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Dermatoglyphic Pattern Configurations: A Review

Review Article

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Abstract

Dermatoglyphics is the science and art of the study of surface markings and patterns of ridges on the skin of the fingers, palm, toes and soles. Finger, palm and sole impressions are said to be products of both environment and heredity, and they are unique, universal, inimitable and classifiable. They can be used for purposes of individualization, identification and comparison of persons. A relationship was reported between unusual dermatoglyphic features and several medical disorders with chromosomal abnormalities. Cummins and Midlo, and Penrose listed and defined dermatoglyphic features, outlined accepted methods of dermatoglyphic analysis, and provided a nomenclature that was intended to serve as a universal standard. Hence it is essential to have sufficient knowledge about normal dermatoglyphic configuration patterns for carrying out routine dermatoglyphic analysis and clinical applications in medical field.This article describes in details about the normal fingerand toe pattern configurations; palmar and plantar patterns and landmarks; footprint patterns;qualitative and quantitative analysis of dermatoglyphics on fingers, palms, toes and soles; topological classification of palmar and plantar dermatoglyphics; palmar and plantar flexion creases;white lines; and the various fingerprint classifications.Thus,apart from personal identification, dermatoglyphics serves as an excellent tool in screening population for several medical disorders, systemic conditions with genetic abnormalities and congenital anomalies.

Keywords: Loop; Arch; Whorl; Dermatoglyphics; Ridge Count; Pattern Configuration; Palm; Toe; Finger; Flexion Creases.

Introduction

Dermatoglyphicsis the science and art of the study of surface markings and patterns of ridges on the skin of the fingers, palm, toes and soles. These dermal ridges over the palms and soles of an individual are unique, universal, inimitable and classifiable [1]. Finger, palm and sole impressions are said to be products of both environment and heredity and there is a strong evidence that fingerprint patterns tend to run in families. Fingerprints can be used for both criminal and noncriminal purposes. The rules, principles, and definitions for reliable analyses of dermatoglyphics was proposed and developed by Cummins and Midlo along with other investigators [1]. A relationship was reported between unusual dermatoglyphic features and several medical disorders with chromosomal abnormalities, which created a need for a standardized dermatoglyphic terminology. The book by Penrose listed and defined dermatoglyphic features, outlined accepted methods of dermatoglyphic analysis, and provided a nomenclature that was intended to serve as a universal standard [2]. Hence it is essential to have sufficient knowledge about normal dermatoglyphic configuration patterns for carrying out routine dermatoglyphic analysis. Thus, apart from personal identification, dermatoglyphics serves as an excellent tool in screening population for several medical disorders, systemic conditions with genetic abnormalities and congenital anomalies.

Ridge Detail (Minutiae)

Epidermal ridge patterns reveal numerous irregularities of direction, discontinuities, and branching of individual ridges termed as minutiae. They are highly variable and their number, type, shape, and position are unique to the individual. Apart from identification purposes, minutiae are not known to be of any medical value. The six common types of minutiae are island, end of ridge, short ridge, interstitial line or ridge, enclosure and fork.

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A comb is a ridge formation in which three or more parallel ridges join another ridge almost at right angles to their direction of flow [3].

Fingers

Fingertip Pattern Configurations

There are two types of structural characteristics of fingerprints namely pattern types and minutiae.Galton divided the ridge patterns on the distal phalanges of the fingers into three main groups: arches, loops, and whorls [3]. Arch patterns account for approximately 5 to 15 percent of the fingerprint patterns and consists of two types namely Plain arches and Tented arches. Loop patterns is the commonest type accounting for 60 to 65 percent of fingerprint patterns and consists of two types: Ulnar loop (ridges flowing towards the little finger) and Radial loop (ridges flowing towards the thumb). Whorl patterns account for 30 to 35 percent of fingerprint patterns and are categorized into four subgroups: Plain, Double loop (lateral loops), Central pocket loop and Accidental.

The three types of fingerprint minutiae are bifurcations, ridge endings, and dots. A bifurcation occurs when one friction ridge splits into two friction ridges like a fork in a road. A friction ridge may come to an abrupt end, forming an ending ridge. A friction ridge may be short, rather than continuous, with an ending ridge on each end and is known as a short ridge. The third type of minutiae is the dot, which appears as a dot between two friction ridges and is the shortest possible ridge. Minutiae are best observed under magnification [3].

Pattern area consists of the cores, deltas, and ridges which appear in the loop or whorl patterns. The pattern areas of loops and whorls are enclosed by type lines.Type lines are the two innermost ridges which start parallel, diverge, and surround or tend to surround the pattern area. Core is the approximate centre of the fingerprint pattern. Delta or triradius is that point on a ridge at or in front of and nearest the centre of the divergence of the type lines. The type of pattern depends upon the number of triradii (a triradius is a point formed by the meeting of three different ridge fields). Ridge can take several characteristics like Staple or recurve, Convergence, Appendage, Bifurcation, Divergence, Rod enclosed in recurving, Enclosure or island, Dot, Short ridge, Long ridge, Incipient ridges and Ending ridge. A bifurcation is the forking or the dividing of one ridge into two or more ridges. A divergence is the spreading apart of two ridges which have been running parallel or nearly parallel. Angles are formed by the abutting of one ridge against another (two ridges involved). Focal points or target areas are those areas within the pattern that contain ridgecharacteristics (Galton details) that are used for comparison and classification [3].

Loop Patterns

A loop is defined as a type of fingerprint pattern in which one or more of the ridges enter on either side of the impression; recurve, touch, or pass an imaginary line drawn from the delta to the core; and terminate or tend to terminate on or toward the same side of the impression from which such ridge or ridges entered. A loop pattern must have a delta, a sufficient recurve and one or more ridge count across a looping ridge. A delta can be a Bifurcation, abrupt ending ridge, dot, short ridge, meeting of two ridges or a point on the first recurving ridge located nearest to the centre and in front of the divergence of the type lines. When there are two or more possible deltas that conform to the definition, the one nearest the core is chosen. A sufficient recurve can be defined as that part of a recurving ridge between the shoulders of a loop that is free of any appendages abutting upon the outside of the recurve at right angles. The core is placed on or within the innermost sufficient recurve.The shoulders of a loop are the points at which the recurving ridge definitely turns inward or recurves and the core is placed inside the shoulders.Loops present at the centre of the pattern can be Interlocking loops, Two loops or incomplete loops. If an essential element of a loop is missing, the pattern will be classified as a tented arch [4].

Ridge counting is defined as the number of ridges intervening between the delta and the core. For the process of ridge counting an imaginary line is placed between the core and the delta and each ridge which crosses or touches the line is counted. Rules to be followed during ridge counting are: delta and core are not counted; if the line touches a ridge at the point of bifurcation, two ridges are counted; if the line crosses an island, both sides are counted; fragments and dots are counted only if they appear to be as thick and heavy as other ridges in the pattern; a white space must intervene between the delta and the first ridge count, or the first ridge must be disregarded; if the core is located on a spike which touches the inside of the inner most recurving ridge, the recurve is included in the ridge count only when the delta is located below a line drawn at right angles.

There are two types of loops namely Radial and Ulnar Loops. Loops flowing in the direction of the little finger are ulnar loops, whereas loops flowing in the direction of the thumb are called as radial loops.Loops are also termed either a right slanted (those patterns where ridges flow to the right) or left slanted (those patterns where ridges flow to the left).To determine the direction of flow of the loops, tracing should begin at the core and follow the ridges away from the delta; and from the recurve to the open end of loop [4].

Arch Patterns

Plain Arch: A plain arch is defined as a type of fingerprint pattern in which the ridges enter on one side of the impression and flow or tend to flow out the other with a rise or wave in the centre. The ridge formations can be ending ridges, bifurcations, dots, but they all tend to follow the general ridge contour. The crest of an arch is the highest point reached by the rising friction ridge seen mostly in the middle of the friction ridge. The plain arch has absence of patterns like delta, real core, or a ridge tracing [4].

Tented Arch: A tented arch is defined as a type of fingerprint pattern in which most of the ridges enter on one side of the impression and flow or tend to flow out on the other side, as in the plain arch; however, the ridge or ridges at the centre do not. There are three types of tented arches: the type in which ridges at the centre form a definite angle of90 degrees or less; the type in which one or more ridges at the centre form an upthrust by rising at a sufficientdegree from the horizontal plane, which is 45 degrees or more; and the type approaching the loop, possessing two of the three basic essential characteristics [4].

Whorl Patterns: A whorl is defined as a type of fingerprint pattern in which at least two deltas are present with a recurve in front of each. There are four types of whorls: The plain whorl, the central pocket loop whorl, the double loop whorl, and the accidental whorl [4].

1. Plain Whorl: A plain whorl possesses two deltas and at least one ridge making a complete circuit, which may be spiral, oval, circular, or any variant of a circle. Characteristic features for plain whorl are the type lines for both deltas does not have to be the same ridge; an imaginary line drawn between the two deltas must cross at least one of the recurving ridges within the inner pattern; and a recurving ridge cannot be construed as a circuit as the recurve is spoiled.

2. Central Pocket Loop Whorl: It has the features of both loops and whorls and is called as bulb or flower pattern. The central pocket loop possesses two deltas and at least one ridge making a complete circuit, which may be spiral, oval, circular, or any variant of a circle. In a central pocket loop whorl, at least one recurve or obstruction at right angles to, free from appendage, must cross the inner line of flow. Characteristic features for central pocket loop whorl are: the pattern looks like a loop with a small whorl insideridges; has two deltas; and fulfils the requirements of the loop with one or more whorlridges around the core.

3. Double Loop Whorl: A double loop whorl is a pattern that consists of two separate loop formations with two separate and distinct sets of shoulders and two deltas.

4. Accidental Whorl: An accidental whorl is a pattern consisting of a combination of two different types of patterns, or a pattern which conforms to none of the definitions. Examples are Loop and Tented Arch; Loop and Plain Whorl; Loop and Central Pocket Loop; Combination of a Loop and Double Loop Whorl. If there is an issue between two types of patterns in the whorl pattern or ridges which conform to more than one subdivision, the priority in naming in the descending order is: Accidental, Double loop, Central pocket loop and Plain.

Dermatoglyphic Landmarks

The three basic dermatoglyphic landmarks found on the fingertip patterns are the triradii, cores, and radiants. A triradius is formed by the confluence of three ridge systems. The geometric center of the triradius is designated as a triradial point which is the meeting point of three ridges that form angles of approximately 120 degrees with one another. Extralimital triradii are rarely encountered on the fingers or toes but are commonly observed in the hypothenar areas of the palms and the hallucal areas of the soles. Core is the approximate centre of the fingerprint pattern and may be of different shapes. The radiants (type lines) are ridges that emanate from the triradius' and enclose the pattern area and constitute the skeletalframework of the pattern area [4].

Patterns of Middle and Proximal Phalanges

Considerably less attention has been paid to the configurations on the middle and proximal phalanges than to the fingertip patterns. Pattern configurations reported on the middle and proximal phalanges are vestigial loop, double loop whorl, and a vestigial double loop. They may be useful in discriminating between monozygotic and dizygotic twins as well as in personal identification.

The fingers above the interdigital area of the palm are separated into sections called finger joints. The thumb is made up of two joints, while the fingers are made up of three joints each. Fingerprints are prints from the first joint of the fingers. The second and third joints do not display patterns such as arches, loops, and whorls. However, they all have similar ridge flow. The creases between the joints are similar between fingers. There is generally one crease between the first and second joints of the fingers, two creases separate the second and third joints, one crease between the third joint and the interdigital area of the palm in the index and little fingers, and two creases separate the third joint and the interdigital area of the palm in the middle and ring fingers. While most people have these major anatomical regions in common, the interdigital, hypothenar, and thenar positions, creases and minutiae are unique to each individual [4].

The second and third joints do not have arch, loop, and whorl patterns like the first joints.

These finger joints have many thin, dense, extensive vertical creases, and it can be difficult to see the pattern of ridge flow. The ridges of the ring and middle finger joints are generally horizontal, wavy lines and the joints of the little and index fingers have ridges that slant downward, away from the inner fingers.

Palms

Palmar Pattern Configurations

The palm has been divided into several anatomically defined areas which include the sites of embryonic volar pads, the thenar area, four interdigital areas, and the hypothenar area [5].

Thenar and First Interdigital Areas

These two areas are closely related anatomically and in dermatoglyphic analyses they are usually considered as one area and labelled as thenar/first interdigital (Th/Il) area. In most cases, there is no pattern in the Th/Il area but the ridges follow a mild curve around the base of the thumb. Since no true pattern is present, this configuration is called a vestige. A vestige or a true pattern can be present in either the thenar or the I1 area or in each of the areas at the same time. Usually, loops are present and rarely whorls are encountered.

Thenar Area

Thenar area is bordered on one side by the radial longitudinal crease and on the other by the base of the thumb. The ridges generally flow in a half-moon pattern in concentric curves around the thumb. While the ridges of the hypothenar flow out the side of the hand, the ridges of the thenar flow out the bottom of the hand. A vestige pattern is present in the thenar which looks like two narrow, flattened loops that meet. Minor creases often appear as thin white lines arranged in a basket weave pattern, or appear as deeper, horizontal scratches. The webbing between the thumb and index finger is thinner than the muscular base of the thumb, thus creates a large starburst crease pattern in that area. The edge creases of the thenar are parallel with the flow of the ridges, unlike those in the hypothenar [5].

Second, Third, and Fourth Interdigital Areas

A variety of fingerprint patterns (arch, loop, and whorl) can develop on the surface of the fingertip. Similarly, the ridge flow on the palmar surface of the hand develops as the volar pads on the palms recede and patterns such as loops or whorls can be observed in the hypothenar area of the palm. The interdigital area displays a significant amount of unique ridge detail and patterns. Deltas are located below the index, middle, ring, and little fingers.

The delta beneath the index finger is more or less an equilateral delta, with the three angles of the delta at roughly 120° each. The deltas directly under the middle and ring fingers have two obtuse angles and one acute angle forming a Y shape with the acute angle pointing upwards toward the third joints of the fingers. The delta under the little finger is shifted toward the ring finger with the shape similar to the deltas below the middle and ring fingers, and the acute angle facing the delta below the ring finger [5].

The ridges originating from the delta under the little finger flows in a loop from that delta to the delta under the ring finger. The ridges originating from the delta under the middle finger flow along the top of the distal transverse crease in a wave pattern and out the side of the hand (on the hypothenar side). The ridges originating from the delta under the index finger flow diagonally across the entire width of the palm. These ridges pass between the distal transverse crease and the proximal transverse crease. The interdigital area is the most variable segment of the palm, with its complex concentration of deltas, looping patterns, ridge flow and variable amount of detail.

Each interdigital area is bordered laterally by digital triradii. The digital triradii are always located proximal to the base of digits II-V. Digital triradii are labeled a, b, c, and d, starting from the triradius located at the base of digit II and moving toward the triradius associated with digit V and they delineate the various interdigital (ID) areas. The second interdigital area (I2) lies between triradii a and b, the third interdigital area (I3) between triradii band c, and the fourth interdigital area (I4) between triradii c and d. If a digital triradius is absent, the midpoint of the base of the corresponding digit can be used to separate the interdigital areas.

Configurations encountered in the interdigital regions are loops, whorls, vestiges, and open fields. Loops are the most common patterns found in the distal palm. Almost invariably, they open distally (U) into the nearest interdigital space. Whorls are rarely present. Vestiges (V) are relatively common interdigital configurations and they do not represent true patterns but consist usually of a series of straight parallel or converging ridges having a direction different from the neighbouring ridged areas. Open fields (0) are the most common ridgeconfigurations encountered in the distal palm and are truly patternless areas formed by almost parallel ridges. Occasionally, two ridge configurations can be present in the same interdigital area. True patterns are relatively rare in the I2 area but are common in both I3 and I4 areas [5].

Hypothenar Area

True patterns are commonly present in the hypothenar area (Hy). The patterns are whorls, loops, and tented arches, simple arches, open fields, vestiges, and ridge multiplications.

Whorls (W) in the hypothenar area, have three triradii instead of two. Arches are the most frequent patterns in the hypothenar areas and open fields are rare.If two configurations are present in the hypothenar area, the triradius close to the palmar axis are termed axial triradii (t). Symbols t, t', and t'' are used to designate the position of these triradii in the proximal-distal direction on the palm. The axial triradius (t) separates thehypothenar area from the thenar area.

The ridges of the hypothenar flow at a slight downward angle out of the side of the palm.

The ridges closest to the centre of the palm funnels inwards, narrows around the proximal transverse crease and widens until the ridges flow out the side of the hand. With the presence of consistent ridge flow, a loop or whorl which are larger in size are observed. At the base of the palm, near the centre is the carpal delta which denotes the area where the ridge flow from the hypothenar meets the ridge flow of the thenar. The position of the carpal delta may be either at the base of the hand near the wrist or higher in the palm, usually near the centre of the palm in the junction between the hypothenar and thenar. Many of the minor creases specific to the hypothenar area are located along the edge of the palm commonly known as the writer's palm. Wrist has extensive creases without clear ridge details [5].

Palmar Landmarks

The digital and axial triradii and the main line traced from each constitute important landmarks for dermatoglyphic analysis. There are four digital triradii in the distal portion of the palm which are found in the metacarpal region at the base of digits II, III, IV, and V. Each triradius is normally associated with one digit and are termed as a, b, c, and d. The two distal radiants of each digital triradius run laterally to the nearest interdigital area subtending the digit concerned. The proximal radiant is typically directed toward the center of the palm. Traced along its whole course within the palmar area, it constitutes a palmar main line.

There are four main lines, each emanating from one of the digital triradii and are denoted by capital letters A, B, C, and D. Not infrequently a number of triradii other than four is found in the distal palm because a triradius may be missing, two triradii may be fused into a single triradius, or there may be an additional (accessory) triradius or triradii in some of the interdigital areas. Usually, digital triradius c will be missing. The extra triradii are referred to as a', b', c', and d', according to the nearest digital triradius. A special case of a missing triradius is an interdigital triradius, which may subtend two or more digits. They are typically present in zygodactyly and are referred to as zygodactyloustriradius.The main-line formula constitutes the first part of the palmar formula and is followed by the position of the axial triradius or triradii and then by the symbols used for the palmar configuration areas in the following order: hypothenar, thenar/first interdigitalarea, second, third, and fourth interdigital areas [5].

Axial triradius (t) is present on all hands and occurs usually very near the proximal palmar margin, superficial to the wrist bones near the axis of the fourth metacarpal bone. The position of this triradius varies in the proximal-distal direction along the axis of the fourth metacarpal bone and, also in the ulnar-radial direction of the axial triradius. Also, there can be more than one axial triradius on the palm. The axial triradii found in the proximal region of the palm, near the wrist crease is also referred as normal or proximal position and is denoted as t. A triradius situated near the center of the palm is termed t'' and called as distaltriradius. A triradius present between between t and t'' is called intermediate or distal triradius and denoted as t'. An extremely distally displaced triradius, such as is occasionally found distally to the proximal transverse crease, can be termed t'''.

A displaced axial triradius occurs in medical disorders and is considered significant.

The position of the axial triradius is generally described indirectly by measuring the angle formed by lines connecting the axial triradius and the digital triradii a and d (the atd angle).

The position of an axial triradius is expressed accurately by measuring the axial t distance, i.e., the ratio between the palm's length and the distance between the triradius and the distal wrist crease. Axial triradius can be laterally displaced to the radial side, ulnar side, or in an extreme case can be found in the hypothenar region very near the ulnar edge of the palm, or may even be extralimital [5].

Zygodactyly refers to the absence of digital triradii as a result of soft tissue webbing or syndactyly of digits. Commonly, an interdigital or zygodactyloustriradius will be present replacing the missing triradii of the digits involved. Ulnar triradius is an additional triradius in the palmar hypothenar area, usually in association with a hypothenar pattern, but located toward the ulnar side of the hand. t''' triradius is an axial triradius that is extremely distally displaced (over 55%). Depending on the palmar creases, t''' triradii can be located distal to the proximal transverse crease or beyond a simian crease. Accessory triradius is an additional triradius that occurs in palmar interdigital areas II-IV. Accessory triradii are located more proximal than the digital triradii and are lettered a'-d' after the closest digital triradius. Pattern intensity is a quantitative approximation of pattern complexity in fingers, palm, or sole. Pattern intensity can be determined by summing the number of triradii or by adding the number of loops with whorls counting as 2 loops.

Foot Print Patterns

The various topographical areas and the triradii of the soles are similar to those of the palms. The patterns occur more frequently only in the most distal parts of the sole. Afootprint is considered to bean impression of the morphological features or shape of the weight-bearing areas of the plantar surface of the foot. The plantar surface leaves an impression of its various morphological features on the surface with which itcomes incontact. The shape, size, form, and other features of the foot print are unique to an individual. Even left and right feet cannot make identical footprints; and identical twins (monozygotic) do not have identical footprints.

The shape of the footprint may be normal, flatfoot, semi-flatfoot, curved foot, or a combination. Flatfoot (pes planus) is defined as the condition in which the foot does not have a normal arch, and thus, the complete instep region ofthe plantar surface of the foot is impressed on the surface. In some individuals a semi-flat foot condition can be seen. Footprints can be classified into four types based onthe relative morphological lengths of the first, second, and third toes. These toe lengths are known to vary among individualsa swell as populations [6].

The toe area forms an important part of footprintmorphology. The shape and size of the toe vary to agreatextentfromindividualtoindividual.Long toes,short toes, round toes, missing toes, partially cut toes,and damaged toes can sometimes be used to base anopi nionregardingpersonalidentification. The position of the toe pad, inter-spaces between the toes, distance of each toe pad fromthe ball region/line, and contours of the toe pad (oval,rounded, long, and short) may also show unique features. Similarly,thepresenceo rabsenceofthetoe stem may also be considered important. A big toestem (toe-1 stem) is usually impressed in a footprint;however, stem impressions of toes 2, 3, and 4 and perhaps toe 5 are rarely seen in a footprint. The number and shape of humps in the toe or ball line also vary in the footprints ofdifferent individuals. A hump maybe defined as a protruding curvature in the ball line. The hump may be straight,curved, bulging, or irregular. The toe line can have one, two, or morehumps, ornohumps.

Another individual characteristic often present in footprints are crease marks which are formed by the skinfolds in the plantar surface of the foot. Crease marks can be in a vertical direction, horizontal, crossed in somecases. Some prints have a single bigcrease mark running through the ball region, othersmay have numerous crease marks in the ball as well asin theinstepregion and they may be absent in a few cases. Identity may also be based upon deformities and other peculiar characteristics of footprints such as the presence of horizontal ridges running across the instepregion. Other temporary peculiarities of footprints likepits, cracks, corns, wounds maybe helpful in establishing identity. The individual characteristics of footprints canalsobenotedfromtheinsolesoffootwear [6].

The ridge density is defined as the number of ridges in a defined space of finger, palm, and footprints with which the sex of a person can be determined. According to Acree et al [7], fingerprints of females show finer epidermal ridge details and have significantly higher ridge density in a defined space than males. Kanchan et al [8] studied the footprint ridge density of south Indian subjects following the method devised by Acree et al [7] which included four areas in footprints: the medial border of the great toe (F1), the ball of the great toe (F2), the ball of the 5th toe below the triradius point (F3), and the central prominent part of the heel (F4). The mean footprint ridge density was found to be higher in females than in males in all of the defined areas of the footprint.

Toes

The types of patterns encountered on the distal phalanges of the toes are essentially the same as those of the fingertips. The only difference is in the designation of loops, which are called loop fibular and loop tibial, rather than ulnar and radial as used on the fingers. However, there are differences in the pattern type frequencies between the fingers and toes, the toes showing considerably more arches and fewer whorls than the fingertips in the same group of individuals [9].

Soles

Plantar Pattern Configurations

The pattern areas on the soles are similar to those on the palms. However, the thenar area on the tibial side of the sole is greatly elongated and is divided into a proximal and a distal section. There are four plantar interdigital areas, labelled I-IV in a tibiofibular direction. The distal thenar and first interdigital areas are combined and referred to as the hallucal area. The long hypothenar area (on the fibular side of the sole) is also divided into proximal and distal sections. A region of the sole that does not have an analog in the palm is the calcar area, which refers to ridged skin covering the heel.

Dermatoglyphic configurations encountered on the soles are basically like those on the palms; i.e., they include whorls, loops [tibial and fibular], arches, and open fields. The most common patterns in normal individuals in the sole are whorls and the large distal loop. The hallucal area (the distal thenar and the first interdigital areas combined) covers the tibial area of the ball of the foot. Patterns present are arch tibial, arch fibular, arch proximal, loop distal, loop tibial, whorl and open fields [9].

Because the first interdigital area belongs morphologically to the hallucal area, there are usually only three interdigital areas identified on the distal sole, labelled usually II, III, and IV. Areas II-IV are bordered laterally by plantar digital triradii a and b, band c, and c and d, respectively. Loops, Vestiges (V) and open fields (0) are the patterns present.

The hypothenar area covers the fibular side of the sole between the interdigital areas and the heel and it has a proximal and a distal part. True patterns may be found in both, in either, or in neither of the parts. Sometimes there is presence of open field [lack of patterns] consisting of more or less parallel ridges. The calcar area occupying the heel of the foot is usually patternless and there is less information in the literature on plantar patterns than on palmar configurations. Plantar formula utilizes the configurations of all eight plantar areas in the following order: hallucal, interdigital II, interdigital III, interdigital IV, distal hypothenar, proximal hypothenar, calcar, and proximal thenar [9].

Plantar Landmarks

There are five digital triradii in the distal region of the sole. Triradius a, b, c, and d are present in the tibiofibular direction, each of them located proximal to each of the digits II-V and the fifth triradius e, is located in the vicinity of the base of digit I (great toe). An additional triradius may be present in the hallucal area which is denoted as e' or f.

Frequently, one or more triradiil abeled p (proximal) are observed proximal to the hallucal and interdigital regions, near the junction of the hallucal and second interdigital areas.

Also, a plantar digital triradius may be missing or two triradii may be replaced by one interdigital triradius in an intermediate position. Plantar interdigital triradii are common, and are mostly represented by the fusion of the a and b triradii into an ab triradius. Main lines can be traced from the proximal radiants of triradii a, b, c, d, and e according to specific rules, however it is difficult [10].

A triradius when present in the proximal portion of interdigitalII, III, and IV is lettered p, p', and p" respectively. The digital triradii (a-d) are sometimes difficult to obtain on a single print. Zygodactyly commonly is found on the sole and is reflected by an absence of one or more of the digital triradii. In the hallucal area, there may be both an e and f triradius, only an e or an ftriradius, or neither an e nor f triradius. Toe patterns are similar to finger patterns such as loops, arches and whorls. Loops can be either fibular or tibial loops [10].

Qualitative Traits

The correct methodologies developed for qualitative analyses of dermatoglyphics on fingers, palms, toes and soles, have been related to pattern types on fingers and toes, on the five palmar and the eight plantar areas, the alignment and reduction of main lines and palmar digital triradii, position and number of axial triradii in the palm, digital and interdigital triradii in the soles, and to ridge details the minutiae [11].

Quantitative Analysis

Quantitative methods of analyses usually concern ridge count on fingers, toes, the inter digital areas of the palm and the plantar hallucal area. Many dermatoglyphic characteristics can be described quantitatively, e.g., by counting the number of triradii or ridges within a pattern and measuring distances or angles between specified points. Quantitative analysis includes pattern intensity, ridge counting, position of axial triradius and main-line index [12].

Pattern Intensity

Pattern intensity refers to the complexity of ridge configurations and is expressed by counting the number of triradii present. A digit can have pattern intensity of 0-3. The pattern intensity of the palm or sole can be expressed as the sum of all triradii present. Interdigital and extralimital triradii are included in the triradial count.

Ridge Counting

Ridge counting is used to indicate the pattern size and pattern type to some extent [13].

1. Finger and toe ridge counts

The counting is done along a straight line connecting the triradial point to the point of core. Ridges containing the point of core and the triradial point are both excluded from the count and interstitial lines are also not counted. Whorls that possess two triradii and at least one point of core allow two different counts to be made, one from each triradius and are specified as radial and ulnar counts. It must be remembered that a radial loop has an ulnar triradius from which the count is made, whereas an ulnar loop has a radial count. Patterns with three triradii offer three possible ridge counts. Because the ridge counts are used to express the pattern size, only the largest count is scored in a pattern with more than 1 possible count. A total finger ridge count (TFRC) represents the sum of the ridge counts of all ten fingers, where only the larger count is used on those digits with more than one ridgecount. An absolute finger ridge count (AFRC) is the sum of the ridge counts from all the separate triradii on the fingers. The TFRC and the AFRC are same if no whorls are present on the fingertips. The TFRC expresses the size of a pattern, whereas the AFRC reflectsthe pattern size as well as the pattern intensity, which depends on the pattern type. A high ridge count indicates whorl and a nil ridge count indicates arch pattern [13].

2. Ridge counts of the digital areas of the palms

Ridges are often counted between two digital triradii and is mostly done between triradii a and b which is referred to as the a-b ridge count. Counting is carried out along a straight line connecting both triradial points excluding the ridges forming the triradii. The b-c and c-d ridge counts are rarely used in dermatoglyphic analysis for medical purposes and it is difficult to count because of the direction of the ridges.Ridge counting in patterns lacking triradii [extralimital triradii] is done approximately and an estimation is arrived. On fingertips,patterns with extralimital triradii are almost alwayslarge whorls and a triradius on either the ulnar or the radial side, or both sides, may be missing. Patterns with extralimital triradii are very rare on the fingertips but are relatively common on the palms and soles.The values of the other nine available digits are assessed and the ridge count value for missing or mutilated fingertips can be calculated using a regression line based on the mean values of the fingertip ridge counts on each digit [13].

Position of The Axial Triradius

The position of the axial triradius has been considered to be of great importance and has been used as a valuable dermatoglyphic trait in individuals with various medical disorders. The position of the axial triradius can be determined by the width of the atd angle; the ratio of axial t distance to total length of the palm along an axial line; t, t', t'' based on subjective estimates, ridge counting, and breadth ratio [14, 15].

1. Atd angle: Atd angle is formed by lines drawn from the digital triradius a to the axial triradiustand from this triradius to the digital triradius d. The more distal the position of t, the larger the atd angle. If there are more than one axial triradius, the widest atd angle is considered.If accessory a' or d' triradii are present on the palm, the most radial a triradius and the most ulnar d triradius be used as the starting points of the measurement and the widest atd angle is obtained for assessment. The important shortcoming is that the atd angle is age dependent and it is influenced by the shape of the palm or by variation of the position of landmarks, such as the a and d triradii. The numerical values of the atd angles have been employed in determining the axial triradius positions. The discrepancies in atd angles experienced by investigators indicated the need for objective criteria in describing the position of the axial triradius. Part of the discrepancy concerning conversions of numerical values of the atd angle into positional descriptions of the t triradius may result from the relationship between the shape of the hand and the size of the atd angle. The atd angle does not express the magnitude of any radial or ulnar deviation of the axial triradius [14].

2. Measurement of Distal Deviation: For determining the position of the axial triradius, the ratio between the length of the palm and the length of the distance between the wrist crease and the axial triradius is used. The vertical distance between the most distal wrist crease and the most proximal crease of the third digit is measured. The distance between the axial triradius and the distal wrist crease is also measured and expressed as a percentage of the length of the palm which is less age dependent than the atd angle and it is not influenced by the shape of the palm or by variation of the position of landmarks, such as the a and d triradii. It therefore offers more information about the position of the axial triradius than does the atd angle. However, the method does not reflect the lateral deviation of the axial triradius [15].

3. Ridge counting: Ridge counting between the triradii d and t has been proposed as yet another means of describing the position of the axial triradius. The resulting number is smaller when the t is distally placed than when it is in a proximal position. The advantage of this method is that the d-t ridge count is constant in an individual and independent of age. This method also has several disadvantages and is rarely used to record the position of the t triradius.

4. Breadth Ratio: Breadth ratio is rarely used to determine the t position and is based on a measurement of the perpendicular distance from t to a line drawn between the a and d triradii. This measurement is expressed as a ratio of the a-d distance.

Main-Line Index

The main-line formula indicates the general direction of palmar ridge flow. A main-line index was proposed based on the sum of the two numbers corresponding to the exits of main lines A and D. The main-line index is recorded for each palm separately and it gives the palmar ridge transversality. A low value for the index indicates vertical ridge alignment, whereas a high value reflects a tendency for the palmar ridge direction to be horizontal [16].

Digital Indices

The Delta index, the index of pattern intensity is computed from the sum of all triradii of the 10 fingers or toes. The index of complexity attributes a number to each pattern and may vary between 10 (all simple arches) and 50 (all whorls). Individual pattern value is based on a scale of seven pattern types ascending in complexity in which the numbers are added for the ten fingers, and consequently the individual pattern value varies between 10 (all arches) and 70 (all whorls). Other derived indices are the total ridge count (TRC), the individual quantitative value, and the absolute ridge count including both counts in the case of a whorl [17].

Palmar Indices

The most commonly used are the palmar index of pattern intensity and the total palmar ridge count (TPRC) which corresponds to the sum of the interdigital ridge counts of the palm, (a - b) + (b- c) + (c - d). The mainline index (MLI) and the modified mainline index which consist of the sum of the numbers (given to the areas where the mainlines end) of the four mainlines, reflect directly a more transversal, intermediate or longitudinal ridge alignment in the total palm. Both the relative interdigital distances for which the a-b, b-c and c-d distances (in mm or half mm) are expressed as percentages of the a-d distance, and the mean ridge breadth reflect variation of early growth processes of pad, and pad and ridge formation. Other variables studied are Flexion Creases and Secondary Creases. Flexion creases are expressed on fingers, palms, toes and soles. Palmar creases are differentiated in major, minor and secondary creases [17].

Dermatoglyphic Topology

The complex of configurations present on the whole surface of the palms or soles makes it difficult in comparing the dermatoglyphic traits of healthy individuals with medically compromised persons. Hence, Penrose and Loesch introduced a topological classification which is based on a description of all loops and the enumeration of all the triradii, with the exception of digital triradii. Each whorl is rated as the equivalent of two loops, and arches, vestiges, and other ridge configurations, which are not considered as true patterns, are neglected.

Topological Classification of Palmar Dermatoglyphics

For classification purposes, the palm is divided into five configurational areas. The thenar and first interdigital areas are considered as Area I, Areas II, III, IV, and Area V, the hypothenar area, which is denoted as H. Loops are classified as peripheral and central, instead of distal and proximal. The cores of peripheral loops point away from the center of the palm, whereas the cores of central loops point toward the center of the palm. Some loops are also named as tented loops. The following triradii are considered for analysis: Triradius in distal and proximal part of area I, Axial triradii, Border triradius (including extralimital triradii), Triradius deviated to radial side of palm, Triradius near the center of hypothenar area and the Interdigital triradii. The formula of an analysed palm is written in the following order: Loops according to the numerical order of the areas (i.e., I, II, III, IV, H); Triradii in alphabetical order (a-d), followed by the number of unspecified interdigital triradii; and the exit of main-line A [18].

Topological Classification of Plantar Dermatoglyphics

Only the patterns in the distal part of the sole are analysed and recorded. The interdigital regions are labelled I, II, III, IV, and V, with V reserved for the hypothenar distal area. Loops are specified according to the general directions of their cores into distal and proximal or, fibular. In the hallucal area, three types of loops are recognized. The triradii near the tibial border of the sole, triradii close to the fibular edge of the sole; and centrally placed, proximal triradii, and interdigital triradii are analysed. The plantar formula is written in the following order: loops in numerical order of the areas, with distal preceding proximal and fibular loops; and triradii in alphabetical order, followed by the number of unspecified digital triradii [19].

Flexion Creases

Flexion creases represent the location of firmer attachment of the skin to underlying structures. Palmar creases are usually included in routine dermatoglyphic analysis because their alterations may be of diagnostic value in a variety of medical disorders. Flexion creases are formed during early intrauterine life and, and can be influenced by factors causing aberrant development of the embryo. The creases were believed to result from flexion of the foetal skin. It is believed that palmar and digital creases are secondary features determined by the form and particularly by the function of the developing hand instead of having a primary genetic determination. The palmar and digital flexion creases will be referred to as regular and irregular according to the frequency of their occurrence. The regular creases are generally found in each normal individual and, in case of the digital creases, on each digit. They include the thenar crease,the proximal and distal transverse palmar creases, the distal interphalangeal crease, the proximal and distal creases of the proximal interphalangeal creases, and the metacarpophalangeal and metatarsophalangeal creases. Irregular Creases include the oblique crease (OC), the extra crease (EC) and the accessory crease (AC). Unlike the regular creases, the irregular creases are not always present on the digits. When present, the oblique crease is found only on the proximal phalanx, the extra crease appears on any phalanges and theaccessory crease is found on the distal phalanx only [20].

The creases of the hand conform to the flexibility of the hand. The three major creases of the palm and multiple minor creases of the palm and finger joints are recorded as curved or jagged white lines. Creases can be wide or narrow and are white because they are furrowed areas of skin that do not come into close contact with a substrate and are therefore not developed by powders, ink, or chemicals. The length of each crease varies between individuals, just as ridge flow or patterns vary.The distal transverse crease displays a crow's-feet pattern and separates the interdigital area from the hypothenar. This crease starts at the edge of the palm as a wider line and ends narrowly in the interdigital between the index and middle fingers. The proximal transverse crease separates the interdigital area from the thenar. This crease starts at the edge of the palm between the thumb and index finger, runs roughly parallel to the distal transverse crease and ends somewhere in the hypothenar. The radial longitudinal crease, also known as lifeline,begins near or at the beginning of the proximal transverse crease and curves around the thenar to the base of the hand. Plantar flexion creases also exhibit characteristic and varied features in the population [21].

Palmar Flexion Creases

Human palms are covered by creases of different length, depth, and direction and are classified by Loeffier into groups: major, minor, secondary and other hand creases [20].

Major Creases

There are three major creases: the radial longitudinal crease, the proximal transverse, and the distal transverse crease. The radial longitudinal crease, commonly called the thenar, thumb, or vertical crease, is the curved crease encircling the thenar eminence and ending at the radial side of the hand above the distal wrist crease. The proximal transverse (or proximal horizontal) crease is found usually just distal to the middle of the palm and its radial end is either fused with or shifted distally from the thenar crease. Theproximal transverse crease sweeps from the radial border of the palm in a gentle, proximally concave bow across the palm and ends usually at the medial border of the hypothenar eminence. The distal transverse (or distal horizontal) crease is located between the proximal crease and the heads of the underlying metacarpal bones. It originates in the space between the index and middle fingers, the crease curves gently proximally, ending on the ulnar edge of the palm.The three major palmar flexion creases and a crease in the axis of the middle finger may form a crude letter M on the palmar surface [20].

Variations in the course and appearance of the major palmar flexion creases in a normal population were described by Alter [22]. Sometimes the proximal and distal transverse creases are replaced by or joined into one single crease that traverses the whole palm. This single transverse flexion crease is usuallyreferred to as a simian crease or line. This crease may be present in higher proportion in individuals with developmental defects and thus may have medical diagnostic value.Several variants of the single transverse crease are reported. One variant shows a fusion of the distal transverse crease with a lengthened proximal transverse crease. Variations in appearance of the proximal transverse crease have been noted and have been linked to medical disorders. Sydney line represents a proximal transverse crease that extends beyond the hypothenar eminence to the ulnar margin of the palm. The distaltransverse crease persists and appears normal. Purvis-Smith considered a Sydney line to be any configuration in which the proximal palmar crease extends toward the ulnar margin of the palm past the midline axis of the fifth finger. Variants of the Sydney line were also observed. Hand malformations are associated with alterations of the palmar creases that relate to the flexion movement of the involved hand. In individuals with an absent, rudimentary, or hypoplastic functionless thumb, the thenar crease is missing [23].

Minor Creases

Loeffler divided the minor creases into four groups: [24]

1) Three longitudinal creases which run from the central part of the wrist toward the third, fourth, and fifth digits and are referred to as the middle, ring, and little finger creases respectively; 2) The accessory distal crease may occasionally be found under the third and fourth digits, beyond the distal transverse crease; 3) E lines may be located at the distal ulnar edge of the palm between the origin of the distal transverse crease and themetacarpophalangeal crease of the fifth finger; 4) A hypothenar crease occurs occasionally in the hypothenar eminence, running in a proximal-distal direction concave toward the ulnar side of the palm.

Secondary Creases

Any visible palmar creases other than major and minor creases are termed as secondary creases and they vary with age and sex.

Other Hand Creases

They include phalangeal creases, extra digital crease, metacarpophalangeal creases and wrist creases.

Phalangeal creases

The thumb normally has a single phalangeal flexion crease, whereas all other fingers have a proximal and distal flexion crease, one at each interphalangeal joint. Sometimes one of the two interphalangeal creases will be missing on the little finger. Presence of a single digital crease is associated with abnormally short phalanges or with finger flexion deformities. Creases related to joints reflect the flexion movements and the digital creases are absent over non-functional joints.

Extra Digital Crease

Occasionally, an additional transverse crease can be found just beyond the regular distal interphalangeal flexion crease of one or more digits, most frequently on the middle finger. This extra crease is present at birth and persists during life.

Metacarpophalangeal creases

Metacarpophalangeal creases divide proximal phalanges from the palm region and they are of three types namely boundary, ring, and accessory creases. The boundary crease is the main crease which divides the phalanx from the palm. Sometimes an additional crease is present distal to the boundary crease which resembles a ring and is termed as ring crease. It is usually found only on the middle and ring finger. Accessory creases are shorter and may be separate from or branch out from the boundary crease [25].

Wrist creases

They are usually two in number in the wrist area and are referred to as the proximal and distal wrist (or bracelet) creases.

Plantar Flexion Creases

As the skin creases on the volar aspects of the feet develop in late intrauterine life, they have been considered as the single most reliable physical index of maturity. Apart from their use in assessing gestational age, sole flexion creases have little known clinical significance. One of the reasons for the lack of information on sole creases may be that they become rather inconspicuous after early childhood. Schenk proposed a morphologic scheme of the plantar creases based on nine majorCreases. According to this scheme, the creases are defined as follows: Crease 1 originates under the second toe and runs almost straight in the direction of the heel. Crease 2 beginsbetween the first and second toes or under the second toe and continues arching toward the fibular side of the sole. Crease 3 starts between the second and third toes and runs obliquely toward the fibular side. Crease 4 originates under the third toe and bows toward the tibial border, crosses crease 2, forming a forklike figure with it that is characteristic for newborns. Crease 5 starts between the fourth and fifth toes and runs toward the centre of the sole, varying greatly in its length forming a fork. Crease 6 was not designated. Crease 7 originates between the fifth toe and the fibular border of the sole and runs obliquely or almost straight toward the centre of the sole. Crease 8 runs from the fibular border toward the centre of the distal planta. Crease 9 begins at the tibial border of the thenar area and runs toward the centre of the distal planta. Crease 10 originates in the area between the great toe and the tibial borderof the sole. Not all creases are necessarily present on each sole of the newborn [26].

In a study on polish population, the most frequent creases found were creases 1 and 2.

In neonates and small children, a transverse crease was usually observed. This crease was more or less horizontal, extending from the thenar eminence to the external border of the foot. Although the creases ran in various directions in relation to the long axis of the foot, longitudinal and oblique creases predominated. Presence or absence of furrows on palms and soles are considered as significant findings in certain medical disorders. Presence of a marked crease between the first and second toes, also called as sandal crease is a characteristic feature in patients with Down syndrome and Rubinstein-Taybi syndrome [26].

White Lines

A variable number of shallow grooves of different length, width, and direction observed on the fingertips are called as white lines. The white lines are probably caused by skin buckling rather than skin flexion and they cross the epidermal pattern areas of the fingertips in various directions, independently of the direction of the papillary ridges. According to most observers the incidence of white lines increases, with age. Females generally showed a higher frequency of white lines than males. White lines in children were virtually limited to the thumb. Among all the fingers that had white lines, slightly more than half were found on the left hand mainly on the third, fourth, and fifth digits. An increase in the frequency of white lines among patients suffering from various skin diseases, celiac diseases, epilepsy and other medical disorders were reported [27].

Fingerprint Classification

Fingerprint classification is the process of organizing large volumes of fingerprint cards into smaller groups based on fingerprint patterns, ridge counts, and whorl tracings. Bertillonage classification system was based on anthropometric measurements, but it fell out of favour by the turn of the twentieth century. Fingerprints were historically stored in filing cabinets according to their alphanumeric classification designations. Historically the fingerprint card was classified and the filing cabinets searched by hand according to that classification label. The advent of the Automated Fingerprint Identification System (AFIS), commonly known as the fingerprint computer, has mostly negated the need for manual classification and filing of hard copies of fingerprint records. Fingerprints are now recorded on a scanner (a livescan device) attached to a computer and are stored digitally [28].

Henry Classification

Henry Classification System developed bySir Edward Henry, Azizul Haque, and Chandra Bose in 1897 was a popular classification system in English speaking countries. Juan Vucetich also developed a classification system used in Spanish-speaking countries.

Most of these systems involve analysing the pattern types of the fingers and assigning alphanumeric designations to each finger resembling fraction with a numerator and a denominator. The fraction line is known as the classification line. The modified Henry system with the FBI extension has six components: the primary, secondary, subsecondary, major, final, and key. The key consists of the count of the first loop appearing on the card excluding the little fingers. The Major division of the classification consists of the ridge count or ridge trace value of the thumbs, right hand over left hand. The Primary is the numeric value of the finger where a whorl appears. The Secondary portion of the classification indicates the pattern type of the index fingers and is always indicated by a capital letter. The Subsecondary division of the classification is the grouping of ridge count and/or whorl trace symbols for the index, middle, and ring fingerprints appearing on the card. The Final consists of the ridge count of a loop appearing in the fingerprints of little fingers [29].

Primary classification assigns numerical value to only the whorl patterns present in the fingerprint record and is written as a fraction. Each finger is numbered from 1 to 10, starting with the right thumb as finger number one, proceeding through the right index, right middle, right ring, and right little fingers. The left thumb is finger number six, followed by the left index, left middle, left ring, and left little fingers. The fingerprint card, also known as a tenprint card, is numbered 1-10. The fingers are each assigned a point value if a whorl is found on that finger and the point values decrease by half while proceeding through the remaining eight fingers. The numerator is the sum of the point values for the even numbered fingers plus one and the denominator is the sum of the point values for the odd numbered fingers plus one. Number one is added to both the top and bottom values in order to avoid a fraction that reads 0/0 [29].

NCIC Classification

The National Crime Information Center (NCIC), a division of the FBI's Criminal Justice Information Services (CJIS), is a national repository of computerized criminal justice Information created in 1965 by J. Edgar Hoover and upgraded in 1999 to NCIC 2000. The NCIC fingerprint classification system consists of a 2-letter code to each pattern type. The 2-letter codes for each of the 10 fingers are combined to form a 20-character classification. Each fingerprint's code is listed in sequence, from the number 1 finger (right thumb) to the number 10 finger (left little finger). Ridge counts of loops and whorl tracings are also included in the coding system to further classify pattern types. NCIC is unique in that it does not include the actual fingerprint images and it gives a wealth of information regarding the fingerprint patterns of the individual [28].

Integrated Automated Fingerprint Identification System (IAFIS) This is a new NCIC classification system which is based on fingerprint patterns. The new IAFIS NCICsystem utilizes two characters per finger, or a total of twenty characterson a line [28].

Automated Fingerprint Identification System (AFIS)

It is a computerized designation of fingerprint patterns for searching within the database. In this system, designations are very simple and is based on pattern recognition. There are five possible designations: A (Arch or tented arch patterns); W (Any type of whorl); R (Right slanted loop); L (Left slanted loop); S (Scar) and X (Amputated or missing finger) [28]. The usefulness of dermatoglyphic pattern configurations in the diagnosis of several medical and dental disorders has been well established in our previous published literature [30-40].

Summary

The simplest pattern to be found on the fingertips is an arch which is formed by a succession of more or less parallel ridges, which traverse the pattern area and form a curve that is concave proximally. Arches can be low or high arches. The arch pattern is subdivided into two types. The simple (or plain) arch (A) is composed of ridges that cross the fingertip from one side to the other without recurvins. If, however the ridges meet at a point so that their smooth sweep is interrupted, a tented arch is formed. The point of confluence is called a triradius because ridges usually radiate from this point in three different directions.

In the tented arch, the triradius is located near the midline axis of the distal phalanx. The distal radiant of the triradius usually points vertically toward the apex of the fingertip. The most common pattern on the fingertip is a loop. In this configuration, a series of ridges enters the pattern area on one side of the digit, recurves abruptly, and leaves the pattern area on the same side. If the ridge opens on the ulnar side the resulting loop is termed an ulnar loop, whereas if it opens toward the radial margin it is called a radial loop. A loop has a single triradius which is usually located laterality on the fingertip and always on the side where the loop is closed. The size of loop can be measured by counting the ridges. There is also presence of transitional loops.

A whorl (W) is any ridge configuration with two or more triradii with one on radial side and the other on the ulnar side of the pattern. The ridges in a simple whorl are commonly arranged as a succession of concentric rings or ellipses. Such patterns are described as concentric whorls. Another configuration spirals around the core in either a clockwise or a counterclockwise direction and is called a spiral whorl. As in the loop, the size of the whorl is determined by means of a ridge count. A central pocket whorl is a pattern containing a loop within which a smaller whorl is located. Central pockets are classified as ulnar or radial according to the side on which the outer loop opens. Another type is composed of interlocking loops, which may form either a lateral pocket or a twin (or twinned) loop pattern. In a twin loop whorl, the ridges emanating from each core open toward the opposite margin of the finger and the pattern cannot be designated as either ulnar or radial. In a lateral pocket loop whorl both ridges emanating from the core emerge on the same side of the pattern and the pattern can be described as a radial or ulnar subtype. They are classified as double loop whorls.Complex patterns, which cannot be classified as one of the above patterns, are called accidentals. They represent a combination of two or more configurations, such as a loop and a whorl, triple loops, and other unusual formations.

The palm itself contains ridge characteristics such as deltas, bifurcations, and ending ridges.

The anatomical regions of the palm include three main areas of the palm and the creases. Four deltas are present in the palmar area just below the fingers and each have a distinct position, shape, and associated ridge flow. The palm and finger joints are unique areas of ridge flow, separated by creases. There are three main areas of the palm are the interdigital, the hypothenar, and the thenar. The interdigital area is the portion of the palm directly below the index, middle, ring, and little fingers. The thenar area is the portion of the palm at the base of the thumb. The thenar area is characterized by half-moon-shaped ridge flow that curves around the thumb. Basket weave patterned creases crisscross the surface of the thenar.

The hypothenar, also known as the writer's palm, is the portion of the palm below the interdigital area and across from the thenar area. The hypothenar area is characterized by uniform ridge flow that originates from a funnel in the centre of the hand and spreads out to exit the side of the hand known as the writer's palm. Each area is a more or less distinct unit which in most palms is delineated by partial boundaries formed by triradii or by patterns in the form of loops or whorls. The axialtriradius, which is normally located near the proximal margin of the palm between the thenar and hypothenar eminences, can occur at various positions distal. Each anatomical area is associated with one of three major creases in the palm: the distal transverse crease, the proximal transverse crease, and the radial longitudinal crease. The inner finger joints have horizontal, wavy creases. The outer finger joints [the joints of the little and index fingers] have ridges that slant downward, away from the inner fingers.

The atd angle is an indication of the degree of distal displacement of the axial triradius; the angle increases as the triradius is more distally located. The distal displacement of the axial triradius can be quantitated by calculating the percent distance from X to the axial triradius of the total distance from X to Y. The number of ridges between triradii a and b is the a-b ridge count, and the size of fingertip patterns can be determined by counting the number of ridges crossing a line drawn from the triradius to the core. The sum of the ridge count on all 10 fingers is the total ridge count (TRC). The terminations of main lines A-D are traced from the a-d triradii. The main-line index (MLI) is the sum of terminations of the A and D main lines.

Normally, there are 2 flexion creases on each digit and 3 major palmar creases (the distal transverse crease (DTC), the proximal transverse crease (PTC), and the thenar crease (TC). Variant creases, indicated by number are: 1) An extension of the PTC to the ulnar border of the hand is called a Sydney line. 2) An extension of the DTC to the radial border of the palm results in a horizontal transverse crease and may represent either fusion of the normal 2 creases or loss of either one. 3) A simian crease is a single transverse palmar crease that replaces the DTC and PTC and may represent either fusion of the normal 2 creases or loss of either one. Line X indicates the most distal wrist crease and line Y the most proximal Matacarpo-phalangeal crease of digits 3 and 4. The distance from X to the axial triradius over the distance from X to Y, expressed as a percentage, can be used to classify the axial triradius. If there is more than one axial triradius, the one most distally located is used.

Dermatoglyphic configurations encountered on the toes and soles are basically like those on the fingers and palms; i.e., they include whorls, loops [tibial and fibular], arches, and open fields. The eight plantar areas are hallucal, interdigital II, interdigital III, interdigital IV, distal hypothenar, proximal hypothenar, calcar, and proximal thenar. There are five digital triradii in the distal region of the sole.

Classification systems categorize fingerprint records according to the pattern types found on the fingers. The Henry classification uses alphanumeric designations for fingerprint pattern types and lists them above and below a classification line. NCIC classification is a system that applies a two-letter code to each fingerprint pattern type. Integrated Automated Fingerprint Identification System (IAFIS)is a new NCIC classification system which is based on fingerprint patterns. Automated Fingerprint Identification System (AFIS) is a new system for computerized designation of fingerprint patterns.

Conclusion

Fingerprints and Palm prints are unique to each person. Palms prints can be used for purposes of individualization, identification and comparison of persons. Footprints present certain individual characteristics that can form the basis of identification of a person in forensic examinations. Foot prints can be used to estimate the biological profile, stature, sex, and body weight of persons. Dermatoglyphics have scientific basis for their role as a genetic marker in various systemic disorders and syndromic conditions. A thorough knowledge about the normal dermatoglyphic configuration patterns is very essential for clinical applications. By understanding the relationship between medical disorders and dermatoglyphic variations, it can serve as an excellent, non-invasive tool in the diagnosis of several systemic conditions. Thus, dermatoglyphics is an accessible, inexpensive, useful, reliable and noninvasive method of exploring the genetic associations of medical disorders and syndromic conditions.

References

[1]. Cummins H, Midlo C. Finger prints, palms and soles: an introduction to dermatoglyphics. New York: Dover Publications; 1961.
[2]. Penrose LS. Memorandum on dermatoglyphic nomenclature. Jinrui idengaku zasshi. Jpn J Hum Genet. 1969 Jun;14(1):57-75.
[3]. Galton F. Finger prints. Macmillan and Company; 1892:3-5.
[4]. Hawthorne M. Fingerprints: analysis and understanding. CRC Press; 2017 Jul 27.
[5]. Campbell ED. Fingerprints and palmer Dermatoglyphics. E-fingerprints. net. 1998.
[6]. Krishan K, Kanchan T. Identification: Prints-Footprints. InEncyclopedia of Forensic and Legal Medicine: Second Edition 2015 Nov 4 (pp. 81-91). Elsevier Inc.
[7]. Acree MA. Is there a gender difference in fingerprint ridge density?. Forensic Sci. Int. 1999 May 31;102(1):35-44.
[8]. Kanchan T, Krishan K, Aparna KR, Shyamsunder S. Footprint ridge density: a new attribute for sexual dimorphism. Homo. 2012 Dec;63(6):468-80. Pubmed PMID: 23137779.
[9]. Schaumann B, Alter M. Dermatoglyphics in Medical disorders. 1976: 1-258.
[10]. Cummins H, Midlo C. Palmar and plantar epidermal ridge configurations (dermatoglyphics) in European-Americans. Am. J. Phys. Anthropol. 1926 Oct;9(4):471-502.
[11]. Cummins H. Methodology in palmar dermatoglyphics. Middle American Research Series, Tulane Univ., publ. 1936;7:23-81.
[12]. Miller JR. Dermatoglyphics. J Invest Dermatol. 1973 Jun 1;60(6):435-42.
[13]. Holt SB. Dermatoglyphics in medicine. Crit Rev Clin Lab Sci. 1972 Jan 1;3(2):227-55.
[14]. PENROSE LS. The distal triradius t on the hands of parents and sibs of mongol imbeciles. Ann Hum Genet. 1954 Jul;19(1):10-38.Pubmed PMID: 13208023.
[15]. David TJ. The palmar axial triradius t. A new method of location. Hum Hered. 1971;21(6):624-7.Pubmed PMID: 5149965.
[16]. Shiono H. Dermatoglyphics in medicine. Am J Forensic Med Pathol. 1986 Jun 1;7(2):120-6.
[17]. Reed T. Dermatoglyphics in medicine--problems and use in suspected chromosome abnormalities. Am J Med Genet. 1981;8(4):411-29.Pubmed PMID: 7018239.
[18]. Penrose LS, Loesch D. Topological classification of palmar dermatoglyphics. J Intellect Disabil Res. 1970 Jun;14(2):111-28.
[19]. HOLT, S. B.: Dermatoglyphic patterns. In Harrison, G. A. Genetical Variation in Human Populations. Oxford, Pergamon. 1961: 79.
[20]. Popich GA, Smith DW. The genesis and significance of digital and palmar hand creases: preliminary report. J Pediatr. 1970 Dec;77(6):1017-23.Pubmed PMID: 5486619.
[21]. Uchida IA, Soltan HC. Evaluation of dermatoglyphics in medical genetics. Pediatr Clin North Am. 1963 May 1;10(2):409-22.
[22]. Alter M. Variation in palmar creases. Am. J. Dis. Child. 1970 Nov 1;120(5):424-31.
[23]. Johnson CF, Opitz E. Unusual palm creases and unusual children. The Sydney line and "type C" palmar lines and their clinical significance in a child development clinic. Clin Pediatr (Phila). 1973 Feb;12(2):101-12.Pubmed PMID: 4119799.
[24]. Holt SB. The genetics of dermal ridges. Thomas. 1968.
[25]. Okajima M. Metacarpo-phalangeal and ring creases in twins. Am J Phys Anthropol. 1967 May;26(3):349-55.Pubmed PMID: 6068200.
[26]. Penrose LS, Loesch D. Dermatoglyphic sole patterns. a new attempt at classification. Hum Biol. 1969 Sep;41(3):427-48.Pubmed PMID: 5372298.
[27]. Durham NM, Plato CC, editors. Trends in dermatoglyphic research. Springer Science & Business Media. 1990 Oct 31.
[28]. Daluz HM. Fundamentals of fingerprint analysis. CRC Press; 2018 Oct 26.
[29]. Henry ER. Classification and uses of finger prints. H.M. Stationery off., by Darling & son, ltd; 1913.
[30]. Santhosh kumar, M.P. Role of Dermatoglyphics as a Diagnostic Tool in Syndromes and Systemic Disorders. Int J Dentistry Oral Sci. 2021;08(5):2390-2400.
[31]. Santhosh kumar, M.P. Role of Dermatoglyphics as a Diagnostic Tool in Medical Disorders. Int J Dentistry Oral Sci. 2021;08(5):2348-2356.
[32]. Santhosh kumar, M.P. Role of Dermatoglyphics as a Diagnostic Tool in Dentistry. Int J Dentistry Oral Sci. 2021;08(04):2146-2152.
[33]. Ak H. Knowledge and awareness about oral cancer among undergraduate dental students. Asian J Pharm Clin Res. 2016 Jul 1;9(4):165-7.
[34]. MP SK. Knowledge, Attitude and practices regarding needlestick injuries among dental students. Asian J Pharm Clin Res. 2016;9(4):312-5.
[35]. Kumar S. Knowledge, attitude and practices of dental students toward dental management of patients on antiplatelet therapy. Asian J Pharm Clin Res. 2016;9(3):7.
[36]. Gayathri MM. Knowledge, Awareness and Attitude among dental students about hepatitis B infection. j. pharm. sci. res. 2016 Mar 1;8(3):16870.
[37]. Ahamed A, Kumar MS. Knowledge, attitude and perceived confidence in handling medical emergencies among dental students. j. pharm. sci. res. 2016 Jul 1;8(7):645-649.
[38]. Malay KK, Duraisamy R, Brundha MP, Kumar MP. Awareness regarding anemia among 1 st year dental undergraduate students. Drug invent. today. 2018 Aug 1;10(8):1463-1467.
[39]. Kumar MP. Dental management of patients on antiplatelet therapy: Literature update. Asian J Pharm Clin Res. 2016;9(3):6.
[40]. Santhosh kumar, M.P. Surgery first orthognathic approach in the correction of dentofacial deformities-An overview. Int J Oral Sci.2021;8 (1): 1072-1076.