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MATERIALS AND
METHODS
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The study was carried out at the Institute of Forensic Science, Gujarat Forensic Sciences University during the period from September 2009 to March 2013. The study included 93 convicts mostly male and 136 controls, which included Gujarati population of different age groups of both male and female. The control group was obtained from nonrelated individuals of different age groups, with no obvious genetic disorders. While selecting control, care was taken to rule out any hereditary disorders in family by taking detailed history. Whereas the convicts case study was done in Sabarmati Central Jail, Ahmedabad.

Materials Required: (Fig 26)
1. Kores quick drying duplicating ink.
2. A Rubber roller.
3. Inking Slab- Thick glass sheet fixed over wooden support.
5. White ‘Map Litho’ paper with a glazed surface on one side.
6. Pressure pad made up of rubber foam.
7. Cotton puffs.
8. Scale.
9. Pencil, Pen
11. Needle with a sharp point, for ridge counting.
12. Magnifying lens.
13. Soap and Napkin for washing and drying hands.
14. Lenin tester for ridge counting.
15. Stereo Microscope
16. AFIS
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Materials and Methods

Fingerprint ink

Roller

Glass slab with roller

Fig No.26

Method of Dermatoglyphic Printing:

Dermatoglyphic prints were taken by standard ink and roller method described by Cummins and Midlo in 1961. This method was selected because of following advantages.

➢ It is a simple technique.
➢ It has low cost.
➢ It is less time consuming.
➢ It does not require much space and time.
➢ Clarity of prints.

Steps in the Printing Method:

1. The subjects were asked to thoroughly clean their hands with soap and water. They were also asked to dry their hands, but the care was taken that there was some moisture in their hands.
2. The requisite amount of ink daub was spread uniformly on the glass plate by the rubber roller to get a thin even ink film on the glass slab.
3. The thin film of ink was applied on the palm by passing the inked rubber roller uniformly over the palm and digits taking care that the hollow of the palm and the flexor creases of the wrist were uniformly inked.
4. The palm was examined for the uniformity of the ink, and if found otherwise ink was also applied to the hollow of the palm with the help of cotton puffs.
5. Right hand of the subject was then placed on the sheet of paper (kept over the pressure pad) from proximal to distal end. The palm was gently pressed between

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 inter-metacarpal grooves at the root of fingers, and on the dorsal side corresponding
to thenar and hypothenar regions. The palm was then lifted from the paper in reverse order,
from the distal to proximal end.

6. The fingers were also printed below the palmar print by rolled fingerprint (Fig 27)
method. The tip of the fingers were rolled from radial to ulnar side to include all the
patterns in the standard fingerprint slip.

7 The same procedure was repeated for the left hand on separate paper.

8 The printed sheets were coded with name, age, sex, of the convicts and similarly for the
controls.

9 The prints were then subjected for detailed dermatoglyphic analysis with the help of
magnifying hand lens. The qualitative and quantitative methods of analysis were done for
both palm and fingerprints. The details were noted on the same paper with the pencil/ pen.

As per the ethical committee informed consents were taken from the individuals by asking them
to sign on a consent porforma.

Fig No. 27 Process of taking rolled fingerprints
QUALITATIVE ANALYSIS:

a. Fingertip pattern: Digital patterns were divided as per Galton into three main groups namely arches, loops and whorls. Arches were subdivided as plain and tented.
b. Palmar Pattern: True pattern configurations (tented arches, loops and whorls) were recorded from thenar and first interdigital areas, second, third and fourth interdigital areas and hypothenar area.

QUANTITATIVE ANALYSIS:

**Fingerprint Indices:** All the indices were calculated for male and female, convicts and control and control and convicts male.

a. Pattern Intensity Index = \( \frac{2 \times \text{Whorls} + \text{Loops}}{n} \)
b. Where \( n \) = the total number of fingers on both sides combined.
c. Dankmeijer’s Index = \( \frac{\text{Arches} \times 100}{\text{Whorls}} \)
d. Furuhatta’s index= \( \frac{\text{Whorls} \times 100}{\text{Loop}} \)
e. Poll’s index= \( \frac{\text{W} \times \% - \text{A} \times \%}{100} + 1 \)

**TFRC:** Ridge count: Fingers: This was done along a straight line drawn from the core to the triradius. In case of whorls the larger of the two counts was noted.
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The largest ridge counts on all the fingers were added to arrive at the total finger ridge count.

PALMS:

A-B ridge count: Estimation of this parameter was done by counting the ridges intersecting a line joining digital triradii a and b.

Atd angle: The maximal atd angle on each palm was measured by drawing lines from the digital triradii a and d to the most distally placed axial triradius. The a-b count and the atd angle were recorded for both palms and expressed as the sum total.

Flexion creases: The prints were analysed for the presence of Simian crease and Sydney line.

CLASSIFICATION OF FINGERPRINTS:

Fingerprints data increased over a period of time and it became inevitable to classify the fingerprints of 10 digits to minimize the hurdle and labour in searching and references. Thus various classification systems of fingerprint system have been developed which basically utilized numbers, letters and other symbols selected to indicate certain pattern characteristics. There are nearly fifty such methods in use throughout the different countries of the world. The method in almost universal use is known as the Galton-Henry Method or the Henry system, its name being derived from its originators, Sir Francis Galton and Sir Edward Richard Henry.

Under Henry system, fingerprints are in two classes, those which are given numerical value, and those which are not. Whorls and Composites have numerical value. Arches and Loops are not having any numerical value.

The Primary Classification (of all Ten Fingers)

This is a version of the Henry system, and is the first classification used by the FBI to "whittle down" the possible suspects in a crime.

The fingers are paired, placing one finger in the numerator of a fraction and the other in the denominator. This way all ten fingers can be paired.
If a whorl pattern is found on the first pair of fingers (R. Index/R. Thumb), it is given a value of 16. A whorl on the next pair would be given a value of 8. The next pair, 4, and then 2, then one for the last pair. Arches and loops are valued at 0. Just so the fractions don't end up with 0 in the numerator or denominator, we will add 1 to the top and bottom of the fraction.

Ex: If a whorl was found on the R. Index finger and the R. Middle finger, the following fractions would result:

\[
\begin{align*}
16 & + 0 & + 0 & + 0 & + 0 & + 0 \\
& & & & & \\
0 & + 8 & + 0 & + 0 & + 0 & + 0
\end{align*}
\]

If we add 1 to the top and bottom, we end up with a fraction of 17/9.

\[
\begin{align*}
16 & + 0 & + 0 & + 0 & + 0 & + 0 & + 1 & & 17 \\
& & & & & & & = & \\
0 & + 8 & + 0 & + 0 & + 0 & + 1 & & 9
\end{align*}
\]

Therefore, we can eliminate all suspects that do not have this fraction.

In both numerator and denominator positions one score is added for convenience of calculation. Thus if whorl is present in each finger, the total score at the numerator is multiplied by the total score at the denominator. This gives the maximum of 32x32=1024 score.

If no one is present in any of the fingers then the score distribution will be 1/1.

This way by the presence or absence of whorl in fingers any number from 1 to 1024 can be the total score. On the basis of this scoring a total of 1024 boxes are made of each are termed pigeon holes.
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According to the total score of a person his fingerprint is preserved in the box, bearing the 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 fingerprints efficiently, so that, when necessary for comparative study with another, the desired fingerprint can be very easily and quickly searched out.

**Secondary Classification:**

The patterns occurring in the index fingers constitute the secondary classification. The patterns are always indicated by capital letters. The right index finger being considered the new numerator and the left index the denominator. If arch is in the right index and ulnar loop is in the left index then the secondary will be A/U.

Group or sub secondary: The patterns of whorl and loops of index and middle fingers of both hands comprise this group. Actually the ridge tracing of whorls (I, M, O) and count of loops (I and O) of index and middle fingers are considered. In ridge tracing of whorls trace from the lower branch of the left delta, following it towards right delta.

**AFIS: (AUTOMATED FINGERPRINT IDENTIFICATION SYSTEM)**

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, technological advances have made possible the classification and retrieval of the fingerprints by computers.

Thus AFIS came into existence which is one of the most powerful tools for the expression of scientific evidences- that no human being is exactly the same as any other human being. It has been revealed by current science that people (and in a broader sense, all organic entities) differ significantly in almost every way.

AFIS provided majority of solutions to many challenges prevailing in the field of fingerprint sciences. It has excellent capacity of storing and searching vast quantities of data very rapidly. Secondly it has increased consistency in classification and search criteria. It can also help in eliminating of large volume of stored hard copy of fingerprints.
Therefore it can be concluded that AFIS is one of the most important technology that can be used to store, search and compare the chance prints from the existing data.

The first AFIS system was conceptualized and developed in 1974 by Printrak, then a division of Rockwell International. The fledgling version of AFIS (Fig 29) was adopted by the FBI. Now there are many companies which supply AFIS technology to countries around the world.

![Automated Fingerprint Identification System](image)

**Fig No. 29** Automated Fingerprint Identification System
Fig No. 30 Ten print database entry screen. Centers, deltas, and patterns are automatically set. NCIC and Henry are also automatically set, however, all information can be edited by user.

Fig No. 31 A latent finger to TP card hit with common points selected by user.
The Sequential Steps in the AFIS is as Follows:

1. The first step is to receive and store multiple data of each entrant to the system. This includes name, date of birth, and other record information. (Fig 30)
2. Enhances and sharpens the ridge detail for maximum accuracy when prints are scanned.
3. Automatically scans and classifies all ten fingers of each entrant at high speed.
4. Compares a suspect impression, classified in the same manner, to the database of known impressions.
5. Ignores all the impressions that, on the basis of the data entered, could not be a match and generates a numerical score for each of the top possibilities based on how closely they resemble the subject of the search.
6. Displays the match report in descending order, of the top possibilities that cannot be eliminated on the basis of the image data received and the numerical score assigned to them. In the interests of efficacy, most systems are programmed to display only the top choices. (Fig 31)

The fact that should be understood is that all AFIS systems are elimination systems not identification systems. Computers do not, at present identify fingerprints. The final function of the technology in this progression is the presentation of the top scoring possibilities. These possibilities may or may not include a match.

AFIS includes a software program to perform fingerprint encoding referred to as algorithm. When a fingerprint is scanned into an AFIS system, the encoding software allows the computer to see the actual ridge characteristics (bifurcations and ridge endings). A map is created of the location and direction of all characteristics contained in the scanned impression. The image of the fingerprint is therefore converted into numerical information that is easily stored in the computer memory.

Automated classification does not rely on the pattern designation, slope and core/delta designations that were so problematic in manual collections. It depends entirely on location and direction of minutiae, and their spatial relationship to each other. An AFIS search is unaffected by unrecorded loops and delta, so vital to the effectiveness of a manual system.
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The challenges faced in the AFIS system are as follows:

1. Impressions not placed accurately in the designated space at time of inking arrest fingerprints.
2. Uneven or excessive recoding medium (eg. Ink).
3. The end of the finger is a soft moveable pad. Pressure and twisting during the recording can significantly distort the distances between minutiae.
4. Permanent and temporary scars. All of the above also affects crime scene fingerprints.

Searching the database:

The searches not possible in the manual system can be easily done by digitization method of the AFIS:

- **Latent to database**: New latent fingerprints can be searched against the file to establish if that crime can be associated to any subject with a previous record.
- **Latent to Latent**: New latent fingerprints can be searched against the file of existing latent impressions to detect connections between crimes.
- **Re-searches**: Latent fingerprints associated to serious crimes can be re-searched on a regular basis to determine if the donor, here to for unknown, has been added to the database in the interim.
- **Regional searches**: Searches can be restricted to a specific region when indicated by investigative factors. This reduces pressure on the system operation and shortens the search time.
- **Ten Print Searches**: A known set of fingerprints is searched against the database to determine if the same person is present under another name.

The advent of computers heralded a new age for many forensic sciences and among the first to utilize the technology was the science of fingerprints. The process of capturing, storing, searching, and retrieving fingerprints via computer is now a standard occurrence among police agencies and forensic science laboratories. An AFIS can store millions of print images that can be searched in a matter of minutes by a single operator. The core of this electronic system is a standard format developed by the FBI and the National Institute of Standards and Technology (NIST), with the advice of the National Crime Information Center (NCIC), which provides for
the conversion of fingerprints into electronic data and their subsequent exchange via telecommunications and computers. Apart from AFIS a new automated fingerprint system known as the Integrated Automated Fingerprint Identification System, or IAFIS. IAFIS can also digitally capture latent print and 10-print images and then do the following:

1. Enhance an image to improve its quality.
2. Compares crime scene fingerprints against known 10-print records retrieved from the database.
3. Search crime scene fingerprints against known fingerprints when no suspects have been developed.
4. Automatically searches the prints of an arrestee against a database of unsolved cases.

Thus the heart of AFIS technology is the ability of a computer to scan and digitally encode fingerprints so that they can be subjected to a high speed computer processing. The AFIS uses automatic scanning devices that can 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 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 file prints. In this manner computer can make thousands of fingerprint comparisons in-a second. During this search for the match, the computer uses a scanning system that assigns prints 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 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 and developing suspect’s lists and time in investigating the suspects generated by the computer.