fingerprints are not revealed by VMD, superglue, powders or other techniques may be used subsequently.

4. Fingerprint powders: Powdering is one of the oldest techniques for detecting fingerprints on smooth non-porous articles is quite effective and widely used; many latent fingerprints are still found by this simple method. There are many powders such as milled aluminium or brass, or molybdenum disulfide are significantly more sensitive and generally more effective at developing fingerprints on smooth, clean surfaces than the more traditional black or white powders which are of a more granular nature. The metallic flake powders are most effectively applied with a fine glass fiber brush. Surfaces which are dirty or contaminated will sometimes take up too much of the flake powders all over the surface so that granular black or white powders may be more suitable. Rough or grained surfaces may sometimes be treated using iron, cobalt or nickel based powders used with a magnetic applicator although superglue fuming is probably to be preferred.

5. Superglue fuming method: Super Glue fuming produces a white-appearing latent print. Super Glue is approximately 98 to 99 percent cyanoacrylate ester, and it's this chemical that actually interacts with and visualizes a latent fingerprint. Cyanoacrylate ester fumes can be created when Super Glue is placed on absorbent cotton treated with sodium hydroxide or by heating the glue. The fumes and the suspect material are contained within an enclosed chamber for up to 6 hours.

6. Small particle reagent (SPR): SPR consists of a suspension of molybdenum disulfide suspended in an aqueous detergent solution. This is used by

agitating the reagent mixture so that the particles are temporarily suspended in the liquid and holding the article to be treated under the liquid allowing the molybdenum disulfide particles to deposit onto the surface. The article is gently removed and drawn through a container of clean water. The molybdenum disulfide particles adhere to fats deposited in the fingerprint, producing a gray-black image.

B. Fingerprint Development from Porous Surfaces:

The most common porous surfaces examined for fingerprints include paper, wall paper; cardboard and matt emulsion painted surfaces. The reagents used for these surfaces react either with amino acids, traces of fats and lipids or chlorides absorbed into the surface.

Development techniques on porous surface would be: visual examination; fluorescence examination; powders; superglue fuming; DFO; ninhydrin; physical developer.

1. 1,8-Diazafluoren-9-one (DFO): The most sensitive reagent currently available for detecting fingerprints on porous surfaces is DFO. This compound reacts with amino acids deposited in the fingerprints to produce a faintly colored but intensely fluorescent compound which can be easily photographed.

2. Ninhydrin: This is a widely used process which reacts with amino acids and produces a purple colored product. Articles are dipped into a solution of ninhydrin and acetic acid in an inert carrier solvent and then heated in a humid atmosphere for rapid fingerprint development, the optimum conditions are 65% relative humidity and 80°C for 3-4 minutes. The developed purple colored fingerprints can be easily recorded using conventional photography.

3. Physical developer (PD): the only available technique for detecting fingerprints is PD when a porous surface has been wet. This reagent is an aqueous solution of silver nitrate containing a Fe(II)/ Fe(III) redox couple and two detergents. The exact reaction mechanism is unknown although it may detect intercalated sodium chloride molecules present in the small amounts of fat deposited in the absorbed fingerprints. The developed fingerprints are gray black in color and can be recorded using conventional photography.

C. Other methods include:

1. Iodine Fuming Method: The oldest method is iodine fuming which is based on the fact that iodine has the property to sublime. Iodine is a solid crystal that, when heated, is transformed into a vapor without passing through a liquid phase. The suspect material is usually placed in an enclosed cabinet with iodine crystals. When heated, the vapors will combine with the constituents of the latent print and make it visible.

2. Osmium Tetroxide Method: This method depends upon the presence of fatty acids in the perspiration. Osmium tetroxide in the presence of fatty acids is reduced to free Osmium which is dark in colour like most of the finely divided metals. This method is best for recently made prints and not for the several months old prints.

3. Chem Print Method: Chem Print is a trade name of solution which is marketed commercially in an aerosol-type container for ready use. It has been used

successfully by many police agencies in the development of latent prints on cardboard and all other paper products, wood, fabrics and other allied materials. The solution is sprayed on all sides of the material thoroughly by holding the dispenser roughly 8 inches from the evidence surface and it is allowed to dry. The dried material is subjected to 94⁰C approximately for rapid development of latent prints. It takes several hours for development. Fresh prints become visible earlier than the old prints. The developed prints should be photographed as soon as possible.

4. Hydrofluoric Acid method: Hydrofluoric Acid method is used for the development of latent fingerprints on glass. The area between the ridges is etched (leaten away) by the acid. The waxy substance of the print itself repels the liquid.

5. Tannic Acid Method: A 10% solution of tannic acid is used to set the albumin content, which is present in perspiration, thereby making the latent print visible.

6. Mercuric Iodide Method: By using the fumes of mercuric iodide latent prints on paper and other allied materials can be developed. The fumes of mercuric iodide may be obtained by heating a mixture of 4 parts of mercury and 5 parts of iodine in a dish. The suspected material is run across the fumes of mercuric iodide, for development of latent prints.

7. Bromine Method: Bromine, in vaporous form, may be used as a developer of latent prints on paper and other allied materials.

8. Reducing Agents for Developing Latent Prints: Organic reducing agents like amidol, pyrogallol or hydroquinone may also be used for developing the latent prints. The reducing agent is brushed on the surface where the latent print is suspected. A piece of photographic film is pressed against the brushed surface. The film is then developed in ammonia and water vapours before it is fixed.

9. Fleming's Reagent Method: Fleming's Reagent is a mixture of osmic acid, chromic acid and glacial acetic acid. This reagent is used to develop latent impression on the basis of presence of fatty acids in perspiration. The suspected material is treated with Fleming's Reagent and when the vapours of the reagent penetrate the fatty deposits, the metallic salts are reduced to metals. The material is then soaked in Diazine fast yellow dye or Berbarine or a colourless dye which fluoresces in ultra-violet light. The background glows brightly while the metallic salts on the print area gives a crisp black image. The print should be photographed immediately.

10. Lazer method: Lazer method was developed by Ontario Provincial Police and Xerox Research Center in Canada. Lazer takes the advantage of the fact that perspiration contains a variety of component that fluoresces when illuminated by lazer light. The light emitted can be either viewed directly or recorded photographically through specially selected filters^{70, 71}.

11. Radiology: Recently an X-Ray method was evolved for developing fingerprints on the skin of the victim based on technique of Electronography. In this method lead powder is deposited on the skin where the suspected prints are found

and X-Ray beams are focused on the print. This is followed by taking X-Ray plates photographs. This method is applicable on dead body only⁷².

12. Bacteriological method: A microbiological technique for visualization of latent prints has been discovered. This one utilises the ability of a strain of *Acinetobacter Calcoaceticus*, to proliferate on the material present in the print deposit. When the bacteria are brought in contact with a print, under the appropriate conditions, they multiply and form colonies on the ridges. As a result of this growth, the characteristic fingerprint pattern becomes apparent⁷³. Other new chemicals used in the lifting of the fingerprint are as follows:

- a. **Benzo (F) Ninhydrin**
- b. **1-2 Indanedione**
- c. **Cds Nanocrystal**
- d. **Lanthanide.**
- e. **Zinc Chloride Solution**
- f. **Nonpolar Ninhydrin**
- g. **5-Methylthioninhydrin (5-MTN)**
- h. **2-Isononylninhydrin (INON, Thermanin)**

AGE OF LATENT PRINT

In forensic studies it is essential to identify the age of the latent print, found on crime object, certainly under laser illumination. The colour of the fresh print differs from that of the old print. This difference must have arisen from chemical

transformation of luminescent components in the latent print. An attempt has been made to study the stability of the components of palmar sweat which is responsible for the cause of latent prints that allow the estimation of the age of latent prints, when analysed by TLC and HPLC method.

PRESERVATION OF DEVELOPED PRINT

Latent prints which have been visualized must be permanently preserved for future comparisons and possible court evidence. A close-up photograph can be taken preferably with a fingerprint camera.

Prints on large immovable objects that have been developed with a powder can best be preserved by lifting with a broad adhesive side of the tape and pulled up. This type is then placed on a properly labelled card, this provide a good background contrast wide the powder.

Nowadays computer can scan and digitally encode finger prints. The computer uses a scanning system for search. The automatic fingerprint identification system (AFIS) has drastically reduced the time required for matching and issuing reports by fingerprint expert.

More researches are being done on new methods of recording latent fingerprints. The Japanese are using the method of autoradiography using radioactive carbon C14.

RECENT ADVANCES IN FINGERPRINT TECHNOLOGY^{74, 75, 76, 77}

- ❖ A new method called micro-X-ray fluorescence, or MXRF - Here the detection of fingerprints based on elemental composition using micro-X-ray fluorescence.
- ❖ Minutiae Interoperability Exchange Test (MINEX) - Here Minutiae templates (fraction of the size of fingerprint images) are used which require less storage memory and can be transmitted electronically faster than images.
- ❖ The Personal Digital Assistant (PDA) device - It capture, fingerprints from the dead, which is helpful in cases of mass fatalities.
- ❖ Diagnostic 3D ultrasound of fingers - Used for biometric identification based on matching paired images using internal fingerprint structures that would be difficult to fake, offering the possibility of a unique automated fingerprint identification system.
- ❖ Surface-enhanced Raman spectroscopy (SERS) - can able to detect latent prints on human skin based agents to visualize latent prints.
- ❖ A new technology developed at Purdue University that detects trace amounts of explosives, drugs or other materials left behind in the prints. The new technology also can distinguish between overlapping fingerprints left by different individuals.
- ❖ By looking for compounds known to be present in a certain fingerprint, it is possible to separate it from the others and obtain a crystal clear image of that fingerprint. The image could then be used with fingerprint recognition software to identify an individual.

- ❖ A new approach to fingerprinting mummified fingers involves removal and rehydration of the finger pads (including the epidermal, dermal, and adipose tissues) followed by inking and rolling, using a gloved finger for support. The technique produces a superior quality of print without amputation of the finger, yielding excellent results and assisting in obtaining positive identification.
- ❖ New advanced optical imaging technique including CCD cameras, Near Infrared Imagers, Ultraviolet Imager and Acoustic Optical Tunable Filters are used.
- ❖ Time resolved imaging is a relatively new forensic procedure for detection and imaging of latent fingerprint on fluorescent substrate, like paper, cardboard and fluorescent paint. Ordinary fluorescent imaging of latent fingerprint on these surfaces result in poor contrast – instead the specimen are treated with a phosphorescent dye that preferentially adheres to the fingerprint which allows time resolved discrimination between the fingerprint phosphorescence and the background fluorescence.
- ❖ Researchers in Isreal Home Police have found that fingerprints on adhesive tape can be used for DNA fingerprinting. This probable source of DNA is from shedded skin cells.
- ❖ Eosin blue dye along with a phase transfer catalyst (t-tetrabutylammonium iodide) has been used to detect latent fingerprint on a wide range of surfaces including paper, glass steel, lamination sheet, polythene, plastic and Bakelite. A red coloured complex is deposited along the ridges within one minute, making the latent prints visible.

PRACTICAL APPLICATION OF FINGERPRINTS⁶²

- 1) Recognition of chance impression left at a scene of crime.
- 2) Criminals often leave their fingerprints at the site of crime, unknowingly or unconsciously, which, though not apparently visible, can subsequently be developed and studied successfully.
- 3) They can be taken even from a decomposed body, either from the peeled-off epidermis of the fingers or from the dermis when the epidermis is lost.
- 4) To apprehend internationally operating criminals, details of fingerprints can be sent from one country to another by telecommunication.
- 5) Prevention of impersonation.
- 6) As an extra precaution on cheques, bank notes and other legal documents that may bear a fingerprint in addition to manual signature.
- 7) In case of unknown dead bodies, skin from finger tips should be removed and preserved in 10% formalin and handed over to police in a sealed packet for onward transmission for evaluation
- 8) As with fingerprints, the skin pattern of palms, soles and even lips, are said to be unique and have been used in identification.

SOURCE OF DATA:

Data will be collected from students and staff belonging to South Indian origin (Karnataka, Andhra Pradesh, Tamil Nadu, Kerala) of J.N.Medical College, Belgaum.

METHOD OF COLLECTION OF DATA:

Study design: A cross sectional study.

Study period: From November 2010 to November 2011.

Sample size:

For this type of study to discriminate between general groups using Like hood Ratio sample size of 100 will be required for each of the gender.

Total: 200 (100males and 100 females).

Inclusion criteria: Students and staff belonging to South Indian origin (Karnataka, Andhra Pradesh, Tamil Nadu, Kerala) of J.N.Medical College , Belgaum.

Exclusion criteria: Subjects with history of Celiac disease, Dermatitis, Eczema, AcanthosisNigricans, Scleroderma, Dry or Atrophic skin, Rickets , Acromegaly and Leprosy⁷⁸.

Method of collection of data:

Informed expressed consent will be taken and a pre-tested proforma specially designed for this purpose will be used for collecting the information.

Instruments used for data collection(Shown in Fig No.2 & 3):

Printers black Ink, glass plate, roller, horseshoe lens, pencil, measuring tape, pin and proforma.

The subjects will be properly explained about the objectives of the intended study. They will be asked to wash and dry their hands to remove dirt and greese. For collection of fingerprints, a plate of about 12x12 inches will be cleaned and uniformly smeared with a thin layer of black printer ink by using the roller. After that subject

will be asked to apply their finger on the smear plate and then transfer on the duly prepared fingerprint card, keeping in mind the need to minimise possible technical sources with regular pressure on the pro forma. In this way for each and every individual the entire prints of ten fingers will be prepared. Only plain prints will be taken (no roll prints).

After taking fingerprints, the upper portion of radial border of each print will be chosen as an area for data collection because all fingerprint pattern types show a similar ridge flow in this region. The cores of loops and whorls pattern are away from this region. In this selected areas of prints, epidermal ridges of both males and females will be counted carefully within a square of 5mm X 5mm drawn on a transparent film fixed to the lens. Counting will be started from one corner of the square to the diagonally opposite corner. Some specific criteria will be observed during the counting procedure such as the dots, which will not be counted, and the handle of the fork and a lake will be counted as two ridges. Hence this value will represent the number of ridges/25mm² and will reflect the ridge density value.

Analysis Plan:

Value was obtained for all 10 fingers and the mean will be calculated. This mean represents a single data point for that particular individual. The data are assumed to be normally distributed. Specific comparison of means will be made and calculations will be performed using SPSS, version 16.0, statistical analyses programme (SPSS Inc., Chicago, IL, USA). Posterior probability inferences of gender, based on ridge density values will be made by calculating the likelihood ratio (LR) based on the Baye's theorem⁷⁹. The favoured odds will be computed.

$$LR = \frac{\text{Probability of a given finger print originating from a male contributor (C)}}{\text{Probability of a given finger print originating from a female contributor (C1)}}$$

$$\text{Probability of a given finger print originating from a female contributor (C1)}$$

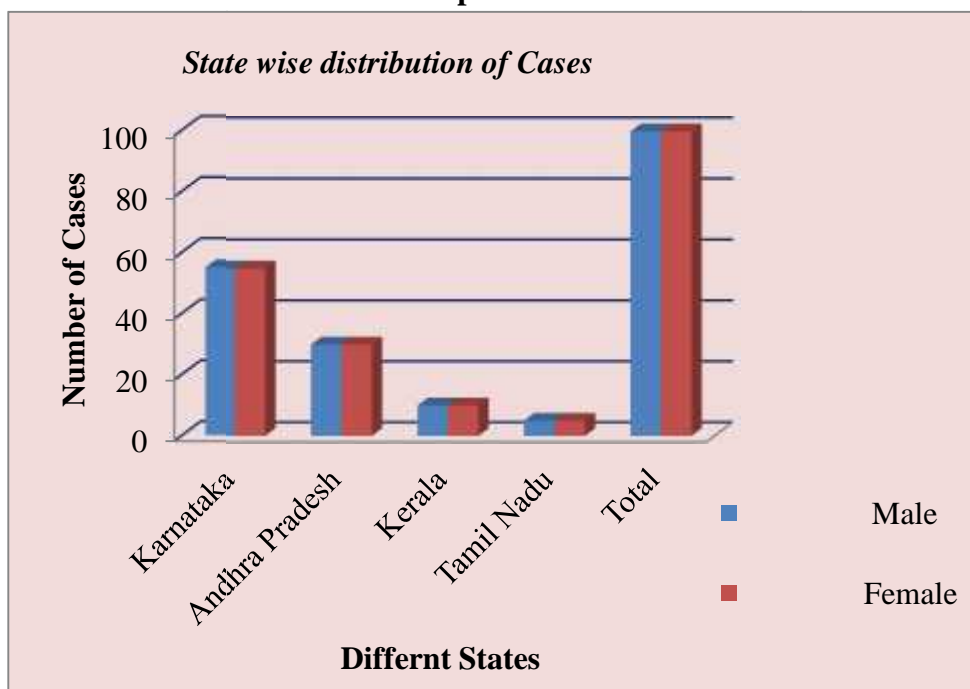
We have collected fingerprint from the students and staff belonging to South Indian origin (Karnataka, Andhra Pradesh, Tamil Nadu, Kerala) of J.N.Medical College, Belgaum, from November 2010 to November 2011 between the age groups of 18 to 65 years.

Maximum numbers of cases were from Karnataka; least numbers of cases were from Tamil Nadu(Shown in Table No.08 and Graph No.01).

Table08: State Wise Distribution of Males and Females

State Wise Distribution	Male	Female
Karnataka	55	55
Andhra Pradesh	30	30
Kerala	10	10
Tamil Nadu	05	05
Total	100	100

Graph No: 01



Study sample consists of equal number of males (100) and females (100)(Shown in Table No.09 and Graph No.02).

Total 09: Sex wise distribution

Sex	Male	Female
Total number	100	100

Graph No: 02

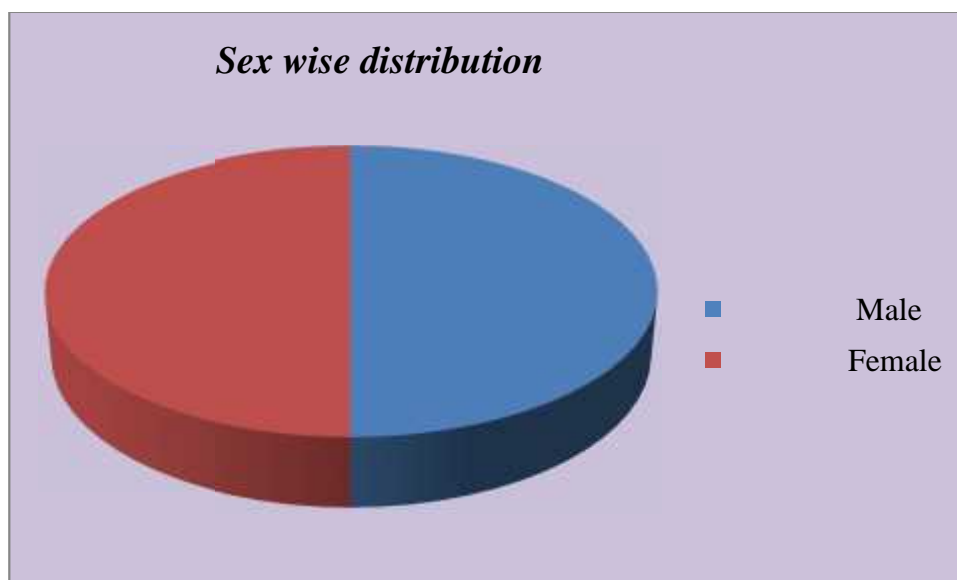


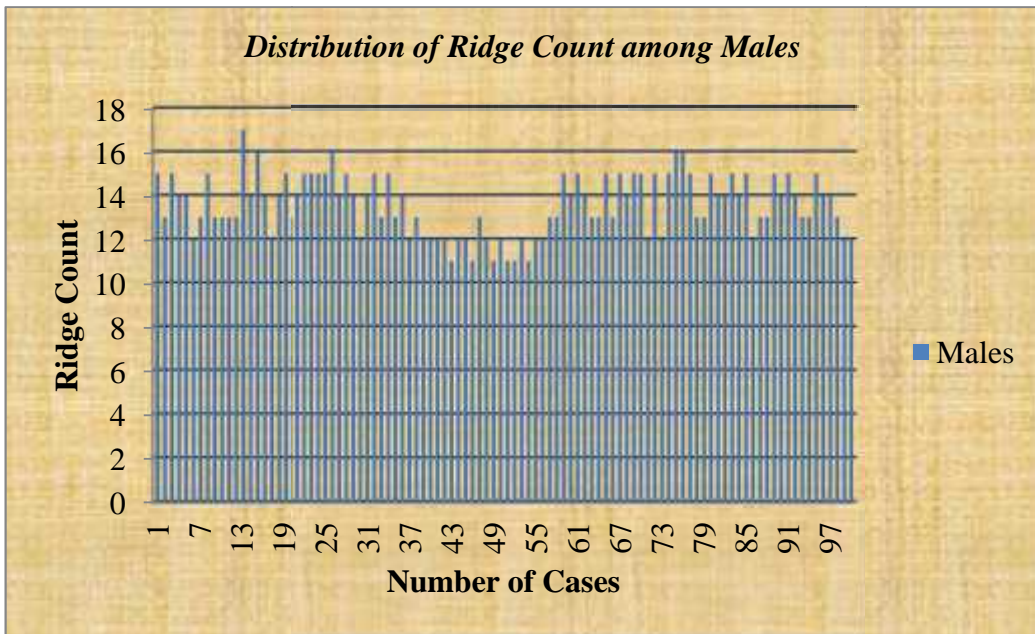
Table No.10 shows that Females tend to have high ridge density compared to the males. It is clear from the table that male with ridge count 15 ridges/25mm² constitute 89% of total males whereas female with ridge count 16 ridges/25mm² constitute 75% of total female subjects. On the other hand no female subjects are found with ridge count less than 13 ridges/25mm² and no male subjects are found to have ridge count more than 18 ridges/25mm².

Table No. 10: Distribution of Ridge Count among Males and Females

Ridge Count	Male		Female	
	No of Cases	%	No of Cases	%
11	06	06	-	-
12	20	20	-	-
13	23	23	-	-
14	20	20	06	06
15	26	26	07	07
16	04	04	29	29
17	01	01	24	24
18	-	-	22	22
19	-	-	07	07
20	-	-	03	03
21	-	-	02	02
Total	100		100	

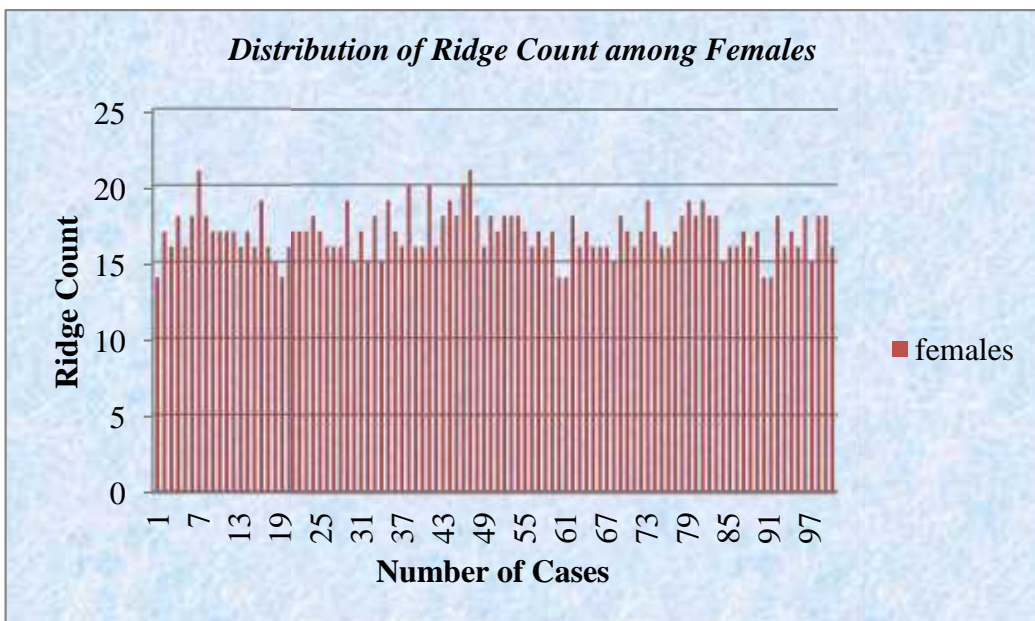
Distribution of Ridge Count among Males shown in Graph No: 03

Graph No: 03



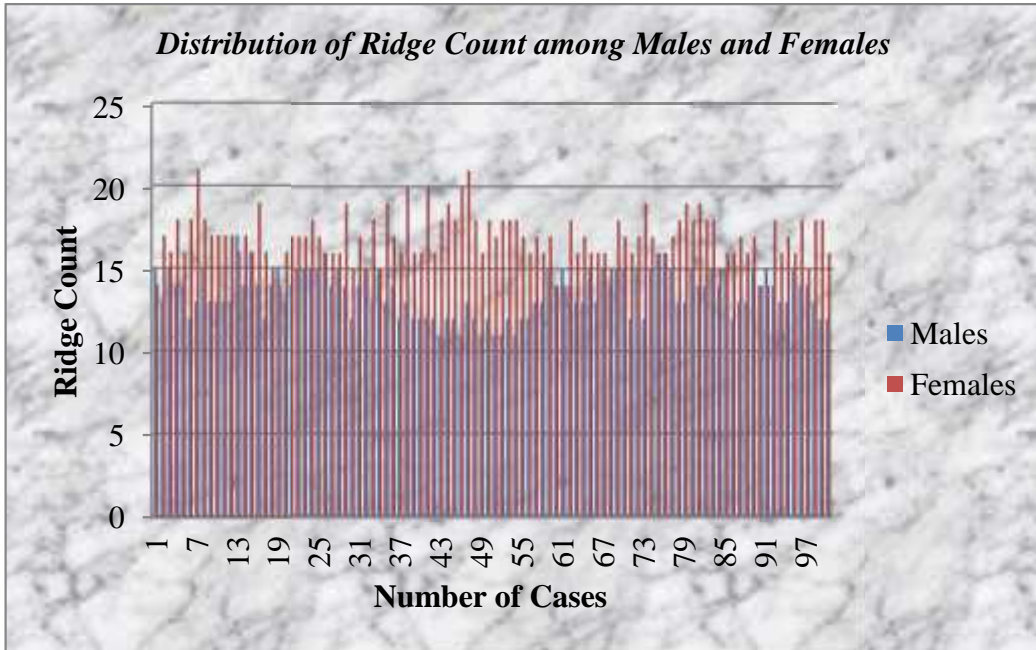
Distribution of Ridge Count among Females shown in Graph No: 04

Graph No: 04



Distribution of Ridge Count among Males and Females shown in Graph No: 05

Graph No: 05



Distribution of Blood Group in relation to Ridge Count shown in Graph No: 06

Graph No: 06

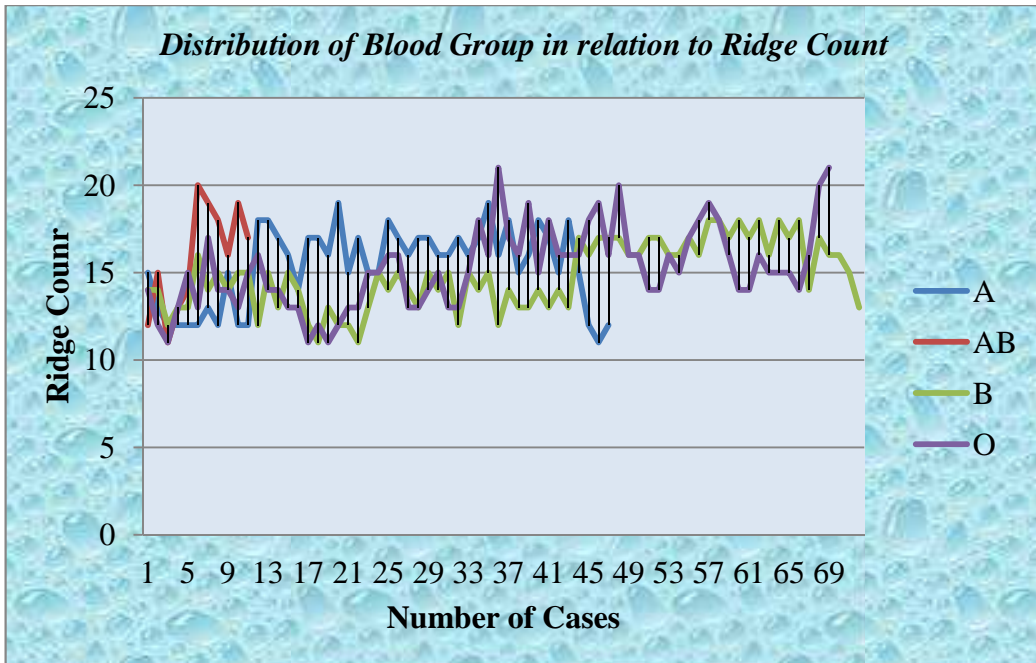


Table No.11 shows the descriptive statistics of dermal ridges for male and female subject. From the table it is clear that, the ridge density ranges from 11-17 ridges/25mm² in males and 14-21 ridges/25mm² in females. The analysis of variance (ANOVA) results show that males have significantly lesser density than females with $P < 0.001$ (Significant). The mean value of ridge count for male is 13.56 and that of female is 16.92. The Identification Point for male is <15 and for female is > 16 .

Table No.11: Descriptive Statistics of Dermal Ridges for Male and Female Subjects

	Male	Female
Mean RC	13.56	16.92
Standard Deviation	1.38	1.48
Standard Error	0.138	0.149
Minimum	11	14
Median	14	17
Maximum	17	21
Identification Point	<15	> 16
Calculated Range	11-17	14-21
Demarking Point	< 14	>16

$t = 16.55P < 0.001$ (Significant)

Table No.12 shows the probability density for male(C) and female (C¹) and using the Likelihood Ratio LR (C/C¹) and (C¹/C) are calculated.

Results shows that fingerprint with ridge density of 15 ridges/25mm² is more likely to be of male and fingerprint with ridge density of 16 ridges/25mm² goes in favour of female. In other words, based on the posterior probability and favoured odd, if for example a print with ridges density 17 is found at a scene, the ratio for it to be female compared to male will be 84:29 i.e. roughly 8:3.

Table No. 12: Probability densities and likelihood ratios derived from observed fingerprint ridge count

Ridge Count	Probability density		Likelihood Ratio		Favoured Odds	
	Male(C)	Female(C ¹)	LR(C/C ¹)	LR(C ¹ /C)	M	F
11	0.056	0.001	56	0.018	00.97	00.01
12	0.187	0.002	93.50	0.10	00.94	00.02
13	0.224	0.004	56	0.018	00.90	00.04
14	0.194	0.056	03.88	0.288	00.81	00.17
15	0.252	0.065	03.87	.257	00.72	00.28
16	0.038	0.281	00.13	7.39	00.42	00.71
17	0.009	0.233	00.038	25.88	00.29	00.84
18	0.005	0.213	00.023	42.60	00.15	00.90
19	0.004	0.065	00.061	16.25	00.12	00.95
20	0.003	0.029	00.103	09.66	00.07	1
21	0.001	0.019	00.052	19	00.00	1

It is observed that 95% of males are having ridge density of 15 ridges/25 mm² and 84% of females are having ridge density of 16 ridges/25 mm² as shown in the Table No.13.

Table No. 13: Sex Wise Distribution of Ridge Count

Sex	Ridge Count (Ridges/25mm ²)		Total
	15	16	
Male	95	5	100
Female	16	84	100

$\chi^2 = 126.349$, DF=1, P=<0.001

More number of B and O blood group individuals is having ridge density of 15 ridges/25 mm² as shown in Table No.14.1.

Table No. 14.1: Distribution of Ridge Count among different Blood Groups

Blood Group	Ridge Count (Ridges/25mm ²)		Total
	15	16	
A	22(45.80)	26(54.20)	48
B	45(62.50)	27(37.50)	72
AB	05(45.50)	06(54.50)	11
O	39(56.50)	30(43.50)	69
	111	89	200

$\chi^2 = 3.723$, DF=3, P=0.293

Average number of ridge count among B blood group individuals is more as shown in Table No.14.2.

Table No.14.2: Average number of Ridge Count among different Blood Groups

Blood Group	Average number of Ridge Count (Ridges/25mm ²)
A	15.3+2.22
B	24.8+1.90
AB	15.8+3.06
O	15.2+2.32

F=1.121, DF=3 and 96, P=0.342

More number of males are having blood groups B and O, more number of females are having blood groups A and AB as shown in Table No.15.1.

Table No. 15.1: Sex Wise Distribution of Cases among different Blood Groups

Blood Group	Male	Female	Total
A	16	32	48
B	44	28	72
AB	4	7	11
O	36	33	69
Total	100	100	200

$\chi^2 = 9.838, DF=3, P=0.020$

It is observed that 16 male individuals of Blood group A are having ridge density of 15 ridges/25 mm² and no males had ridge density of 16 ridges/25 mm² as shown in Table No.15.2

Table No. 15.2: Sex Wise Distribution of Ridge count among Blood Group A Subjects

Blood Group	Sex	Ridge Count (Ridges/25mm ²)		Total
		15	16	
A	Male	16	0	16
	Female	6	26	32
		22	26	48

$\chi^2 = 25.185, DF=1, P < 0.001$

Among Blood group B individuals, 43 males are having ridge density of 15 ridges/25 mm² and 26 females are having ridge density of 16 ridges/25 mm² as shown in Table No.15.3.

Table No. 15.3: Sex Wise Distribution of Ridge count among Blood Group B Subjects

Blood Group	Sex	Ridge Count (Ridges/25mm ²)		Total
		15	16	
B	Male	43	1	44
	Female	2	26	28
		45	27	72

$\chi^2 = 56.104, DF=1, P < 0.001$

Our study showed that 4 male individuals of Blood group AB are having ridge density of 15 ridges/25 mm² and no male had ridge density of 16 ridges/25 mm² as shown in Table No.15.4.

Table No. 15.4: Sex Wise Distribution of Ridge count among Blood Group AB Subjects

Blood Group	Sex	Ridge Count (Ridges/25mm ²)		Total
		15	16	
AB	Male	4	0	4
	Female	1	6	7
		5	6	11

P=<0.015

It was found that majority of Blood group O males are having ridge density of 15 ridges/25 mm² and majority of females are having ridge density of 16 ridges/25 mm² as shown in Table No.15.5.

Table No. 15.5: Sex Wise Distribution of Ridge count among Blood Group O Subjects

Blood Group	Sex	Ridge Count (Ridges/25mm ²)		Total
		15	16	
O	Male	32	4	36
	Female	7	26	33
		39	30	69

$\chi^2 = 32.089, DF=1, P=<0.001$

OBSERVATIONS

- 1) Significant difference in fingerprint ridge density exists between males and females.
- 2) A fingerprint with ridge density of 15 ridges/25 mm² is more likely to be of male and fingerprint with ridge density of 16 ridges/25 mm² goes in favour of female.
- 3) Ridge count is different for each finger. It is found that thumb finger tends to have less ridge count compared to other finger. Ring finger and Little finger showed higher ridge density compared to other fingers.
- 4) Average ridge count doesn't differ in all the four blood groups (Table No.14.1 & 14.2) but the percentage of distribution of gender into two categories is significantly different in all the blood groups (Table No.15.1 - 15.5).

Since many decades various studies have been done to determine the sex from fingerprint pattern, friction ridge characters and ridge count. But many studies have been conducted on ridge count, mainly for race determination and genetic inheritance of ridge pattern²⁸.

The present study “Determination of sex from fingerprint ridge density” is taken to widen the view of ridge count and is aimed at establishing the association between sex and the fingerprint ridge density among South Indian population (Karnataka, Andhra Pradesh, Tamil Nadu, and Kerala).

In our study ridge density ranged from 14 to 21 ridges/25 mm² for females with a mean of 16.92 ridges/ 25 mm² (SE = 0.14), and from 11 to 17 ridges/25 mm² for males with a mean of 13.56 ridges/25 mm² (SE = 0.13). Females were found to have significantly higher ridge density than males ($p < 0.001$). It is observed that 95% of the males have a mean ridge density of 15 ridges/25 mm² and 87% of the females have a mean ridge density of 16 ridges/25 mm². It is observed that none of the males have a mean ridge density of more than 18 ridges/25mm² and there are no females who have a mean ridge density below 13 ridges/25mm².

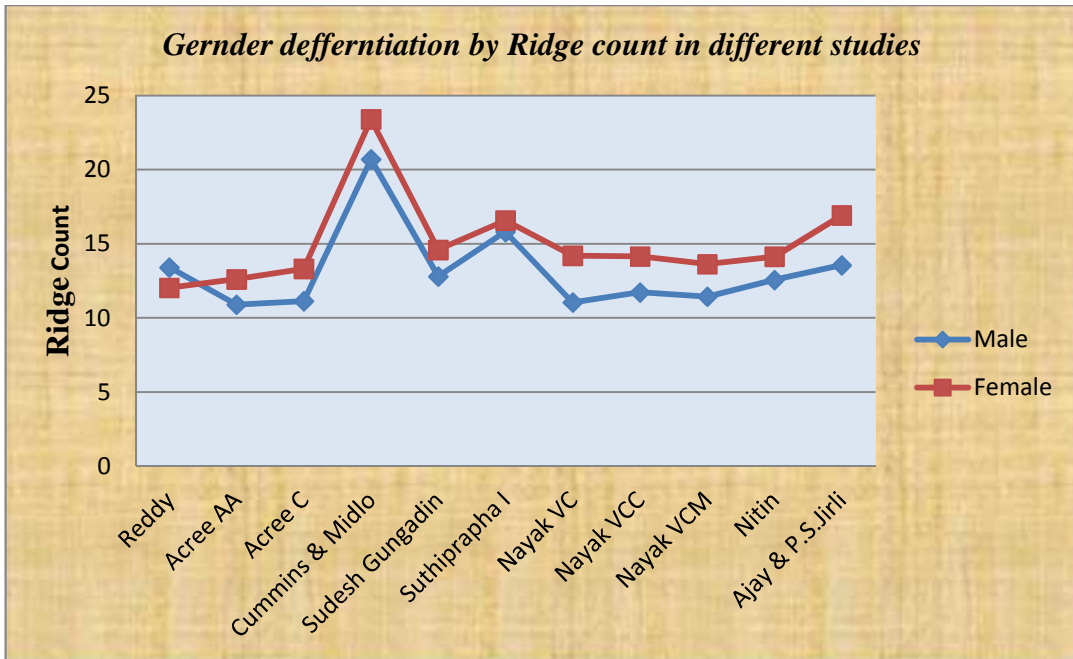
The statistical analysis of LR (C/C1) and the favored odds show that a ridge count of 15 ridges/25mm² is more likely to be of male origin. Posterior probability using the Baye’s theorem (P=0.72) and a ridge count of 16 ridges/25mm² is more likely to be of female origin (P=0.71). A print showing a count of 11 ridges/25 mm² will have a high probability to be that of male (P=0.97), while no female in this study was found to have 11 ridges. Similarly a ridge count of 21 ridges/25 mm² will be more in favor of female (P=1.0), while there was no male found in this category.

In the past many studies (Table No. 16) have been done to establish the association between sex and the fingerprint ridge density.

Table No. 16: Gender differentiation by finger ridge count among various studies

Author		Race	Male	Female
Reddy ²³		Bagatha's of Araku Valley India	13.41	12.04
Acree ⁷	(Acree AA)	African American	10.90	12.61
	(Acree C)	Caucasian	11.14	13.32
Cummins & Midlo ¹⁶		Americam	20.70	23.40
Sudesh Gungadin ²⁶		Karnataka, India	12.80	14.60
Suthiprapha I ²⁸		Thailand	15.81	16.58
Nayak VC ²⁹		Karnataka, India	11.05	14.20
Nayak VC ³⁰	(Nayak VCC)	Chinese	11.73	14.15
	(Nayak VCM)	Malaysian	11.44	13.63
Nitin ³¹		Karnataka, India	12.57	14.14
Ajay & P.S. Jirli (present study)		Karnataka, India	13.56	16.92

Graph No 07: Gender differentiation by Ridge count in different studies



The present study showed significant difference in the ridge density among both genders and males tends to have lesser ridge density as compared to females, which is consistent with the study by Cummins H and Midlo C¹⁶. Where study showed that number of ridges per centimeter (which is ridge density) in males is less compared to a female. This has shown similar trend in gender difference as compared to other studies in the past on other races. This shows that this trend is universal among all races.

Many works²⁹ done on ridge thickness in fingerprints showed that males have coarser finger ridges than females which suggest that males will have fewer ridges in a given area than females (lesser ridge density) which is in favour of our study where males showed coarser ridges than females and in another study by Cummins H¹⁵ found that men have coarser epidermal ridge than women which again goes in favour towards our study, but these studies have not mentioned about the ridge density.

In contrast to our study, the ridge density in males was more than females in separate studies done by Steinberg FS²⁵, Plato CC²² and ReddyGG²³. Whereas our study correlate with the study done by Suthiprapha I.

Steinberg FS²⁵ studied digital and palmar dermatoglyphics of 184 males and 224 females of American Negros and observed that the total mean ridge counts on both hands are significantly different in males and females. Where mean ridge count was more in males and less in females.

In a similar study by Plato CC²² on digital and palmar dermatoglyphics of American Caucasians and found that bilateral ridge counts are significantly different in the females while in the males no difference was seen. This study also denotes males have significantly higher ridge counts than females for the left and right hands and total ridge counts.

In another study by Reddy GG²³ also showed, the mean ridge count for males (13.41) was more than females (12.04).

These contradictory results could be due to racial variations and different counting methods used to count the ridges.

Moore's²⁶ study tells that mean ridge to ridge distance is more in males when compared to females, but he studied only 10 males and 10 females and Okajima¹⁷ also found that the Fork Index is higher in females than in males fingerprints. These again uphold the trend as in the present study and by Suthiprapha I.

The present study has shown that the males of southern region of India on an average have lesser ridge density than the Thai males of Intira Suthiprapha's study. The females of southern region of India have similar ridge density to the Thai female

of Intira Suthiprapha's study. But the common fact in both the studies is females within the population studied have significantly greater number of ridges than males. This shows that trend is maintained as in other previous studies. According to Suthiprapha I males have a ridge density of 16 ridges/25 mm² and females 17 ridges/ 25 mm² in Thai population.

Gungadin S²⁸ conducted a study on 500 subjects (250 males and 250 females of Karnataka) and found that finger print ridge count of less than 13 ridges/25 mm² is more likely to be of a male and finger print ridge count of more than 14 ridges/25 mm² is likely to be of a female, which is consistent with the present study.

The present study is also consistent with the study conducted by Acree M²⁷ on 400 subjects (i.e. 200 Caucasian males and females, 200 Africa American males and females), where he observed that males tend to have lesser ridge density (11 ridges/25 mm²) than females (12 ridges/25 mm²) in Africans and Caucasian Americans.

The present also upholds the fact of Gutierrez²⁹ study, which tells that women tend to have significantly higher ridge density in distal region of all 10 fingers than males.

In two different studies done by Nayak VC, one on Indian population²⁹ and another on Chinese and Malaysian Population³⁰, where he noticed that males tend to have lesser fingerprint ridge density (i.e. 12ridges/25 mm² Indians and Chinese, 11 ridges/25 mm² in Malaysian males) compared females(i.e.>12 ridges/25 mm² in Indians, >13 ridges/25 mm² in Chinese and Malaysian females) which correlate with the present study.

Recent study by Nithin MD³⁴ on Gender differentiation by finger ridge count among South Indian population observed that women have a significantly higher ridge count (>14 ridges/25 mm²) than men (<13 ridges/25 mm²), which is also in favour with the present study.

Studies in the past and present have more or less given an insight about the difference in finger print ridge density. This study has taken care of the details of the breadth and furrows of epidermal ridges and then statistically demonstrating the significant differences in male and female fingerprint ridge density.

The results of the study are quite encouraging and this ultimately would help as a useful tool for the fingerprints experts either in the field of Forensic Science or law enforcement field. In fact, the aim of taking the study was to help the authorities concerned to minimize or restrict their field of investigation and concentrate on a particular gender. This study has proved that there is an increased ridge density in female gender than male gender because of less coarseness of ridges. The study of Sex determination by fingerprint ridge density is specific i.e. P value is < 0.001 . It is significant. This study has proved that there is a significant gender difference in fingerprint ridge density. Though the results are not 100% confirmative but definitely significant.

These significant results would immensely help the fingerprint experts and law enforcement authorities to direct their search to a particular gender. Eventually help the investigating officers to save time by sorting out the gender of the suspects and speeding the investigation.

In the present study an attempt is made to describe the densities of epidermal ridges and their association with the gender. This study is supporting the hypothesis that women tend to have a statistically significant greater ridge density than men. The present study has shown that a fingerprint with ridge density of 15 ridges/25 mm² is more likely to be of male and fingerprint with ridge density of 16 ridges/25 mm² goes in favour of female. Results are significant because the P value is < 0.001.

The findings of this study could be concluded that fingerprint ridge density is the indicator to establish the gender. Fingerprint ridge characteristics may be used to predict the gender. Finally, this study provides information which is useful for forensic science to assist the fingerprint examiners to direct their search to a particular gender, although those are not the rule for identification but it may be used as one of all trends for fingerprint identification.

Similar studies must be carried out on a larger population and focus on people from various racial origins. Additionally, further replicate studies should be conducted on South Indian population.

If this limitation is overcome, then gender differentiation by finger ridge density would be much more valuable and accurate.

Identification by fingerprints is being reliable however the identification of sex can be made out to some extent by counting of ridges. Thus, if the sex of the suspect is known, the investigating officer can direct their search to a particular sex and eventually the investigating officer would save time in nabbing the suspects.

- The fingerprint of 100 males and 100 females of South Indian population (Karnataka, Andhra Pradesh, Tamil Nadu, and Kerala) are taken. Ridge counts are done in the upper portion of radial boarder of the prints in an area of 25 mm^2 and the mean value of ridge count of ten fingers is calculated.
- Results showed that, males have a ridge density ranging between 11 to 17 ridges/ 25 mm^2 and no males are found to have a ridge density of $18 \text{ ridges}/25 \text{ mm}^2$. Females have a ridge density ranging between 14 to 21 ridges/ 25 mm^2 and no females have a ridge density of $13 \text{ ridges}/25 \text{ mm}^2$. Using Baye's Theorem and Posterior Probability method the likely hood ratios were calculated, with a P value of < 0.001 , which is significant. It is found that there is a significant difference in the ridge density of females compared to males.
- Women tend to have statistically significant greater ridge density, hence finer ridge details than men. A fingerprint with ridge density of $15 \text{ ridges}/25\text{mm}^2$ is more likely to be of male and fingerprint with ridge density of $16 \text{ ridges}/25\text{mm}^2$ goes in favour of female.
- Average ridge count doesn't differ in all the four blood groups but the percentage of distribution of gender into two categories (i.e $15 \text{ ridges}/25 \text{ mm}^2$ and $16 \text{ ridges}/25 \text{ mm}^2$) is significantly different in all the blood groups.

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Figure No.1: Showing different patterns of fingerprints

Figure – 1.1 Arch



Figure – 1.2 Loop



Figure – 1.3 Whorl



Figure-1.4 Composite



Figure No.02: Showing different instruments used for taking fingerprints



Figure No.03: Showing method of taking fingerprints in the pro forma

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Jawahar Lal Nehru Medical College,
KLE University, Bellary.


"DETERMINATION OF SEX FROM FINGERPRINT RIDGE DENSITY AMONG
SOUTH-INDIAN POPULATION OF J N MEDICAL COLLEGE - A ONE YEAR
CROSS SECTIONAL STUDY."

PROFORMA

1. Name: Bansavari J SL NO: 3
 2. Age: 183 yrs
 3. Sex: male female
 4. Address: Gowaboin Nigal, Bellary
 5. Blood Group of the Individual: B + ve

FINGER PRINTS.

1. RIGHT HAND FINGERS:

	Thumb	Index	Middle	Ring	Little
					
Ridge count					

2. LEFT HAND FINGERS:

	Index	Middle	Ring	Little
Ridge count				
Sex				
Age				
Place				

Bansavari J

Figure No.04: Showing all ten fingerprints on the proforma

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Jawahar's Nair's Medical College,
JCE University, Belgium






"DETERMINATION OF SEX FROM FINGERPRINT RIDGE DENSITY AMONG
SOUTH INDIAN POPULATION OF J N MEDICAL COLLEGE - A ONE YEAR
CROSS SECTIONAL STUDY."

PROFORMA






1. Name: BANUMATHI SL NO: 2
 2. Age: 23 yrs
 3. Sex: Female
 4. Address: SHIVABANU Nagar, Belgauw
 5. Blood Group of the individual: B +ve

FINGER PRINTS

1. RIGHT HAND FINGERS:

	Thumb	Index	Middle	Ring	Little
					
Ridge count					

2. LEFT HAND FINGERS:

	Thumb	Index	Middle	Ring	Little
					
Ridge count					

Average ridge count of all fingers:
 Date: 6-10-11
 Sign: Banumathi

Figure No.05: Showing method of counting of fingerprints ridges

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Jawahar's Nair's Medical College,
JCE University, Belgium






"DETERMINATION OF SEX FROM FINGERPRINT RIDGE DENSITY AMONG
SOUTH INDIAN POPULATION OF J N MEDICAL COLLEGE - A ONE YEAR
CROSS SECTIONAL STUDY."

PROFORMA






1. Name: BANUMATHI SL NO: 2
 2. Age: 23 yrs
 3. Sex: Female
 4. Address: SHIVABANU Nagar, Belgauw
 5. Blood Group of the individual: B +ve

FINGER PRINTS

1. RIGHT HAND FINGERS:

	Thumb	Index	Middle	Ring	Little
					
Ridge count					

2. LEFT HAND FINGERS:

	Thumb	Index	Middle	Ring	Little
					
Ridge count					

Average ridge count of all fingers:
 Date: 6-10-11
 Sign: Banumathi

INFORMED CONSENT

Date:

Time:

Place:

I Mr./Ms.....aged.....years

give my free and voluntary consent to Dr BF0110001 , postgraduate student at JNMC Belgaum to take my entire prints of ten fingers.

OBJECTIVES AND THE PURPOSE OF THE STUDY

I am fully aware that this research, "Determination of sex from fingerprint ridge density among south Indian population-a one year cross sectional study" is Dr BF0110001s dissertation topic required for partial fulfillment of his degree in Forensic medicine and Toxicology (MD). I also understand the importance of such a pioneering research work, results of which have got prime importance in solving various criminal and civil cases and in giving justice to the people of this great nation. I am very much aware that Dr BF0110001, who is also coincidentally a teacher to me is the sole investigator and this entire project is being done by him purely at his own expenses. Dr BF0110001 has explained to me in very simple words that this project is all about identification of sex of a person, when only fingerprints of that person's are available at the scene of crime so that the investigating officer can direct their search to a particular sex and eventually the investigating officer would save time in nabbing the suspects.

PROCEDURE

Dr BF0110001 has explained to me clearly and in a very simple language that the procedure involves collection of entire prints of ten fingers by black printer ink using the roller, and I have personally seen these devices which as per my knowledge are the simple and safe. My common sense says this procedure is simple, safe, non-invasive, non-time consuming (as it hardly takes 3-4 minutes) and more over requires a single sitting for collection of entire data.

ALTERNATIVES

The procedure explained to me is one of the simplest. I find no reason whatsoever to withdraw from such a beautiful and simple study and more over the question of penalty or removal from the study do not arise at all as it is a single sitting, four minute procedure.

PRIVACY AND CONFIDENTIALITY

Dr.BF0110001 has whole heartedly expressed to me that my privacy is a matter of serious concern to him ,he has also explained to me in very clear terms that under no circumstances, however inevitable, he would not reveal the data of study or my identity, by whatever means.

INSTITUTIONAL /SPONSORS POLICY

I totally agree with Dr BF0110001's view points that even a layman understands that question of injury does not arise in such a noble kind of study.

FINANCIAL INCENTIVES FOR PARTICIPATION

I am totally conscious that as my investment as a participant in this study is just 4 min of my spare time, I have no right to claim any embursement whatsoever from DrBF0110001 as I have enrolled in this study solely as a matter of professional interest and not to have financial or other gains.

CONTACT DETAILS

Dr BF0110001 is a Postgraduate student in Department of Forensic medicine and Toxicology, his residential address------. His contact number is xxxxxxxxxxxx; he has always been and will continue to be freely available to me 24x7 to clear any of my queries regarding this project.

AUTHORIZATION TO PUBLISH RESULTS

As long as my privacy and identity are respected, I fully and voluntarily give consent to publish this research work anywhere, anytime, across the globe as I consider this as a very creative and an innovative work in the field of Forensic medicine and Toxicology. Publishing such seminal works is the need of the hour.

I Mr. /Ms.....Aged years were first explained about the project in a very clear and a very simplest possible way regarding each and every aspect of the project. All my doubts were cleared and I have personally gone through this written consent form. Adequate time was provided to me to go through this consent form and also to clarify my doubts, which I had. I am fully aware of my rights as a study participant. Whatever acceptances, gestures and signatures I make are voluntary and totally by my own will.

Signature or left thumb print of participant or legally authorized representative

Consent form

Participant's name.....Participant's signature/thumb print

Experimenters name.....Experimenters' signature

Witness's name.....Witness signature

Date:

(The study subjects of this project are above 18 years, the consent of parent or guardian is not necessary)

Department of Forensic Medicine and Toxicology,
JawaharlalNehruMedicalCollege,
KLE University, Belgaum.

**“DETERMINATION OF SEX FROM FINGERPRINT RIDGE DENSITY
AMONG SOUTH INDIAN POPULATION OF J N MEDICAL COLLEGE - A
ONE YEAR CROSS SECTIONAL STUDY.”**

PROFORMA

1. Name: _____ SL NO: _____
2. Age : _____yrs
3. Sex:male/ female
4. Address:
5. Blood Group of the individual :

FINGER PRINTS

1.RIGHT HAND FINGERS:

	Thumb	Index	Middle	Ring	Little
Ridge count					

2. LEFT HAND FINGERS:

	Thumb	Index	Middle	Ring	Little
Ridge count					

Average ridge count of all fingers:

Date:

Place:

Signature

Key to Master Chart

A	:	Age
AP	:	Andhra Pradesh
Avg	:	Average
BG	:	Blood Group
F	:	Female
I	:	Index Finger
KA	:	Karnataka
KL	:	Kerala
L	:	Little Finger
LH	:	Left Hand
M	:	Middle Finger
M	:	Male
R	:	Ring Finger
RC	:	Ridge Count
RD	:	Ridge Density
RH	:	Right Hand
S	:	State
S.No	:	Serial Number
T	:	Thumb Finger
TN	:	Tamil Nadu

ANNEXURE-I
PHOTOGRAPHS

ANNEXURE-II
CONSENT FORM

ANNEXURE-III
PROFORMA

ANNEXURE-IV
MASTER CHART

A S.No	B A (yrs)	C Sex M/F	D BG	E S	F - RC												RD
					G - RH						H - LH						
					T	I	M	R	L	Avg	T	I	M	R	L	Avg	
1	19	M	A +ve	KA	13	14	15	14	16	14	13	14	15	16	15	15	15
2	27	M	O+ve	KA	10	13	12	15	13	13	09	13	15	15	13	13	13
3	24	M	O-ve	KA	14	14	15	15	16	15	12	15	15	13	14	14	15
4	22	M	B+ve	KA	11	13	13	15	14	13	13	16	14	16	15	15	14
5	33	M	B+ve	KA	13	11	14	15	14	13	15	15	16	14	15	15	14
6	32	M	B+ve	KA	12	09	10	12	13	11	11	14	13	13	11	12	12
7	28	M	B+ve	KA	10	11	12	13	12	12	11	13	13	13	13	13	13
8	46	M	O+ve	KA	13	14	15	14	13	14	14	15	15	16	15	15	15
9	27	M	A+ve	KA	10	11	13	14	14	12	12	14	16	13	14	14	13
10	27	M	B+ve	KA	12	14	11	15	13	13	10	13	13	12	13	12	13
11	24	M	B-ve	KA	11	10	14	15	11	12	12	14	13	13	13	13	13
12	26	M	O+ve	KA	10	13	14	15	14	13	12	11	14	16	13	13	13
13	28	M	O+ve	KA	15	18	16	18	16	17	15	16	16	17	17	16	17
14	31	M	O+ve	KA	11	15	15	14	15	14	12	12	15	14	12	13	14
15	26	M	B+ve	KA	13	14	16	17	18	16	13	15	15	15	15	15	16
16	26	M	B+ve	KA	11	14	14	14	16	14	13	11	15	14	13	13	14
17	53	M	AB+ve	KA	08	10	12	13	12	11	09	11	13	13	12	12	12
18	28	M	O+ve	KA	11	12	14	16	15	14	13	13	14	15	12	13	14
19	44	M	B+ve	KA	14	13	14	14	13	14	14	15	15	18	17	16	15
20	45	M	O+ve	KA	10	11	13	15	14	13	10	11	14	15	12	12	13
21	40	M	B+ve	KA	11	11	15	13	13	13	11	15	15	15	15	14	14
22	21	M	AB+ve	KA	12	13	15	15	17	14	13	15	16	16	16	15	15
23	20	M	O+ve	KA	15	13	15	15	15	15	14	13	16	13	13	14	15
24	19	M	A-ve	KA	13	14	15	14	16	14	14	17	14	17	14	15	15
25	26	M	B+ve	KA	12	15	16	17	15	15	11	14	15	14	15	14	15
26	27	M	O+ve	KA	10	17	18	17	19	16	14	17	18	17	16	16	16
27	20	M	O+ve	KA	15	12	14	14	14	14	12	14	13	12	15	13	14
28	19	M	B+ve	KA	14	14	15	16	15	15	15	14	16	14	15	15	15

A	B	C	D	E	F												RD
					G						H						
					T	I	M	R	L	Avg	T	I	M	R	L	Avg	
29	38	M	O+ve	KA	11	13	12	14	16	13	13	12	13	16	17	14	14
30	28	M	B+ve	KA	11	11	12	14	14	12	10	13	12	13	13	12	12
31	24	M	O+ve	KA	11	13	13	13	15	13	13	15	16	15	16	15	14
32	23	M	B+ve	KA	13	13	15	17	15	15	13	13	16	17	15	15	15
33	18	M	B+ve	KA	10	12	11	14	13	12	11	13	15	15	12	13	13
34	19	M	B+ve	KA	12	13	15	14	14	14	14	12	16	16	15	15	15
35	19	M	O+ve	KA	13	13	12	12	13	13	13	13	14	13	13	13	13
36	20	M	B+ve	KA	16	13	13	12	14	14	13	13	12	13	13	13	14
37	19	M	B+ve	KA	13	13	12	12	12	12	13	12	12	12	12	12	12
38	18	M	O+ve	KA	11	12	13	13	13	12	12	11	13	15	13	13	13
39	24	M	A+ve	KA	11	10	13	11	11	11	12	12	12	12	11	12	12
40	18	M	A+ve	KA	11	12	12	12	11	12	11	12	11	11	12	11	12
41	19	M	A+ve	KA	11	13	13	12	12	12	11	11	12	12	13	12	12
42	17	M	A-ve	KA	11	11	12	12	11	11	13	12	11	12	12	12	12
43	20	M	O+ve	KA	12	11	11	11	12	11	11	12	11	12	11	11	11
44	10	M	A+ve	KA	10	11	13	11	12	11	12	11	13	11	12	12	12
45	18	M	O+ve	KA	12	11	12	13	11	12	12	11	12	12	13	12	12
46	19	M	B+ve	KA	11	11	11	12	11	11	11	12	11	12	11	11	11
47	19	M	B+ve	KA	13	14	13	13	13	13	12	13	11	12	11	12	13
48	19	M	B+ve	KA	11	11	11	12	12	11	13	12	13	12	11	12	12
49	24	M	A-ve	KA	12	11	11	11	10	11	10	11	12	11	11	11	11
50	23	M	B+ve	KA	11	11	12	12	12	12	11	11	10	10	11	11	12
51	22	M	AB+ve	KA	11	10	11	11	10	11	11	11	10	10	10	11	11
52	22	M	O+ve	KA	11	10	10	12	13	11	11	11	10	11	10	11	11
53	22	M	A-ve	KA	11	10	11	10	13	11	11	13	11	12	11	12	12
54	22	M	B+ve	KA	11	10	12	12	12	11	11	10	11	11	12	11	11
55	22	M	O+ve	KA	10	11	11	13	12	11	12	11	13	11	11	12	12

A	B	C	D	E	F											RD	
					G						H						
					T	I	M	R	L	Avg	T	I	M	R	L		Avg
56	20	F	AB+ve	KA	13	13	15	17	14	14	14	12	15	15	14	14	14
57	21	F	B+ve	KA	13	15	16	18	16	16	16	16	18	18	17	17	17
58	20	F	B+ve	KA	13	13	15	16	18	15	13	16	18	18	16	16	16
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60	24	F	O+ve	KA	13	15	16	17	15	15	12	17	19	19	19	17	16
61	26	F	A+ve	KA	16	17	20	19	18	18	15	16	20	20	18	18	18
62	23	F	O+ve	KA	14	17	23	21	18	19	22	18	23	25	23	22	21
63	20	F	A+ve	KA	15	16	20	20	19	18	17	15	15	19	18	17	18
64	25	F	O+ve	KA	13	15	18	19	18	17	13	16	17	18	18	16	17
65	19	F	B+ve	KA	13	14	15	19	18	16	15	16	18	16	18	17	17
66	20	F	B+ve	KA	13	14	18	18	17	16	14	18	19	17	16	17	17
67	20	F	B+ve	KA	13	14	16	20	20	17	17	17	16	20	17	17	17
68	28	F	B+ve	KA	14	12	16	15	16	15	16	11	18	17	16	16	16
69	25	F	A+ve	KA	12	14	18	17	18	16	16	16	19	18	17	17	17
70	28	F	O+ve	KA	14	18	18	16	16	16	14	16	17	18	17	16	16
71	27	F	O+ve	KA	14	18	18	21	18	18	17	16	22	20	18	19	19
72	32	F	A+ve	KA	13	15	14	15	19	15	15	18	17	18	17	17	16
73	20	F	O+ve	KA	13	15	14	16	14	14	16	13	17	16	14	15	15
74	25	F	A+ve	KA	10	10	13	16	17	13	13	11	17	16	15	14	14
75	23	F	B+ve	KA	11	15	18	17	16	15	12	14	16	19	17	16	16
76	23	F	A+ve	KA	11	15	18	20	18	16	14	17	17	17	19	17	17
77	30	F	B+ve	KA	14	16	17	18	16	16	14	16	19	20	18	17	17
78	20	F	B+ve	KA	12	15	17	18	16	16	16	17	17	17	18	17	17
79	26	F	O+ve	KA	14	17	18	17	17	17	16	17	21	18	18	18	18
80	27	F	A+ve	KA	13	14	19	18	20	17	14	19	18	17	17	17	17
81	23	F	O+ve	KA	12	13	18	15	15	15	15	18	18	18	15	17	16
82	20	F	B+ve	KA	13	13	18	15	16	15	15	16	16	17	18	16	16
83	21	F	O+ve	KA	10	14	16	15	15	14	17	17	16	15	17	16	16

A	B	C	D	E	F											RD	
					G						H						
					T	I	M	R	L	Avg	T	I	M	R	L		Avg
84	21	F	A+ve	KA	16	15	18	19	21	18	14	18	20	20	18	19	16
85	18	F	O+ve	KA	12	15	16	17	17	15	16	13	17	14	16	15	16
86	18	F	B+ve	KA	15	21	28	23	20	21	16	13	18	16	18	17	16
87	19	F	A+ve	KA	15	11	17	15	15	15	15	15	16	15	15	15	19
88	18	F	A+ve	KA	15	15	17	15	15	15	16	16	19	19	17	18	15
89	19	F	A+ve	KA	13	15	15	16	15	15	14	15	15	17	15	16	17
90	19	F	A+ve	KA	14	16	17	19	19	17	17	18	19	18	22	19	15
91	19	F	O+ve	KA	17	16	16	17	15	16	14	15	17	18	16	17	18
92	19	F	A+ve	KA	15	16	16	17	19	17	14	16	15	17	15	16	15
93	21	F	O+ve	KA	15	18	20	20	17	18	16	17	20	22	20	20	19
94	21	F	B+ve	KA	15	17	17	19	17	17	13	16	16	16	17	16	17
95	21	F	O+ve	KA	15	15	16	17	16	16	15	18	16	16	15	16	16
96	21	F	AB+ve	KA	14	17	18	21	17	17	15	16	21	21	20	20	20
97	21	F	B+ve	KA	16	17	17	18	19	17	15	15	16	17	17	16	16
98	21	F	O-ve	KA	16	18	19	27	17	19	17	16	16	21	20	19	16
99	19	F	O+ve	KA	14	16	15	19	19	17	18	18	19	21	18	19	20
100	17	F	O+ve	KA	14	16	16	22	15	17	15	15	19	20	19	19	16
101	18	F	B+ve	KA	19	20	20	22	21	20	23	18	21	23	17	20	18
102	18	F	AB+ve	KA	20	18	22	22	21	21	18	22	21	21	21	21	19
103	18	F	A+ve	KA	19	18	17	17	16	17	15	16	18	19	19	18	18
104	18	F	O-ve	KA	11	16	16	16	16	15	15	16	17	17	16	17	20
105	18	F	O-ve	KA	19	16	19	18	18	18	17	16	18	18	18	18	21
106	18	F	B+ve	KA	18	17	19	18	18	18	20	17	16	17	18	17	18
107	18	F	A+ve	KA	16	18	18	21	16	18	15	18	16	21	17	18	17
108	19	F	AB+ve	KA	17	18	19	21	17	18	17	16	19	22	16	19	18
109	18	F	B+ve	KA	13	16	17	17	15	16	16	18	18	19	18	18	17
110	18	F	B+ve	KA	17	16	16	16	16	16	14	16	17	18	17	17	18

A	B	C	D	E	F											RD	
					G						H						
					T	I	M	R	L	Avg	T	I	M	R	L		Avg
111	29	M	O +ve	AP	09	11	10	13	11	11	12	12	12	15	11	12	12
112	26	M	O+ve	AP	12	12	15	13	12	13	13	14	13	13	13	13	13
113	20	M	B+ve	AP	09	12	14	13	13	12	12	14	15	14	13	14	13
114	19	M	B+ve	AP	12	14	15	15	12	14	13	14	15	16	15	15	15
115	20	M	B+ve	AP	12	11	13	15	14	13	12	13	13	14	16	14	14
116	21	M	B+ve	AP	10	11	11	17	15	13	13	15	16	17	18	16	15
117	21	M	B+ve	AP	12	14	14	14	15	14	10	14	15	16	14	14	14
118	19	M	O+ve	AP	11	12	13	15	15	13	14	12	14	15	12	13	13
119	21	M	B+ve	AP	13	13	14	13	14	13	11	12	13	13	12	12	13
120	20	M	O+ve	AP	13	14	16	16	16	15	12	16	16	15	13	14	15
121	19	M	A+ve	AP	13	09	12	12	13	12	11	13	15	13	11	13	13
122	20	M	B+ve	AP	12	13	15	15	14	14	15	13	15	16	15	15	15
123	20	M	B+ve	AP	11	12	14	15	16	14	12	13	14	15	16	14	14
124	21	M	A-ve	AP	13	14	14	16	16	15	13	15	15	16	15	15	15
125	20	M	B+ve	AP	12	16	17	15	13	15	12	15	14	16	17	15	15
126	21	M	B+ve	AP	10	11	14	14	13	12	12	12	13	13	11	12	12
127	20	M	O+ve	AP	13	15	16	16	16	15	13	15	16	18	15	15	15
128	20	M	A+ve	AP	12	12	13	13	12	12	09	11	13	13	11	11	12
129	20	M	O-ve	AP	11	14	15	16	14	14	13	15	16	16	13	15	15
130	20	M	O+ve	AP	14	16	16	18	16	16	14	15	15	16	15	15	16
131	19	M	O+ve	AP	15	16	17	17	16	16	15	14	16	18	16	16	16
132	17	M	A+ve	AP	11	13	15	18	17	15	11	13	14	17	15	14	15
133	17	M	O+ve	AP	12	11	14	13	13	13	12	12	13	15	13	13	13
134	21	M	O+ve	AP	11	14	11	12	13	12	12	13	15	16	12	14	13
135	19	M	B+ve	AP	14	15	14	17	14	15	15	11	13	15	15	14	15
136	18	M	O-ve	AP	14	13	13	13	13	13	14	12	15	14	13	14	14
137	18	M	O+ve	AP	13	14	15	15	14	14	15	14	16	13	13	14	14

A	B	C	D	E	F											RD	
					G					H							
					T	I	M	R	L	Avg	T	I	M	R	L		
138	19	M	O+ve	AP	15	13	17	15	16	15	13	14	14	14	14	14	15
139	19	M	B+ve	AP	12	14	12	14	15	13	12	12	14	15	15	14	14
140	18	M	B+ve	AP	14	13	17	15	14	15	13	15	16	18	15	15	15
141	21	F	A+ve	AP	14	15	16	17	16	16	16	18	17	16	15	16	16
142	20	F	A+ve	AP	16	17	19	18	18	18	17	15	16	18	15	16	17
143	20	F	O+ve	AP	14	15	17	18	18	16	14	13	17	15	18	15	16
144	20	F	B+ve	AP	16	15	18	18	16	17	16	17	16	16	17	16	17
145	19	F	O+ve	AP	11	13	16	16	15	14	14	14	13	16	14	14	14
146	20	F	O+ve	AP	13	11	13	16	15	14	12	15	14	15	13	14	14
147	27	F	B+ve	AP	16	16	20	11	19	16	18	17	20	20	18	19	18
148	20	F	O+ve	AP	15	15	17	17	16	16	13	17	15	16	18	16	16
149	20	F	A+ve	AP	16	15	17	17	18	17	15	15	18	17	17	16	17
150	19	F	A+ve	AP	11	15	15	16	17	15	14	15	19	20	19	17	16
151	20	F	A+ve	AP	15	18	17	18	17	17	14	13	17	14	14	14	16
152	20	F	B+ve	AP	13	14	16	17	16	15	15	16	16	16	16	16	16
153	20	F	O+ve	AP	12	13	15	16	15	14	13	15	15	17	16	15	15
154	20	F	B+ve	AP	15	15	17	19	19	17	16	18	18	17	19	18	18
155	18	F	A+ve	AP	12	17	19	18	17	17	16	17	16	18	17	17	17
156	17	F	A+ve	AP	13	13	16	17	15	15	16	15	16	18	17	16	16
157	18	F	A+ve	AP	15	15	17	18	16	16	14	16	19	19	16	17	17
158	18	F	A+ve	AP	14	15	20	21	19	18	17	19	22	21	21	20	19
159	18	F	O+ve	AP	13	16	16	18	16	16	13	15	19	18	18	17	17
160	21	F	AB+ve	AP	13	16	18	19	16	16	15	16	17	17	16	16	16
161	19	F	A+ve	AP	15	16	15	17	17	16	15	15	16	16	15	15	16
162	18	F	B+ve	AP	15	16	18	18	18	17	14	17	17	20	18	17	17
163	18	F	O+ve	AP	15	16	18	17	16	16	15	20	19	21	18	19	18
164	18	F	O+ve	AP	16	17	18	22	19	18	16	17	21	17	23	19	19

A	B	C	D	E	F											RD	
					G						H						
					T	I	M	R	L	Avg	T	I	M	R	L		Avg
165	18	F	B+ve	AP	15	15	21	19	19	18	17	19	20	20	16	18	18
166	19	F	AB+ve	AP	15	18	19	19	20	18	16	19	21	20	20	19	19
167	19	F	O+ve	AP	17	16	19	19	20	18	15	18	20	21	17	18	18
168	17	F	A+ve	AP	14	16	18	17	21	17	15	17	21	20	18	18	18
169	21	F	B+ve	AP	15	14	13	15	15	14	15	15	16	17	17	16	14
170	21	F	A+ve	AP	15	16	16	15	13	15	15	16	17	18	18	17	15
171	29	M	O +ve	KL	9	11	10	13	11	11	12	12	12	15	11	12	11
172	26	M	O+ve	KL	12	12	15	13	12	13	13	14	13	13	13	13	13
173	23	M	B+ve	KL	9	12	14	13	13	12	12	14	15	14	13	14	12
174	21	M	B+ve	KL	12	14	15	15	12	14	13	14	15	16	15	15	14
175	23	M	B+ve	KL	12	11	13	15	14	13	12	13	13	14	16	14	13
176	21	M	B+ve	KL	10	11	11	17	15	13	13	15	16	17	18	16	13
177	21	M	B+ve	KL	12	14	14	14	15	14	10	14	15	16	14	14	14
178	22	M	O+ve	KL	11	12	13	15	15	13	14	12	14	15	12	13	13
179	21	M	B+ve	KL	13	13	14	13	14	13	11	12	13	13	12	12	13
180	21	M	O+ve	KL	13	14	16	16	16	15	12	16	16	15	13	14	15
181	21	F	A+ve	KL	14	15	16	17	16	16	16	18	17	16	15	16	16
182	21	F	A+ve	KL	16	17	19	18	18	18	17	15	16	18	15	16	18
183	21	F	O+ve	KL	14	15	17	18	18	16	14	13	17	15	18	15	16
184	21	F	B+ve	KL	16	15	18	18	16	17	16	17	16	16	17	16	17
185	22	F	O+ve	KL	11	13	16	16	15	14	14	14	13	16	14	14	14
186	21	F	O+ve	KL	13	11	13	16	15	14	12	15	14	15	13	14	14
187	27	F	B+ve	KL	16	16	20	11	19	16	18	17	20	20	18	19	16
188	22	F	O+ve	KL	15	15	17	17	16	16	13	17	15	16	18	16	16
189	23	F	A+ve	KL	16	15	17	17	18	17	15	15	18	17	17	16	17
190	21	F	A+ve	KL	11	15	15	16	17	15	14	15	19	20	19	17	15

A	B	C	D	E	F												Total Avg
					G						H						
					T	I	M	R	L	Avg	T	I	M	R	L	Avg	
191	21	M	AB+ve	TN	12	12	13	15	14	13	12	13	14	15	15	14	13
192	26	M	B+ve	TN	15	11	13	13	12	14	14	14	14	14	14	14	14
193	20	M	B+ve	TN	13	12	14	13	14	13	11	12	14	15	15	13	13
194	19	M	A+ve	TN	11	11	13	13	12	12	10	12	12	11	12	11	12
195	20	M	A+ve	TN	10	12	13	14	13	12	11	10	13	13	12	12	12
196	21	F	B+ve	TN	16	17	16	17	15	16	19	20	22	20	20	20	16
197	18	F	O+ve	TN	12	14	15	18	15	15	14	12	14	15	16	14	15
198	23	F	A+ve	TN	13	18	20	20	19	18	15	17	19	20	18	18	18
199	21	F	AB+ve	TN	17	19	17	16	18	17	15	18	20	18	18	18	17
200	19	F	B+ve	TN	13	15	15	16	15	15	14	16	16	18	17	16	15