

■ REVIEW ARTICLE

Digitopalmar Dermatoglyphic Traits in Medical and Genetic Conditions: A Potential Indicator

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ABSTRACT

Dermatoglyphics is the investigation of ridge patterns on hands and feet. Dermatoglyphs are created in the fetus by the 12th week and are under solid yet not restrictive hereditary influence. There have been applications of dermatoglyphics in various fields but its relevance to diseases has not been explored in the Indian context. The present review focuses on the history, embryogenesis, theories, and topology of dermatoglyphics with emphasis on the various studies in India. The databases that were searched for the keywords 'dermatoglyphics' and 'medical diseases' were EBSCO host, Academia and Google scholar. Out of the obtained results, 40 studies were selected as per the relevance to the topic. This review highlights the utility of dermatoglyphics in different areas of science. Dermatoglyphics can be essentially used as a potent tool for diagnosis of medical conditions. Dermatoglyphics also offers the advantage of being a simple, cost-effective, and non-invasive screening tool for the prediction of disorders having a genetic predisposition.

KEYWORDS | dermatoglyphics, digitopalmar, genetic disorders

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INTRODUCTION

HUMAN SKIN ON THE PALM AND SOLE IS marked by various grooves of different configurations. Dermatoglyphics is the science, which investigates the ridge designs on palms, fingertips, toes and soles.¹

The investigation of patterns on fingers and its application for individual identification proof was started in 1892 by Francis Galton. Joannes Evangelista Purkinje is credited with the logical investigation of these in 1823. The broadest depiction and characterization of skin patterns were made in 1926 by Harold Cummins, who coined the term 'dermatoglyphics'.¹

Dermatoglyphic designs are created by the 12th week of fetal life and are influenced by hereditary. The pattern setups on the palm are shaped by raised equal columns of sweat gland openings. Environmental fetal impacts are clear if the distinctions existing between both the hands of monozygotic twins are considered.¹

In 1924, Bonnevie found that the epidermal cells at the basal layer were under mechanical pressure forces due to their fast growth. As a result, the cells get directed towards the delicate underlying dermis, bringing about the arrangement of the essential ridges.²

Kücken put forward a numerical model to show the effect of pressure influences on the formation of these dermal patterns. The authors expected that the ridge course may be controlled by zones of increased stress during the association of Merkel cells with each other and with the dermal areas. These cells may be moved towards the main forces, which characterize the position of the palm ridges.²

Numerous investigations have upheld a connection between dermatoglyphics and the cerebrospinal axis, particularly with a setting to the type of pattern and the division of the nerves and blood flow pathway. Such

examinations propose that these designs match the pathway of the nervous and venous network beneath. Despite the fact that there is clearly a relationship between the advancement of the nervous system and the skin patterns, adapted by their basic ectodermal source, palmar distribution cannot be clarified distinctly with the nervous division, particularly with respect to the intricate dermatoglyphic patterns, for example, loops and whorls.²

The fibroblast theory on the arrangement of dermatoglyphic designs suggests the association of fibroblasts which can create critical stretch forces, influencing the extracellular framework and the development of these ridges. However, there is no support for the affiliation occurring among finger ridge designs and fibroblasts.²

The morphogenesis of the dermal ridges happens all the while along with the development of the axial brain structures of the same origin from ectoderm. Ridge designs show up on the pad of the fingers, palms and soles. The process of the development begins in 6.5 gestational weeks, starting in the palms, followed by the fingertips, and the soles. Nearing 10.5 weeks, palmar pads display fast development and start differentiating in location and shape. At the same time, there happens a fast development of the cerebral hemispheres. Toward the termination of the fourth embryonic month, the fetus obtains epidermal ridge arrangement similar in a grown-up, whereas the primary divisions of the central nervous system are fully formed.²

A basic time during this differentiation is the third embryonic month when diverse external variables may influence the normal differentiation of the ridges bringing about structural brain anomalies.²

When created, the ridge designs stay unaltered for the duration of entire life, even unchanging after superficial skin wounds. Based on the normal ectodermal origin of papillary ridges and brain structures, characterized times of development, dermatoglyphics may act as possible biomarkers in deciding the hour of effect of the genetic factors.²

The digito-palmar dermatoglyphic studies

include the observation and analysis of the following parameters:

1. **Fingertip pattern:** The ridge patterns on the fingertips were divided into three main forms by Galton (1892): Whorls, Arches and Loops.
 - (i) *Arches (A):* "It is the simplest pattern formed by almost parallel ridges, which form a proximally concave curve".
 - (ii) *Loops (L):* "It is the most common pattern on the fingertip where a ridge series enter at one side of the digit, recurve, and leave on the same side".
 - (iii) *Whorls (W):* "It is any ridge configuration with two or more triradii".
2. **Ridge Counting:** The pattern size is determined by it. The ridges are counted along a line joining the point of core to the triradius. Counting of ridges can be done between two digital triradii; a and b, b and c, & c and d.
3. **'ATD' Angle:** "It is formed by lines drawn from the digital triradius (a) to the axial triradius (t) and from this triradius to the digital triradius (d)".

Uses of dermatoglyphics as an indicator of various diseases:

Cardiopulmonary Conditions:

Bronchial Asthma: It is a syndrome where patient can experience a variety of symptoms such as wheezing, airflow obstruction, chest tightness, coughing and shortness of breath.³ It is one of the most extensively studied condition with a well-established genetic basis.⁴ On assessing the correlation of fingerprint pattern with bronchial asthma, it was found that there was a decreased mean value of arches and high frequency of increased whorls & radial loops in females and ulnar loops in males, with a higher Absolute Finger Ridge Count (AFRC). It was concluded that the fingerprints can serve as a biomarker for bronchial asthma and help in early recognition and thus effectively managing the disease.^{3,4}

Pulmonary Tuberculosis: The genetics play a major role in the cause of pulmonary tuberculosis as "Mannose Binding Protein Gene" has been associated with the vulnerability to pulmonary

tuberculosis in India.⁵ Palmar dermatoglyphic studied in pulmonary tuberculosis showed that there was a dominance of whorl patterns with a decrease in loop pattern. A narrowed atd angle was also observed along with a significant difference in Total Finger Ridge Count (TFRC) and AFRC.^{5,6} These findings can act as supports in the early diagnosis of pulmonary tuberculosis.

Hypertension: The existing literature shows that genetic factors have significant role in the genesis of essential hypertension. Analysis of dermatoglyphics in essential hypertensives showed a greater number of arches, radial loops, and ulnar loops than controls. The chances of an individual acquiring essential hypertension can be determined by the use of study of dermatoglyphs as genetics is involved in the cause of essential hypertension.⁷

Neurological conditions:

Mental Retardation: "It is characterized by a sub average intellectual function in combination with deficit in adaptive behaviour". When the dermal patterns were studied in the mentally retarded group, it was found that the number of ulnar loops was more than any other pattern in the mentally retarded group. There was a statistically significant lower mean TFRC value in mentally retarded males as opposed to the females. A significant increase in the palmar patterns in hypothenar & fourth and third interdigital areas in affected males was found. In case of females, an increase in the palmar pattern in hypothenar areas and fourth interdigital was seen when compared with controls. A higher value of atd angle with an increased inclination towards Sydney line and Simian crease could be seen in affected children.⁸

Epilepsy: "Epilepsy is a neurological disorder characterized by abnormal brain activity resulting in seizures or periods of unusual behavior, sensations, and sometimes loss of awareness". On studying the dermatoglyphic patterns in epileptics a significant variation in the c-line, a-b ridge count, finger-tip and palmar pattern was found. When analyzing the mean values of a-b ridge count, they were higher in epileptics. C-line patterns had a decreased count of ulnar and proximal type patterns. A

significant difference in arch type of palmar patterns was found. In the affected population, the count of loops was higher and vestiges were not seen. These results can help in correlating antenatal factors may to the cause of epilepsy.⁹ A statistically significant increased ATD angle in both hands of male and female epileptics and only in left hand of female epileptics was also noted.¹⁰

Schizophrenia: It may be caused by an interaction of genetics and environment with modified brain chemistry and structure. In catatonic schizophrenics, it was found that patients had characteristic qualitative and quantitative dermatoglyphic features like more arches, loops and fewer whorls; less frequency of patterns in thenar area; smaller ATD angle. These differences might be genetic marker for catatonic schizophrenia.¹¹

Medical conditions:

Diabetes: Diabetes Mellitus is a condition that may result either due to insufficient production of glucose or failure to utilize insulin properly resulting in high blood glucose levels.¹² Numerous studies have found following dermatoglyphic features in the diabetics: increased frequency of whorls¹³ and arches,¹⁴ higher Total Finger Ridge Count (TFRC)^{13, 14} and Absolute Finger Ridge Count (AFRC)¹⁵. The findings of the research suggest that dermatoglyphic characteristics may be used for diagnosis or prediction of chances of developing diabetes later in life.¹⁵

Thalassemia: Thalassemia is a complex series of genetic disorders, which involve underproduction of hemoglobin. People whose hemoglobin does not produce enough β protein, are said to have β thalassemia. Studies on association of fingerprint patterns and β thalassemia revealed an increasing number of whorls, lesser number of loops, lesser atd angle mean in patients than in controls. A significant difference in the dermatoglyphic patterns in thalassemic patients can be observed.¹⁶

Congenital Deafness: Researches suggest that about half of the cases of childhood hearing impairment are genetically influenced. The risk for hearing impairment increases in a

child with an affected parent. Among affected males, the pattern distribution on right hand fingertips, number of whorls, various patterns frequencies in III interdigital area of right hand and in IV interdigital area in the left hand showed statistically significant differences. Also, frequency of arches was found more in the deaf in the hypothenar area. The III interdigital area pattern frequencies in left hand of affected females were higher than controls. It was noted that the simian crease was of higher incidence in the left hands of the affected individuals, and the mean ridge count was decreased in them in contrast to the control group. These characteristic findings may prove to be helpful in screening the population.¹⁷

Carcinoma:

Carcinoma Breast: Various genes (BRCA1, BRCA2, p-53 etc.) have been linked to the causation of cancer.¹⁸ The arch pattern was seen to be increased and a lower count of the radial loops in both the thumbs, the left index and middle finger was seen in individuals with breast cancer. Highest frequency of arch pattern in all five fingers, lower values of Total Finger Ridge Count (TFRC) & Absolute Finger Ridge Count (AFRC) were also found.¹⁹ In another study, it was also observed that six or more whorls were characteristic to the cancer patients. Such findings may indicate the use of dermatoglyphs as a screening tool for carcinoma breast.¹⁸

Head and Neck Cancer: "Head and neck cancer is the group that affects the mouth, nose, throat, larynx, sinuses, or salivary glands". On examination of dermatoglyphic features in cancer patients, the finger tip ridge pattern of thumb showed lower percentage of loops, arches and higher percentage of whorls, the finger tip ridge pattern of index finger showed a higher percentage of whorl in cancer patients. Finger tip ridge pattern of ring finger showed lower percentage of ulnar loops in control and lower percentage of whorls in cancer patients. Finger tip ridge pattern little finger showed higher percentage of ulnar loops and lower percentage of whorls in cancer patients. The finger prints do not necessarily establish a diagnosis but should prompt the physician to look deeply for

hidden diseases.²⁰

Musculoskeletal conditions:

Rheumatoid Arthritis: "It is a multifactorial condition and the dermatoglyphic patterns can be affected by factors determining rheumatoid arthritis in utero".²¹ In males increased arches and decreased loops / whorls were found. An associated increased partial simian crease was also noted. An increase in whorls in both hands, arches on third finger; both arches, whorls on 4th finger of left hand; decrease in loop in first finger in both the hand was seen in the females.^{21, 22} A study also reported an increased total finger ridge count in patients. A statistically significant increase in the pattern intensity was observed among female patients. It can be said based on these findings that there is some relationship between the qualitative as well as quantitative traits of dermatoglyphics and rheumatoid arthritis.²²

Dermatological conditions:

Vitiligo: It is a condition where there is a loss of pigment cells of the skin leading to areas of skin becoming discolored. On analyzing the dermatoglyphic traits in patients of vitiligo, it was observed that there were increase in total ulnar loops, total loops, and finger ridge counts. Also, the true palmar patterns (TPP) in right thenar, right hypothenar, and the interdigital area of both the hands was seen to be raised in the male patients. A lower number of arches, radial loops, whorls, absolute finger ridge count, and true palmar patterns (TPP) in right ID (Interdigital) 3&ID (Interdigital) 4 was also recorded in them. Whereas, in the female patients, a higher number of true palmar pattern, arches, in right ID, right hypo-thenar, and a-b ridge count and a lower number of total ulnar loops, total loops, whorls, total radial loops, absolute finger ridge count, total finger ridge count, TPP in right ID2 and left ID3 was seen. A higher value of ATD angle was observed in all the patients.²³

Eczema: "It is an inflammatory condition of the skin, characterized by spongiosis with varying degrees of acanthosis and a superficial perivascular lymphocytic infiltrate". It can occur due to a complex interaction between

genetic susceptibility and environmental risk factors. Pulmonary function tests are valuable investigations in the management of patients with respiratory symptoms in eczema. Studies established that there is a random relation between dermatoglyphic pattern, eczema and lung functions. Population with decreased arches in both hands may develop eczema.²⁴

Psoriasis: "Psoriasis is a common familial chronic papulo-squamous inflammatory skin disorder of unknown cause". A significant increase in total ridge count, decrease in a-b ridge count has been noted in this population. The frequency of palmar patterns has been found to be increased in all areas in psoriatic males; but in female psoriatics it is increased in thenar, 3rd and 4th interdigital areas. A significant decrease in ATD angle in female psoriatics has been associated. There are characteristic dermatoglyphic patterns in psoriasis affected individuals as opposed to healthy population.²⁵

Leprosy: Leprosy, an infectious disease caused by *Mycobacterium leprae* has been one of the causes of high morbidity and deformity in India. A screening method helps in early diagnosis and thus prevention of these.²⁶ In these patients, in multibacillary: a decreased number of whorls and increased number of the loops, in paucibacillary: increased whorls and decreased loops, was seen.²⁷ Also, a reduced atd angle was associated with the leprosy patients.²⁶ Dermatoglyphic analysis can be useful diagnostically to differentiate multibacillary, paucibacillary leprosy and control.

Dental Conditions:

Malocclusion: It is a widely occurring condition seen influenced by diet patterns, genetics and environment.²⁸ On studying the relationship between fingerprints and malocclusion, a statistical association was revealed between increased frequency of whorl patterns and class 1 and increased frequency of loops with class 2 malocclusion.^{28,29} Class 3 malocclusion had predominance of arches and whorls as compared to other classes of malocclusion.²⁸ Based on these studies, it can be said that dermatoglyphics and types of malocclusion are related to one another.

Oral submucous fibrosis (OSMF): "OSMF is a precancerous condition characterized by the accumulation of collagen in the lamina propria of the oral mucosa".³⁰ There was predominance of ulnar loops and arches, decreased frequency of fingertip whorl patterns, decreased ATD angle, frequency of palmar accessory triradii on right hand and total a-b ridge count, presence of hypothenar pattern in OSMF.^{30,31} However, a decrease in arches, radial loop and whorl in these patients was also found in one of the studies.³² Thus, it can be said that dermatoglyphics can predict the probable occurrence of OSMF in smokeless tobacco users.

Oral Squamous Cell Carcinoma (OSCC): Increased frequency of ulnar loop and arch, decreased number of simple whorls, palmar accessory triradii on both hands, mean ATD angle and total a-b ridge count, presence of hypothenar pattern, was noted in the studies.^{30,31} The results of these studies emphasize the role of dermatoglyphics for establishing the genetic tendency of a person to develop OSCC.

Impacted Teeth: "Impacted teeth are those which fail to erupt in dental arch within expected time or classically defined as teeth retained in the jaw beyond their normal date of eruption, encircled by their coronary bag and without contacting the oral cavity". In the study of the dermatoglyphics of the impacted teeth group, a lower frequency of whorl, arch regions and a higher frequency of loop region was seen. The findings highlight a relationship between the tented whorl and arch patterns with the chances of impacted teeth. This indicates that the formation of ridges is influenced by genetic factors.³³

Dental Caries: Dental caries is one of the major conditions of dentistry and genetics plays a determining factor for an individual's resistance against them. A statistically significant increased number of whorls in the 2nd finger, a decreased total ridge count in children with a dental caries were found. It can be concluded that dermatoglyphic patterns and the relationship with total ridge count could emerge as a new method to establish the risk towards dental caries.

Periodontal Diseases: These diseases are unique in themselves owing to a varied aetiology and symptoms. Dermatoglyphic studies have shown an increased tendency of loops in subjects with healthy gums and an increased tendency of whorls in subjects with calculus. It was concluded that a possible relation between dermatoglyphics and periodontal disease stages exists.³⁵

Dental Archform: In dentistry, the arch form is important for stability, occlusion, & esthetics and is the typical expression of a person's development. In persons with square or ovoid arch form, an increased frequency of whorls; with ovoid or tapered archform, increased ulnar loop pattern and with tapered arch form, increased radial loop pattern were observed. The treatment of malocclusion can be benefited by the dermatoglyphic analysis as a pointer for formation of the dental arch form at an earliest time.³⁶

Non medical uses of dermatoglyphics:

Handedness: Handedness is the preference for the one of the hands over the other for daily activities. The presentation of hand is developed in fetus and is based on the hand which is held close to the mouth. The leucine rich repeat transmembrane neuronal (LRRTM1) gene is associated with left handedness which brings about the fact that handedness has a genetic basis. The left-handed people were found to show particular fingerprint patterns, like peacock and the radial loop modified. Also, characteristic patterns on the thenar and hypothenar regions of the left-handed people were observed, along with changes in the crease patterns. Thus, these typical findings can help us in determining the handedness of an individual.³⁷

Blood Groups: The ability of fingerprints as a method of identification (as in determination of blood groups and sex) has led to its increased use in the detection of crime and criminals. An increased number of loops were found in persons with blood group 'O' followed by blood group 'A' and 'B'. Incidence of whorls was found to be predominant in 'O' followed

'A' and 'B' blood groups. In Among all the blood groups, arches were least commonly found.³⁸ Also, loops were found to be dominating in blood group A, B, AB and O (Rh positive and Rh-negative) individuals, except O negative where frequency of whorls were increased. There is a relationship between fingerprint patterns, blood group and gender and thus predicting gender and blood group of a person can be done on the basis of fingerprint pattern.³⁹

Sports Performance: One of the motives of sport competition is to detect sports ability at its earliest and direct it effectively.⁴⁰ In a study involving national level boxers, it was found that loop patterns were predominant and composite loop patterns were very few in number in the fingertips.⁴¹ Another study demonstrated an increased frequency of loops on the thenar area which might act as a genetic marker for detection of sports talent.⁴² ATD angle was found to be low in students involved in sports as compared to controls, in a study suggesting that measuring the ATD angle before selection of athletes is preferable for a better performance in sport.⁴⁰

Ethnic Affiliation: As the formation of dermatoglyphs is influenced by genetic factors, this science can be used to establish the eccentricities of human populations. One of the researchers studying the bilateral differences in the finger and palmar dermatoglyphics of the Limboo population of Sikkim noted that the Limboo showed similarities with the East Asian populations of Assam and North-East India.⁴³

Academics: Dermatoglyphic Multiple Intelligence Test (DMIT) can be used as a screening tool for determining the career choices according to the prominent innate intelligence.⁴⁴ It may also be used by the academic institutions to help in determining the growth and development of the student's brilliance, perspective and competence on the educational front. Similarly, the results may be used by the facilitators to guide the students according to their natural learning manner and skills.⁴⁵

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The authors declare that there is no commercial or financial links that could be construed as conflict of interests.

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