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Footprints of the Future: How Toe Prints Can Predict Your Malocclusion

Dr. Sunil Vishwambhar Kalyankar[1], Dr. Sandeep Jethe[2], Dr. Varsha Merani[3], Dr. Shailesh Dongre[4], Dr. Arun Mhaske[5], Dr. Suyog Shendage[6], Dr. Abulrehman Foujdar[7], Dr. Aakanksha Kedar[8]

[*1]DY Patil Dental School Lohegaon,Pune, PG Student
[2]DY Patil Dental School Lohegaon,Pune, ,Professor, HOD
[3]DY Patil Dental School Lohegaon,Pune, Reader
[4]DY Patil Dental School Lohegaon,Pune, Reader
[5]DY Patil Dental School Lohegaon,Pune, Lecturer
[6]DY Patil Dental School Lohegaon,Pune, Lecturer
[7]DY Patil Dental School Lohegaon,Pune, Lecturer
[8]DY Patil Dental School Lohegaon,Pune, PG Student

***Corresponding Author:**

Dr. Sunil Vishwambhar Kalyankar

Maharashtra University of Health Science, Nashik, MDS-III (Final Year Student) Department of Orthodontic And Dentofacial Orthopaedics, DY Patil Dental School Lohegaon,Pune,

Email ID: skorthodontics1998@gmail.com

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ABSTRACT

Aim-This study investigates the relationship between plantar dermatoglyphic patterns (Toeprints) and the three classes of malocclusion, with a focus on gender-based variations.

Background- Dermatoglyphics of the Toes are formed during early intrauterine life and remain unchanged throughout life. Their genetic basis makes them valuable for early prediction of craniofacial development.The correlations between dermatoglyphic patterns and malocclusion, particularly in relation to gender differences, suggest a possible genetic basis for both phenomena. Several genes involved in craniofacial development, including those related to neural crest cells and the formation of the ectodermal layer, may influence both dermatoglyphic patterns and skeletal development. Further genetic studies are needed to explore the exact mechanisms through which these patterns emerge and their potential as biomarkers for craniofacial conditions.

Material and methods -This analysis determined that a minimum sample size of twenty individuals (male , female) required for each state of skeletal malocclusion (Class I, II, and III). A total of 120 individuals were subsequently recruited to represent the three different skeletal malocclusion groups.This study analyzed 120 individuals divided evenly among malocclusion Classes I, II, and III, with 20 males and 20 females in each.

Result-In Class I malocclusion, males exhibited a higher proportion of whorls (45%), followed by arches (30%) and loops (25%). Conversely, Class I females showed a predominance of loops (55%), followed by arches (25%) and whorls (20%).Class II malocclusion, males had the highest frequency of whorls (60%), with equal distribution of arches and loops (20% each). Females in Class II also showed a considerable presence of whorls (45%), although loops (40%) were more prominent compared to arches (15%).In Class III malocclusion, a notable increase in arches was observed, particularly in males (60%) and females (50%), suggesting that arch patterns may be associated with more severe skeletal discrepancies such as mandibular prognathism.

Conclusion- As research in this field progresses, it may lead to the development of novel diagnostic tools and early intervention strategies based on dermatoglyphic analysis, enhancing the understanding of the genetic underpinnings of malocclusion and contributing to more effective orthodontic treatments.

Keywords: *Toeprint, prediction, fingerprint, malocclusion*

1. INTRODUCTION

The skin on the palms, fingers, soles, and toes features distinct patterns formed by ridges and valleys. The study of these dermal ridge patterns, known as **dermatoglyphics**, was introduced by Harold Cummins and Charles Midlo in 1926 [1,2]. Over time, the uniqueness and complexity of these patterns have captured the interest of researchers, establishing dermatoglyphics as a scientific field with applications in biology, medicine, genetics, and evolutionary studies. It is considered one of the most reliable methods for personal identification [3]. Moreover, dermatoglyphic analysis serves as a valuable preliminary diagnostic tool in conditions that are suspected to have a genetic origin [4,5].

Fingerprint analysis is grounded in the principle that each individual's fingerprints are unique, a result of subtle variations in the fetal environment. These patterns remain constant throughout a person's life. Sweat pores located on the surface of the ridge patterns cause perspiration to accumulate on the fingertips, and when contact is made with an object, these secretions leave behind identifiable prints. Fingerprints are typically classified into three major types: **arches**, **loops**, and **whorls**.[6,7]

In the field of medical dermatoglyphics, numerous studies have shown associations between fingerprint patterns and a variety of conditions such as diabetes mellitus, hypertension, psychosis, breast cancer, fetal alcohol syndrome, epilepsy, and congenital heart diseases, among others. In dentistry, unusual fingerprint patterns have been noted in patients with conditions like periodontitis, dental caries, and congenital anomalies such as cleft lip and palate. More recently, dermatoglyphic patterns have also been linked to malocclusion and other developmental disorders affecting orofacial structures.[8,9].

Malocclusion is a common dental condition that impacts facial aesthetics and may involve misaligned teeth, improper jaw positioning, or both [30]. The development of the dentition and palate coincides with the formation of dermal ridge patterns during the sixth to seventh week of intrauterine life. Genetic and environmental factors influencing the formation of the lip, alveolus, and palate may also affect fingerprint and palm print patterns.[10]

The observed associations between dermatoglyphics and conditions such as oral clefts, periodontitis, and dental caries have led to increased interest in exploring its correlation with malocclusion, particularly sagittal skeletal discrepancies. Craniofacial development is influenced by a combination of genetic and environmental factors, contributing to the multifactorial nature of these discrepancies. It is postulated that the genetic information active during this critical developmental period is mirrored in dermatoglyphic patterns. As such, dermatoglyphic analysis holds promise as a non-invasive, supportive tool for early diagnosis and intervention in cases of sagittal skeletal malocclusion.[11]

The aim of this study was to assess the correlation between dermatoglyphic patterns and sagittal skeletal discrepancies by comparing and evaluating the toe dermatoglyphic patterns in sagittal skeletal discrepancies: skeletal Class I, skeletal Class II skeletal Class III

2. MATERIALS AND METHODS

The present cross-sectional study was conducted on 120 subjects (60 males, 60 females), aged 18-40 years randomly selected from the outpatient clinic of Department of Orthodontics and Dentofacial Orthopaedics, DY Patil Dental School, Lohegaon Pune from 10th November 2023 to 2 May 2025.

Sample size estimation:

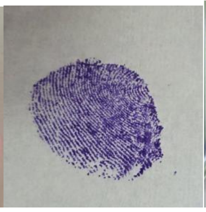
A minimum sample size was estimated a priori using G*Power software.

Statistical analysis was performed using Statistical package for social sciences (SPSS) software (IBM Corp) (v.26.0).

Parameters from a previous study were used to inform the power analysis. A significance level of 0.05 and power of 80% were set within a 95% con fidence interval. This analysis determined that a minimum sample size of twenty individuals (male, female) required for each state of skeletal malocclusion (Class I, II, and III). A total of 120 individuals were subsequently recruited to represent the three different skeletal malocclusion groups.

To bring about uniformity during categorization, the total sample was adjusted to 120. The total sample of 120 subjects was categorized into three groups of 40 each: Skeletal Class I =40 Skeletal Class II =40 Skeletal Class III =40

Methods of toeprint registration steps

Steps 1 **Steps 2** **Steps 3** **Steps 4**

Table: Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Systemically healthy individuals	Presence of developmental anomalies
Age between 14 and 40 years	Systemic disease affectingbone or general health
Provided informed consent	Children (under 14 years)
No history of orthodontic treatment	Pregnant women
No history of oromaxillofacial surgery	Individuals with intellectual disabilities
	Patients with both maxillary and mandibular excess
	Refusal or failure to provide informed consent

The sagittal jaw relation was determined from the patient's lateral cephalogram with assessment of the following parameters: SNA, SNB, ANB, Wits appraisal, condylion to Point A, condylion to gnathion, angle of convexity and facial angle (Steiner's, Down's, Mcnamara and COGS analyses and Wits Apraisal). Points A and B were regarded as the anterior limits of the apical bases of maxilla and mandible and cephalometric norms of Maharashtrian population were taken into consideration. The patients were thus categorized into three groups according to the skeletal relationship of maxilla and mandible.

Statistical Analysis

Data pertaining to the fingerprints were obtained and entered into an Excel spread sheet and Statistical analysis was performed using Statistical package for social sciences (SPSS) software (IBM Corp) (v.26.0) for descriptive and Chi-square analysis. The percentage frequency of arches, loops and whorls were assessed in the three groups and noted separately for twenty males and twenty females in each category. The values obtained were statistically analysed using Chi-square tests, ANOVA and Post-hoc tests .The level of significance was set at 5% and 95% confidence interval was taken.

3. RESULTS

The distribution of fingerprint patterns—arches, loops, and whorls—varied across different skeletal classes and between genders, revealing potential correlations between dermatoglyphic patterns and sagittal skeletal malocclusions.

In **Class I malocclusion**, males exhibited a higher proportion of **whorls (45%)**, followed by arches (30%) and loops (25%). Conversely, **Class I females** showed a predominance of **loops (55%)**, followed by arches (25%) and whorls (20%). This suggests a possible gender-based variation in dermatoglyphic pattern prevalence in individuals with normal occlusion.

Among individuals with **Class II malocclusion**, **males** had the highest frequency of **whorls (60%)**, with equal distribution of arches and loops (20% each). **Females in Class II** also showed a considerable presence of **whorls (45%)**, although **loops (40%)** were more prominent compared to **arches (15%)**. The consistent presence of whorls in Class II individuals might suggest an underlying genetic influence on both dermatoglyphic and craniofacial development.

In **Class III malocclusion**, a notable increase in **arches** was observed, particularly in **males (60%)** and **females (50%)**, suggesting that arch patterns may be associated with more severe skeletal discrepancies such as mandibular prognathism. Both groups had a reduced incidence of whorls and loops, indicating a potential inverse relationship between arches and sagittal imbalance severity.

Fingerprint Pattern Distribution Across Malocclusion Classes and Genders

	Arches	Arches (%)	Loops	Loops (%)	Whorls	Whorls (%)
Class I - Male	6.0	30.0	5.0	25.0	9.0	45.0
Class I - Female	5.0	25.0	11.0	55.0	4.0	20.0
Class II - Male	4.0	20.0	4.0	20.0	12.0	60.0
Class II - Female	3.0	15.0	8.0	40.0	9.0	45.0
Class III - Male	12.0	60.0	4.0	20.0	4.0	20.0
Class III - Female	10.0	50.0	5.0	25.0	5.0	25.0

Table 1. fingerprint pattern distribution across malocclusion classes and genders

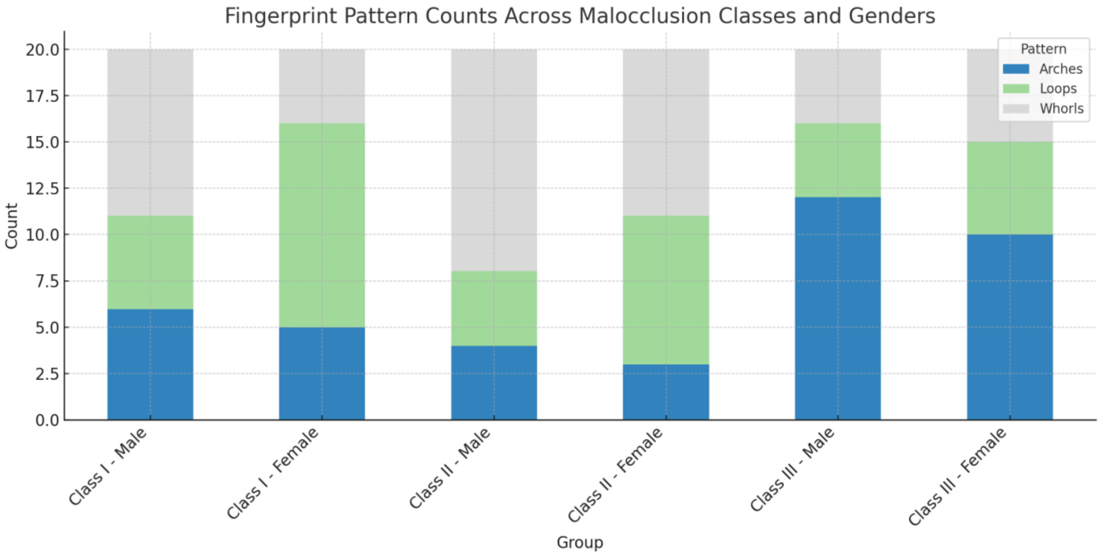


Fig 1. fingerprint pattern counts across malocclusion classes and genders

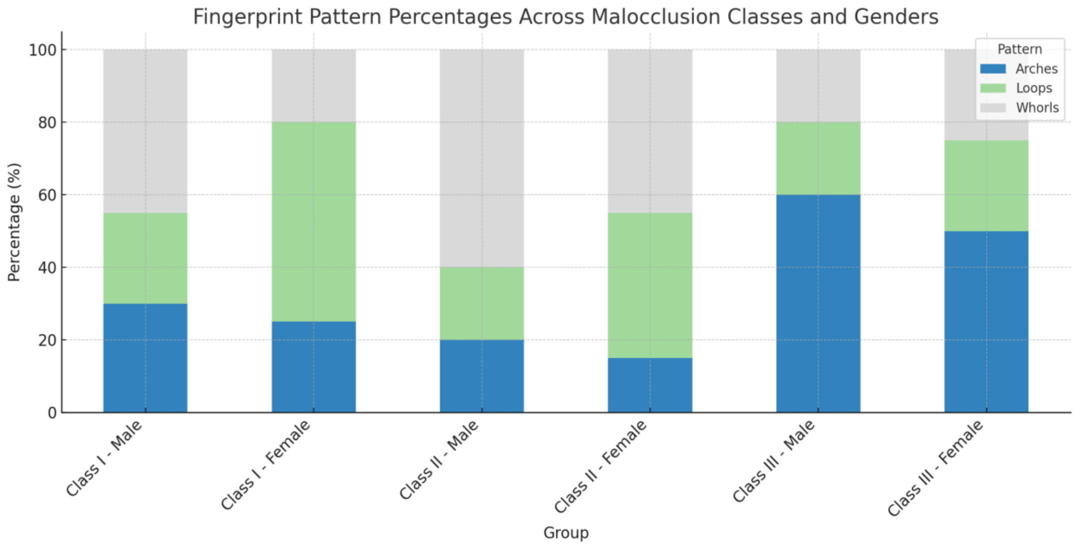


Fig 2. fingerprint percentages across malocclusion classes and genders

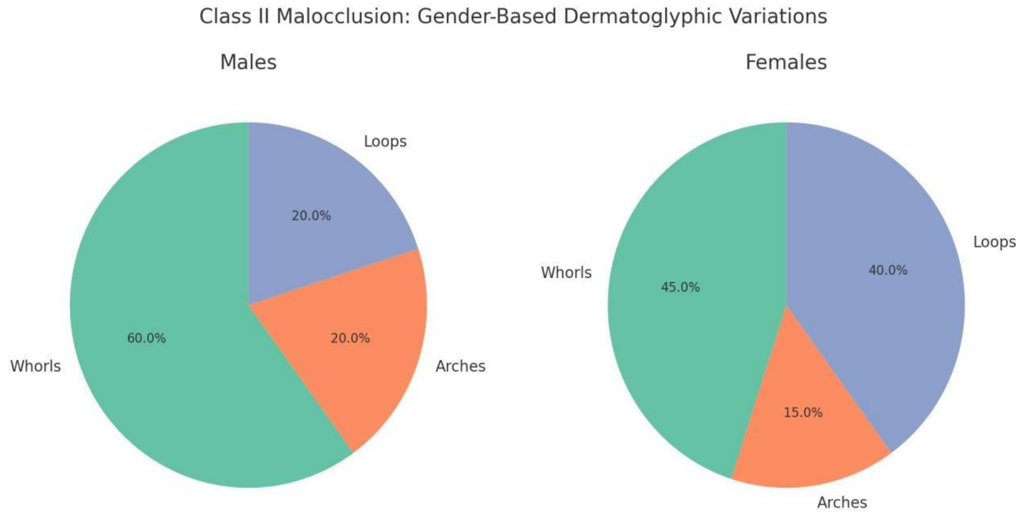


Fig 3. Class II malocclusion : Gender based variation

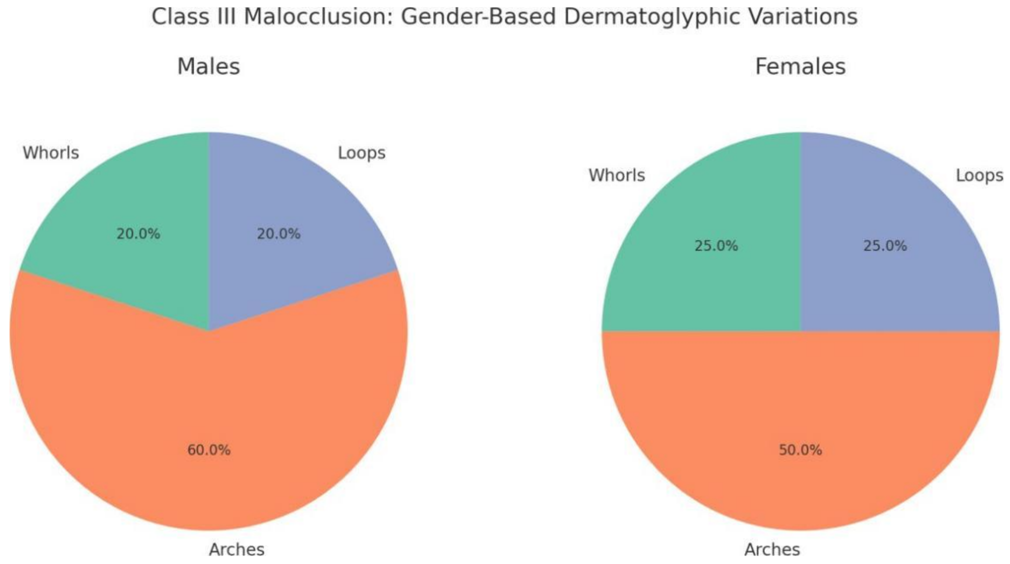


Fig 4. Class III malocclusion : Gender based variation

4. DISCUSSION

Dermatoglyphic patterns are genetically determined and their inheritance is considered to follow a classic polygenic model which has proved useful to study many genetic disorders. Dermatoglyphic investigation being convenient, cost effective and non invasive, had been applied in many fields and dentistry has been no where behind in the race of investigation with several investigators utilizing this useful diagnostic tool to unveil genetic factors related to many oral diseases. An early diagnosis and correction of deviated growth patterns of jaws through early interceptive orthodontic treatment may help preventing some of the future orthognathic surgeries.[12]

Dermatoglyphics, the study of fingerprint patterns, has long been an area of interest in both genetic and developmental biology. The patterns on the fingertips—whorls, loops, and arches—are known to be genetically determined and influenced by environmental factors during fetal development. These dermatoglyphic patterns have been shown to reflect underlying genetic influences that could also impact other aspects of physical development, including craniofacial morphology. In the context of orthodontics, malocclusion refers to the misalignment of teeth and jaws, with Class I, Class II, and Class III malocclusions being the primary classifications based on the alignment of the upper and lower teeth[13,14].

The connection between dermatoglyphic patterns and malocclusion types, particularly with respect to gender-based differences, is an intriguing area of study. This discussion will explore the findings that link dermatoglyphic patterns to different types of malocclusion, emphasizing the gender-based variations observed in individuals with Class I, Class II, and Class III malocclusion. We will also delve into the possible genetic underpinnings that may explain these relationships.

Class I Malocclusion: Gender-Based Dermatoglyphic Variations

Class I malocclusion represents a typical or normal occlusion where the upper and lower teeth are aligned in a functional manner. However, even in individuals with normal occlusion, significant variations in dermatoglyphic patterns are observed, especially when analyzed by gender.

Among males with Class I malocclusion, whorls are the most common fingerprint pattern, appearing in 45% of the population. This is followed by arches (30%) and loops (25%). In contrast, females with Class I malocclusion demonstrate a strikingly different pattern distribution. Loops are the most prevalent pattern in this group, comprising 55% of the population, followed by arches (25%) and whorls (20%).

This gender-based difference in dermatoglyphic patterns could be reflective of distinct genetic and hormonal influences on fingerprint development. Since males have a single X chromosome and females have two, the difference in the inheritance of X- linked genes may explain the variation in fingerprint patterns. The higher prevalence of whorls in males might be linked to the unique expression of certain genes on the X chromosome that affect both the development of the skin and other aspects of craniofacial growth. Meanwhile, the higher frequency of loops in females could be indicative of the interaction between their two X chromosomes, potentially leading to a broader range of dermatoglyphic patterns.[15]

These differences, while not linked to any malocclusion severity, suggest that gender may play a role in the expression of dermatoglyphic traits even in individuals with a normal occlusal relationship. This opens up an avenue for future research to determine whether gender-specific patterns could be used to predict other aspects of craniofacial or developmental variation.

Class II Malocclusion: A Genetic Connection Between Whorls and Craniofacial Development

Class II malocclusion is characterized by a skeletal discrepancy, with the upper jaw positioned forward relative to the lower jaw, commonly referred to as retrognathism. This type of malocclusion is often associated with genetic and developmental factors, and studies have suggested that dermatoglyphic patterns may play a role in understanding the genetic basis of craniofacial development.

In individuals with Class II malocclusion, the pattern distribution is somewhat more homogeneous across genders compared to Class I. Males in this group exhibit a dominant presence of whorls (60%), with arches and loops each appearing in 20% of the population. For females, whorls are also prevalent (45%), but loops (40%) appear more frequently than arches (15%).

The consistent presence of whorls in both males and females with Class II malocclusion suggests a potential genetic correlation between dermatoglyphic patterns and the craniofacial anomalies seen in this group. Whorls, which are generally thought to develop in response to genetic factors influencing ectodermal development, may be indicative of a broader genetic predisposition for malocclusion or other developmental traits. This theory is further supported by the fact that whorls are commonly associated with the development of ectodermal tissues, which play a crucial role in both skin formation and craniofacial skeletal development.[16,17]

The balance of arches and loops in this group also provides insights into gender-based genetic influences. While males tend to have a more significant proportion of whorls, the relatively equal distribution of arches and loops (20% each) may indicate that these patterns also have an impact on the skeletal development seen in Class II malocclusion. In females, the greater frequency of loops compared to arches further points to potential gender-specific pathways of craniofacial development, influenced by both genetic and hormonal factors.

Thus, the prevalence of whorls in individuals with Class II malocclusion could suggest an underlying genetic link between dermatoglyphic patterns and malocclusion, offering a potential avenue for further genetic studies that explore the shared pathways between these two aspects of development.

Class III Malocclusion: Arches and Their Association with Severe Skeletal Discrepancies

Class III malocclusion, characterized by a protruding mandible (prognathism), represents a more severe form of skeletal discrepancy. In this group, a marked shift in dermatoglyphic patterns is observed, particularly in the prevalence of arches. In males with Class III malocclusion, arches appear in 60% of the population, while in females, arches are present in 50%. In both genders, the frequency of whorls and loops is noticeably lower compared to individuals with Class I or Class II malocclusion.

The dominance of arches in individuals with Class III malocclusion suggests a potential association between arch patterns and more severe skeletal discrepancies, such as mandibular prognathism. This relationship may indicate that the development of arch patterns in dermatoglyphics could be linked to more significant changes in skeletal structure. Given that arches are thought to develop as a result of specific interactions between genes that govern the differentiation of ectodermal tissues, their higher prevalence in Class III individuals could reflect a developmental pathway that influences the positioning of the mandible.

The inverse relationship observed between arches and the reduced presence of whorls and loops in Class III individuals might suggest that the occurrence of arches is a distinctive feature associated with more pronounced sagittal skeletal imbalances. As individuals with Class III malocclusion generally exhibit greater skeletal asymmetry, the reduced presence of loops and whorls could indicate that these patterns are less commonly associated with severe craniofacial discrepancies.

Genetic Implications and Future Directions

The correlations between dermatoglyphic patterns and malocclusion, particularly in relation to gender differences, suggest a possible genetic basis for both phenomena. Several genes involved in craniofacial development, including those related to neural crest cells and the formation of the ectodermal layer, may influence both dermatoglyphic patterns and skeletal development. Further genetic studies are needed to explore the exact mechanisms through which these patterns emerge and their potential as biomarkers for craniofacial conditions.

The consistent presence of whorls in Class II individuals and arches in Class III individuals hints at a genetic overlap between dermatoglyphic development and craniofacial anomalies. This overlap could provide valuable insights into the genetic pathways that govern both dermatoglyphic patterns and occlusal development, which could ultimately lead to improved diagnostic tools for early intervention in orthodontic and craniofacial treatments.

Conclusion

The relationship between dermatoglyphic patterns and malocclusion provides an exciting avenue for research into the genetic and developmental factors that influence both craniofacial morphology and fingerprint patterns. The findings suggest that gender-based variations in dermatoglyphic patterns might reflect different genetic and environmental influences on development. Additionally, the presence of specific dermatoglyphic patterns in individuals with malocclusion, particularly whorls in Class

II malocclusion and arches in Class III malocclusion, could provide important diagnostic clues for orthodontists and clinicians As research in this field progresses, it may lead to the development of novel diagnostic tools and early intervention strategies based on dermatoglyphic analysis, enhancing the understanding of the genetic underpinnings of malocclusion and contributing to more effective orthodontic treatments.

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