INTRODUCTION
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History

On a relatively small area of the body of human and his arboreal ancestors, the skin has a specialized structure which is corrugated with narrow ridges. Pattern traceries of these fine ridges aroused interest long before the onset of modern civilization. Among many other curious documents are the neolithic carvings at cave Brittany, which reflects the unquestionable evidence of human interest in the fine ridges on skin (Cummins, 1956). It is the study of the configurations formed by these ridges that is referred to as 'Dermatoglyphics'. The word 'Dermatoglyphics' literally means the patterns formed by the epidermal ridges of the skin, and this has been derived from Greek (dermē - Skin + glyphe - Carve). This word was coined by Harold Cummins (1926) to describe the study of the patterns on palm, palmar surface of fingers, sole and the plantar surface of the toes. It is now well understood that ridged skin is not strictly confined to the palmar and plantar surfaces. Ridges occur over the tips of digits, and on the digital margins, where as along the margins of the palm and sole they extend about halfway to the dorsal surface (Cummins and Midlo, 1945).
Science of dermatoglyphics seems to have been well known to Indians centuries ago who used the thumb print for personification purposes. "Emperor's Thumb Mark" in China has served as official seal since centuries. High degree of significance attached to thumb impression by Chinese dates back to third century B.C (Cummins and Midlo, 1945).

The first categorical description of dermal ridges, their arrangement on palm and fingers came from Nehemiah Grew (1684). His terms like 'triangles' and 'ellipticks' have now been transformed in modern parlance to triradii and loop patterns, respectively. In the following year a publication of Midlooc (1685) on Humen Anatomy includes a short account of the epidermal ridges of the thumb. A later publication by Malpighi (1686), described human ridge system similarly. During the eighteenth century, Hintze (1747) noticed the minute details of the papillary ridges on the sole. Another remarkable work is due to Kayer (1788), who identified further peculiarities of arrangement of dermal ridges and recognized the variation at individual level. Schroter (1814) further described the arrangement of ridges and pores. However, it was Purkinje (1823) to undertake the studies on the diversity of finger print patterns and he suggested, perhaps the first system of classification. He recognized nine basic pattern types. The modern science of epidermal ridge patterns came alive during the twenty
years 1880-1900 with the works of Kerschel, Faulds, Galton and Henry. The credit for a sound and scientific approach to this subject goes to Francis Galton (1882). He initiated his studies on the significance of personal identification, which were later extended to cover inheritance and ethnic differences in dermatoglyphic traits. Faulds (1880) inferred the forensic utility of finger prints thus giving a new significance to the subject for the purposes of personal identification. Kerschel (1880) in the same year published his observations on use of dermatoglyphics in personal identification. Henry's (1901) contribution to this field is his widely recognized classification of finger prints, reducing the pattern types to four (arches, loops, whorls and composites) as opposed to nine in the system after Purkinje (1823).

During the first few decades of this century, the use of dermatoglyphics was thus extended from its place in criminology to anthropology, comparative zoology and human genetics.

A proper understanding of dermatoglyphics in man necessitates a knowledge of their genesis mechanisms. Despite the recent increasing importance of dermatoglyphics in human genetics, the knowledge about the development of these traits is in infancy. The orderly sequence of events is most critical, while the duration of each stage varies within a certain time range (Mulvihill and Smith, 1969). Many studies on the dermal ridges have been reported from the standpoint of developmental anatomy. Most of them are concerned with
The works of Kölliker (1848-49), Engel, Wilson (1880), Lewinski (1883), Kollman (1883), Bonnevie (1927, 1929, 1932) and Hale (1948) established that the critical phase of differentiation of epidermal ridges in the human fetus begins in fetus of approximately 70 mm C.R. length (or 7th week) and is completed at 150 mm (12th fetal week) C.R. length.

Dermatoglyphic patterns are found on the sites of the volar pads. These pads appear during the 6th and 7th fetal week and begin to regress during 4th fetal month (Holt, 1973). The rate at which the pads regress, the period at which the regression begins, as well as the time of onset of progression of ridge development are thought to be under genetic control (Cummins 1923, Cummins and Sicomo 1923, and Hale 1952). It is clear that the volar pads have important function in determination of ridge patterns but the underlying mechanisms remain obscure. It is believed that the ridges develop at right angles to lines of growth stress; that asymmetry of the volar pads leads to asymmetry in the ridge patterns (ulnar/radial loops) (Salmon et al. 1978). The geometry of relations between loops and triradii is discussed by Penrose (1965), who states that the developing patterns follow the laws of topology, but the surface they cover is defined by the interaction of the fetus's genetic constitution with the early intrauterine environment.
The detailed structure of individual ridges varies greatly. The ridges are non continuous segments of varying lengths, branchings and certain irregularities. The variability is further multiplied at individual level. No two individuals in this universe are known to have identical dermal configurations. Differences, though minor, occur even among the monozygotic twins. Several authors (Roberts and Coope, 1972; Chamla and Salhy, 1973 and Jantz and Owsley, 1977) have, however, used dermatoglyphics as a group characteristics as racial and ethnic differences can be made out in terms of dermatoglyphic traits. A study of Japanese twins (Okajima, 1967) showed that the total number of minutiae in a particular dermal region may be useful for the purpose of individualization, however, for ethnic and medical applications, only the major pattern types seem important.

Genetics

Genetics of dermatoglyphic traits have been investigated since the work of Kristine Bonnevie (1924) on heritability of finger ridge counts. This study was followed initially by the works of Newmann (1931) and Geipel (1941). Bonnevie's method of counting ridges to quantitative measures of finger ball patterns was extended over to family studies in works of Holt (1956, 1957), Fang (1950), Anderson (1963) and Loesch (1971). Several studies examined the nature of
inheritance of atd angles (Penrose, 1949, 1954) a-b ridge counts (Fang 1950, Pons 1964), and the ridge count of hallucal patterns of soles (Smith, 1964). Evidence coming from familial correlations, corroborated by twin studies (Newman, 1931; Holt, 1957; Lamy et al., 1957; Nance et al., 1974) and Nance 1976) indicate that dermatoglyphic traits are mainly under genetic control, however, the total number of controlling genes remains uncertain. There is a wide agreement that the heredity of most dermatoglyphic features conforms to a polygenic system of inheritance with individual genes contributing a small additive effect (Schaumann and Alter 1976). There are metrical differences between sides of the body and human body is bilaterally asymmetrical in this sense. Holt's (1954) study on British sample appreciable genetic basis for the ridge count asymmetry. Kavalvada (1963) and Bener (1979) have further confirmed the report by Holt (1954). Holt (1954) attributed the asymmetry in the finger ridge counts to environmental factors but another study on Australian-European family data pointed out towards a significant hereditary component (Singh, 1970). Except Mukherjee (1966), almost all other workers could find no differences between the two sexes (Hashad and M. 1970; Bener, 1979). The palmar flexion creases often regarded secondary to early flexional folding in the skin during the limb development (Popich and Smith, 1970). Association of unusual palmar creases with certain well defined chromosomal anomalies such
as Down’s syndrome, trisomy-D (Uchida, Patau and Smith, 1962), trisomy-E (Penrose 1969) is a pointer towards a genetic basis. Reed et al. (1979) could not draw any conclusions concerning the maternal influences.

While most of the studies lend support to the idea of a genetic basis for dermatoglyphic characteristics, the results are mutually inconsistent and unreliable. Meninger and his associates (1976) opined that it is not possible to develop a really satisfying hypothesis of inheritance for the immensely complicated features such as total ridge count. Most of the genetic information bearing on inheritance of dermatoglyphic patterns is not compatible with any single genetic model, and even those studies which endeavour to show a simple mendelian inheritance of some dermatoglyphic features recognize the environmental factors playing an important, yet unmeasurable role (Alter 1966). Taking the analogy of animal systems, the developmental pathways of a stable and canalized character should be symmetrical with respect to the two sides of any individual. Any asymmetry which appears will be an expression of local disturbances, whether arising from differences of environment or chance inequalities of cell development comparable to developmental noise well established in certain instances (Nather, 1957; Reeve and Robertson, 1954). Single gene disorders like tuberous sclerosis (David 1972), Thalassemia (Tay 1976), Phenyl
Ketonuria (Alter, 1967) are not correlated with any particular dermatoglyphic pattern types, which support the idea of polygenic inheritance. Polygenic control of dermatoglyphics could also be an explanation for no recognizable linkage between dermatoglyphic traits and Mendelian genetic markers.

A part of the difficulty in genetic analysis of dermatoglyphic data may be due to the unsatisfactory classification (Cummins and Midlo 1943), which is highly ramifying (Kloepfer and Cummins, 1963). A new approach suggested by Penrose and Loesch (1969, 1970) is becoming increasingly useful in handling the dermatoglyphic data.

**Dermatoglyphics in Medicine**

Inspite of the widely recognized multifactorial nature of inheritance and in face of the great likelihood that any single classification may prove to be insufficient for a quantitative analysis of dermatoglyphic data. Several reports have appeared in the literature claiming association of dermatoglyphic traits with different diseases. Among other points of interest in association of dermatoglyphics with certain pathological condition is the potential of diagnosis. It was Harold Cummins (1939) to first demonstrate the possible use of dermatoglyphic data in clinical medicine, but its value was not fully recognized until the work of Walker (1957). Walker (1957) noticed the peculiar dermatoglyphic features in
Mongolism. Since then the field of dermatoglyphics has received ever increasing attention of the medical practitioners. Today some patterns of epidermal ridges are widely accepted as useful aid in diagnosing or at least delineating certain syndromes, several malformed conditions due to numerical and structural aberrations of the chromosomes and a few disorders controlled by genetic and environmental components (Leo Reyes, 1963).

During the last two decades investigations dealing with the association of dermatoglyphics with certain diseases has opened new diagnostic avenues. Can dermatoglyphic features distinguish the persons affected by certain diseases from those who are normal is a very pertinent question (Saksena and Kumar, 1978). It is to be remembered that the significance of dermatoglyphics does not lie in presence of abnormal pattern types but is rather due to increased or decreased frequency of normal patterns (Ross, 1979).

Three well established autosomal trisomic conditions associated with specific distortions of the ridge configurations include Trisomy-21 (Mongolism or Down's syndrome), Trisomy-13 (Edward's syndrome) and Trisomy-13 (Patau's syndrome). Following the significant discovery of human chromosome number as 46, Lejeune et al. (1959) examined the chromosomal constitution of Down's syndrome as trisomy of chromosome number 21. Long before the chromosomal basis
for Down's Syndrome was accepted, Cummins (1939) has demonstrated marked differences in the pattern frequencies between affected and normal children. One very important dermatoglyphic feature diagnostic of Mongolism is simian crease. This crease is found in about 35-60 per cent of the affected cases (Cummins et al., 1950; Rowe and Uchida, 1961). Features of diagnostic value are increase in overall pattern intensity (Feng, 1950) and on hypothenar region a high frequency of ulnar loops (Bolt, 1964), and distal displacement of the axial triradius (Cummins, 1939; Penrose, 1954; Walker, 1957). Smith and Turrall (1963) have reported deviant dermal ridge arrangement on the soles. Hallucal tibial arch, a rare occurrence in normal individuals is another significant feature of Down's Syndrome (Nora and Fraser, 1974). Other notable contributions describing the use of dermatoglyphics in diagnosing mongolism are: Beckman et al. (1965), Reed et al. (1970), Tumpin and Le jeune (1953).

Diagnostic dermatoglyphic features like, high frequency of arches (Uchida et al., 1962, 1964; Alter, 1966), and increased frequency of radial loops (Cummins and Midlo 1960; Ross 1953) have been associated with Trisomy-18 or Edward's syndrome (Edwards et al., 1960). Uchida et al. (1962, 1964) have noticed the characteristic single crease on the fifth finger along with simian crease in about fifty per cent cases of this syndrome.
Patau et al. (1960) reported a new trisomy syndrome, also designated as Patau's syndrome, which is characterized by an extra D-chromosome. Significant association of distally located axial triradius, more number of thenar Patterns (Uchida et al. 1962, 1964; Penrose, 1964), predominance of arches and radial loops over ulnar loops (Salmon and Linderbaum, 1978) are found to be associated with this syndrome. Penrose (1972) and Tuncbilek et al. (1972) have noticed a relative increase in pattern intensity and a low ridge count in Trisomy-8.

Investigations on sex chromosomal anomalies have proved to be futile in this regard. Complication in interpretation of results is further intensified by sex differences. An excess of sex chromosome material seems to reduce the complexity of the digital patterns (Penrose, 1967), whereas, syndromes with deficient chromosomal material are found to result in a reverse effect (Penrose, 1967; Saldana-Garcia, 1979). Among males an additional chromosome seems to be of major importance in reducing the size of dermal patterns (Saldana-Garcia, 1975). Females of Turner's phenotype are reported to have reduced frequency of arches (Holt and Lindsten, 1964), and small sized patterns both in the hypothenar and thenar regions (Saldana-Garcia, 1979). Low ridge count and small sized dermal patterns are reported on the hands of patients with Klinefelter's constitution (Holt, 1963, 1964; Uchida et al.,
However, dermal patterns in XXYY and XXXXY phenotypes are grossly distorted (Uchida et al., 1964; Holt, 1973). Hypothenar radial arches, which are otherwise associated with absent 't' condition, have been found in condition like XXXY (Ellis et al., 1961) and XXXY (Vormittag and Weininger, 1972). Super females' (XXX) chromosomal types have been shown to have a dominance of radial loops and arches with overall reduction in the total ridge counts (Uchida et al., 1964; Holt, 1964; Saldana-Garcia 1975).

Significant correlations of structural aberrations of autosomes with dermal configurations have been reviewed by Salmon and Lindenbaum (1973) and Preus and Fraser (1972).

Short arm deletion of fourth chromosome have been found to have dysplastic dermal ridges (Miller et al., 1969) and an increased frequency of arches (Guthrie et al., 1971). The cat-cry syndrome (short arm deletion of chromosome 5) has been reported to be associated with increased frequency of whorls, thenar patterns and a slight distal shift of the axial triradius (Warburton and Miller, 1967; Penrose and Loesch 1971 and Shiono et al., 1977). A high positioning of axial triradius and a missing 'c' triradius are reported to be associated with short arm deletion of 18th chromosome, whereas a long arm deletion of the same chromosome (chromosome-16) revealed bilateral simian creases, missing or misplaced axial triradius at the base of the digits and
thenar termination of a-mainline, and a slight increase of frequency of whorl patterns on the digits (Penrose, 1969; Kavalski et al., 1970; Plato et al., 1971).

Various claims for association of dermatoglyphics with non-chromosomal disorders tend to disagree mutually. Neurofibromatosis is perhaps the first non-chromosomal anomaly investigated as early as 1933. This disease is characterized by an unusual incidence of central pocket loop pattern on the fifth finger of each hand (Blotevogel, 1933). Hodges and Simon (1962) reported dominance of whorls on finger tips and termination of D-main line in the 4th interdigital area. A similar finding was later reported by Vormittag et al. (1973). However these results were not verified by later studies (Grosse, 1975). Similarly, contradicting reports occur for the 'Rubinstein Taybi Syndrome' in which broad thumbs and great toed patients are known to have an increased triradii at apices (Berg et al., 1966; Salmon, 1968), radial loops on third and fourth fingers (Jankar, 1965), more arches on finger tips, an extra triradius on the right thumb (Robinson et al., 1966). A recent study by Atasu (1979) characterized these patients with increased frequency of arches, decreased frequency of ulnar loops and reduced ridge counts on fingers. Santos et al. (1980) reported a significant increase in whorls on all fingers with slight increase in digital pattern intensity, among asthmatic patients. Single isolated study
on Retinoblastoma patients found increased number of hypo-
thenar patterns (Vidal et al., 1969). Gibbs and Warburton
(1967) noticed increase in number of whorls in patients with
Psoriasis. Piatkowska and Sokolonski (1973) found cleft
palate patients with fewer patterns on fourth interdigital
zone whereas, Vermittag and Meninger (1980) reported a high
total ridge count and increased number of hypothenar patterns
on right palm of patients with cleft palate. Dermatoglyphic
data from brachydactyous individuals and their relatives
revealed significant conclusions. Exceptionally low ridge
counts (means 19.5 and 3.0 for males and females respectively);
deficiency in number of triradii on all five digits and high
pattern intensity, and great toes were characteristic features
of affected individuals which distinguished them from their
normal relatives (Penrose and Holt, 1966). The prominent
features associated with Leukemia include, sydney line
(Subowitz et al., 1969; Purvis-Smith and Kenser, 1973), high
frequency of whorls (Purvis-Smith and Kenser 1973), high
frequency of ulnar loops (Verbov, 1970). A recent study
(Gustavson and Jagell, 1980) on 'Sjogren-Larsson syndrome
(SLS)' showed an increased 'Morbus Down Score' which is
considered to reflect a pathological influence on the forma-
tion of dermatoglyphics in the SLS during the early prenatal
life. Many other diseases have been studied which include,
phenylketonuria (Alter, 1967), Parkinson's disease (Barbeau

Studies enunciated by Hale et al. (1961) brought forth several differences in dermatoglyphic features between various kinds of heart diseases. Characteristic variations of this type have since then been added to the previously known clue (presence of accessory nipple) to the existence of congenital heart (Silverman and Bernstein, 1955). Later studies, revealed statistical correlations between several dermatoglyphic traits and congenital heart (Burguet and Collard, 1968; Cecarelli et al., 1968; David, 1969; Alter, 1970; Burguet et al., 1970; Birnholtz, 1972; Sato et al., 1977, 1979 and Annapurna et al., 1978). The forthcoming evidence, however, points out that the specificity of these features is low due to huge variations in palmar prints encountered in different genetic diseases or abnormalities determined during intrauterine life. Well identified dermatoglyphic differences between different populations or ethnic groups may mean that not all differences (that is, between dermatoglyphics of patients and normal controls) are of diagnostic importance. Nevertheless, factors such as embryonic edema (Penrose, 1967), intake of certain drugs like thalidomide (Adams, 1965; Holt, 1968), exogenous environmental agents such as rubella (Alter and Schulenberg, 1966; Achs et al., 1966; Purvis-Smith and Menser, 1968) are known
to alter dermatoglyphs during intrauterine development. Most congenital cardiovascular anomalies have their genesis in early gestation during embryogenesis (Alter and Schulenberg, 1970). In the majority of cases, though a hypothesis of genetic origin cannot be nullified, yet no specific etiologic basis has been established. Thus, whether they are exclusively under environmental control (Campbell, 1965; Jackson, 1968), or based upon heredity alone (McKusick, 1964), or an interaction of both (Nora and Nora, 1978) remains a subject of research. The embryological development of heart and palmar pattern formation are not quite synchronous. Cardiac differentiation takes place from the third to the 8th week (Pattern, 1968), whereas, dermatoglyphic differentiation occurs from 7th to 12th week of intrauterine life (Hale et al., 1961). Rawles (1955), however, suggested that the ridge development is intimately associated with volar pad development, which occurs during the 7-8 intrauterine week, concurrent with cardiac formation. Hence, it is logical that any environmental factor interfering with cardiac formation may also interfere with the pattern formation.

The problem of etiology of congenital heart has lately been attracting increasing attention. Demonstration of an association between individual types of heart disease and somatic hereditary traits may throw significant light on causation of the condition and perhaps aid the diagnosis of
the anomaly. Dermatoglyphics are an example of such a somatic heredity trait (Casco, 1964). Nevertheless, a fullest understanding of the diagnostic potential of the epidermal features awaits thorough exploratory studies. Most of the previous applications of the study of palmar dermatoglyphics emphasized an examination of twinning, population frequencies, forensic anthropology, diagnosis of mongolism, and a few isolated chromosomal aberrations. A majority of reports dealing with dermatoglyphics of congenital malformation of heart have considered the 'congenital heart' as a single entity. There is no reason, however, to expect all the types of cardiac malformations which may be etiologically heterogeneous, to show the same deviations from the normal distribution of dermal patterns. Thus, considering the group of cardiac malformations as a whole may obscure any pattern abnormalities characteristic of a particular type of heart lesion (Preus et al., 1970). A sufficient amount of data are needed to provide clues to intriguing problems such as relation of dermatoglyphic characteristics with specific types of heart anomalies. The present investigation is a step in this direction. The main issue in this study is to testify the use of dermatoglyphics in differential diagnosis of congenital heart disease. Besides, an attempt is made as to its prognostic value, a question initially raised by Hale et al. (1961).