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Original Article

Assessment of The Relationship Between Palatal Rugae Patterns and Vertical Craniofacial Growth in an Iranian Population During 2023

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Abstract

Background: Palatal rugae patterns have been associated with various conditions and may serve as prognostic indicators for related disorders. This study aimed to evaluate palatal rugae patterns and their relationship with vertical craniofacial growth patterns in an Iranian population.

Methods: A total of 180 samples were classified using the Jarabak Index and SN-GoGn angle based on cephalometric analysis. Participants were divided into three skeletal growth groups: Average, horizontal, and vertical (n=60 each). Rugae patterns were assessed using manual and non-manual methods according to the Modified Thomas and Kotze and Hauser classification systems. Statistical analysis was performed using Chi-square, one-way ANOVA, and Fisher's exact tests.

Results: The wavy pattern was the most prevalent rugae type across all groups. Significant differences were observed in the frequencies of left breaks ($P=0.04$), total breaks ($P=0.04$), right converging ($P=0.01$), and total converging patterns ($P=0.05$). The odds ratios for developing a long face (vertical pattern) were 13.2 for right converging, 3.27 for total converging, 0.4 for total breaks, and 0.3 for left breaks patterns.

Conclusion: A converging rugae pattern, particularly on the right side, is associated with an increased likelihood of vertical growth pattern, whereas a breaks pattern, especially on the left side, is more frequently observed in individuals with normal vertical facial growth.

Keywords: Biomarkers, Hard palate, Orthodontics, Skeletal, Anatomical landmark

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Introduction

Palatal rugae are anatomical folds composed of fibrous connective tissue, randomly organized in the front portion of the hard palate. They start formation in the third month of embryonic development from the connective tissue around the palatine process of the maxillary bone. The development of palatal rugae is governed by interactions among mesenchyme and epithelium, marked by the expression of certain extracellular matrix components. The formation and expansion of rugae transpire locally, characterized by epithelial thickening, followed by the aggregation of fibroblasts and collagen fibers in the underlying connective tissue, which subsequently assume a distinct direction. Upon formation, the length of the rugae may vary owing to natural development; nonetheless, their shape stays invariant through an individual's life, even when subjected to trauma or chemical damage.[1]

Palatal rugae serve many purposes, including limiting food escape, facilitating mastication, increasing taste perception, controlling tongue posture, and helping in baby suckling.[2,3] Furthermore, they influence the articulation of sounds like "s" and "sh", thereby improving speech.[4]

In 1732, Winslow published the initial definition of rugae,[5] and the word "Rugoscopy," referring to the study of rugae, was originally used by the Spanish investigator Hermosa in 1932. In 1889, Allen was the pioneer in proposing the employment of rugae for individual identification, emphasizing their distinctiveness and

distinguishing traits.[5] In 1911, Goria established the first categorization system for palatal rugae. Since then, over 13 categories have been suggested by various scholars, delineating several sorts of rugae forms, such as: Straight, Curved, Papillary, Cross-linked, Breaks, Branch, Wavy, Annular (Ring), Converging, Diverging, among others.[6-8]

Previous research has examined the correlation between palatal rugae and numerous factors, including race and gender,[9] identification of individuals,[10] dental malocclusions,[11] number of teeth,[12] skeletal growth,[13] and dental caries rates.[14] It has been proposed that an identical arrangement of rugae morphology might be seen among the majority of research subjects in each of these instances. Consequently, rugae morphology may operate as a prediction indicator for the probability of developing any of the previously described conditions.[9-14]

The morphology of palatal rugae may significantly foresee skeletal growth patterns owing to common genetic pathways linking rugae formation and osseous growth. For example, the involvement of bone morphogenetic protein (BMP) in the formation of craniofacial features and palatogenesis is well recognized.[15]

The examination of the correlation between palatal rugae and other parameters is now a significant subject in contemporary research across many groups, taking into account the racial and genetic disparities within cultures. There is markedly few evidence pertaining to this association among the Iranian population; the researcher identified only a study conducted in Babol investigating the correlation between rugae patterns and horizontal craniofacial development patterns.[16] Consequently, there is an urgent need for more research in this domain, since these occurrences are affected by individuals' race and nationality, which may produce divergent results even among distinct ethnic groups within a single nation.[17] Therefore, this retrospective study aimed to determine the palatal rugae patterns and explore their relationship with vertical craniofacial growth patterns in an Iranian population for the first time.

Methods

Patients

In this retrospective study, data were collected from the archives of the Orthodontics Department and additional cases in Iran in the study period (2023). Information from 180 patients in this department was gathered using high-quality Lateral cephalometric radiographs, plaster casts of the maxilla, and clear, high-resolution photographs of the patients' rugae. The required sample size was calculated based on previous studies[18,19], using the following formula for comparison of two proportions:

$$n = (Z_{\alpha/2} + Z_{\beta})^2 * (p_1(1-p_1) + p_2(1-p_2)) / (p_1-p_2)^2$$

Where $Z_{\alpha/2}$ is the standard normal deviate corresponding to a type I error of 5% ($\alpha = 0.05$), Z_{β} is the standard normal deviate corresponding to a type II error of 20% ($\beta = 0.20$, power = 80%), p_1 is equivalent to 0.65, and p_2 is equivalent to 0.40.

The samples were categorized into three groups—average, vertical, and horizontal—based on the Jarabak Index (62 to 65 percent), the SN-GoGn angle (27 to 37 degrees), and the Frankfort-mandibular plane angle (20 to 30 degrees) concerning vertical craniofacial growth patterns.

Previously diagnosed cases were retrieved from the department archive, and only their dental casts were evaluated for rugae pattern analysis. The cephalometric data correspond to prior assessments performed by orthodontic faculty members. In addition, patients presenting during the study period were examined and diagnosed by an orthodontic specialist before rugae evaluation.

All rugae shapes were assessed by a single examiner using the referenced visual classification system. No discrepancies were observed in matching clinical forms to the defined categories. Patterns not fitting any category were recorded as non-specific and are presented in the study tables.

The inclusion criteria for this study are as follows [19]:

- Individuals aged 15 years and older
- Individuals with various vertical craniofacial growth patterns
- Availability of high-quality plaster casts of the patients without any defects before orthodontic treatment
- High-quality photographs of the patients' maxilla
- Cephalometric data in a natural head position for analysis
- Complete dentition (up to the second molars, excluding third molars)

The exclusion criteria include [19,20]:

- Patients with a history of severe trauma to the midface
- Surgical treatments involving the jaw and palate
- Orthodontic treatments
- Congenital or acquired craniofacial deformities, such as cleft lip and palate

The Classification of Palatal Rugae

The classification of palatal rugae patterns was conducted using the Modified Thomas and Kotze and Hauser system.[21] In this classification, referenced in Figure 1, rugae patterns are divided into 10 distinct categories, each with specific names and shapes. Additionally, if the researcher encountered rugae shapes that did not fit into the established classification during the study, these rugae patterns would be labeled as "nonspecific".

The Determination Methods of Rugae Patterns

To determine the rugae patterns, both manual and nonmanual methods were employed. In the manual method, the rugae prominences were traced on the plaster cast using either black or red graphite pencils, thereby delineating the rugae pattern clearly.

This examination was conducted by an observer under adequate lighting and direct visibility, utilizing a magnifying glass when necessary. A sample of this

procedure is illustrated in Figure 2. In the non-manual method, the classification of samples was performed through the analysis of the patients' lateral cephalometric radiographs from the department's database, in accordance with the Jarabak Index and the SN-GoGn angle (and if necessary, the FMA, when there were discrepancies between these two criteria).

Subsequently, the photograph corresponding to the patient's maxillary cast was reviewed by an observer, and the rugae patterns for each patient were identified (Figure 3).

Statistical Analysis

All statistical analyses were performed using SPSS version 27.0. To examine the relationships among the variables under investigation, Chi-square tests and, when necessary, Fisher's exact test were utilized. Additionally, One-Way ANOVA was employed to assess differences in means among quantitative variables across more than three groups. A P-value of less than 0.05 was considered statistically significant. To predict the likelihood of patients developing various vertical craniofacial growth disorders, odds ratio analysis with a 95% confidence interval was applied.

Results

In this study, the sample consisted of 180 patients, comprising 72 males (40%) and 108 females (60%). Each of the control groups (average), Case 1 (horizontal), and Case 2 (vertical) included 60 individuals. In the average group, there were 38 females (63.3%) and 22 males (36.7%). The horizontal group consisted of 30 females (50%) and 30 males (50%). The vertical group also included 60 individuals, of whom 40 were females (66.7%) and 20 were males (33.3%). When comparing the frequency of the two sexes among these three groups, no statistically significant difference was found ($P=0.14$) (Table 1).

The mean age of all participants in the study was 22.53 ± 7.9 years; it was 22.47 ± 7.8 years in the average group, 21.07 ± 7.19 years in the horizontal group, and 24.05 ± 8.5 years in the vertical group. Consequently, the mean age in the vertical group was higher than that in the other two groups; however, this difference was not statistically significant ($P=0.12$). Additional information is provided in Table 2.

Table 3 shows the frequencies of rugae patterns among all participants in the study. The highest frequency of palatal rugae patterns among all participants in the study was the wavy pattern, which was observed in 160 individuals, corresponding to 88.9% of the patients. In the average group, the most common rugae pattern was also wavy, with a frequency of 51 individuals, accounting for 85% of participants in that group. Similarly, in the horizontal and vertical groups, the wavy pattern had frequencies of 54 individuals (90%) and 55 individuals (91.7%), respectively. Statistically significant differences were

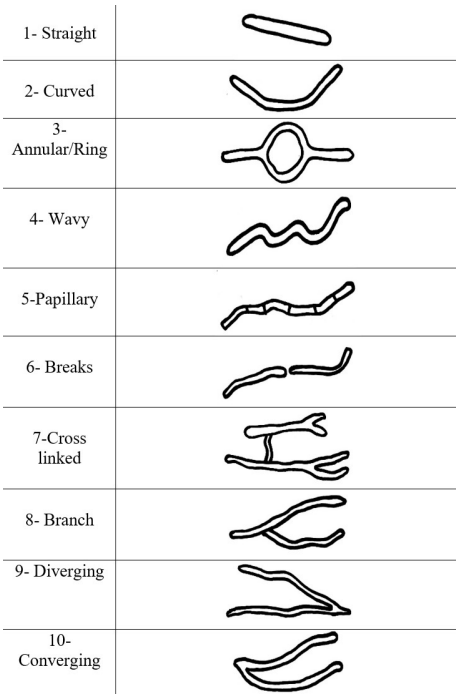

Figure 1. The Modified Thomas and Kotze and Hauser classification system for palatal rugae patterns

Figure 2. Use of black graphite pencil for marking and coloring rugae in plaster casts

Table 1. Gender distribution Frequency Among All Study Participants.

Gender	Total Frequency (%)	Average Frequency (%)	Horizontal Frequency (%)	Vertical Frequency (%)	*P*-value
Male	(40) 72	(36.7) 22	(50) 30	(33.3) 20	
Female	(60) 108	(63.3) 38	(50) 30	(66.7) 40	0.14
Total	(100) 180	(100) 60	(100) 60	(100) 60	

Figure 3. Patient information, lateral cephalometric radiographs, and orthodontic photographs

Table 2. Mean and Range of Age in the Study Groups.

Age	Total	Average	Horizontal	Vertical
Mean ± SD	22.53 ± 7.9	22.47 ± 7.8	21.07 ± 7.19	24.05 ± 8.5
Minimum	15	15	15	15
Maximum	48	48	43	47
P-value		0.12		

found in the frequencies of the left breaks, total breaks, right converging, and total converging patterns among the three groups ($P = 0.04$, 0.04, 0.01, and 0.05, respectively).

Regarding the mean number of rugae, significant differences were not observed among the various patterns across the three groups, except for the papillary and diverging groups. The overall mean number of diverging rugae in the horizontal (1.13 ± 0.34) and vertical (1.35 ± 0.55) groups was higher than that in the control group (1.03 ± 0.18), and this difference was statistically significant ($P = 0.006$).

The overall mean count of the papillary pattern in the horizontal group (1.09 ± 0.30) was lower than that in the vertical (1.82 ± 0.98) and control (1.25 ± 0.46) groups, and this difference was statistically significant ($P = 0.04$). Additional details are provided in Table 3.

According to Table 4, the most frequent pattern in both average and vertical groups was the wavy pattern, with frequencies of 51 individuals (85%) and 55 individuals (91.7%), respectively. Statistically significant differences were observed in the frequencies of total breaks, total converging, right converging, and left breaks between the two groups ($P = 0.022$, 0.018, 0.002, and 0.014, respectively).

As shown in Table 5, the wavy pattern was also the most common in both average and horizontal groups, with frequencies of 51 individuals (85%) and 54 individuals (90%), respectively. No statistically significant differences were found in the frequencies of any patterns between these two groups.

Table 6 indicates that the wavy pattern was predominant in both horizontal and vertical groups, with frequencies of 54 individuals (90%) and 55 individuals (91.7%), respectively. Statistically significant differences were found in the frequencies of total breaks and left breaks between these two groups ($P = 0.03$ and 0.02, respectively).

According to the statistical data obtained from the odds ratio analysis, individuals with a converging pattern on the right side have a 13.2 times higher likelihood of being classified in the vertical growth pattern group compared to those who do not exhibit this pattern. This suggests that they have a greater chance of developing a long face.

- (Odds ratio = 13.245, 95% Confidence Interval; 1.652 – 106.207)

Additionally, statistical analyses revealed that individuals with a converging pattern (total) have a 3.27 times higher likelihood of being classified in the vertical growth pattern group (long face) compared to those who do not exhibit this pattern.

- (Odds Ratio = 3.273, 95% Confidence Interval: 1.181 – 9.069)

Conversely, individuals with a breaks pattern have a 0.4

Table 3. Comparison of the frequencies of various rugae patterns among all participants in the study across average, horizontal, and vertical groups.

Rugae Patterns		Total Frequency (%)	Average, Frequency (%)	Horizontal, Frequency (%)	Vertical, Frequency (%)	*P*-value
Straight right	Absent Present	(56.1) 101 (43.9) 79	(50) 30 (50) 30	(55) 33 (45) 27	(63.3) 38 (36.7) 22	0.33
Straight Left	Absent Present	(60.6) 109 (39.4) 71	(58.3) 35 (41.7) 25	(60) 36 (40) 24	(63.3) 38 (36.7) 22	0.85
Straight Total	Absent Present Mean ± SD	(35) 63 (65) 117 1.85 ± 1.31	(30) 18 (70) 42 2.05 ± 1.33	(35) 21 (65) 39 1.85 ± 1.5	(41.7) 25 (58.3) 35 1.63 ± 1.06	0.31 0.38
Curved right	Absent Present	(35) 63 (65) 117	(36.7) 22 (63.3) 38	(36.7) 22 (63.3) 38	(31.7) 19 (68.3) 41	0.82
Curved Left	Absent Present	(35) 63 (65) 117	(36.7) 22 (63.3) 38	(38.3) 23 (61.7) 37	(30) 18 (70) 42	0.59
Curved Total	Absent Present Mean ± SD	(15.6) 28 (84.4) 152 2.66 ± 1.48	(16.7) 10 (83.3) 50 2.42 ± 1.40	(20) 12 (80) 48 2.83 ± 1.59	(10) 6 (90) 54 2.66 ± 1.47	0.31 0.36
Wavy right	Absent Present	(20) 36 (80) 144	(23.3) 14 (76.7) 46	(18.3) 11 (81.7) 49	(18.3) 11 (81.7) 49	0.73
Wavy Left	Absent Present	(36.1) 65 (63.9) 115	(40) 24 (60) 36	(31.7) 19 (68.3) 41	(36.7) 22 (63.3) 38	0.63
Wavy Total	Absent Present Mean ± SD	(11.1) 20 (88.9) 160 2.68 ± 1.35	(15) 9 (85) 51 2.8 ± 1.45	(10) 6 (90) 54 2.74 ± 1.23	(8.3) 5 (91.7) 55 2.51 ± 1.38	0.48 0.5
Annular/ring right	Absent Present	(84.4) 152 (15.6) 28	(88.3) 53 (11.7) 7	(85) 51 (15) 9	(80) 48 (20) 12	0.45
Annular/ring Left	Absent Present	(79.4) 143 (20.6) 37	(80) 48 (20) 12	(81.7) 49 (18.3) 11	(76.7) 46 (23.3) 14	0.78
Annular/ring Total	Absent Present Mean ± SD	(79.4) 143 (20.6) 37 1.16 ± 0.37	(80) 48 (20) 12 1.17 ± 0.39	(81.7) 49 (18.3) 11 1.18 ± 0.41	(76.7) 46 (23.3) 14 1.14 ± 0.36	0.78 0.97
Papillary right	Absent Present	(91.1) 164 (8.9) 16	(91.7) 55 (8.3) 5	(93.3) 56 (6.7) 4	(88.3) 53 (11.7) 7	0.62
Papillary Left	Absent Present	(90) 162 (10) 18	(93.3) 56 (6.7) 4	(88.3) 53 (11.7) 7	(88.3) 53 (11.7) 7	0.57
Papillary Total	Absent Present Mean ± SD	(83.3) 150 (16.7) 30 1.40 ± 0.72	(86.7) 52 (13.3) 8 1.25 ± 0.46	(81.7) 49 (18.3) 11 1.09 ± 0.3	(81.7) 49 (18.3) 11 1.82 ± 0.98	0.7 <u>0.04</u>
Cross- linked right	Absent Present	(98.3) 177 (1.7) 3	(96.7) 58 (3.3) 2	(98.3) 59 (1.7) 1	(100) 60 0	0.36
Cross-linked Left	Absent Present	(93.9) 169 (6.1) 11	(95) 57 (5) 3	(93.3) 56 (6.7) 4	(93.3) 56 (6.7) 4	0.91
Cross- linked Total	Absent Present Mean ± SD	(92.8) 167 (7.2) 13 0.07 ± 0.25	(91.7) 55 (8.3) 5 0.08 ± 0.27	(93.3) 56 (6.7) 4 0.07 ± 0.25	(93.3) 56 (6.7) 4 0.07 ± 0.25	0.92 0.92
Branch right	Absent Present	(78.9) 142 (21.1) 38	(83.3) 50 (16.7) 10	(75) 45 (25) 15	(78.3) 47 (21.7) 13	0.53
Branch Left	Absent Present	(86.7) 156 (13.3) 24	(83.3) 50 (16.7) 10	(83.3) 50 (16.7) 10	(93.3) 56 (6.7) 4	0.17
Branch Total	Absent Present Mean ± SD	(70) 126 (30) 54 1.20 ± 0.45	(70) 42 (30) 18 1.22 ± 0.43	(66.7) 40 (33.3) 20 1.30 ± 0.57	(73.3) 44 (26.7) 16 1.06 ± 0.25	0.73 0.29
Breaks right	Absent Present	(72.8) 131 (27.2) 49	(70) 42 (30) 18	(68.3) 41 (31.7) 19	(80) 48 (20) 12	0.3
Breaks Left	Absent Present	(81.1) 146 (18.9) 34	(75) 45 (25) 15	(76.7) 46 (23.3) 14	(91.7) 55 (8.3) 5	<u>0.04</u>
Breaks Total	Absent Present Mean ± SD	(62.2) 112 (37.8) 68 1.44 ± 0.69	(55) 33 (45) 27 1.42 ± 0.64	(56.7) 34 (43.3) 26 1.53 ± 0.83	(75) 45 (25) 15 1.46 ± 0.7	<u>0.04</u> 0.89
Converging right	Absent Present	(89.4) 161 (10.6) 19	(98.3) 59 (1.7) 1	(88.3) 53 (11.7) 7	(81.7) 49 (18.3) 11	<u>0.01</u>
Converging Left	Absent Present	(91.1) 164 (8.9) 16	(91.7) 55 (8.3) 5	(91.7) 55 (8.3) 5	(90) 54 (10) 6	0.93
Converging Total	Absent Present Mean ± SD	(82.2) 148 (17.8) 32 1.13 ± 0.34	(90) 54 (10) 6 1 ± 00	(83.3) 50 (16.7) 10 1.20 ± 0.42	(73.3) 44 (26.7) 16 1.13 ± 0.34	<u>0.05</u> 0.53

Table 3. Continued.

Rugae Patterns		Total Frequency (%)	Average, Frequency (%)	Horizontal, Frequency (%)	Vertical, Frequency (%)	*P*-value
Diverging right	Absent Present	(70) 126 (30) 54	(75) 45 (25) 15	(70) 42 (30) 18	(65) 39 (35) 21	0.49
Diverging Left	Absent Present	(75) 135 (25) 45	(70) 42 (30) 18	(85) 51 (15) 9	(70) 42 (30) 18	0.09
Diverging Total	Absent Present Mean ± SD	(52.8) 95 (47.2) 85 1.18 ± 0.41	(48.3) 29 (51.7) 31 1.03 ± 0.18	(61.7) 37 (38.3) 23 1.13 ± 0.34	(48.3) 29 (51.7) 31 1.35 ± 0.55	0.24 <u>0.006</u>
Nonspecific right	Absent Present	(78.9) 142 (21.1) 38	(76.7) 46 (23.3) 14	(86.7) 52 (13.3) 8	(73.3) 44 (26.7) 16	0.18
Nonspecific Left	Absent Present	(78.3) 141 (21.7) 39	(73.3) 44 (26.7) 16	(80) 48 (20) 12	(81.7) 49 (18.3) 11	0.5
Nonspecific Total	Absent Present Mean ± SD	(62.2) 112 (37.8) 68 1.32 ± 0.56	(56.7) 34 (43.3) 26 1.31 ± 0.55	(71.7) 43 (28.3) 17 1.24 ± 0.44	(58.3) 35 (41.7) 25 1.4 ± 0.65	0.18 0.64

Underlined Numbers indicate the *P*-values under 0.05

Table 4. Comparison of the frequencies of various rugae patterns between average and vertical groups.

Rugae Patterns		Average, Frequency (%)	Vertical, Frequency (%)	*P*-value
Straight Total	Absent Present	(30) 18 (70) 42	(41.7) 25 (58.3) 35	0.18
Curved Total	Absent Present	(16.7) 10 (83.3) 50	(10) 6 (90) 54	0.28
Wavy Total	Absent Present	(15) 9 (85) 51	(8.3) 5 (91.7) 55	0.25
Annular/ring Total	Absent Present	(80) 48 (20) 12	(76.7) 46 (23.3) 14	0.66
Papillary Total	Absent Present	(86.7) 52 (13.3) 8	(81.7) 49 (18.3) 11	0.45
Cross-linked Total	Absent Present	(91.7) 55 (8.3) 5	(93.3) 56 (6.7) 4	0.73
Branch Total	Absent Present	(70) 42 (30) 18	(73.3) 44 (26.7) 16	0.68
Breaks Total	Absent Present	(55) 33 (45) 27	(75) 45 (25) 15	<u>0.022</u>
Converging Total	Absent Present	(90) 54 (10) 6	(73.3) 44 (26.7) 16	<u>0.018</u>
Diverging Total	Absent Present	(48.3) 29 (51.7) 31	(48.3) 29 (51.7) 31	1
Nonspecific Total	Absent Present	(56.7) 34 (43.3) 26	(58.3) 35 (41.7) 25	0.85
Breaks Left*	Absent Present	(75) 45 (25) 15	(91.7) 55 (8.3) 5	<u>0.014</u>
Converging right*	Absent Present	(98.3) 59 (1.7) 1	(81.7) 49 (18.3) 11	<u>0.002</u>

*The two patterns highlighted were compared due to the statistically significant differences in their frequencies as shown in Table 3. Underlined Numbers indicate the *P*-values under 0.05

Table 5. Comparison of the frequencies of various rugae patterns between average and horizontal groups.

Rugae Patterns		Average, Frequency (%)	Horizontal, Frequency (%)	*P*-value
Straight Total	Absent Present	(30) 18 (70) 42	(35) 21 (65) 39	0.56
Curved Total	Absent Present	(16.7) 10 (83.3) 50	(20) 12 (80) 48	0.63
Wavy Total	Absent Present	(15) 9 (85) 51	(10) 6 (90) 54	0.41
Annular/ring Total	Absent Present	(80) 48 (20) 12	(81.7) 49 (18.3) 11	0.82
Papillary Total	Absent Present	(86.7) 52 (13.3) 8	(81.7) 49 (18.3) 11	0.45
Cross-linked Total	Absent Present	(91.7) 55 (8.3) 5	(93.3) 56 (6.7) 4	0.73
Branch Total	Absent Present	(70) 42 (30) 18	(66.7) 40 (33.3) 20	0.69
Breaks Total	Absent Present	(55) 33 (45) 27	(56.7) 34 (43.3) 26	0.85
Converging Total	Absent Present	(90) 54 (10) 6	(83.3) 50 (16.7) 10	0.28
Diverging Total	Absent Present	(48.3) 29 (51.7) 31	(61.7) 37 (38.3) 23	0.14
Nonspecific Total	Absent Present	(56.7) 34 (43.3) 26	(71.7) 43 (28.3) 17	0.09
Breaks Left*	Absent Present	(75) 45 (25) 15	(76.7) 46 (23.3) 14	0.83
Converging right*	Absent Present	(98.3) 59 (1.7) 1	(88.3) 53 (11.7) 7	0.028**

*The two patterns highlighted were compared due to the statistically significant differences in their frequencies as shown in Table 3.
**Although this difference is statistically significant, it lacks clinical relevance due to the small difference in counts between the two groups (1 versus 7).

times lower likelihood of being classified in the vertical growth pattern group, indicating that these individuals are more likely to fall into the average group.

- (Odds Ratio = 0.407, 95% Confidence Interval: 0.188 – 0.884)

Finally, individuals with a breaks pattern on the left side have a 0.3 times lower likelihood of being classified in the vertical growth pattern group compared to those who do not exhibit this pattern.

- (Odds Ratio = 0.273, 95% Confidence Interval: 0.092 – 0.808)

Discussion

As previously mentioned, the palatal rugae pattern is linked to several elements, including skeletal development patterns. Multiple studies have emphasized the significance of rugae patterns in forecasting skeletal growth, attributable to common genetic mechanisms

Table 6. Comparison of the frequencies of various rugae patterns between horizontal and vertical groups.

Rugae Patterns		Horizontal, Frequency (%)	Vertical, Frequency (%)	*P*-value
Straight Total	Absent Present	(35) 21 (65) 39	(41.7) 25 (58.3) 35	0.45
Curved Total	Absent Present	(20) 12 (80) 48	(10) 6 (90) 54	0.125
Wavy Total	Absent Present	(10) 6 (90) 54	(8.3) 5 (91.7) 55	0.75
Annular/ring Total	Absent Present	(81.7) 49 (18.3) 11	(76.7) 46 (23.3) 14	0.5
Papillary Total	Absent Present	(81.7) 49 (18.3) 11	(81.7) 49 (18.3) 11	1
Cross-linked Total	Absent Present	(93.3) 56 (6.7) 4	(93.3) 56 (6.7) 4	1
Branch Total	Absent Present	(66.7) 40 (33.3) 20	(73.3) 44 (26.7) 16	0.43
Breaks Total	Absent Present	(56.7) 34 (43.3) 26	(75) 45 (25) 15	0.03
Converging Total	Absent Present	(83.3) 50 (16.7) 10	(73.3) 44 (26.7) 16	0.18
Diverging Total	Absent Present	(61.7) 37 (38.3) 23	(48.3) 29 (51.7) 31	0.14
Nonspecific Total	Absent Present	(71.7) 43 (28.3) 17	(58.3) 35 (41.7) 25	0.13
Breaks Left*	Absent Present	(76.7) 46 (23.3) 14	(91.7) 55 (8.3) 5	0.02
Converging right*	Absent Present	(88.3) 53 (11.7) 7	(81.7) 49 (18.3) 11	0.3

*The two patterns highlighted were compared due to the statistically significant differences in their frequencies, as shown in Table 3. Underlined Numbers indicate the *P*-values under 0.05

linking rugae formation and osseous growth, notably involving bone morphogenetic protein (BMP)[15]. However, the available information regarding this relationship in the Iranian population is significantly limited. Therefore, this study aimed to determine the palatal rugae patterns and examine their correlation with vertical craniofacial growth patterns in an Iranian population. We investigated whether rugae patterns can serve as a predictive indicator for potential skeletal discrepancies. If a reliable association is established, preventive orthodontic and orthopedic interventions could be initiated at an earlier stage, or appropriate recommendations could be provided to parents timely.

In this study, irrespective of the type of craniofacial growth disorder, the most prevalent palatal rugae pattern in the examined population was the wavy pattern, which aligns with the findings reported by Heydari et al. (2021) [16] in the Iranian community. Conversely, a study conducted by Sheikhi et al. (2018) [22] also within the Iranian population identified the straight pattern as the most common; however, similarly to this study, the wavy pattern was noted as the second most frequent. Furthermore, research conducted by Rahebi et al. (2023) [17] involving three Iranian ethnic groups (Fars, Sistani, and Turkman) showed that the wavy pattern was the most common pattern among the Fars ethnic group. In contrast, for the Sistani and Turkman groups, it was recognized as the second most prevalent pattern after the straight pattern. This suggests that both wavy and straight patterns may be among the most common rugae patterns in the Iranian population overall. This variation in the ranking of common patterns may be related to sample sizes, methods used for analyzing rugae patterns, or even ethnic differences.[17]

In relation to this topic, studies have also been conducted in other communities. For instance, in the study conducted by Sudhakar et al. (2022) [19] in the southern Indian population, the wavy pattern was found to be the most prevalent, mirroring the findings of Zhang et al. (2022) in China [23] and Alshammari et al. (2022) in Saudi Arabia.[24] However, a study conducted by Sapassety et al. (2023) in southern India [13] identified the straight pattern as the most common rugae configuration, while Subhan et al. (2023) reported the curved pattern as the most frequent in the Pakistani population.[25] The discrepancies seen across different research may be ascribed to variables like nationality, ethnicity, sample size, and methodological variances.[17,26]

In this study, the most common palatal rugae pattern observed in the control group (average) was the wavy pattern, which aligns with the findings from Sudhakar et al..[19] Conversely, the study conducted by Subramonia et al. (2021) in the Indian population identified the curved pattern as the most prevalent pattern among various rugae patterns.[18] The discrepancies in these data may be ascribed to variances in rugae patterns across other countries and races.[17,26]

In the horizontal group, the wavy pattern was also the predominant rugae configuration, corroborating the results of both Sudhakar et al. (2022) [19] and Subramonia et al. (2021).[18]

Similarly, in the vertical group, the wavy pattern remained the most common pattern. However, considering the differences in rugae patterns among various ethnic groups,[26] studies conducted by Sudhakar et al. (2022) [19] and Subramonia et al. (2021) [18] indicated that the most frequent patterns in vertical growth groups were divergent and annular, respectively.

There was a statistically significant difference in the frequencies of total breaks, left breaks, total converging, and right converging patterns among the three groups. In contrast, the study conducted by Subramonia et al. (2021) in the Indian population [18] found significant differences among other patterns, including annular, curved, and wavy. This discrepancy in the findings between the Iranian and Indian populations may again be attributed to variations in palatal rugae patterns across different nationalities and ethnicities.[26]

In this study, the wavy pattern was found to have the highest mean number of palatal rugae in the average group. However, in the horizontal (Short face) and vertical (Long face) groups, the curved pattern exhibited the highest mean count of rugae. These findings appear to be unique to this study, as there are no comparable results available in the literature.

Moreover, the mean counts of the diverging and

papillary patterns were higher in the vertical group compared to the other two groups, and this difference was statistically significant. Given that these findings have not been extensively explored in previous studies, they are also considered specific to this research.

In this study, statistically significant differences were found in the frequencies of total breaks, left breaks, total converging, and right converging patterns between the average and vertical groups. The association between variables was evaluated by calculating odds ratios (ORs) with corresponding confidence intervals. Specifically, individuals with the total breaks pattern had a 0.4 times lower likelihood of being classified in the vertical growth pattern (Long face). Conversely, those with the total converging pattern had a 3.27 times higher likelihood of developing a long face. This contrasts with the findings from Subramonia et al. (2021), who reported that individuals with curved and converging patterns had a higher likelihood of being classified in both the average and vertical groups. Additionally, their study indicated that those with curved, wavy, converging, and particularly annular patterns had an increased chance of being placed in the vertical group.[18]

By comparing the palatal rugae patterns on the left and right sides, we found that individuals with a converging pattern on the right side had a 13.2 times higher likelihood of developing a long face. Additionally, individuals with a breaks pattern on the left side were found to have a likelihood of 0.3 for developing a long face.

No statistically significant differences were found in the frequencies of any rugae patterns between the average and horizontal (short face) groups. In contrast, Subramonia et al. (2021) reported significant differences in the frequencies of curved, wavy, and converging patterns between these two groups.[18]

In the present study, statistically significant differences were found in the frequencies of total breaks and left breaks patterns between the horizontal (short face) and vertical (long face) groups. Individuals with the breaks pattern were more likely to be classified as having a short face. In contrast, Subramonia et al. (2021) reported that individuals with the diverging pattern had a higher likelihood of being categorized in the horizontal group in their study conducted on an Indian population.[18]

One of the major strengths of this study is the absence of similar research conducted within the Iranian population. However, future studies with larger sample sizes are recommended to further validate the association between palatal rugae patterns and skeletal discrepancies. Multicenter investigations involving diverse Iranian subpopulations may enhance the generalizability of the findings.

Additionally, the use of advanced digital scanners and three-dimensional imaging technologies is suggested to improve the accuracy and reproducibility of rugae pattern analysis.

Conclusion

Based on the findings of this study, it can be concluded that the most common palatal rugae pattern in the population sampled was the wavy pattern. Additionally, individuals with a converging pattern (especially on the right side of the palate) are likely to have a higher chance of developing a long face. Conversely, individuals with a breaks pattern (particularly on the left side) are more likely to be classified as average in terms of vertical craniofacial growth pattern.

Limitations

The limitations of this study include the difficulty in accessing an adequate number of samples with skeletal disorders. Additionally, the lack of readily available and affordable scanners and digital measurement tools for examining palatal rugae patterns posed challenges to the research.

Authors' Contribution

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Competing Interests

The authors declare no conflict of interest.

Data Availability Statement

All the data of this study are available from the corresponding author upon reasonable request.

Ethical Approval

This study was reviewed and approved by the Ethics Committee of the School of Dentistry at Shahid Beheshti University of Medical Sciences (Ethical code: IR.SBMU.DRC.REC.1402.042).

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