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Comparison of Palatal Rugae Patterns between Males and Females in Relation to Age among Iraqi Samples

Firas Abdulameer Farhan*[1], Ali Jameel Abdul Sahib[2], Mustafa Mahdi Jassim[3]

[1]Department of Prosthodontics, College of Dentistry, University of Baghdad, Baghdad, Iraq. ORCID https://orcid.org/0000-0003-0023-6761
[2]Department of Prosthodontics, College of Dentistry, University of Baghdad, Baghdad, Iraq. ORCID https://orcid.org/0009-0001-1394-0451
[3]Department of Prosthodontics, College of Dentistry, University of Baghdad, Baghdad, Iraq. ORCID https://orcid.org/0000-0001-6938-4274

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* **Corresponding Author:** Firas Abdulameer
Email: firas.farhan@codental.uobaghdad.edu.iq
https://orcid.org/0000-0003-0023-6761

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Abstract

The palatal rugae region provides a relatively firm and stable soft-tissue foundation that may contribute to secondary support and resistance to anterior displacement of maxillary dentures. Its relative resistance to post-extraction resorption makes it a useful anatomical landmark. The aim of this study was to assess the number, shape, and distribution of palatal rugae in a partially edentulous Iraqi population between males and females across three age groups (30–45, 46–60, and 61–70 years). The study included 60 partially edentulous Iraqi adults (30 males and 30 females) attending the Department of Prosthetic Dentistry, College of Dentistry, University of Baghdad. Maxillary impressions were obtained and poured with dental stone to produce 60 casts. Rugae were counted for each participant, outlined with a fine black pencil, and photographed by a Nikon D7100 camera. Adobe Photoshop was used to enhance visualization without altering morphology. Rugae were classified as straight, curved, wavy, or circular according to the Thomas and Kotze system. Data were analyzed using SPSS. Females showed a higher mean number of rugae than males (7.30 vs. 6.60), but the difference was not statistically significant. Curved rugae were most prevalent, followed by straight and wavy patterns. Converging rugae occurred exclusively in males, whereas circular rugae were absent. No significant association was found between sex and rugae pattern distribution (P=0.163). Palatal rugae number showed no significant differences by sex or age. Curved rugae were predominant, indicating that palatal rugae may serve as useful supplementary anatomical features in partially edentulous individuals.

Keywords: Palatal rugae, Rugae morphology, Sex differences, Age groups, Iraqi population

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Introduction

Palatal rugae, also known as *plicae palatinae transversae* or *rugae palatinae*, are irregular, often asymmetric transverse elevations of the mucosa and underlying connective tissue located in the anterior hard palate. They extend laterally from the incisive papilla and anterior median palatine raphe (1). In addition to their anatomical characteristics, palatal rugae contribute to oral functions, including food manipulation and transport, tactile and mechanosensory perception, and tongue positioning during mastication and speech. Their specialized sensory structures, including mechanoreceptive elements such as Merkel cells, may contribute to the perception of pressure and tactile stimuli (2,3).

The palatal rugae area is particularly valuable in prosthodontics because its firm, stable soft tissue creates a dependable foundation. Unlike the residual alveolar ridge—which steadily reshapes and breaks down after teeth are lost, the anterior palate holds up exceptionally well over time, making it a reliable reference point for clinicians.[4] When designing distal-extension removable partial dentures, extending the base across the rugae offers useful extra support and helps prevent the denture from shifting forward. That said, this acts as a helpful backup rather than a replacement for primary, tooth-borne retention. Clinicians also regularly count on the palatal rugae and incisive papilla as dependable landmarks when positioning upper front teeth and shaping the front of the occlusal rim (5,6).

Palatal rugae begin forming early in fetal development, usually around the third month of pregnancy. While their overall arrangement stays fairly constant over time, subtle shifts—especially in length—can happen naturally as the jaw and face grow. Because of this, it is best not to view them as entirely permanent throughout life. Factors like normal aging, facial growth, trauma, orthodontic tooth movement, constant pressure, and long-term denture wear can all alter their number, length, and shape (6).
The stability of palatal rugae remains controversial. Lysell, in 1955, reported age-related changes in rugae number, including a reduction after approximately 23 years of age. In contrast, English et al., in 1988, reported that the characteristic rugae pattern remained essentially unchanged during growth and throughout life, except in the presence of pathological or degenerative conditions. These findings suggest that rugae stability may depend on the specific characteristic examined and the population studied. Rugae number and morphology may also be influenced by genetic background, age, sex, environmental factors, and local mechanical influences (7).

Despite their anatomical and prosthodontic relevance, limited evidence is available regarding palatal-rugae characteristics in partially edentulous individuals, particularly in the Iraqi population. Partial tooth loss may modify the functional environment of the palate through changes in tongue pressure and prosthetic coverage. Additionally, sex-related differences in rugae characteristics may reflect anatomical and biological variation relevant to prosthodontic assessment. Therefore, this study aimed to evaluate the number, morphology, and distribution of palatal rugae in partially edentulous Iraqi patients and to compare these characteristics between males and females across three different age groups (30-45, 46-60 and 61-70 years).

Materials and Methods

Study Design and Sample Selection

A cross-sectional observational study was conducted to evaluate the number and morphological characteristics of palatal rugae in partially edentulous Iraqi patients. The

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participants were divided into two groups according to sex: Group I (males), comprising 30 partially edentulous male patients, and Group II (females), comprising 30 partially edentulous female patients. The participants were further subdivided into three age groups: Group 1 (G1), aged 30-45 years; Group 2 (G2), aged 46-60 years; and Group 3 (G3), aged 61–70 years. The participants were well-informed about the study and written informed consent was obtained before enrollment. Strict eligibility criteria were used to exclude conditions that could distort rugae features (8):

Inclusion criteria: Iraqi adults aged 30–70 (grouped into 30–45, 46–60, and 61–70 years) with partial upper tooth loss (more than two spaces), well-defined rugae, and no history of dental prostheses or craniofacial defects.
Exclusion criteria: Individuals with active palatal disease, prior orthodontic or surgical treatment, palatal trauma, or faint, indistinguishable rugae patterns.

Maxillary impression and cast fabrication

Each participant underwent a preliminary examination to confirm eligibility and assess palatal-rugae visibility. Upper stock impression trays were selected to ensure complete coverage of the hard palate and surrounding rugae tissue. Maxillary impressions were taken using irreversible hydrocolloid (Cavex CA37, Haarlem, Netherlands) prepared strictly according to manufacturer specifications. Upon removal, each impression was evaluated visually; those exhibiting significant voids, surface tears, or dimensional distortion were rejected and repeated.

The acceptable impressions were poured with high-strength Type IV dental stone (Elite Stone, Zhermack, Italy) mixed at the recommended water-to-powder ratio. The stone mixture was vibrated into the impressions to eliminate trapped air and allowed to set completely. After retrieval, the resulting casts were thoroughly inspected under light. Models presenting with fractures, air bubbles, or surface defects within the rugae domain were excluded from the study and replaced (Figure 1).



Figure. 1: Maxillary dental stone casts showing the recorded palatal rugae area

Recording and classification of palatal rugae

The palatal rugae on each maxillary cast were evaluated posteriorly, starting from the incisive papilla. To maintain consistency, the analysis included only clearly identifiable rugae extending from the median palatal region toward the lateral palate; minor ridges and ambiguous markings were excluded. Rugae counts were recorded for the right and left sides individually and then summed for a participant total. Using the Thomas and Kotze (9) classification system, the rugae were categorized by length as primary (>5 mm), secondary (3–5 mm), or fragmentary

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(<3 mm), with any markings under 2 mm excluded. Morphologically, they were classified as straight, curved, wavy, or circular, while their unification patterns were noted as either converging or diverging. All measurements and classifications were tracked separately for each side.

Examiner calibration and measurement reliability

Two skilled examiners independently assessed all maxillary casts after completing a calibration session to ensure consistency in the assessment. For easier identification, each ruga was carefully outlined using a fine black pencil. The casts were then photographed using a Nikon D7100 DSLR camera (Nikon Corporation, Tokyo, Japan), with the camera distance, angle, and lighting kept consistent for all specimens. The photographs were processed using Adobe Photoshop (Adobe Inc., San Jose, CA, USA) to improve the clarity and visibility of the rugae without modifying their original morphology. Finally, both examiners independently recorded the number and morphological patterns of the rugae according to the predefined classification criteria (Figure 2).

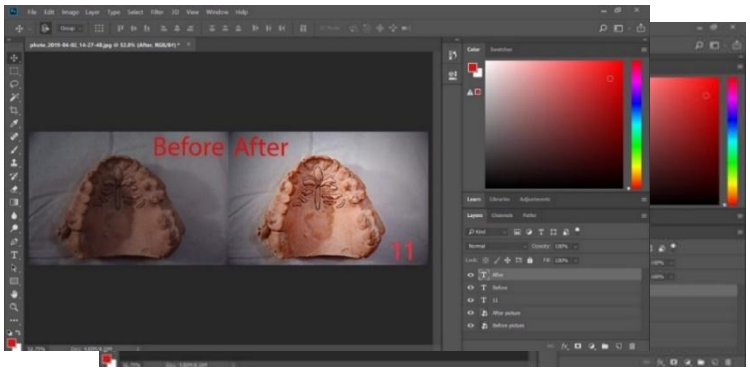


Figure. 2: Adobe Photoshop software used for digital measurement of the palatal rugae area

Results

The mean number of palatal rugae was 8.33 ± 2.94 in males and 9.40 ± 3.68 in females, with no statistically significant difference between the two sexes (P=0.220). Regarding age, the mean number of palatal rugae was 9.35 ± 3.74 among participants aged 30–45 years, 9.85 ± 2.29 among those aged 46–60 years, and 7.40 ± 3.64 among those aged 61–70 years. The difference in the mean number of palatal rugae across the three age groups was not statistically significant (P=0.154). These findings indicate that neither sex nor age was significantly associated with the number of palatal rugae in the study sample (Table 1).

Table 1: Descriptive Statistics and Sex-Based Comparison of Palatal Rugae Number across Age Groups

Sex	No. of participants	Total No. of rugae	Mean No. of rugae	SD	P<0.05
Male	30	251	8.33	2.94	0.220
Female	30	282	9.4	3.68	
Age groups (M+F)					
G1	20	187	9.35	3.748	0.154
G2	20	197	9.85	2.291	
G3	20	148	7.4	3.643	

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The distribution of palatal rugae according to their morphological patterns in both sexes is presented in Figure 3. Curved rugae were the most prevalent morphological pattern (n=131), followed by straight (n=127), wavy (n=123), circular (n=106), diverging (n=34), and converging rugae (n=20).

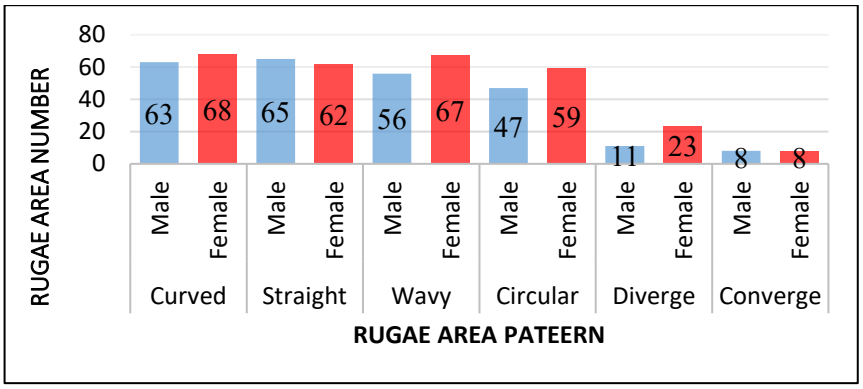


Figure. 3: Distribution of rugae area between male and female according to shape

On the other hand, the distribution of palatal rugae patterns across the age groups is presented in Table 2. A one-way analysis of variance (ANOVA) was used to assess whether the mean number of palatal rugae of each morphological pattern differed among the three age groups (G1, G2 and G3 years). The analysis demonstrated statistically significant differences among age groups for straight rugae P<0.001) and curved rugae P<0.001). In contrast, no statistically significant differences were observed for wavy rugae (P=0.251), circular rugae (P=0.168), or diverging rugae (P=0.629). These findings indicate that age-group differences were observed for the distribution of straight and curved rugae, while the other patterns did not show statistically significant difference across age groups.

Table 2: Descriptive Statistics and Sex-Based Comparison of Palatal Rugae Pattern across Age Groups

Rugae pattern	G1 group Mean ± SD	G2 group Mean ± SD	G3 group Mean ± SD	F	P value
Straight	2.95 ± 1.96	1.30 ± 1.03	2.10 ± 1.37	9.973	<0.001
Wavy	2.30 ± 1.49	2.10 ± 1.25	1.75 ± 1.68	1.397	0.251
Curved	1.65 ± 1.13	3.00 ± 1.33	1.90 ± 1.07	16.787	<0.001
Circular	2.30 ± 2.47	1.50 ± 1.50	1.50 ± 2.14	1.816	0.168
Converging	0.35 ± 0.58	0.00 ± 0.00	0.65 ± 0.81	0.745	0.399
Diverging	0.90 ± 1.94	0.40 ± 0.68	0.40 ± 0.59	0.471	0.629

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Discussion

Palatal rugae have been widely considered useful anatomical structures because of their relative stability, distinct morphology, and resistance to major changes following tooth loss. (4,9) In the present study, the mean number of palatal rugae was higher in females (9.40 ± 3.68) than in males (8.33 ± 2.94); however, this difference was not statistically significant (p = 0.220). This finding suggests that sex did not significantly influence the overall number of palatal rugae in the studied partially edentulous Iraqi population. Similar findings reported in previous studies indicate that although differences in rugae number may be observed between males and females, these differences are not necessarily statistically significant. Variations among studies may be related to ethnic background, sample characteristics, classification criteria, and methodological differences.(10,11,12).

The present study also demonstrated no statistically significant difference in the total number of palatal rugae among the three age groups (P=0.154). The mean rugae count was highest in participants aged 46–60 years (9.85 ± 2.29), followed by those aged 30–45 years (9.35 ± 3.74), while the lowest mean was observed in the 61–70-year group (7.40 ± 3.64). Although this pattern suggests a possible reduction in the number of identifiable rugae with increasing age, the difference was not statistically significant. This may indicate that the overall number of palatal rugae remains relatively consistent across adulthood, despite individual variation and possible age-related changes in the palatal tissues.(13,14).

Regarding morphological patterns, curved rugae were the most prevalent among both sexes (n=131), followed by straight (n=127), wavy (n=123), circular (n=106), diverging (n = 34), and converging rugae (n=20). The predominance of curved rugae indicates that this pattern was the most frequently observed morphological configuration in the present Iraqi sample. However, no statistically significant association was found between sex and rugae morphology, suggesting that the distribution of morphological patterns was generally comparable between males and females (2,15,16).

The significant differences observed for selected morphological patterns may reflect age-related variation in the visibility, preservation, or expression of individual rugae rather than a generalized change in palatal-rugae morphology. Factors such as mucosal changes associated with aging, differences in the degree of tooth loss, and individual anatomical variation may contribute to these findings. Therefore, although the total number of rugae did not vary significantly with age, certain morphological characteristics appeared to show age-related differences in this sample (2,16).

Overall, the findings suggest that the number of palatal rugae is relatively consistent between sexes and across age groups, whereas the distribution of specific morphological patterns may vary with age. The absence of a significant sex-related difference supports the potential usefulness of palatal rugae as stable anatomical features in the studied population (2,17). However, the significant age-related differences in selected patterns indicate that individual rugae morphology should be interpreted cautiously when used for identification or as an anatomical reference. Further studies involving larger and more diverse Iraqi samples are recommended to confirm these findings and clarify the influence of age and sex on palatal-rugae morphology.

In the present study, the curved pattern was the most prevalent rugae form in both males and females, followed by the straight and wavy patterns. The converging pattern was observed only among male participants, whereas no circular rugae were identified in either sex. These findings differ from those reported in several populations in which the wavy pattern was predominant.

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Kapali et al. (1997), investigated palatal-rugae patterns in Australian Aboriginal and Caucasian populations and demonstrated population-related differences in rugae characteristics. Similarly, studies conducted in several other populations have reported variations in the relative frequencies of wavy, curved, and straight patterns. The adult Mediterranean study by Shukla et al. reported that curved, wavy, and straight patterns occurred at approximately similar frequencies, while circular and convergent patterns were uncommon.(12,18).

The predominance of the curved pattern in the present Iraqi sample therefore represents an interesting finding when compared with populations in which wavy rugae are more common. These differences may be related to changes in palatal morphology among populations, which can arise from genetic and developmental influences. At the same time, differences in study methodology should also be taken into account. Variations in sample size, age distribution, ethnic background, dental status, classification methods, the criteria used to define individual rugae, and examiner interpretation may all contribute to the differences reported between studies. The 2020 review by Chong et al. emphasized that the existing literature demonstrates considerable heterogeneity and conflicting evidence regarding population and sex differences in palatal-rugae morphology (2,18).

In particular, the observation that curved rugae were predominant in the present Iraqi sample should not be used to conclude that an unidentified cast with predominantly curved rugae necessarily belongs to an Iraqi individual. Such an inference would require substantially larger samples, independent validation cohorts, standardized methodology, and appropriate multivariable statistical or discriminant analyses. The current study can instead be considered preliminary population-specific evidence that may contribute to future research investigating palatal-rugae variation in Iraqi populations (19).

Future investigations should include larger samples from different geographical regions of Iraq and should consider age, sex, Kennedy classification, location and duration of tooth loss, denture history, and other relevant clinical variables. Standardized digital imaging and three-dimensional analysis may also improve the objectivity and reproducibility of rugae assessment. Such studies could determine whether the differences observed in the present investigation represent genuine population-specific characteristics or are primarily attributable to sample and methodological factors. Further studies are recommended to evaluate palatal rugae patterns using digital intraoral scanning and three-dimensional (3D) digital models.

Conclusion

Within the limitations of this study. The total number of palatal rugae showed no significant differences according to sex or age in the studied partially edentulous Iraqi population. Curved rugae were the most prevalent pattern, with no significant sex-related differences in morphology. However, significant age-related differences were observed for straight, curved, and converging patterns. Overall, palatal rugae demonstrated relative stability in number and may serve as useful supplementary anatomical features. Further studies with larger and more diverse Iraqi samples are recommended to validate these findings.

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Competing interests statement

No conflict of interest.

Author contributions

Firas Abdulameer Farhan considered and designed the study, supervised the research, interpreted the data, and critically revised the manuscript. performed the experimental procedures, collected the data, and drafted the manuscript. Ali Jameel Abdul Sahib carried out the statistical analysis, assisted with data interpretation, and revised the manuscript for important intellectual content. Mustafa Mahdi Jassim contributed to the study design, reviewed the literature, and critically revised the manuscript. All authors read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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