

Review Article

Dermatoglyphics: in health and disease - a review

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Received: 12 November 2013

Accepted: 2 December 2013

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ABSTRACT

Dermatoglyphics is the study of finger print patterns and the term was coined by Harold Cummins in 1926. Finger prints are imprints of epidermal ridges, which are formed in early embryonic life, during 10th to 16th week of intrauterine life and remain permanent during whole life. Dermatoglyphic patterns have polygenic inheritance and are affected by environmental factors in the uterus. Finger print patterns are mainly of three types: arches whorls and loops; though there are more than 100 ridge characteristics, called Galton's details, in a single rolled finger print. Dermatoglyphics is not only used in the identification of an individual but also serves as a mirror of one's potential and talent. In this review, we will be discussing Dermatoglyphics and its important role in the diagnosis of chromosomal disorders and other diseases which have some genetic bases.

Keywords: Dermatoglyphics, Finger prints, Arch, Whorl, Loop

INTRODUCTION

Dermatoglyphics (from Greek: derma= skin, glyph= carving) is the scientific study of the skin ridge patterns on the fingers, toes, palms of hands and soles of feet. The purpose of these ridges is to impart firmer grip and to avoid slippage. Dermatoglyphics can be traced back to 1892, when one of the most original biologists of his time Sir Francis Galton, a cousin of Charles Darwin, published his work on fingerprints. The study was later on termed as Dermatoglyphics by Dr. Harold Cummins, even though the process of finger print identification had already in use for several hundred years.¹

The most famous of ancient finger print designs are carvings on the wall of Neolithic burial passage, situated on the island of Brittany L'île de Gavrinis, its inner walls are covered with incised designs of circular patterns, spirals, arches, sinuous and straight lines occurring on various combinations.² In ancient time, finger prints were used on pottery to indicate the maker

and brand of pottery. In ancient Assyria, finger prints served as a seal to give authenticity to documents of importance. They appeared in clay tablets, now treasured in British Museum.³ An aboriginal Indian carving was found at the edge of Kejimikoojir lake in Novascotia, where within the outlines of human hand carved in stone showed lines which represented dermatoglyphics and flexions creases.¹ Sir William Herschel, a collector in Bengal (1858) was the first person to take finger and hand prints of a contractor which is still preserved in museum of London. He used the system for identification of criminals.³

The Ridges are differentiated in their definitive form during third to fourth month of fetal life and once formed remain permanent and never change throughout the life except in dimensions in proportion to the growth of an individual. The original ridge characteristics are not disturbed unless skin is damaged to the depth of 1mm.³ Development of dermatoglyphic pattern is under genetic control. This is evident from the clear resemblance of

dermatoglyphics among related persons. There are many diseases known to be caused by abnormal genes. Whenever there is any abnormality in the genetic makeup of parents, it is inherited to the children and is reflected in dermatoglyphic pattern.⁴

Dermatoglyphics as a diagnostic aid is now well established in number of diseases which have strong hereditary basis and is employed as a method for screening for abnormal anomalies.⁵ Apart from its use in predicting the diagnosis of genetic disease; dermatoglyphics is also used in forensic medicine in individual identification, physical anthropology, human genetics and medicine. Sir Galton Francis (1892) published a book "finger prints", which included the first classification of finger prints. He used ridge characteristics called 'minutea', still called Galton's details.⁶

DEVELOPMENT OF EPIDERMAL RIDGES

The ridge pattern depends upon the cornified layer of epithelium and dermal pattern. There is proliferation of cells in the lower zone of epidermis which projects in the dermis as regular spaced thickenings and the dermis subsequently projects upwards in the epidermal hollows, called dermal papillae. This is followed by appearance of elevations formed by them on the skin surface which are known as epidermal ridges.¹

Differentiation of epidermal ridges takes place early in fetal development. The ridge pattern is genetically determined and is affected by environmental factors. There exists relationship between epidermal ridge and fetal volar pads, because in course of development the ridge pattern is formed at the site of these pads.⁷ Environmental factors such as external pressure on fetal pads and embryonic fetal finger movements could influence ridge formation.⁸ Dermatoglyphics traits such as such as finger ridge count develop between 10th to 17th week post conception.⁹ Dermatoglyphic features are inherited through a polygenic system with individual genes contributing an additive genetic component.⁸ ¹⁰Ridge formation is influenced by individual differences in developmental stability and first and second trimester insults on the embryo result in dermatoglyphic changes.^{8,11}

FINGER PRINT TYPES

There are three types of finger prints:

1. Visible prints are also called as patent prints because these are visible to the naked eye without development and are left in some medium like blood, dirt, ink or grease on the finger.
2. Latent prints are not apparent to the naked eye and are formed from water, salt, amino acids and oils

contained in the sweat. These can be made visible by dusting, fuming or chemical reagents.

3. Impressed prints or plastic prints. These prints are indentations left on soft pliable surfaces such as clay, wax, paint or another surface that will take the impression. These are visible to the naked eye.

PATTERNS OF FINGER PRINTS

There are three basic finger print patterns a) Arches b) Loops c) Whorls¹²

- a) Arches: These are found in five percent of finger print patterns. The ridges run from one side to another of patterns, making no backward turns. Ordinarily there is no delta in an arch pattern. There are four types of arch patterns 1) Plain arches 2) Radial arches 3) Ulnar arches 4) Tented arches.¹³
- b) Loops: Loops occurs in about 60 to 70% of finger prints. One or more ridges enters on either side of impression, recurves, touches or crosses the line running from the delta to the core and terminates on or in the direction of the side, where the ridge or ridges entered. In ulnar loop the ridges open on the ulnar side, in radial loops the ridges open on the radial side.¹³
- c) Whorls: These are seen in about 25 to 35 % of finger print patterns. In a whorl some of the ridges make a turn through at least one circuit. Any finger print pattern which contains two or more deltas will be a whorl pattern. There are six types of whorls: a) concentric whorl - the ridges are arranged in concentric rings around the core. b) Spiral whorl - the ridges spiral around the core in clockwise or anticlockwise direction. c) Mixed whorl- it contains circles and spirals in same pattern. d) Central pocket whorl-it contains a smaller pocket within a loop. e) Twin whorl-in these ridges arising from each core open towards the opposite margin of the finger. f) Accidental whorls-these represents combination of two or more of above configurations.¹³

RIDGE CHARACTERISTICS

A single rolled finger print may have as many as hundred or more identification points, called as ridge characteristics which are as follows:^{8,14,15}

1. Ridge dots - an isolated ridge unit whose length approximates its width in size.
2. Bifurcation - the point at which one friction ridge divides into two friction ridges. It can be double bifurcation or opposite bifurcation.
3. Trifurcation - the point at which one friction ridge divides into three friction ridges.

4. Ending ridge - a single bifurcation ridge that terminates within the friction ridge structure.
5. Ridge crossing - a point where two ridge units intersect.
6. Enclosure - a single friction ridge that bifurcates and rejoins after a short course and continues as a single friction ridge.
7. Spur - a bifurcation with one short ridge branching of a longer ridge.
8. Bridge - a connecting friction ridge between parallel running ridges.

OTHER LAND MARKS

- a) Triradii - a triradius is formed by the confluence of three ridge systems.
- b) Core - it is approximate center of the palm. The core may be of different shapes. In ridge counting the point of core (not the whole core) is used.
- c) Radiants - these are ridges that arise from triradius and enclose the pattern area.
- d) Delta - the point on a ridge, at or in front of and nearest the centre of divergence of the type lines delta area is a triangular area from where the ridges radiate outwards.

Animal finger prints: Humans are not the only ones with the finger prints. Some primates like gorillas and chimpanzees and kola bear have their own unique finger prints.

Adermatoglyphia: It is a rare condition which causes people to be born without any finger prints. It is also known as immigration delay, disease because affected individuals report significant difficulties on entering countries that requires finger print recording.^{16,17}

DERMATOGLYPHICS IN HEALTH

The type of finger print is unique based on the genetic characteristics of each individual. In addition of predictive value of finger prints in various diseases dermatoglyphics is used in identification of an individual. Identification is a set of physical characteristics, functional or psychic, normal or pathological that defines an individual.¹⁸ Due to uniqueness of finger prints, these can be used to identify the criminals at crime scene, dead or unconscious person in blast injuries or mass disaster injuries, accidental exchange of new born babies, in prevention of impersonation of cheques, bank notes and even for national identification.¹⁹ Dermatoglyphics can be used to determine or exclude parentage under circumstances of uncertainty of paternity of child.²⁰

Dermatoglyphics is like a map that allows one to understand his own potential and talent. Temperament and character can be correlated with finger print pattern. Whorl signifies stubbornness, composite is a sign of faithless and unreliable character, loop signifies lack of perservance, arch denotes merciless crude behavior. A person with ulnar loop on all fingers is clear spirited, mild mannered and strong willed person (melancholic), cool in judgment and ruthless in business. A person having whorls on all fingers is restless, doubting, sensitive, clever, eager for action and inclined to crime. A mixture of whorls and loops signifies a neutral character, kind, obedient, truthful but often undecided and impatient. Arches and radial loops occurs in person who is ambitious,²⁰ cool, stubborn, disobedient, defiant and rebellious.²⁰

There is a correlation between cephalic size, form of an individual and type of finger print pattern. In Chinese (brachycephalic) there is increased frequency of whorls and arches, in English (dolichocephalic) there is reduction of whorls and increase in arches. There is association between whorls and blood group B, a loop and blood group A, person with blood group O have more loops and fewer whorls. In general females have narrow ridges, more arches and fewer whorls. Females also have large frequency of hypothenar IV interdigital patterns. The finger prints of imbecile and idiots are similar to the finger prints of monkeys. In these people palmar hypothenar pattern is dominant, arches are more, axial triradius located centrally and simian crease is present. In imbecile persons there is great reduction of whorls in the right index and ring fingers.²⁰

Brown Caucasoid and Indians showed higher frequency of patters in hypothenar area. Africans and Mongolians showed highest frequency in the fourth interdigital pattern, thenar and first interdigital pattern in Americans, second interdigital pattern in Nigroes and third interdigital pattern in Europeans. Dermatoglyphics has been used to differentiate between mono and dizygotic twins, which are not differentiable from DNA finger printing.²¹

DERMATOGLYPHICS IN DISEASE

Dermatoglyphics as a diagnostic tool is now well established in a number of diseases which have strong hereditary basis.^{22,23} The dermatoglyphic patterns are analyzed in various ways like a) Quantitative analysis of finger prints i.e. loops, arches, whorls. b) Total finger ridge count. c) Absolute finger ridge count. d) Position of axial triradii. e) Total number of palmer triradii. f) a-b ridge count g) ATD angle.^{8,24}

Commins H (1936)²⁵ was the first person to show the possible use of dermatoglyphics in clinical medicine. In the recent decades a considerable improvement has been achieved in the concept of relations between the types of fingers ridges and some individual disorders.²⁶⁻²⁸

Epidermal ridges are formed between 11-24 weeks of gestation and after this period epidermal ridges do not change.⁹ Since skin and brain develop from same ectoderm, dermatoglyphic variations are informative for early developmental brain disturbances.²⁹ Dermatoglyphics is considered as a window of a congenital anomalies and is sensitive indicator of intra uterine anomalies.³⁰ The current status of dermatoglyphics is such that the diagnosis of some illnesses can now be done on the basis finger prints alone.²⁹ The ridge malformations may be congenital or acquired. The congenital malformations of dermatoglyphics are of four types: (a) Ridge aplasia implies absence of pattern (b) Ridge hypoplasia implies reduced height of ridges (c) Ridge dissociation means breaking of ridge- inherited as autosomal dominant trait (d) Ridge of the end indicates the vertical ridges which run off the end of the finger prints- also inherited as autosomal dominant trait.³¹

A. *Dermaoglyphics in diseases which are purely genetic disorders*

1. Down's syndrome (trisomy 21). These patients have mainly ulnar loops, significantly different atd angle, single transverse palmer crease (simian line), lower ridge count along digital midlines.^{32,33}
2. Turner's syndrome. Predominance of whorls, although the pattern of frequency depends on the particular chromosomal abnormality.³⁴
3. Klinefelter's syndrome. Excess of arches on digit 1, more frequent ulnar loops on digit 2, over all fewer whorls, lower ridge count for loops and whorls and total reduction of finger ridge count.³⁵
4. Patau syndrome. Excess of arches on the finger tips and single palmar crease in 60% people.³⁵
5. Edwards's syndrome (trisomy 18). 6-10 Arches on finger tips and single palmar crease in 30% people.³⁵
6. In inborn blindness there are abnormal triradii and excess of arches on finger prints.³⁶
7. Noonan syndrome. Increased frequency of whorls on finger tips and the axial triradius 't' and increased incidence of single transverse palmer crease.³⁷

B. *Dermatoglyphics in other diseases which have some genetic background*

1. Neurological diseases:

Since brain and skin develop from same ectoderm, dermatoglyphic variations are informative for early developmental brain disturbances.⁸

- a) Alzheimer's disease: There is increased frequency of ulnar loops and decreased frequency of whorls and arches, radial loop on the 4th and 5th digits are more frequent like in Down's syndrome.³⁸
- b) Schizophrenia: There is significant increase in whorls and decrease in loops in male Schizophrenics and there is significant reduction in arches all in patients.⁴⁹
- c) Cerebral palsy: There is increased frequency of arches, radial loops and whorl pattern and decreased pattern of ulnar loop, decrease in TFRC and 'ab' ridge count.⁴⁰
- d) Neurofibromatosis: There is increased frequency of central pocket whorls on the little fingers of both hands and left little finger shows increase in TFRC and 'ab' ridge count.⁴¹
- e) Epilepsy: These patients show significant changes in 'ab' ridge count, TFRC, AFRC, atd, tad, td angles, lateral deviation, C-line, finger ridge count and distal deviation.⁴²

2. Heart diseases

- a) Congenital heart diseases: There is overall increased incidence in hypothenar pattern with increase in atd angle. There is increased frequency in Sydney line in Ventricular septal defect and Tetralogy of Fallot, distal displacement of axial triradius is increased in PDA.^{43, 44}
- b) Rheumatic heart disease: There is decreased frequency of arches in males and increased frequency of whorls in females. There is increased frequency of patterns in 3rd interdigital area in males and decreased 'td' ridge count, increased multiple axial triradius in females.⁴⁵
- c) Coronary heart disease: The etiology of coronary heart disease is multifactorial, with genetic predisposition having an important role. In these patients there is significant decrease in loops and increase in whorls in males. The palmer pattern is significantly decreased in thenar area in females, 3rd interdigital area in both males and females, increase in '4' palmar triradii in males and '5' palmar triradii in females and significant decrease in '6' palmer triradii in both sexes.²⁴

3. Diabetes mellitus

In type 1 DM there is increased frequency in whorls, and decreased ulnar loop, increased frequency of Sydney line, and increased incidences of arches in females.⁴⁶ In Maturity onset diabetes mellitus, there is decrease in mean value of TFRC, AFRC, increase in arches and decrease in whorls.⁴⁷

4. *Cancer cervix*

There is decrease in frequency of ulnar loops and increase in arches with increase in 'atd' angle, decrease in TFRC and decrease in 3rd interdigital palmer pattern.⁴⁸

5. *Leprosy*

There is high frequency of palmer pattern in thenar and 1st interdigital area on left palm, with slight increase in frequency of distal axial triradii.⁴⁹

6. *Essential hypertension*

There is increase in TFRC, decreased frequency of axial triradius 't' in right palm of females and 't and t' in right palm of male, decreased atd angle and absence of axial of triradii in 10% cases.⁵⁰

7. *Bronchial Asthma*

There is higher frequency of whorls and lower frequency of arch.⁵¹

8. *Rheumatoid Arthritis*

There is increase in arches and decrease in loops and whorls in males, where as in females there is increase in whorls and decrease in loops on the 1st finger of both hands, with increase in arches on 3rd digit and whorls on 4th digit of left hand.⁵²

9. *Tuberculosis*

There is predominance of whorls and decrease in loop pattern; mean TFRC and AFRC are higher with narrower atd angle.⁵

10. *Carcinoma breast*

The mammary buds begin to develop during 6th week of intrauterine life and at the same time finger ridges also begin to develop. In carcinoma breast patients there are 6 or more whorls in the total finger pattern, increase in whorls in right ring and little fingers.⁵⁴

11. *Sickle cell anemia*

There is increased frequency of whorls and decreased frequency of ulnar loops and in some cases there are Sidney creases.⁵⁵

CONCLUSION

Dermatoglyphics is one of the oldest and still the most useful techniques available to mankind. Finger ridge patterns are formed due to underlying interlocking pattern of dermal papillae which produce overlying corresponding epidermal ridges. This pattern is unique to

an individual and is a classic model of polygenic inheritance. Dermatoglyphics, as a means of identification, has been used by man from ancient times, but use of dermatoglyphic features in the diagnosis of various diseases has received attention from 17th century. Dermatoglyphics plays an important role in the diagnosis of chromosomal disorders and other diseases which have genetic background. Since dermal ridges develop during 6th-13th weeks of gestation, genetic message carried in the genome - normal or abnormal - is deciphered during this period and is reflected in dermatoglyphics. Many structures of the body like the brain, mammary glands, lips, alveoli, plate etc. develop during the same period as the finger ridges, abnormal developmental insults on these structures in uterus is likely to be reflected in the dermatoglyphic patterns.

From the above discussion we conclude that dermatoglyphics is a simple, inexpensive and bed side diagnostic aid for conditions of chromosomal aberrations and various inheritable diseases.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: Not required

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DOI: 10.5455/2320-6012.ijrms20140207

Cite this article as: Bhat GM, Mukhdoomi MA, Shah BA, Ittoo MS. Molecular dermatoglyphics: in health and disease - a review. *Int J Res Med Sci* 2014;2:31-7.