Journal of
Oral Health and Oral Epidemiology

https://johoe.kmu.ac.ir
doi:10.34172/johoe.2505.1740
JOHOE. 2026;15:2505.1740

Original Article

Subjects with a converging palatal rugae pattern on the right side are twice as likely to develop hypodontia

Hamed Mortazavi[1], Kazem Dalaie[2], Mahshid Namdari[3], Rokhsare Boorchi[4], Mohammadreza Zirehpour[4], Nastaran Sharifi[4], Mohammadreza Behnam Roudsari[5], Maryam Sadat Shirmardi[5*]

[1]Department of Oral Medicine, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[2]Department of Orthodontics, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[3]Community Oral Health Department, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[4]School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[5]Dental Research Center, Research Institute of Dental Sciences, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran

*Corresponding Author: Maryam Sadat Shirmardi, Email: shirmardi.maryams97@gmail.com

Abstract

Background: Studies have emphasized the correlation between palatal rugae patterns and various phenomena, confirming their value as prognostic indicators for the emergence of related disorders. This study aimed to evaluate, for the first time, the correlation between the rugae pattern and the anomalies in tooth number (particularly hypodontia) in a group of Iranian individuals.

Methods: The study divided 120 individuals into two categories based on tooth number: the control group, with a normal number of teeth, and the case group (hypodontia), those who had fewer teeth than normal. The rugae patterns were classified using the Modified Thomas and Kotze classification and Hauser classification, and their identification of the type of rugae pattern was done using both manual and non-manual methods. In addition, panoramic photographs were employed to determine the number of teeth. Data analysis was done using the chi-square test, Fisher's exact test, and one-way ANOVA.

Results: In this study, wavy rugae were the most prevalent pattern. Additionally, it was found that molars were the most frequently missing teeth in the case group. There was a significant difference between the two groups regarding the presence of left-diverging ($P=0.02$) and right-diverging patterns ($P=0.03$), such that individuals with a right-diverging pattern had a 2.3-fold likelihood, and those with a left-diverging pattern had a 0.4-fold likelihood of developing hypodontia.

Conclusion: Individuals who have a right-diverging pattern are more likely to develop hypodontia, while those who have a left-diverging pattern are more likely to have normal dentition.

Keywords: Biometrics, Hard palate, Anatomic landmark, Hypodontia, Tooth agenesis

Citation: Mortazavi H, Dalaie K, Namdari M, Boorchi R, Zirehpour M, Sharifi N, et al. Subjects with a converging palatal rugae pattern on the right side are twice as likely to develop hypodontia. J Oral Health Oral Epidemiol 2026;15:2505.1740. doi:10.34172/johoe.2505.1740

Received: May 16, 2025, **Revised:** August 27, 2025, **Accepted:** December 6, 2025, **ePublished:** April 13, 2026

Introduction

The palatal rugae constitute a section of the oral cavity roof, comprising connective tissue that envelops the maxillary bone, situated posterior to the incisive papilla and anterior to the hard palate.[1] Rugae provide crucial functions in several oral activities, particularly tongue placement during mastication,[2] suckling and chewing food in infants,[3] and taste perception.[4]

Goria implemented the initial classification in 1911.[2] In 1937, it was shown that palatal rugae begin to develop in the third month of gestation and maintain their pattern until death.[5] Currently, 13 approaches for identifying rugae patterns have been documented by several researchers.[2,6-9] Multiple rugae patterns have been identified, including straight, curved, papillary, cross-linked, breaks, branch, wavy, annular (ring), converging, diverging, and others.[6,7]

Palatal rugae patterns are linked to dental malocclusion, facial skeletal growth, blood group types, periodontal diseases, dental caries, and other dental disorders.[3,10-14]

As mentioned, previous studies have emphasized the correlation between palatal rugae patterns and various phenomena, confirming their value as prognostic indicators for the emergence of related disorders. This study focuses on the correlation between palatal rugae patterns and tooth number in an Iranian population for the first time.

Tooth agenesis denotes the congenital absence of one or more teeth and their corresponding buds, classified into several categories based on the number of missing teeth. Hypodontia is characterized by the absence of one to six teeth, oligodontia is defined by the absence of more than six teeth, and anodontia refers to the total absence of all teeth or other dental structures.[15]

Genetic factors are a primary cause of agenesis.[15] The

Sonic Hedgehog gene (SHH), expressed in the epithelium of palatal rugae in the oral cavity, plays a role in dental disorders.[16] The Wingless-related integration site (WNT) and Bone morphogenetic protein (BMP) Signaling pathways are primary mediators of tooth development, and obstruction of these pathways can impede tooth development.[3]

Given that palatal rugae patterns are affected by nationality and ethnicity[1], further research in this domain is necessary, as findings may differ among various ethnicities within a country. Palatal rugae patterns have been examined in a limited number of studies worldwide; however, none have been conducted among the Iranian population. This gap in research was the primary reason for conducting this study. Nevertheless, few studies have examined rugae patterns in the Iranian population, mainly emphasizing their use in medico-legal applications and forensic identification.[17-19] The influence of various ethnicities on palatal rugae patterns has also been studied recently.[1,20] Furthermore, given the considerable influence of gender on rugae patterns, it was essential to maintain a balanced representation of male and female participants in this study.[20,21] Therefore, this study aimed to determine the palatal rugae patterns and explore their relationship with hypodontia in an Iranian population for the first time.

Material and methods

Patients

The study population consisted of patients visiting the treatment departments of Shahid Beheshti Dental School, together with records from the orthodontics archive. Data collection involved high-quality panoramic radiographs, upper jaw plaster casts, and photographs, along with tables related to rugae shapes. Accordingly, this study can be considered a retrospective study.

The inclusion criteria for this study were as follows[3]:

- Participants were required to have reached an age sufficient for complete permanent dentition, as determined by radiography, with a minimum age of 10.28 ± 1.66 years to evaluate the calcification of the last permanent tooth (third molar).
- Participants were required to have one or more missing teeth, and their rugae patterns had to be accurately documented.

The exclusion criteria included[3, 22]:

- Patients with congenital craniofacial anomalies, cleft lip and palate, severe transverse maxillary deficiency, and palatal scar tissue.
- Individuals with a history of maxillofacial surgery.
- Participants who had previously undergone orthodontic treatment.
- Casts lacking accurate documentation of rugae patterns.

Sampling was performed using a random sampling technique, with 60 participants selected for each group according to previous studies.[3,22,23] This research comprised two groups: Group A (control group), consisting of individuals with normal dentition (32 permanent teeth), and Group B (study group), comprising individuals with hypodontia, characterized by having fewer than the normal number of teeth (one to six teeth missing).

Classification of Palatal Rugae Patterns

This study employed the Modified Thomas and Kotze classification and Hauser classification for determining palatal rugae patterns, which is considered more comprehensive than alternative classification systems.[24] Syed et al. highlighted the acceptability of this method.[25] In this classification, shown in Figure 1, rugae patterns are divided into ten distinct categories, each with specific names and shapes. Rugae morphologies that did not conform to known classifications were categorized as "nonspecific," a category also used in other investigations[1]. Furthermore, Gupta's study reported that the morphological pattern of palatal rugae remains more stable over time compared with their quantitative parameters.[26]; hence, this study utilized a categorization system based on rugae shape.

Methods for Determining Palatal Rugae Patterns

Two methods have been proposed for determining

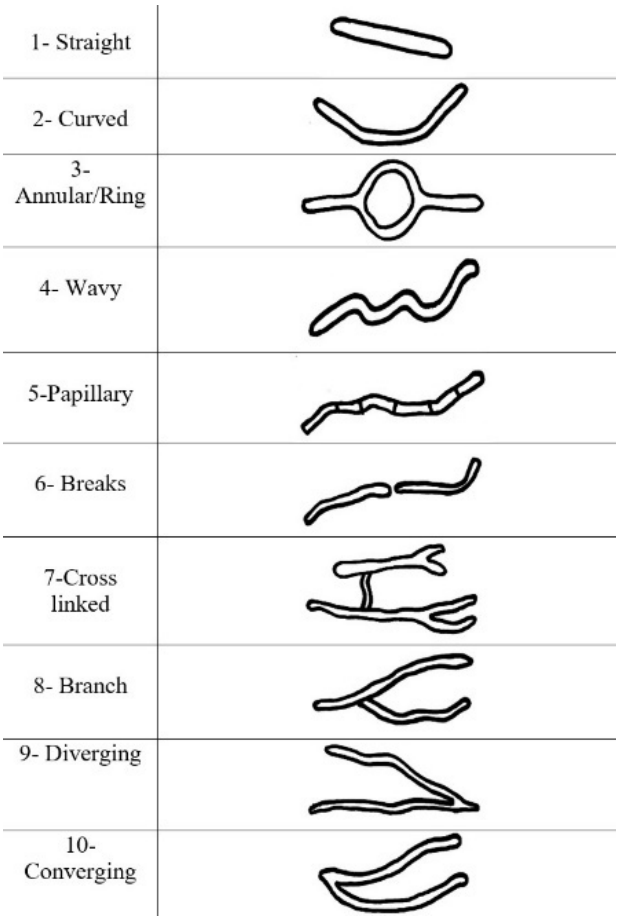

Figure 1. The Modified Thomas and Kotze classification and Hauser classification for palatal rugae patterns

palatal rugae patterns: manual (using graphite pencils) and non-manual (using images). This study utilized both methods to collect a sufficient number of samples. In the manual method, rugae prominences were colored on plaster casts using black or red graphite pencils, thereby delineating the rugae pattern. This examination was conducted under adequate lighting with direct observation, and a magnifying glass was used when necessary (Figure 2).

In the non-manual method, the number of teeth was determined using the faculty dental database through panoramic radiographs, while the palatal rugae patterns were examined using photographs of the upper jaw. Using these two methods, data on the shape, number, and distribution of rugae on both sides of the upper jaw were collected (Figure 3).

Methods for Determining Tooth Number

To ascertain the number of teeth, both erupted and unerupted tooth buds were assessed using panoramic images. This information was documented in a checklist for each patient and subsequently counted and analyzed.

Statistical Analysis

In this study, the chi-square test or Fisher's exact test was used to analyze the relationships among the variables. Additionally, a one-way ANOVA test was utilized to assess mean differences of quantitative variables across more than three groups. Data analysis was conducted using SPSS software version 27.0, and a *P*-values less than 0.05 were considered statistically significant.

Results

In this study, 120 participants (71.7% female and 28.3% male) were divided into two groups: a control group (normal), consisting of 60 individuals (75% female and 25% male), and a case group (hypodontia), also comprising 60 individuals (68.3% female and 31.7% male). There was no significant difference in gender distribution between the two groups ($P = 0.34$) (Table 1). The participants ranged in age from 10 to 42 years, with a reported mean age of 17.66 ± 6.6 years. In the control group, participants were aged 10 to 42 years with a mean age of 15.9 ± 5.5 years, while the case group ranged from 11 to 42 years with a mean age of 19.4 ± 7.2 years.

The average number of missing teeth among all study participants was 1.18 ± 1.5. For the hypodontia group, the average number of missing teeth was higher at 2.37 ± 1.31, with a range of 1–6 in this group.

In the hypodontia group, four individuals were missing anterior teeth, seven were missing premolars, 42 were missing molars, six were missing both premolars and molars, and one was missing both anterior and molar teeth. The most frequently absent teeth were molars, comprising 70% of cases. A total of 140 teeth were reported as missing in the hypodontia group, including:

Figure 2. Delineation of rugae using a black graphite pencil

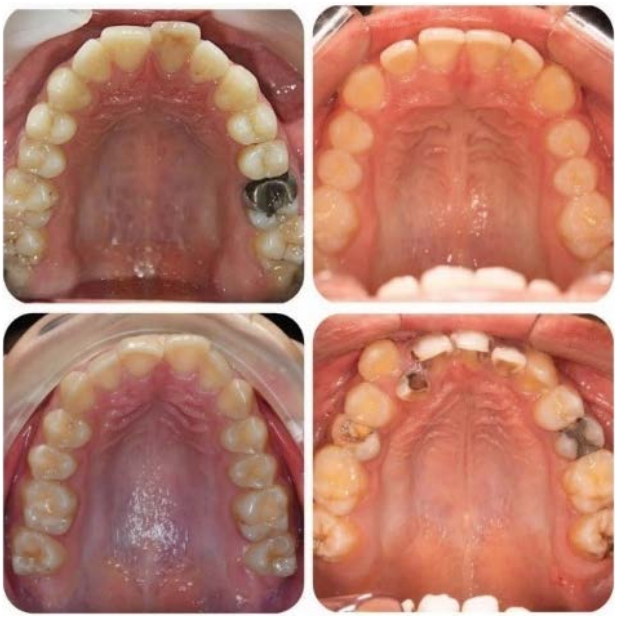

Figure 3. Using photography to record rugae

Table 1. Frequency of gender distribution in all participants in the control and case groups

Gender	Control (normal) Frequency (%)	Case (hypodontia) Frequency (%)	Total Frequency (%)	*P* value
Male	15 (25)	19 (31.7)	34 (28.3)	0.34
Female	45 (75)	41 (68.3)	86 (71.7)	
Total	60 (100)	60 (100)	120 (100)	

- 2 central incisors (1.4% prevalence)
- 4 lateral incisors (2.8% prevalence)
- 1 canine (0.7% prevalence)
- 8 first premolars (5.7% prevalence)
- 14 second premolars (10% prevalence)
- 5 first molars (3.6% prevalence)
- 4 second molars (2.8% prevalence)
- 102 third molars (approximately 73% prevalence)

Table 2 compares the overall frequency of rugae patterns in all study participants and the control and case groups. The highest frequency of rugae patterns among all study participants was observed for the wavy pattern, present in 94 individuals, corresponding to 78.3% of the total participants. In addition, the wavy pattern was the most common in the control (normal) group, found in 46 individuals (76.7%), while in the hypodontia group, it was present in 48 individuals (80%). A statistically significant difference was observed between the frequencies of right-diverging and left-diverging patterns in both the normal and hypodontia groups, with *p*-values of 0.03 and 0.02, respectively. Additionally, among all study participants, the wavy pattern had the highest mean frequency (1.79 ± 1.49). In the control group, the mean number of the wavy pattern was 1.86 ± 1.55, while in the hypodontia group, it was 1.71 ± 1.43. However, no statistically significant difference was found between these two groups regarding this pattern.

Table S1 illustrates the frequency of different types of rugae patterns in women across both groups. The highest frequency of the rugae patterns among all female participants in the study was associated with the wavy pattern, observed in 67 individuals, which corresponds to 77.9% of the total women. In the control (normal) group, the wavy pattern was also predominant, observed in 36 women, accounting for 80% of female participants in that group. Conversely, in the hypodontia group, the most common pattern was curved, identified in 32 women, accounting for 78% of female participants in that group. In both groups, there was no significant difference regarding any rugae patterns in the female population.

Among male participants, the wavy pattern was the most frequent, observed in 27 individuals, representing 79.4% of all men. In the control group, this pattern was found in 10 men (66.7%), while in the hypodontia group, it was present in 17 men, constituting 89.5% of male participants in that group. For male participants, the wavy pattern was detected in 27 individuals, accounting for 79.4% of all men. This pattern was observed in 10 men (66.7%) in the control group, whereas in the hypodontia group, it was evident in 17 men, accounting for 89.5% of the male participants (Table S2).

Finally, the findings revealed that patients with a right-diverging pattern were 2.3 times more likely to develop hypodontia than those without this pattern.

- (OR = 2.347, 95% CI: 1.067–5.162)

Furthermore, the likelihood of developing hypodontia for individuals with a left-diverging pattern was approximately 0.4 times that of those without this pattern.

- (OR = 0.388, 95% CI: 0.168–0.897)

Discussion

Palatal rugae patterns are linked to several features, including the number of teeth. The SHH gene and the genetic pathways BMP and WNT are major factors influencing this association, as they are integral to tooth development and rugae patterns.[3,16]

To date, only a limited number of studies worldwide have investigated the correlation between rugae patterns and tooth count.[3,22,23] Nonetheless, the lack of studies on this subject in Iran highlights the necessity of the present investigation.

The results are consistent with the study of Heydari et al. in an Iranian community,[27] demonstrating that the wavy pattern was the most common rugae pattern in the studied population, irrespective of the type of disease. Similar to this study, Sheikhi et al. found that the straight pattern was the most common, followed by the wavy pattern.[18] Furthermore, Rahebi et al. investigated the association between rugae patterns and ethnicity among the Iranian population, discovering that the most common rugae pattern among the Fars ethnic group was wavy, which is consistent with our findings. For the Turkmen and Sistani ethnic groups, straight was the most common pattern, followed by the wavy pattern[1]. Similar findings have been reported in other communities, including a study conducted in Brazil by Silva-Sousa et al., who discovered that the wavy pattern was the most common.[22] In contrast, Armstrong et al. showed that the curved pattern was the most prevalent in England, followed by the wavy pattern [3]. Ethnicity, race, gender, and population sample size may explain discrepancies across studies conducted in different areas.[1,20]

In this study, the most common rugae pattern among participants with a normal number of teeth was the wavy pattern, consistent with the findings of Armstrong et al.[3] in an English population and Silva-Sousa et al.[22] in Brazil. Similarly, the wavy pattern was the most predominant rugae pattern in the hypodontia group, consistent with the results of Silva-Sousa et al.[22] However, in the studies of Armstrong et al[3] and Moran et al,[23] both conducted in English populations, the most common pattern was the curved pattern. Such differences may be attributed to differences in ethnicity and nationality.[20]

In this study, both groups—those with a normal number of teeth and those with hypodontia—exhibited the highest average number of rugae for the wavy pattern. Moreover, no statistically significant difference was observed in the average number of different rugae patterns between the two groups. As the average number of rugae in each group has not been reported or analyzed in previous studies, this

Table 2. Comparison of the overall frequency of rugae patterns in all study participants and each of the control and case groups

Rugae Pattern	Status	Control (normal) Frequency (%)	Case (hypodontia) Frequency (%)	Total Frequency (%)	*P* value
Straight left	Absent	31 (51.7)	27 (45)	58 (48.3)	0.46
	Present	29 (48.3)	33 (55)	62 (51.7)	
Straight right	Absent	28 (46.7)	33 (55)	61 (50.8)	0.36
	Present	32 (53.3)	27 (45)	59 (49.2)	
Straight total	Absent	19 (31.7)	17 (28.3)	36 (30)	0.55
	Present	41 (68.3)	43 (71.7)	84 (70)	
	Mean ± SD	1.56 ± 1.74	1.40 ± 1.29	1.48 ± 1.52	0.69
Curved left	Absent	31 (51.7)	23 (38.3)	54 (45)	0.14
	Present	29 (48.3)	37 (61.7)	66 (55)	
Curved right	Absent	28 (46.7)	27 (45)	55 (45.8)	0.85
	Present	32 (53.3)	33 (55)	65 (54.2)	
Curved total	Absent	17 (28.3)	15 (25)	32 (26.7)	0.29
	Present	43 (71.7)	45 (75)	88 (73.3)	
	Mean ± SD	1.43 ± 1.34	1.70 ± 1.40	1.56 ± 1.37	0.68
Wavy left	Absent	25 (41.7)	27 (45)	52 (43.3)	0.71
	Present	35 (58.3)	33 (55)	68 (56.7)	
Wavy right	Absent	20 (33.3)	25 (41.7)	45 (37.5)	0.35
	Present	40 (66.7)	35 (58.3)	75 (62.5)	
Wavy total	Absent	14 (23.3)	12 (20)	26 (21.7)	0.58
	Present	46 (76.7)	48 (80)	94 (78.3)	
	Mean ± SD	1.86 ± 1.55	1.71 ± 1.43	1.79 ± 1.49	0.65
Annular/ring left	Absent	50 (83.3)	50 (83.3)	100 (83.3)	1
	Present	10 (16.7)	10 (16.7)	20 (16.7)	
Annular/ring right	Absent	49 (81.7)	53 (88.3)	102 (85)	0.31
	Present	11 (18.3)	7 (11.7)	18 (15)	
Annular/ring total	Absent	44 (73.3)	46 (76.7)	90 (75)	0.54
	Present	16 (26.7)	14 (23.3)	30 (25)	
	Mean ± SD	0.35 ± 0.63	0.28 ± 0.55	0.31 ± 0.59	0.67
Papillary left	Absent	54 (90)	54 (90)	108 (90)	1
	Present	6 (10)	6 (10)	12 (10)	
Papillary right	Absent	48 (80)	54 (90)	102 (85)	0.12
	Present	12 (20)	6 (10)	18 (15)	
Papillary total	Absent	44 (73.3)	48 (80)	92 (76.7)	0.15
	Present	16 (26.7)	12 (20)	28 (23.3)	
	Mean ± SD	0.33 ± 0.60	0.20 ± 0.40	0.26 ± 0.51	0.38
Cross-linked total	Absent	56 (93.3)	57 (95)	113 (94.2)	0.52
	Present	4 (6.7)	3 (5)	7 (5.8)	
	Mean ± SD	0.08 ± 0.33	0.05 ± 0.21	0.06 ± 0.28	0.69
Branch total	Absent	50 (83.3)	43 (71.7)	93 (77.5)	0.10
	Present	10 (16.7)	17 (28.3)	27 (22.5)	
	Mean ± SD	0.18 ± 0.43	0.33 ± 0.57	0.25 ± 0.51	0.12
Breaks total	Absent	51 (85)	53 (88.3)	104 (86.7)	0.84
	Present	9 (15)	7 (11.7)	16 (13.3)	
	Mean ± SD	0.15 ± 0.36	0.16 ± 0.52	0.15 ± 0.44	0.59
Converging total	Absent	51 (85)	51 (85)	102 (85)	1
	Present	9 (15)	9 (15)	18 (15)	

Table 2. Continued.

Rugae Pattern	Status	Control (normal) Frequency (%)	Case (hypodontia) Frequency (%)	Total Frequency (%)	*P* value
	Mean ± SD	0.18 ± 0.46	0.18 ± 0.43	0.18 ± 0.44	0.81
Diverging left	Absent	38 (63.3)	49 (81.7)	87 (72.5)	0.02
	Present	22 (36.7)	11 (18.3)	33 (27.5)	
Diverging right	Absent	46 (76.7)	35 (58.3)	81 (67.5)	0.03
	Present	14 (23.3)	25 (41.7)	39 (32.5)	
Diverging total	Absent	31 (51.7)	30 (50)	61 (50.8)	0.81
	Present	29 (48.3)	30 (50)	59 (49.2)	
	Mean ± SD	0.63 ± 0.73	0.66 ± 0.79	0.65 ± 0.76	0.85
Nonspecific total	Absent	51 (85)	45 (75)	96 (80)	0.39
	Present	9 (15)	15 (25)	24 (20)	
	Mean ± SD	0.20 ± 0.54	0.28 ± 0.52	0.24 ± 0.53	0.17

information is unique to the present research and cannot be compared with other findings.

The mean number of missing teeth in the hypodontia group of the present study exceeded that reported by Armstrong et al[3] in an English population, yet was lower than the values reported by Moran et al[23] and Silva-Sousa et al[22] in studies conducted in England and Brazil, respectively. However, the molar was the most often absent tooth in this investigation, which is consistent with the findings of Silva-Sousa et al. in Brazil.[22]

The most common rugae pattern among female participants was the wavy pattern. In contrast, Sheikhi et al. found that the most prevalent pattern among Iranian women was the straight pattern, followed by the wavy pattern.[18] Furthermore, Rahebi et al. discovered that among Fars women, the wavy pattern was predominant, whereas in Sistani and Turkmen women, the most common patterns were straight and wavy, respectively[1]. In this study, the most common rugae pattern among women in the normal group was the wavy pattern, while in the hypodontia group, the predominant pattern was curved.

Similarly, among men, the wavy pattern was the most prevalent across all participants, regardless of the number of teeth. However, in Sheikhi et al.'s study within the Iranian community, the most common patterns among men were reported as straight, followed by wavy.[18] Additionally, Rahebi et al. found that among Fars men, the wavy pattern was predominant, but for Sistani and Turkmen men, the most common pattern was straight, with wavy being the second most frequent.[1]

In the hypodontia group of this study, the wavy pattern also had the highest prevalence among men. In contrast, in the normal group of men, the wavy, curved, and straight patterns were equally common.

In summary, a significant difference was found between individuals with a normal number of teeth and those with hypodontia regarding the presence of the diverging pattern. Specifically, individuals with this pattern on the right side of their palate had a 2.3-fold higher chance of developing hypodontia, while those with the pattern on the left side had a 0.4-fold lower chance of the condition. Additionally, Armstrong et al.'s study in an English population also reported a significant difference between rugae pattern shapes and tooth count, indicating that individuals with a wavy pattern had a greater likelihood of normal dentition, whereas those with a curved pattern had a higher chance of hypodontia.[3] Conversely, in Silva-Sousa et al.'s research in Brazil, which utilized a different classification method for rugae, a significant relationship was observed between rugae length and tooth count, highlighting that the absence of secondary or fragmentary rugae was associated with hypodontia.[22]

Conclusion

Based on the findings of this study, it can be concluded that individuals with a diverging pattern on the right side of their palate are likely to have a higher chance of developing hypodontia. Conversely, those with this pattern on the left side are likely to have a normal number of teeth.

Limitations

A limitation of this study was the high cost and limited accessibility of the scanners and digital measuring instruments required to assess rugae patterns. Furthermore, obtaining a sufficient quantity of samples with hypodontia was challenging.

Acknowledgments

Not applicable.

Authors' Contribution

Conceptualization: Hamed Mortazavi, Kazem Dalaei.
Data curation: Mahshid Namdari, Rokhsare Boorchi, Mohammadreza Zirehpour, Nastaran Sharifi.
Investigation: Rokhsare Boorchi, Hamed Mortazavi, Kazem Dalaei.
Formal analysis: Mahshid Namdari, Rokhsare Boorchi.
Methodology: Hamed Mortazavi, Kazem Dalaei, Rokhsare Boorchi, Mahshid Namdari.
Project administration: Hamed Mortazavi, Kazem Dalaei.

Supervision: Hamed Mortazavi, Kazem Dalaei.
Software: Mahshid Namdari, Rokhsare Boorchi, Mohammadreza Zirehpour, Nastaran Sharifi.
Resource: Hamed Mortazavi, Kazem Dalaei, Mahshid Namdari.
Validation: Hamed Mortazavi, Kazem Dalaei, Mahshid Namdari, Mohammadreza Behnam Roudsari, Maryam Sadat Shirmardi.
Visualization: Mohammadreza Behnam Roudsari, Maryam Sadat Shirmardi.
Writing- original draft: Mohammadreza Behnam Roudsari, Maryam Sadat Shirmardi.
Writing- review & editing: Hamed Mortazavi, Mohammadreza Behnam Roudsari, Maryam Sadat Shirmardi.

Competing Interests
The authors declare no conflict of interest.

Data Availability Statement
All data from 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, Shahid Beheshti University of Medical Sciences (ethical code: IR.SBMU.DRC.REC.1402.043).

Funding
None.

Supplementary Files
Supplementary file contains Table S1and S2.

References
1. Rahebi D, Naghavialhosseini A, Pakkhesal M, Rajabi A, Mirzaei F, Salim NA, et al. Palatal Rugae Patterns in Fars, Turkmen, and Sistani Ethnicities in the Eastern Part of the Caspian Littoral of Iran. Diagnostics (Basel) 2023;13(2):200. doi:10.3390/diagnostics13020200
2. Chong JA, Mohamed A, Pau A. Morphological patterns of the palatal rugae: A review. J Oral Biosci 2020;62(3):249–59. doi:10.1016/j.job.2020.06.003
3. Armstrong J, Seehra J, Andiappan M, Jones AG, Papageorgiou SN, Cobourne MT. Palatal rugae morphology is associated with variation in tooth number. Sci Rep 2020;10(1):19074. doi:10.1038/s41598-020-76240-w
4. Bavaresco D, Von Meusel LDZ, Franco A, Makeeva I, Paranhos LR, Cericato GO. Morphology of the palatal rugae before and after orthodontic treatment with and without rapid maxillary expansion and dental extractions. Indian J Dent Res 2020;31(2):241–6. doi:10.4103/ijdr.IJDR_12_19
5. Patil MS, Patil SB, Acharya AB. Palatine rugae and their significance in clinical dentistry: a review of the literature. J Am Dent Assoc 2008;139(11):1471–8. doi:10.14219/jada.archive.2008.0072
6. Luke DA. Development and growth of palatal rugae in the mouse. Acta Anat (Basel) 1988;133(1):41–4. doi:10.1159/000146612
7. Lysell L. Plicae palatinae transversae and papilla incisiva in man; a morphologic and genetic study. Acta Odontol Scand 1955;13(Suppl. 18):5–137.
8. Singh S, Samadi FM, Sonam M, Suhail S. Rugae analysis: aid in forensic odontology – a review. World J Pharm Res 2018;7(3):1320-1331. doi:10.20959/wjpr20183-10814
9. Darijani M, Ebrahimnejad H, Haghani J, Sharifi M, Jazinizadeh M. Prevalence of taurodontism and its associated anomalies in dental patients in Kerman. J Oral Health Oral Epidemiol. 2022;11(3):134-139. doi:10.34172/johoe.2022.02
10. Sapasetty S, Gandikota C. Assessment and Correlation of Dactyloscopy, Cheiloscopy, and Rugoscopy Among Individuals With Different Skeletal Malocclusion—A Cross-Sectional Study. Journal of Indian Orthodontic Society 2023;57(3):156–70. doi:10.1177/03015742221122628
11. Agarwal M, Alex A, Konde S. Relationship between Dermatoglyphics, Cheiloscopy, Rugoscopy, and Dental Caries: A Cross-sectional Study in Bengaluru, Karnataka. Contemp Clin Dent 2018;9(4):577–81. doi:10.4103/ccd.ccd_611_18
12. Saadeh ME, Haddad RV, Ghafari JG. Morphometric analysis of palatal rugae in different malocclusions. J Orofac Orthop 2021;82(2):111–20. doi:10.1007/s00056-020-00256-0
13. Trivedi N. Rugoscopy and Blood Group-An Aid to Forensic Odontology. Indonesian Journal of Prosthodontics 2021:35.
14. Niakan S, Karimi-Afshar M. Partial removable prosthesis in a patient with unilateral maxillectomy: A case report. J Oral Health Oral Epidemiol 2019; 8(3): 161-6. doi:10.22122/johoe.v8i3.1008
15. Aslam K, Jabeen S, Jafri SS, Saeed A, Anjum I. The molecular genetics of selective tooth agenesis. J Pak Med Assoc 2020;70(11):2023–7. doi:10.5455/jpma.42628
16. Sagai T, Amano T, Maeno A, Kiyonari H, Seo H, Cho SW, et al. SHH signaling directed by two oral epithelium-specific enhancers controls tooth and oral development. Sci Rep 2017;7(1):13004. doi:10.1038/s41598-017-12532-y
17. Malekzadeh AR, Pakshir HR, Ajami S, Pakshir F. The Application of Palatal Rugae for Sex Discrimination in Forensic Medicine in a Selected Iranian Population. Iran J Med Sci 2018;43(6):612–22.
18. Sheikhi M, Zandi M, Ghazizadeh M. Assessment of palatal rugae pattern for sex and ethnicity identification in an iranian population. Dent Res J (Isfahan) 2018;15(1):50–6. doi:10.4103/1735-3327.223611
19. Pakshir F, Ajami S, Pakshir HR, Malekzadeh AR. Characteristics of Palatal Rugae Patterns as a Potential Tool for Sex Discrimination in a Sample of Iranian Children. J Dent (Shiraz) 2019;20(1):1–9. doi:10.30476/dentjods.2019.44556
20. Kumar N, Sarvathikari R, Jayaraman V, Mathew P, Jyotsana K. Palatal rugae as an unique and stable marker in personal identification-An interracial pilot study. Indian J Dent Res 2023;34(2):187–90. doi:10.4103/ijdr.ijdr_69_22
21. Rani P, Ananya, Tushar, Ranjan M, Prakash J, Akansha K. Assessment of Palatal Rugae to Aid in Gender Identification in Hazaribag Population-A Cross-Sectional Study. J Pharm Bioallied Sci 2024;16(Suppl 1):S800–s2. doi:10.4103/jpbs.jpbs_1020_23
22. Silva-Sousa AC, Carvalho CS, Marañón-Vásquez GA, Matsumoto MAN, Stuani MB, de Menezes Oliveira MAH, et al. Tooth agenesia might be associated with palatine rugae pattern in a tooth Brazilians population. Research, Society and Development 2021;10(7):e29010716487. doi:10.33448/rsd-v10i7.16487
23. Moran A, Tippett H, Manoharan A, Cobourne MT. Alteration of palatine ruga pattern in subjects with oligodontia: A pilot study. Am J Orthod Dentofacial Orthop 2016;150(2):295–302. doi:10.1016/j.ajodo.2015.12.030
24. Thomas CJ, Kotze TJ. The palatal ruga pattern: a new classification. J Dent Assoc S Afr 1983;38(3):153–7.
25. Syed S, Alshahrani I, Alshahrani A, Togoo RA, Luqman M, Dawasaz AA. Conversion of palatal rugae pattern to scanable Quick Response code in an Arabian population. J Dent Sci 2016;11(3):253–60. doi:10.1016/j.jds.2016.02.004
26. Gupta AA, Kheur S, Alshehri A, Awadh W, Ahmed ZH, Feroz SMA, et al. Is Palatal Rugae Pattern a Reliable Tool for Personal Identification following Orthodontic Treatment? A Systematic Review and Meta-Analysis. Diagnostics (Basel) 2022;12(2). doi:10.3390/diagnostics12020418
27. Heydari F, Gholinia H, Ghorbanipour R. Evaluation of palatal rugae pattern in different sagittal skeletal relationships in orthodontic patients. Caspian Journal Of Dental Research. 2021;10(2):45-51.