Dermatoglyphics and Malocclusion-A Forensic Link

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Authors' contributions

This work was carried out in collaboration between all authors. Authors MTB and PB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AS, NB, AHS and NG managed the analyses of the study. Author AHS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Dermatoglyphics is known to be one of the best available diagnostic tools in genetic disorders. Dermatoglyphics refers to the study of epidermal ridges on the finger & palmer region 1 of the hand and sole. The finger prints are unique characteristic features of an individual and remain unchanged over lifetime. The dermatoglyphics patterns, have the same origin as that of the facial structures, as well develop concurrently. Thus, hereditary and environmental factors leading to malocclusions may also set off peculiarities in fingerprint patterns. This article aims to give brief insight of different aspects of dermatoglyphics studies highlighting is utility in diagnosing malocclusion and other developmental disturbances of the oro-facial structures.

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1. INTRODUCTION

Dermatoglyphics is the art and science of studying the patterns of fingerprints. It was in 1926 that Cummins & Midlo coined the term Dermatoglyphics. The term derived from a Greek word derma meaning “skin”, glyph meaning “carving” [1]. Cummins is also known as the Father of Dermatoglyphics.

It is well known now that the dermatoglyphic patterns are genetically determined [2]. The epidermal ridges are usually laid down between the tenth and eighteenth weeks of gestation. Once laid down, they remain unchanged except for an increase in size in parallel with general growth (Mulvihill and Smith [3]; Lacroix et al. [4]). Their variable characteristics are not duplicated in other people not even in monozygotic twins [5].

The inheritance of dermal traits is considered to follow a classical polygenic model [6]. Their heridabitlity and polygenic trait have proved useful phenotype to study genetic and heritable disorders, sometimes even superior to stereological markers [7]. Cummins [8] first reported association of specific dermatoglyphic patterns in patients with down syndrome which is a genetic disorder. In recent decades, dermatoglyphics findings have been related to various medical disorders, through several investigations, as a result of which dermatoglyphic analysis has been established as a useful diagnostic and research tool in medicine, providing important insights into the inheritance and embryologic development of many studied clinical disorders [9-11].

In dentistry, the significance of dermatoglyphics has been investigated by several investigators, wherein it, has been used to unveil oral diseases like dental caries, oral cancer, bruxism, anomalies of teeth, cleft lip, cleft palate, periodontal disease, dental fluorosis [12-23].

Malocclusion is genetically controlled and forms one of the most common dental diseases. It is hypothecated that hereditary and environmental factors leading to malocclusions may also set off peculiarities in fingerprint patterns. Hence, the deviation from normal occlusions due to extraneous factors at the time of development, should also reflect in the dermal patterns [24].

To date fewer studies have been done on dermatoglyphics traits associated with malocclusion. Hence the present paper, discusses the role of dermatoglyphics in occlusion.

2. DERMATOGLYPHIC LANDMARKS AND PATTERN CONFIGURATION [2]

2.1 Dermatoglyphic Patterns

The Dermatoglyphics patterns are classified into 3 types, that is: Arches, loops, whorls (Fig. 1).

![Fig. 1. Fingertip dermatoglyphic patterns](image-url)
2.1.1 Fingertip patterns

The ridge patterns on the distal phalanges of the fingertips are divided into the three groups.

i) Arches: The Arch pattern is made up of ridges lying one above the other in a general arching formation. The arch pattern is subdivided into two types:
   a. Simple or plain arch composed of ridges that cross the fingertip from one side to the other without recurving.
   b. Tented arch composed of ridges that meet at a point so that their smooth sweep is interrupted.

ii) Loops: It is the most common pattern with series of ridges entering the pattern area on one side of the digit and leaving the area on the same side.

   The loop pattern is subdivided into two types:
   a. Ulnar loop composed of ridges that open on the ulnar side
   b. Radial loop composed of ridges that open on the radial side.

iii) Whorls: It is any ridge configuration with two or more tri-radii. One tri-radius is on radial and the other on the ulnar side of the pattern.

Important landmarks (Fig. 2):

![Fingerprint diagram](image)

Fig. 2. Important landmarks on fingerprint

i) Triradius: Formed by the confluence of three ridge systems that form angles of approximately 120° with one another. The geometric center of the triradius is designated as a triradial point. The triradial point forms one terminus of the line along which ridges are counted.

   ii) Core: It is in the approximate center of the pattern, of fingerprint pattern. The core may be of different shapes. A) In a loop pattern, the core is usually represented by a straight, rod like ridge or a series of two or more such parallel ridges, over which other recurving ridges pass. If a straight ridge is absent in the center of the loop, the innermost recurving ridge is designated as a core. B) In a whorl, the core can appear as a dot or a short ridge (either straight or bent) or it can be shaped as a circle or an ellipse in the center of the pattern.

   iii) Radiant: Which are lines emanating from the tri-radius and enclose the pattern area.

2.2 Quantitative Analysis

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.

The following are some often used parameters (Fig. 3):

**Pattern intensity**: Pattern intensity refers to the complexity of ridge configurations and is expressed, by counting the number of triradii present. According to the number of triradii, a digit can have a pattern intensity 0–3. The simple arch, which lacks a triradius, is assigned the number 0, the tented arch and the loop are both assigned 1, as each has one triradius, and similarly, the pattern intensity of the palm can be expressed as the sum of all triradii present.

**Ridge counts**: Ridges of the digital areas of the palms are often counted between two digital tri-radii. The most frequently obtained ridge count is between triradii a and b and is referred to as the a-b ridge count. Counting is carried out along a straight line connecting both triradial points. The count excludes the ridges forming the triradii.

**Ridge counting**: Ridge counting between the triradius d and t has been proposed as yet another means of describing the position of the axial triradius.
Fig. 3. Landmarks and diagrammatic representation of atd and tab

**Atd angle:** Perhaps the most widely used method is based on the atd angle. This angle is formed by lines drawn from the digital triradius a to the axial triradius t, and from this triradius t to the digital triradius d. The more distal the position of t, the larger the atd angle.

### 3. METHODS OF RECORDING DERMATOGLYPICS

#### 3.1 INK Method [1]

The necessary equipment consists of printers ink, a roller, a glass or metal inking slab, a sponge rubber and a good quality paper with a slightly glazed surface.

**Advantages:**

- Cheapest of all methods
- Requires little training
- Produces instantly visible prints for instant checking

**Disadvantages:**

- The Paraphernalia of the ink pad, roller, and printer’s ink.
- Patient feels dirty on application of the black ink and becomes less uncooperative.
- The ink smudges on researchers hands too.
- Procedure needs assistant for help

#### 3.2 Inkless Method

Inkless method uses latent-print powder and transparent vinyl adhesive sheets. The “scotch tape india ink” method is another example of an inkless method that incorporates the use of a branded transparent tape, colored chalk and white index cart [26]. A modern and acceptable inkless method for taking finger print is a chemical one, described by Walker [27].

**Advantages:**

- The flexibility of the plastic tape allows it to lift surface features not accessible with finger print fluid and paper.
- Increased speed, clarity & neatness.

**Disadvantages:**

- Some subjects may be sensitive to the chemical on the paper
b. Requires training  
c. Durability of the print is not yet verified  
d. Prior to printing thorough skin cleaning is necessary  

3.3 Photographic Method  

In the photo paper method, a working solution is prepared, a blotter is moistened with this mixture, which serves as an inking slab. The part which is to be printed is first pressed against the moist blotter for a few second and is then applied against a sheet of photographic paper. The prints are fixed in hypo, washed and dried as in the usual photographic process [28].

Advantage:  

a. Materials are easily portable  
b. Independent of environmental conditions  
c. Good durability, gives best results for dermatoglyphics and creases  

Disadvantages:  

a. Extensive training required  
b. Prints can’t be checked instantly  
c. Technically difficult  

3.4 Integrated Automated Fingerprint Identification System (IAFIS)  

Scans fingerprints into a computer database, which transforms it into digital minutiae [29].

4. DERMATOGLYPICS IN DENTISTRY  

4.1 Cleft Lip and Palate (CL/P)  

Mathew L et al. [12] found increased frequency of ulnar and radial loops than the arches and whorls in cleft lip with or without cleft palate patients compared to controls. Interdigital patterns were less frequent in cleft lip and cleft palate patients. Similarly various other studied also reported a significant dermatoglyphic peculiarities in person with CL/P as compared to those without CL/P [14,15,16].

4.2 Dental Caries  

Sharma A and Somani R [16] and Ahmed et al. [17] found highly significant difference in loops between the subject (Caries) and control groups, and also observed significant difference between subject and control groups for microbial growth. Anitha C et al. [18] reported a definite variation in dermatoglyphics between the early childhood caries and caries-free group, indicating that dermatoglyphic patterns can be used as a predictive tool for children with early childhood caries.

4.3 Oral Cancer  

Veena HS et al. [19] found a decreased atd angle, increase patterns in Th/I area and increased pattern frequency in I4 area in OSF patients as compared to normal gutkha chewers. Venkatesh E et al. [20], Gupta A et al. [21] and Ganvir SM et al. [22] in their studies found an increase in frequency of arch and ulnar loop patterns on fingertips in subjects with squamous cell carcinoma.

4.4 Periodontal Diseases  

Atasu M et al. [23] conducted a study with the aim of finding a finger-tip pattern type that would identify the patients with periodontal diseases. The results of their study proved that dermatoglyphics could be used together with the other diagnostic methods such as clinical and radiologic investigations and in the identifying of the patients from distinct groups of PD’s.

4.5 Bruxism  

Increased frequency of whorls and a decrease in frequency of ulnar loops were seen in patients with bruxism than the controls [30].

4.6 Dermatoglyphics Role in Study of Malocclusion  

Malocclusion, which may involve misalignment of the teeth, mal-positioning of the jaws, or a combination of both, can create detrimental effects to a person’s overall facial esthetics, depending on the severity. Both genetic and environmental factors affect craniofacial development, creating an intricate and elaborate multifactorial etiology for malocclusion. The effect of a particular environmental factors on phenotype varies depending on genetic background, which ultimately determines facial and dental morphology [24].
Table 1. Summary of studies that assessed association of dermatoglyphics with malocclusion

<table>
<thead>
<tr>
<th>Author</th>
<th>Group</th>
<th>Age</th>
<th>Sample</th>
<th>Sex</th>
<th>Selection Criteria</th>
<th>Parameters recorded</th>
<th>Dermatoglyphic finding</th>
</tr>
</thead>
</table>
Group 2: Subjects with class I malocclusion | NR       | 25     | Males | NR    |                                                                      | 1. Arches  
2. Loops  
3. Whorls | Craniofacial skeletal class III, associated with  
Increase in arches and ulnar loops, at the expense of whorls on all digits, except digit 2  
Increased frequency of radial loops  
Increased frequency of carpel loops on interdigital area of palms |
| Reddy S et al. (1997) [36] | Group I (Control): Individuals of class I malocclusion  
Group II– Individuals of class II div 1 & 2 malocclusion  
Group III –Individuals of class III malocclusion | 12-14 years | 96     | NR    | NR    | 1. Arches  
2. Loops  
3. Whorls | Class II. Div 1- Increased frequency of arches and ulnar loops and decreased frequency of whorls  
Class III: Increased frequency of arches and radial loops with decreased frequency of ulnar loops | |
| Trehan M et al. (2000) [37] | Group I: Normal Occlusion  
Group II: Bilateral Angels Class I  
Group III: Class II div I Malocclusion  
Group IV: Class III malocclusion | 15-26 years | 60     | Both  | 1. Presence of all permanent teeth excluding 3rd molar & in a sufficient state of eruption to allow measurements.  
2. No previous history of orthodontic treatment  
3. No large coronal restoration that alters tooth coronal shape  
4. Height of palatal vault  
5. Cumulative mesiodistal crown width  
6. Intercanine width  
7. Intermolar width | 1. Molar Relationship  
2. Overjet  
3. Overbite  
4. Height of palatal vault  
5. Cumulative mesiodistal crown width  
6. Intercanine width  
7. Intermolar width | Normal Occlusion  
As the total ridge count increases, the space discrepancy decreases in maxilla  
As tab angle increase in the right hand, the arch length decreases in maxilla and as the atd angle increase in left hand the arch length decrease in mandible |
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<th>Parameters recorded</th>
<th>Dermatoglyphic finding</th>
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</thead>
<tbody>
<tr>
<td>Tikare S et al.</td>
<td>Class 1 Malocclusion</td>
<td>12-16</td>
<td>696</td>
<td>Both</td>
<td>1. Children with fully erupted permanent 2\textsuperscript{nd} molar</td>
<td>1. Loop</td>
<td>Statistically significant association in the whorl patterns between class 1 and class 2 malocclusions.</td>
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<tr>
<td></td>
<td>Class II Malocclusion</td>
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<td></td>
<td>2. Children with history or those undergoing orthodontic treatment were excluded</td>
<td>2. Whorls</td>
<td>No statistically significant association for the other fingerprint patterns and any classes of malocclusion</td>
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<td></td>
<td>3 Groups, based on angles classification of Occlusion</td>
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<td></td>
<td>Group 1(control group):</td>
<td>30 group in 1</td>
<td>30 group in 1</td>
<td>Both</td>
<td>1. Patients in whom orthodontic treatment was given earlier or those undergoing orthodontic treatment.</td>
<td>2. Whorls</td>
<td>a) Overall higher frequency for ulnar loops and lowest for central pocket loops</td>
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<tr>
<td></td>
<td>Subjects with Angles Class I occlusion, with aesthetically pleasing soft tissue profile and acceptable overjet and</td>
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<td>Author</td>
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<tr>
<td>Bhasin et al.; BBJ, 13(1): 1-12, 2016; Article no.BBJ.24451</td>
<td>Group I: Individuals of class I malocclusion</td>
<td>Not mentioned</td>
<td>Total: 24</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>1. Fingertip patterns</td>
<td>1. Whorls pattern: Significantly higher proportion of whorl pattern in Class I as compared to the class II and III.</td>
</tr>
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<td></td>
<td>Group II – Individuals of class II malocclusion</td>
<td>Group I: 10 Group II: 8</td>
<td>Group III: 6</td>
<td></td>
<td></td>
<td>a) Arches</td>
<td>2. Loops: Significantly higher proportion of subjects from class II and III had Loop pattern compared to the class I. Increased proportion loops in class III as compared to class II, but no statistical significance.</td>
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<td></td>
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<td></td>
<td>b) Loops</td>
<td></td>
<td>3. 12/13/14 area palmar pattern:</td>
<td></td>
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<tr>
<td>Rajput S et al. (2014)</td>
<td>Group I: Individuals of class I malocclusion, Not Mentioned</td>
<td>Total: 24</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>1. Fingertip patterns</td>
<td>Whorls pattern: Significantly higher proportion of whorl pattern in Class I as compared to the class II and III.</td>
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<td></td>
<td>Group II – Individuals of class II malocclusion</td>
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<td></td>
<td>a) Arches</td>
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<td>Group III – Individuals of class III malocclusion</td>
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<td>b) Loops</td>
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<td></td>
<td>4. ab count and atd angle: The average of both is not significantly different between three study groups (for both right and left hands).</td>
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<td>Author</td>
<td>Group</td>
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<tr>
<td>Jindal G et al. (2015) [41]</td>
<td>Subjects were divided into 3 groups based on angles classification: Class I Malocclusion' Class II malocclusion</td>
<td>12-16 years</td>
<td>237</td>
<td>Both</td>
<td>1. Children with fully erupted permanent 2nd molar</td>
<td>1. Ulnar loop pattern was predominant in all types of malocclusion.</td>
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<td></td>
<td>Class II Malocclusion</td>
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<td>2. Children with history or those undergoing orthodontic treatment were excluded</td>
<td>2. High frequency of plain arches and whorls found in class II and class III malocclusion respectively</td>
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<td>3. Loop</td>
<td>3. TRCs higher in class II malocclusion, lower in class III malocclusion</td>
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<td>4. FRC</td>
<td>4. No significant correlation between atd angles.</td>
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<td>5. Atd angle</td>
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</table>
The inheritance of dermal traits follow a polygenic model. Associations of such traits with oral malformations have been studied by Holt SB in 1968 [6]. The epidermal ridges of the fingers and palm and the facial structures originate from the same embryonic tissue: ectoderm. The time of process of development and completion of primary lip and palate and that of dermal ridges are approximately the same, coinciding at 6th-13th week of intrauterine life. The dermal ridge configuration reaches its maximum at around 13 weeks of gestation and is completely established by the 24 weeks of gestation, and once formed, remain constant for lifetime, except in overall size [1-4].

Facial development begins as early as the 4th week of gestation. The palate development begins in 6th week and is completed by the 12th week of gestation [31].

Thus, the face and dermal ridges not only have the same origin but also develop concurrently; the genetic message contained in the genome is deciphered during this period and is also reflected in dermatoglyphic patterns. Thus, any environmental or genetic factors affecting the process of development of dental hard tissues might affect and also get recorded in the dermal ridges. This forms the basis of comparison of malocclusion with that of dermatoglyphics.

The presence of asymmetry between normally symmetric, bilateral traits has been studied using dermatoglyphics patterns [32,33]. Excessive asymmetry between the dermatoglyphic patterns of the left and right hands may signify relatively unstable genetic control during embryogenesis, which in turn, may contribute to the development of malformations [34].

Studies have provided evidence that dermatoglyphic traits are associated with malocclusion. It would be highly valuable from a clinical standpoint if this finding could be substantiated since dermatoglyphic markers could then be used for screening out individuals who might be at an elevated risk of developing malocclusion. However there are few studies conducted in dentistry to establish relationship between finger patterns and malocclusion. Hence the aim was to search for and appraise available studies that pertain to the association between malocclusion and dermatoglyphics.

4.7 Literature Search

The electronic databases of MEDLINE (PubMed), Cochrane, as well Google Scholar were searched for eligible case control studies that assessed dermatoglyphics in malocclusion, published before December 2015. The following terms were used to search for articles “Dermatoglyphics”, “Palm Prints”, “Malocclusion”, “Occlusion”, “Occlusion”, “Orthodontics”. After extensive search only 7 studies were found that fit the search criteria. Table 1, discusses the results of various studies on dermatoglyphic and malocclusion.

5. CONCLUSION

Determination of the genetic and environmental origin of malocclusion is important for orthodontic treatment planning and selection of appropriate treatment modalities. Dermatoglyphics can serve as an easy, accessible, inexpensive and non-invasive method of exploring the genetic associations of malocclusion and for timely prevention, however, it cannot be relied upon as the sole factor. This is due to the fact that numerous other factors such as ethnic and racial variations, congenital, environmental and other local factors can also influence the development of malocclusions. Extensive studies of ridge pattern has to be undertaken with several groups according to their racial and ethnic backgrounds.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES


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