Original articles

Association between dermatoglyphic patterns and malocclusion in 12 - 15-year-old children in Hue city, Vietnam

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Abstract

Background: Dermatoglyphics has been increasingly investigated as a potential indicator for early prediction of malocclusion. This study aimed to evaluate the association between fingerprint patterns and occlusal status in children in Hue city, Vietnam.

Materials and methods: A cross-sectional study was conducted on 177 children aged 12–15 years from March to May 2023 in Hue city. Occlusal status was classified according to Angle's classification. Fingerprint patterns were analyzed, and total finger ridge count was recorded and compared among different occlusion groups.

Results: Children with Class II malocclusion exhibited a higher frequency of ulnar loop patterns and a lower frequency of plain whorl patterns. The latter were observed at significantly higher proportions in Class I and Class III malocclusions ($p = 0.006$). Additionally, significant differences in total finger ridge count were observed among the occlusion groups ($p < 0.05$).

Conclusion: Dermatoglyphic characteristics may be useful as a supportive tool for early identification of malocclusion. This may contribute to timely planning of preventive and interceptive orthodontic treatment in pediatric patients.

Keywords: *dermatoglyphics; malocclusion; total finger ridge count; Angle's classification.*

1. BACKGROUND

The scientific field concerned with the analysis of epidermal ridge patterns on the fingers, palms, and soles is known as dermatoglyphics, a terminology coined by Cummins and Midlo back in 1926. It is derived from two Greek words - *derma* (skin) and *glyphe (*carving) [1]. Established during prenatal development, fingerprint patterns persist throughout life with no structural changes, aside from size enlargement corresponding to physical growth [2].

In recent years, numerous studies have demonstrated associations between fingerprint patterns and various systemic conditions, including diabetes mellitus, hypertension [3], and breast cancer [4], among others [5]. In dentistry, dermatoglyphic variations have also been reported in patients with dental caries, periodontal diseases [6], cleft lip and palate [7] and malocclusion [8-10].

In Vietnam, malocclusion is a highly prevalent condition. According to Dong Khac Tham, the prevalence of malocclusion among the Vietnamese population is 83.2% [11]. Additionally, a study by Hoang Thi Le Giang showed that the malocclusion rate among children aged 12 to 15 years in Vinh city, Nghe An Province is 76% [12].

The epidermal ridges of the fingers and palms, as well as craniofacial structures, originate from the same embryonic layer, the ectoderm [13]. These structures not only share a common origin but also develop concurrently during early intrauterine life [13, 14]. During this critical period, genetic information is expressed and may be reflected in the formation of dermal ridge patterns. Therefore, genetic and environmental factors that influence the development of dental tissues may also be reflected in dermatoglyphic features. This provides a biological basis for investigating the relationship between fingerprint patterns and malocclusion.

Previous studies have reported inconsistent findings regarding the association between fingerprint patterns and different types of malocclusion across various populations [8-10]. To date, no studies have been conducted on this issue in Vietnam. Therefore, this study aimed to evaluate the association between fingerprint patterns and malocclusion among children in Hue City, Vietnam.

2. MATERIALS AND METHODS

2.1. Study population and design

We conducted a cross-sectional study using stratified cluster sampling to select the study participants. The study was conducted in two

secondary schools in Hue City, Vietnam from March to May 2023. First, a comprehensive list of all 21 secondary schools on the northern bank of the Huong River was compiled, from which Huynh Thuc Khang secondary school (Phu Binh ward) was chosen via a random draw. Similarly, from the 20 secondary schools on the southern bank of the Huong River, Thuy Van secondary school (Thuy Van ward) was randomly selected. Subsequently, all classes within each selected school were listed and categorized by grade level: Grade 6 (12 years old), Grade 7 (13 years old), Grade 8 (14 years old) and Grade 9 (15 years old). One class from each grade level was then chosen through a random draw. Thereafter, students within these selected classes who met the established inclusion criteria were recruited for the study, followed by data collection.

In reality, data were collected from 193 children. However, 16 participants were excluded from the study due to unclear fingerprint patterns or differing occlusion on the two sides of the dental arch [9], [15]. Consequently, the final sample consisted of 177 children (89 males and 88 females).

Participants were included if they met the following criteria:

- Aged between 12 and 15 years.
- Presence of all permanent teeth in each dental arch (excluding third molars).
- No history of orthodontic treatment.

Participants were excluded if they met any of the following criteria:

- Presence of mixed dentition or permanent teeth that had not fully erupted to the occlusal plane.
- History of trauma or surgical procedures in the orofacial region.
- Presence of large coronal restorations on first permanent molar that could alter the shape and size of the crown.
- Congenital or acquired deformities of the fingers (e.g., amputations, skin diseases, wounds, or scars).
- Major craniofacial anomalies, such as cleft lip and palate or any recognized syndromes.

2.2. Data Collection

Participants were categorized into four groups based on Angle's classification: Class I normal occlusion, Class I malocclusion, Class II malocclusion, and Class III malocclusion.

Prior to fingerprint collection, each participant's hands were cleaned with alcohol wipes to remove oil, sweat, dirt, powder, and then dried with tissues. Fingerprints from all ten fingers were subsequently captured using a DigitalPersona U.are.U 4500 USB Fingerprint Reader (Crossmatch, USA).

Fingerprint patterns were classified into three primary types and their respective subtypes (Figure 1a-h):

- Arches: subdivided into plain arches and tented arches.
- Loops: subdivided into ulnar loops and radial loops.
- Whorls: subdivided into plain whorls, double loops, central pocket loops and accidental whorls [16].

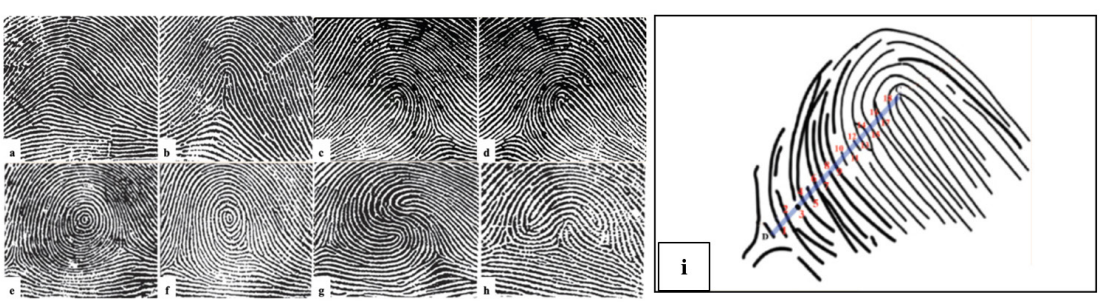

Figure 1. Classification of fingerprint patterns and finger ridge count [16]

a. plain arches
b. tented arches
c. ulnar loops (for left hand)/ radial loops (for right hand) whorls
d. radial loops (for left hand)/ ulnar loops (for right hand) count
e. plain whorls
f. central pocket loops
g. double loops
h. accidental
i. finger ridge

Pattern size was assessed using the Total Finger Ridge Count (TFRC). The calculation process was as follows:

- A straight line was drawn from the triradial point to the center of the pattern.
- The number of ridges intersecting this line was counted to determine the finger ridge count. Note that ridges located exactly at the center or at the triradial

point were excluded from the count (Figure 1i).

- For whorl patterns, which possess two triradial points, the larger of the two ridge counts for each digit was recorded as the finger ridge count.

- The TFRC was then calculated by summing the finger ridge counts of all ten fingers.

To establish intra-examiner reliability for clinical malocclusion classification (Class I normal occlusion, Class I malocclusion, Class II malocclusion and Class III malocclusion), a random subset of 30 students was reevaluated after a 3-week interval by the primary examiner. To prevent recall bias, the participant list was recoded and randomized for the second evaluation. Agreement between the two clinical examinations was evaluated using Cohen's kappa coefficient (). The intra-examiner reliability for clinical occlusion assessment showed high consistency, yielding a Cohen's kappa coefficient of = 0.82 ($p < 0.001$) demonstrating excellent diagnostic reproducibility.

To evaluate inter-examiner reliability for clinical malocclusion classification, a random sample of 30 students was independently evaluated by two calibrated examiners during the school visit. Both examiners were blinded to each other's diagnostic outcomes. Inter-examiner agreement was quantified using Cohen's kappa coefficient (). The inter-examiner reliability for malocclusion assessment demonstrated strong agreement, with a Cohen's kappa coefficient of = 0.81 ($p < 0.001$), confirming excellent diagnostic consistency.

2.3. Statistical Analysis

Data were analyzed using IBM SPSS Statistics 26. For each group, the distribution of dermatoglyphics and the mean TFRC were calculated. The chi-squared test was used to compare dermatoglyphics among different occlusion groups. When the assumption of expected cell frequencies was violated (i.e., expected count < 5 in any cell), Fisher's exact test was applied instead. Data distribution of mean TFRC was evaluated using the Shapiro-Wilk test. Since the data followed a normal distribution ($p > 0.05$), one way Analysis of Variance (ANOVA) was performed to assess differences in mean TFRC across the groups. Statistical significance was set at $p < 0.05$

2.4. Ethical Considerations

The study was approved by the Institutional Ethics Committee of Hue University of Medicine and Pharmacy (Approval No. H2021/140). All participants were provided with detailed information about the study procedures. Written informed consent was obtained from the parents or legal guardians prior to participation.

3. RESULTS

The study included 177 children, with males and females almost equally represented (50.3% and 49.7%, respectively). Class I malocclusion was the most prevalent (68.9%), followed by Class II and Class III malocclusion (12.4% each), while Class I normal occlusion was the least common (6.2%).

Table 1 presents the distribution of fingerprint pattern subtypes across different occlusion groups. A statistically significant difference in the proportion of plain whorl patterns was observed among the four groups ($p = 0.006$).

Table 1. Distribution of fingerprint patterns across occlusion classes

Fingerprint pattern	Class I normal occlusion n (%)	Class I malocclusion n (%)	Class II malocclusion n (%)	Class III malocclusion n (%)	*p*-value
Plain arches	0 (0)	34 (2.8)	4 (1.8)	3 (1.4)	0.177*
Tented arches	0 (0)	6 (0.5)	1 (0.5)	0 (0)	0.899**
Radial loops	3 (2.7)	29 (2.4)	4 (1.8)	6 (2.7)	0.925*
Ulnar loops	51 (46.4)	547 (44.8)	119 (54.1)	94 (42.7)	0.060*
Plain whorls	33 (30.0)	398 (32.6)	46 (20.9)	73 (33.2)	0.006*
Central pocket loops	4 (3.6)	69 (5.7)	12 (5.5)	15 (6.8)	0.702*
Double loops	18 (16.4)	133 (10.9)	32 (14.5)	27 (12.3)	0.190*
Accidental whorls	1 (0.9)	4 (0.3)	2 (0.9)	2 (0.9)	0.171**

* Chi square test; * * Fisher's exact test

As shown in Table 2, loop patterns were significantly more frequent in children with Class II malocclusion than in those with Class I and Class III malocclusion ($p = 0.018$ and $p = 0.028$, respectively). In contrast, whorl patterns were observed at significantly higher proportions in Class I and Class III malocclusion compared to Class II malocclusion ($p = 0.036$ and $p = 0.017$, respectively).

Table 2. Intergroup comparison of the number and percentage of fingerprint patterns across malocclusion classes

Fingerprint pattern	Malocclusion groups			Pairwise comparison (*p*-value [a])		
	Class I	Class II	Class III	Class I vs Class II	Class I vs Class III	Class II vs Class III
Arches, n (%)	40 (3.3%)	5 (2.3%)	3 (1.4%)	0.430	0.125	0.724
Loops, n (%)	576 (47.2%)	123 (55.9%)	100 (45.4%)	**0.018**	0.630	**0.028**
Whorls, n (%)	604 (49.5%)	92 (41.8%)	117 (53.2%)	**0.036**	0.316	**0.017**

[a] Chi square test

According to Table 3, ulnar loop patterns occurred significantly more frequently in the Class II malocclusion group than in Class I and Class III malocclusion ($p = 0.011$ and $p = 0.017$, respectively). Conversely, plain whorl patterns were more prevalent in Class I and Class III malocclusion compared to Class II malocclusion ($p = 0.001$ and $p = 0.004$, respectively).

Table 3. Intergroup comparison of the number and percentage of fingerprint patterns subtypes across malocclusion classes

Fingerprint pattern	Plain arches n (%)	Tented arches n (%)	Radial loops n (%)	Ulnar loops n (%)	Plain whorls n (%)	Central pocket loops n (%)	Double loops n (%)	Accidental whorls n (%)
Class I	34 (2.8)	6 (0.5)	29 (2.4)	547 (44.8)	398 (32.6)	69 (5.7)	133 (10.9)	4 (0.3)
Class II	4 (1.8)	1 (0.5)	4 (1.8)	119 (54.1)	46 (20.9)	12 (5.5)	32 (14.5)	2 (0.9)
***p*-value[a]**	0.409	1.000	0.610	**0.011**	**0.001**	0.905	0.118	0.230
Class I	34 (2.8)	6 (0.5)	29 (2.4)	547 (44.8)	398 (32.6)	69 (5.7)	133 (10.9)	4 (0.3)
Class III	3 (1.4)	0 (0)	6 (2.7)	94 (42.7)	73 (33.2)	15 (6.8)	27 (12.3)	2 (0.9)
***p*-value[a]**	0.219	0.599	0.756	0.562	0.871	0.498	0.551	0.230
Class II	4 (1.8)	1 (0.5)	4 (1.8)	119 (54.1)	46 (20.9)	12 (5.5)	32 (14.5)	2 (0.9)
Class III	3 (1.4)	0 (0)	6 (2.7)	94 (42.7)	73 (33.2)	15 (6.8)	27 (12.3)	2 (0.9)
***p*-value[a]**	1.000	1.000	0.522	**0.017**	**0.004**	0.551	0.484	1.000

[a] Chi square test

The mean total finger ridge counts (TFRC) differed significantly among the four groups ($p = 0.039$; Table 4). The highest mean TFRC was observed in Class II malocclusion, followed by Class I and Class III malocclusion (164.09 ± 48.51, 156.93 ± 42.60 and 137.64 ± 36.78, respectively), while the lowest mean value was recorded in Class I normal occlusion (130.73 ± 28.65).

Table 4. Comparison of mean total finger ridge count across occlusion classes

Groups	Number of subjects (n)	Total finger ridge count
Class I normal occlusion	11	130.73 ± 28.65
Class I malocclusion	122	156.93 ± 42.60
Class II malocclusion	22	164.09 ± 48.51
Class III malocclusion	22	137.64 ± 36.78
Total	177	153.80 ± 42.69
p-value[a]		0.039

[a] One way - ANOVA test.

As shown in Table 5, the mean TFRC was significantly higher in children with Class I and Class II malocclusion than in those with Class I normal occlusion (p = 0.048 and p = 0.019, respectively). Additionally, both groups showed significantly higher mean TFRC compared to Class III malocclusion (p = 0.048 for both comparisons).

Table 5. Intergroup comparison of total finger ridge counts across occlusion classes

Groups	Total finger ridge count (Mean ± SD)	*p*-value[a]
Class I normal occlusion	130.73 ± 28.65	0.048
Class I malocclusion	156.93 ± 42.60	
Class I normal occlusion	130.73 ± 28.65	0.019
Class II malocclusion	164.09 ± 48.51	
Class I normal occlusion	130.73 ± 28.65	0.590
Class III malocclusion	137.64 ± 36.78	
Class I malocclusion	156.93 ± 42.60	0.479
Class II malocclusion	164.09 ± 48.51	
Class I malocclusion	156.93 ± 42.60	0.048
Class III malocclusion	137.64 ± 36.78	
Class II malocclusion	164.09 ± 48.51	0.048
Class III malocclusion	137.64 ± 36.78	
Class I normal occlusion	130.73 ± 28.65	
Malocclusion	155.33+ 43.09	0.064

[a] Tukey's HSD test

4. DISCUSSION

In this study, the prevalence of Class I normal occlusion was relatively low (6.2%) compared to general epidemiological estimates [11, 12]. This discrepancy might have been attributed to variations in data collection sites and participant selection criteria, which could have impacted sample representativeness relative to the general population.

Previous evidence suggests a possible link between dermatoglyphics characteristics and malocclusion. Occlusal development is a multifactorial process, with genetic determinants playing a key role. Notably, epidermal ridge formation occurs during the same embryonic period as craniofacial development. Therefore, genetic factors influencing one process may also affect the other. Consequently, individual genetic characteristics reflected in dermatoglyphics may be associated with variations in occlusal patterns [17]. This current study aimed to analyze and compare fingerprint patterns across different types of occlusions.

In the present study, children with Class II malocclusion exhibited a significantly higher percentage of loop patterns compared with those with Class I and Class III malocclusions. This finding is consistent with the results reported by Deval et al. and Mansata et al. [9, 18].

Children with Class I malocclusion demonstrated a significantly higher percentage of whorl patterns compared with those with Class II malocclusion. Our finding agreed with previous studies by Reddy S. et al. (1997) and Deval et al. (2016) [18, 19]. In contrast, Jindal et al. (2015) reported that children with Class II malocclusion exhibited the highest percentage of whorl patterns among three groups (Class I, Class II and Class III malocclusion) [20]. Furthermore, our findings differ from those of Patel et al. (2022), who reported that children with Class I malocclusion had a higher percentage of whorl patterns compared with those with Class II malocclusion; however, the difference was not statistically significant [10].

We also found that children with Class III malocclusion exhibited a significantly higher percentage of whorl patterns compared with those with Class II malocclusion. This observation is consistent with studies by Reddy S. et al. and Patel et al. but differs from the findings of Tikare et al. (2010), who reported no statistically significant difference between Class II and Class III malocclusion in terms of whorl pattern distribution [10, 17, 19].

Regarding fingerprint pattern subtypes, ulnar

loop patterns were significantly more prevalent in Class II malocclusion than in Class I and Class III malocclusion. This finding is consistent with the study by Reddy S. et al., but contrasts with the reports of Jindal et al. and Tikare et al. [17, 19, 20].

In contrast, plain whorl patterns were observed at significantly higher proportions in Class I and Class III malocclusion compared with Class II malocclusion. To the best of our knowledge, no previous studies have reported similar findings.

With respect to quantitative analysis, the mean TFRC was highest in Class II malocclusion, followed by Class I malocclusion and Class III malocclusion, and lowest in Class I normal occlusion. These results are consistent with studies by Alam et al. (2019) and Jindal et al. [8, 20].

Further analysis showed that the mean TFRC was significantly higher in children with Class I and Class II malocclusion than in those with Class I normal occlusion, while no significant difference was observed between Class I normal occlusion and Class III malocclusion. This finding aligned with the study by Alam et al. [8].

In addition, mean TFRC was significantly higher in Class I malocclusion than in Class III malocclusion, in agreement with the findings of Vignesh et al. (2020) [15]. Although mean TFRC was higher in Class II malocclusion than in Class I malocclusion, the difference was not statistically significant. In contrast, Vignesh et al. reported significantly higher TFRC values in Class I malocclusion compared to Class II malocclusion [15].

Compared with previous literature, our study showed certain discrepancies. One of the primary factors contributing to these differences could be ethnic variation. The prevalence of fingerprint patterns among major population groups could be ranked in descending order: for whorls, Mongoloids > American Indians > Europeans > Africans; for loops, Africans > Europeans > American Indians > Mongoloids; and for arches, Africans > American Indians > Europeans > Mongoloids [21]. Furthermore, a study by Mbaka et al. demonstrated that African populations had a lower TFRC compared to European, Asian, and American populations [22]. Consequently, ethnic variation might account for the variations in mean TFRC and dermatoglyphic characteristics observed across different studies. Additionally, differences in sample sizes, age ranges, and specific inclusion criteria could contribute to discrepancies in research outcomes.

A limitation of our study is that it relied solely on Angle's classification rather than assessing skeletal relationships. While Angle's classification focuses exclusively on dental occlusion, skeletal classification evaluates underlying skeletal discrepancies, typically using lateral cephalometric radiographs. Evidence suggests that skeletal malocclusions have a stronger genetic basis, whereas dental malocclusions are more frequently influenced by environmental factors [23]. Consequently, assessing skeletal relationships instead of dental occlusion may strengthen the association between dermatoglyphics and malocclusion.

To the best of our knowledge, this is the first study in Vietnam to investigate the relationship between dermatoglyphics and occlusal status. This study provides a basis for future research to further explore this association and to address the limitations of the present study, including the limited sample scope (restricted to two secondary schools) and the narrow age range of participants (12 - 15 years). Furthermore, our findings may contribute to the global body of literature on the association between fingerprint patterns and malocclusion. Further large-scale, multicenter studies are recommended to validate and generalize these findings.

In summary, despite some similarities and differences with previous studies, the present findings demonstrated a statistically significant association between dermatoglyphics and different types of malocclusions.

5. CONCLUSION

Our study was subject to several limitations, including imbalanced sample sizes across of occlusion groups, a single-center design, a narrow age range, the lack of sex-stratified analysis and the absence of radiographic skeletal assessment using lateral cephalometric radiographs. Therefore, future studies designed to overcome these limitations are required to draw more definitive conclusions regarding the association between dermatoglyphic characteristics and malocclusion in the Vietnamese population.

Dermatoglyphic analysis may be used as a simple, non-invasive, and economical method for identifying individuals predisposed to malocclusion. As a potential screening tool, it could facilitate early diagnosis and aid in the timely implementation of preventive and interceptive orthodontic interventions in pediatric populations. Nevertheless, longitudinal studies involving larger cohorts and diverse ethnic backgrounds are essential to further

clarify the predictive value of dermatoglyphics in clinical orthodontics.

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