REVIEW OF LITERATURE
History

Lines on the human hand have, since long, been a subject of great interest. Significance of these lines in predicting the course of future event has been emphasized by fortune tellers. Their utility in identifying criminals is also well recognized. However, their biomedical significance is not so well known.

The system of identification by finger prints, had its origins in China where it was in vogue for many centuries. The Chinese employed the finger print systems for the signing of contracts by illiterate persons. In foundling asylums every infant on its reception was recorded for possible identification, the design of his finger tips being the most important part of the record.

The history of Chinese seals begins with the famous seal of Emperor Te1 in Shi, B.C. 246-210. It was carried from white jade, but prior to this seals were made of clay, on one side of which was the name of the owner and on the other the impression of his thumb, the later evidently serving the purpose of identification.
The Chinese, though well acquainted with the various patterns found in finger prints did not, however, develop them into a system of classification.

**Early Scientific Study**

Scientific interest in this field is also old. It dates back to 17th century when scientific workers like Nehemiah Grew, fellow of the College of Physicians and Surgeons of the Royal Society, England in 1681 and Marcello Malpighii, Professor of Anatomy at the University of Bologna, Italy in 1686 described the morphology of various parts of the palm. Other pioneers in this field have been Johannes Evangelist. Purkinje who in 1823 submitted a thesis at University of Breslau for the degree of 'Doctor of Medicine', describing finger prints' type and classifying them in nine major groups. Henry Faulds, an Englishman, working at the Tsukiju Hospital, Tokyo, around 1858 collected the finger prints of Japanese and other nationalities and compared their ethnological differences. He also gave the valuable suggestions of identifying a criminal by his finger prints left at the scene of crime. Sir Francis Galton, England in 1892 took up the study of papillary ridges with great interest and proved through experiments that there is
(3) By far the most advantageous field of biological and medical investigation is that concerned with the topography of the systems of parallel ridges at microscopic level, that is, as seen fairly easily by the naked eye or with a magnifying hand lens. In general now flexion creases are also studied under the field of dermatoglyphics the term having been coined by Cummins and Midlo in 1926.

Cummins' interest in dermatoglyphics was first aroused by the toe configurations of an anatomical subject, the study appeared in 1923.

Kristine Bonnevie (1924) worked on various aspects of inheritance and on embryological processes leading to the expression of particular configuration. She was the first to use "Quantitative Value", based on the ridge count, instead of traditional qualitative values of finger print types to determine the inheritance of finger prints.

In 1926 Cummins published three other papers one dealing with a new way to time intrauterine digital eruptions and another with the ridge configurations of developmental defects.
Dermatoglyphics in Population Studies

Cummins and Midlo (1926) were first to publish dermatoglyphics of European and American population. Cummins in 1927 published dermatoglyphics in Jews and Negroes of West America. This was the start of long study of dermatoglyphics in different social groups which was carried out by Cummins and Midlo and many others throughout the world. In India, considerable work has been done on racial variations of dermatoglyphics and much more is still in progress (Mukherjee, 1970; Kumar Santosh 1974).

Dermatoglyphics and Genetics

Genetic studies of the finger pattern types, arches, loops, whorls were confusing; but study of a quantitative value — the total finger ridge count of the ten fingers — provided an excellent example of polygenic inheritance. Resemblance between relatives was found to be surprisingly close to the number of genes that on average such relatives have in common. For example, a correlation of 0.5 (expected 0.5) was found for parent and child or brother and sister and dizygotic twins, 0.95 (expected 1.0) for monozygotic co-twins, close to zero for husband and wife. The similarity of the total finger ridge count of
monozygotic co-twins (proved to be monozygotic by 
full blood typing) has made finger prints a useful 
adjunct to determining the type of twining. There 
are indications that not many gene loci are involved 
in determining the ridge-count, but no success has 
linkage and chromosomal studies.

At present there is wide agreement that the 
heredity of most dermatoglyphic features confirms to 
a polygenic system, with individual genes contributing 
a small additive effect. Modern cytogenetic methods, 
which allows rather precise identification of chromo-
somes, are certainly to be of great value in studying 
the correlations between individual chromosome aberrations 
and dermatoglyphic features and may lead to establishing 
the loci of genes that influence dermatoglyphics. However 
a limitation to the precise genetic analysis of dermato-
glyphics is the difficulty in delineating some features 
and reducing them to quantifiable characteristics. Many 
transitional features exist and too much latitude for 
subjective classification is still possible. Improvements 
in reliability of classification and more precise 
delineation of dermatoglyphic features will undoubtedly 
be followed by advances in understanding of the 
importance of genetic factors in the development of 
epidermal ridge configurations.
ARCH  LOOP  WHORL

SHOWING DIGIT PATTERNS AND RIDGE COUNT
FROM TRIRADIAL TO POINT OF CORE
Dermatoglyphic analysis has several advantages:

1- It can be applied readily.
2- Results are available immediately as a clinical diagnostic tool.
3- Expensive and elaborate pieces of equipment are not required.
4- The procedure is atraumatic.

DERMATOGLYPHIC NOMENCLATURE

I- Finger Print Topography

Three basic patterns are distinguished (Galton):

(a) Loop (L): The ridges enter and end on the same side forming a hairpin-like pattern. It has a centre or core and a triangle which is called a triradius. If they open towards the ulnar side, they are called as ulnar loops and if they open towards the thumb they are called as radial loop.

(b) Whorls (W): The whorl is a design where the majority of ridges made a circle around the core or hub. It has two triradii.

(c) Arches (A): The ridges run in arches, parallel to each other. It has no triradius.

Distribution of Pattern Types on Single Digits:

On every digit ulnar loops are the most abundant pattern, the frequency ranging downward from
88% in digit V, 74% in III, 62% and 61% respectively in IV and I, and 35% in digit II.

Whorls, next in total frequency, are most numerous on I and IV, 35% and 34% respectively, while II is not much lower, 30%; III and V present a sharp reduction, 16% and 11% respectively. Of all pattern types, radial loops have the greatest relative range of frequency among the digits. They occur in 25% of index finger, 30% in III, 1% in IV and in I and V they are reduced to very small fractional percentages 0%, 0.2% and 0.1%. The frequency of arches is 11%, 7%, 4%, 2% and 1% on II, III, I, IV and V respectively (Cummins and Midlo).

II- Ridge Count from Triradial Point to Point of Core

Ridge count is the number of ridges between the triradius and the core of the pattern. Total ridge count which is the total score of all ten fingers, has been found to be genetically controlled. The ridge count is zero for an arch and twice as much as for a whorl as for a loop of comparable size (Bonnevie).

III- Triradii

The triradii in the palm are more significant than those which are associated with finger print patterns. The meeting point of three different fields
SHOWING DIFFERENT TRIRADII
AND aID ANGLE
of parallel ridges of the patterns is known as triradius which is the main land mark for classification of prints (Cummins and Midlo; Hale et al and Penrose). The triradii are of two types:~

1) Digital triradii: These are known as a, b, c and d in radioulnar sequence located on the base of the 2nd, 3rd, 4th and 5th fingers.

2) Axial triradius: It is indicated as t (near the wrist crease) t" (near the centre of the palm) and t' (intermediate lying near a line transecting the base of the thumb). A composite of X-ray of digits and axial triradii shows that the distribution of axial triradii is confined rather closely to the axis of the 4th metacarpal bone.

IV- atd angle

The atd angle is formed between lines drawn from the triradii at the base of the index and little fingers to the axial triradius. The more distal the axial triradius the larger is the angle. The position of the axial triradius forming an angle greater than 56 degrees is designated as distal or t", between 44 to 56 degree as t' and below 43 degrees as t.

V- Palm

The main areas of palm are the thenar, hypothenar eminences and interdigital areas between different fingers.
MAP OF THE SIX CHIEF DERMATOGLYPHIC AREAS OF THE PALM (CUMMINS & MIDLO 1943)
There are three flexion creases found on the palm, the palmist's 'line of life', 'line of heart' and the 'line of head'. Sometimes two of these, i.e. line of heart and line of head are fused together. In that case, it is called a 'simian line'.

VI- Sole

It is divided into 8 configurational zones viz I, and II hallucal areas combined with the first interdigital areas; III, IV and V interdigital areas, VI hypothenar area, distal and proximal; VII thenar area, distal and proximal, and VIII calcar area (Wilder)

Sexual Variation in Dermatoglyphics (Cummins and Midlo)

There are some differences in the dermatoglyphical findings of males and females which are as follows :-

(1) **Ridge breadth** : In female the ridges are narrower. In young adult males, the mean number of ridges per centimeter is 20.7, a value to be compared with 23.4 in young adult females. Ridges in the females are significantly finer, since on the average there are $2.7 \pm 0.09$ more ridges per centimeter as compared to males. This sexual difference, of-course expresses itself only in the general trend.
(2) **Size of hand**: Females usually have the smaller size of the hand as compared to males.

(3) **Fingerprint types**: Among various racial sample females almost universally differ from males in having more arches and usually they differ also in having fewer whorls. The arch/whorl index is almost without exception higher in females. Radial loops are fewer in females.

**DERMATOGLYPHIC FINDINGS IN NORMAL SUBJECTS**

The following tables give the incidence of patterns of fingers, toes and hallucal area of the sole in normal subject (Penrose):-

**TABLE I - FINGERS**

<table>
<thead>
<tr>
<th>Patterns</th>
<th>Thumb</th>
<th>Index</th>
<th>Middle</th>
<th>Ring</th>
<th>Little</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ulnar loops</td>
<td>60.89</td>
<td>35.20</td>
<td>74.07</td>
<td>87.62</td>
<td>62.27</td>
</tr>
<tr>
<td>Radial loops</td>
<td>0.21</td>
<td>24.70</td>
<td>2.52</td>
<td>0.11</td>
<td>0.98</td>
</tr>
<tr>
<td>Whorls</td>
<td>35.41</td>
<td>29.47</td>
<td>16.37</td>
<td>11.44</td>
<td>34.44</td>
</tr>
<tr>
<td>Arches</td>
<td>3.49</td>
<td>10.63</td>
<td>7.04</td>
<td>0.83</td>
<td>2.31</td>
</tr>
</tbody>
</table>
**TABLE II - TOES**

<table>
<thead>
<tr>
<th>Patterns</th>
<th>I %</th>
<th>II %</th>
<th>III %</th>
<th>IV %</th>
<th>V %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arches</td>
<td>11.8</td>
<td>8.7</td>
<td>4.8</td>
<td>20.9</td>
<td>51.5</td>
</tr>
<tr>
<td>Loops</td>
<td>80.4</td>
<td>72.4</td>
<td>37.5</td>
<td>60.6</td>
<td>48.9</td>
</tr>
<tr>
<td>Whorls</td>
<td>7.8</td>
<td>18.9</td>
<td>57.7</td>
<td>18.7</td>
<td>0.6</td>
</tr>
</tbody>
</table>

**TABLE III**

**INCIDENCE OF PATTERNS ON THE HALLUCAL AREA OF THE SOLE**

<table>
<thead>
<tr>
<th>Patterns</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whorls</td>
<td>30.8%</td>
</tr>
<tr>
<td>Loop distal</td>
<td>48.5%</td>
</tr>
<tr>
<td>Loop tibial</td>
<td>7.3%</td>
</tr>
<tr>
<td>Open field</td>
<td>12.2%</td>
</tr>
<tr>
<td>Others</td>
<td>1.2%</td>
</tr>
</tbody>
</table>
RIDGE COUNT:

Score of all ten fingers.

Males : 145
Females : 127
Normally arch : Nil
Loop : About 12
Whorl : About 19

POSITION OF AXIAL TRIRADIUS:

In most of the persons (64%) it is present towards the wrist but in majority of mongolism patients it is placed distally i.e. towards the finger's base side.

at d ANGLE:

Normally it is about 45% but it may increase in many diseases.

SIMIAN LINE:

It is present in only 2% of normal individuals.

DERMATOGlyphics IN NORMAL INDIan POPULATION:

Broad statistical results of dermatoglyphic analysis of finger, palm, toe and sole prints have been presented by Mukherjee and Saha in normal Bengalee population as follows:

Whorls : 40%
Ulnar loop : 55%
Radial loops: 2%
Arches : 3%
TOTAL RIDGE COUNT:

Score of all ten fingers:
Males : 153.50
Females : 140.12

These results suggested greater homogeneity of the Bengalee caste populations compared to other parts of India.

In North Indian population the dermatoglyphical findings in healthy children were studied by Kumar, Mangal and Kumar.

DERMATOGLYPHICS AS A DIAGNOSTIC AID:

For many years, dermatoglyphics has been accepted as a useful tool in the differentiation between monozygotic and dizygotic twins. Biologically, dermatoglyphics has great value in determining the zygosity type and thus, for renal transplants to be successful the donor and recipient should be identical twins. Thus a biologically appropriate choice may be made from studying the dermal ridges.

Interest regarding the significance of dermatoglyphics in the field of medicine is relatively new. Its significance in Mongolism was first demonstrated by Cummins (1926). In his paper he wrote "In these series of Mongoloids idiots, the dermatoglyphics of finger type and palms present a number of
characteristic markedly differing from those of a racially comparable normal child". It is a pity that this diagnostic aid was not further explored, as with the development of chromosomal staining technique in 1960, it was proved that Mongolism was associated with chromosomal aberration.

Since then, with the rapid development of human cytogenetics, the discovery of chromosomal aberrations and knowledge of genetic diseases and syndromes, the value of dermatoglyphics in clinical medicine has been proved. These are Turner's syndrome, Klinefelter's syndrome, D & E Trisomy, De Lange syndrome, Congenital heart diseases, Schizophrenia, Anencephaly, Phenylketonuria and Neurofibromatosis.

There are other clinical entities in which dermatoglyphical studies are underway in various parts of the world are; Systemic Lupus Erythematosus, Pseudohypoparathyroidism, Thalassaemia syndrome, Diabetes, Leprosy, Coeliac diseases, Leukemia, Schizophrenia, Childhood cirrhosis, Wilson's disease, Sickle cell disease, Cardiovascular diseases, Rubella syndrome, and Retinoblastoma, etc., to name only few.

Some social problems like juvenile delinquency, criminal behaviour and mental retardation are also being investigated for dermatoglyphic markers.
<table>
<thead>
<tr>
<th>Syndrome</th>
<th>Fingers</th>
<th>Palms</th>
<th>Hallucal Area of Foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Down's syndrome (trisomy 21 or</td>
<td>Ten ulnar loops (60%)</td>
<td>Distal axial triradius (85%)</td>
<td>Arch tibial or fibular</td>
</tr>
<tr>
<td>translocation type)</td>
<td>Radial loop on 4th and/or 5th digits.</td>
<td>Single flexion crease (50%)</td>
<td>Large pattern</td>
</tr>
<tr>
<td>Di trisomy</td>
<td>Increased number of arches</td>
<td>Very distal axial triradius</td>
<td>Single flexion crease</td>
</tr>
<tr>
<td></td>
<td>Low TFRC †</td>
<td>Large pattern</td>
<td>The nar pattern</td>
</tr>
<tr>
<td>18 Trisomy</td>
<td>6-10 arches (also on toes)</td>
<td>Distal axial triradius</td>
<td>Single flexion crease</td>
</tr>
<tr>
<td></td>
<td>Single flexion crease on 5th digit.</td>
<td>Single flexion crease</td>
<td></td>
</tr>
<tr>
<td>Cri du chat syndrome (deletion short</td>
<td>Increased number of arches</td>
<td>Distal axial triradius</td>
<td>Open field</td>
</tr>
<tr>
<td>arm of No. 5)</td>
<td>Low TFRC</td>
<td>&quot;Bridged&quot; flexion crease</td>
<td></td>
</tr>
<tr>
<td>Turner's syndrome.</td>
<td>Variable; patterns usually large loops or</td>
<td>Axial triradius slightly more distal</td>
<td>Axial triradius more</td>
</tr>
<tr>
<td></td>
<td>whorls with high TFRC</td>
<td>than average</td>
<td>proximal than average</td>
</tr>
<tr>
<td>Klinefelter's syndrome</td>
<td>Increased No. of arches</td>
<td>Axial triradius more than average</td>
<td>Simian line</td>
</tr>
<tr>
<td></td>
<td>TFRC below average</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deletion long arm of No. 18</td>
<td>Excess whorls</td>
<td></td>
<td>Open field.</td>
</tr>
<tr>
<td>Other syndromes with extra X and Y</td>
<td>Increased number of arches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>chromosomes.</td>
<td>Reduced TFRC; the more X's and Y's present</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>the reduction is greater.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Based chiefly upon the data of Walker (1957), Penrose (1968), Uchida and Soltan (1963) and Holt (1966). † TFRC = Total Finger Ridge Count.
The first investigation of dermatoglyphics in diabetes mellitus was done in 1973 by Verbov, London. He studied dermatoglyphics in early onset (≤ 40 years) diabetes mellitus and found:

1. Decrease incidence of whorls, and increase incidence of arches in early onset female diabetics,
2. Pattern frequencies in left third area in female diabetics and in the fourth area in male diabetics was significantly different,
3. a-b ridge count in female diabetics was low.

Vormittag et al (1974) studied both early and late onset diabetes mellitus and observed:

1. Increase in whorls in both early and late onset male diabetics.
2. Decrease in loops in early onset male diabetics.
3. Increase in arches in both early and late onset male diabetics.
4. In thenar area decrease in pattern frequency of right hand in early onset female diabetics and decrease in late onset diabetes mellitus.
5. In hypothenar area patterns (mainly loops) were more frequent in both male and females.
Bhu et al (1980) from India also studied dermatoglyphics in both early and late onset diabetes mellitus and found -

1. Increase in whorls in early onset male diabetics.
2. Increase in loops in late onset male diabetics while decrease in early onset male diabetics.
3. Increase in arches in early and late onset female and male diabetics.
4. Decrease patterns in III interdigital area in early onset male diabetics.
5. Markedly low incidence in pattern frequency in both sexes and both type.

Gracia-Sagredo et al (1977) also studied dermatoglyphics of 152 diabetic patients (males and females) and grouped the patients according to infantile onset and adult onset. He also observed significant differences.

Piantal I.S. (1978) also observed different dermatoglyphic features in diabetes mellitus.

The role of dermatoglyphics as a diagnostic tool is worth notice. It certainly helps in fortifying a clinical diagnostic impression even if it does not surely lead to confirmation of the diagnosis. As Achs had emphasized, that dermatoglyphic findings
"prompt the physician to make a more thorough examination than usual to find out any hidden abnormality".

If a marker in diabetes mellitus cases could be found, the possible predisposition to such illness can be known right from the birth. What is needed is more research in this branch of science.

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