ORIGINAL ARTICLE

Prevalence of Palatal Rugae as Biometric Markers in the Population of Lahore and Islamabad: A Cross-Sectional Study

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ABSTRACT

Objective: This study primarily aims to examine the different varieties of palatal rugae in our population, focusing on gender differences and their role, generally and in forensics in particular. Palatal rugae are biometric tools that can be used in addition to other identification tools for human recognition, as they are considered unique and stable. The study aims to observe the prevalence of palatal rugae in our population, as subject specialists should encourage and pave the way, facilitate its search, research, and create avenues for future studies.

Study Design: Cross-sectional study.

Place and Duration of Study: This study was conducted at the Department of Oral Biology, Post Graduate Medical Institute (PGMI), Lahore, Pakistan, from 1st September 2021 to 31st August 2022.

Methods: In this study, a total of 320 willing individuals were randomly selected to record their palatal rugae from Islamabad, Lahore, and the peripheries. 160 males and 160 females participated voluntarily, with informed consent, and their biometric records, primarily palatal rugae, were documented. The palatal rugae were recorded with the help of alginate impression material, which was then recorded by pouring the casts. Palatal rugae were studied and analyzed for their types, predominance, and gender variation.

Results: Differences were observed in the palatal rugae of all individuals. The predominant pattern of palatal rugae was wavy and curved in males and females, respectively.

Conclusion: Our study shows that males and females can exhibit different types of palatal rugae. Wavy patterns of palatal rugae are significant in males compared to curved patterns in females.

Keywords: *Biology, Biometric Makers, Gender, Prevalence.*

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Introduction

Establishment of human identity, in essence, is a diverse phenomenon and involves multiple domains, but it relies on conclusive recognition strategies as convincing or absolute techniques that involve precise administration and assessment of dental records.[1] Palatoscopy is the term employed to explain the observation of the Palatal rugae pattern (PRP) to identify an individual. Palatal rugae patterns PRPs are morphological folds termed as "plica palatine," the lamina propria situated at the anterior two-thirds of the hard palate and posterior to the incisive papilla.[2]

These are transverse palatine folds, which are raised, protruding, and are arbitrarily placed in the primary part of the palate. When compared to the palatal raphe, these are directed obliquely and sagitally.[3] The earliest appearance of palatal rugae is observed during the 12th week of intrauterine life. Palatal rugae are fibrils that follow a path within the core and transversely form the base of each ruga as they run in circular curves. These fibrils regulate and control the forms of the palatal rugae. The varied shapes of rugae are depicted by the connective tissue limited

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underneath these areas of epithelial divergence and condensation, which depicts the convergence of fibroblasts and collagen fibers.[3]

The process of development and morphogenesis of the palate is based on the inception, growth, and merging of the palatine shelves from already separate facial protuberances while developing to build the complete palate demarcating the mouth, surrounding lips, and the nose. The palatine shelves comprise primarily cephalic neural crest-derived embryonic connective tissue cells, which layer a simple developing epithelium.[4] The development and arrangement of the palatal shelves are governed by reciprocal epithelial and connective tissue interactions regulated by various signaling pathways and transcription factors. Palatal fusion is based not only on spatiotemporally governed disintegration of the periderm but also on vigorous biological processes that lead to attachment and insertion of the palatal medial edge epithelium to build an inter-shelf epithelial finish, and to the respective dissolution of the epithelial finish to construct a continuous ceiling of the mouth.[5]

In an edentate skeletonized individual, the study of palatal rugae has significant benefits compared to conventional approaches, with economical and practical viability. Nevertheless, an edentate skeletonized individual, the study of palatal rugae has significant benefits compared to conventional approaches, with economical and practical viability. Nevertheless, it is of supreme importance that the ridge forms of the palate should be documented in life through dental prosthesis or casts, as the analysis of rugae for records is inevitable. Palatal rugae records can be fruitful for ethnic profiling, as the literature suggests that they may be specific to certain racial groups.[5] Different ethnic groups have different varieties of palatal rugae patterns. Among the Iranian population, straight variety is the most common, followed by wavy and curved; in the Portuguese population, straight variety was abundant. Similarly, Egyptian, Saudi, Nepalese, and Indian populations showed different rugae patterns.[6] It can be challenging when various conditions, for example, extreme thumb sucking in infancy, orthodontic treatment causing constant stress, which allows drifting of bicuspids and tricuspids in an anteroposterior direction, resulting in movement of the lateral parts of rugae and dental prosthesis, can lead to minute differences in rugae pattern.[7] Although the format or scheme of palatal rugae is personalized for every individual, they are not usually operated in automated biometric approaches like dactyloscopy and retina scan. Therefore, patterns of rugae of the palate are exclusive, and they depict tremendous potential in providing authentic personal details that can be very productive for self-regulated systems based on biological landmarks in identifying individuals and in forensic sciences.[8]

Consequent to palatal rugae formation, their span keeps on changing during palate development as compared to their location, which remains constant throughout life.[9] Hence, it has been demonstrated that they attain their characteristic orientation of structure at birth and procure their ultimate form in adult life. Hence it can be stated that they continue to be durable throughout life. On the other hand, the permanence and reliability of the palatal rugae pattern (PRP) is an area that requires to be addressed and is questionable in recent research. It is suggested that the rugae are intimately related to the teeth as a result of their displacement after the extraction of other teeth, leading to modification of the primitive orientation of the rugae. In contrast, others depict them as constant and durable. The first rugae are the most stable, whereas other researchers propose that the most posterior are the most prevalent. In addition, certain modifications were observed under external pressure, such as finger sucking and orthodontic treatment.

Limited noticeable changes in contrast to the overall state of a person who suffered a third-degree orofacial burn were observed. In spite of the fact that palatal rugae shapes are comparable or analogous among twins, these rugae are not exactly duplicates. Therefore, it can be proposed that these palatal rugae patterns PRPs can be regarded as a classic determinant for forensic applications. They are absolute in their ability to resist changes and are also durable even after the fulfillment of their development. In addition, they can be specifically applied in post-mortem cases in conditions where dactyloscopic evidence cannot be obtained in severely burnt bodies or where they were entirely decomposed.[10]

Hence, in our study, we will document the prevalence of rugae patterns among Pakistani men and women, primarily in Lahore, Islamabad, and some peripheral areas.

Methods

This study was conducted at the Department of Oral Biology, Post Graduate Medical Institute (PGMI), Lahore, Pakistan, from 1st September 2021 to 31st August 2022. Ethical approval was obtained from the Ethical Review Committee of the institute vide registration no: 00-50-A-2024, dated 15th August 2021, in accordance with the ethical norms of the relevant committee on human experimentation, i.e., the Helsinki Declaration of 1975, as revised in 1983.The data were collected and analyzed by a single qualified dental surgeon, so single-observer bias may have occurred. The sample size was calculated using the following formula, with a power of 80% and a significance level of 5%.

Sample Size determination in health studies version 2.0.21 WHO) P1 is the anticipated proportions of palatal rugae pattern in male (Group A) = 45 %P2 is the anticipated proportions of palatal rugae pattern in female (Group B) = 30% p1 – p2 is the difference between proportions = 15%Z is the desired power of study = 80% 1 –βZ is the desired level of significance = 05% 1-α/2.

The calculated sample size was 320. People without established occlusion, any history of palatal trauma, palatal pathology, or palatal surgery, and individuals with known hypersensitivity to alginate impression were excluded. After obtaining informed consent, palatal rugae patterns were collected from 320 participants (160 males and 160 females) aged 20-50 years.

Alginate impressions of the subjects were recorded for males and females, randomly, in proper clinical or hospital settings under strict aseptic conditions. The impressions were then poured in dental stone type III. After obtaining casts from impressions, the casts were analyzed, and the rugae were outlined with a graphite pencil. (Figure 1).

The casts were assigned serial numbers 1-321 for data recording. The rugae patterns were studied and marked for each individual. The results were then compared using SPSS version 27.00 and then analyzed. The data was entered and analyzed by using SPSS (Statistical Package for the Social Sciences) version 27.0. Numeric data like age was presented in the form of mean ± S.D. Categorical data, like the type of palatal rugae, were presented in the form of frequency (%). The chi-square test and Fisher's exact test were used to compare the type of palatal rugae between males and females. As data was non-normal, therefore, Mann Whitney test was used to compare the mean number of each type of palatal rugae between the both genders. The results showed that the mean number of palatal rugae of curved, circular and divergent was significantly higher in females as compared to males while the mean number of palatal rugae of wavy, convergent and straight was significantly higher in males as compared to females. However, no significant difference was observed in mean number of undetermined palatal rugae between the both genders. (Table 1).

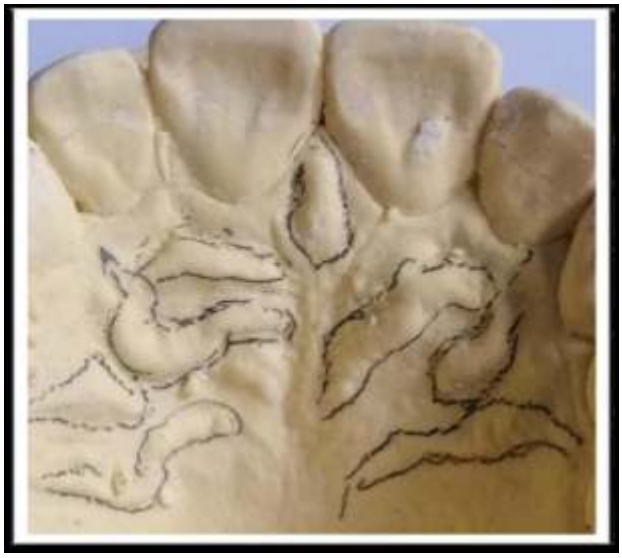

Fig.1: Photograph showing a cast of a male subject with outlined rugae pattern with a graphite pencil

Results

The wavy pattern of the palatal rugae was observed in all male and female participants. The curved pattern of the palatal rugae was observed in all female participants, whereas it was observed in 159 (99.4%) male participants. The circular pattern of the palatal rugae was observed in 44 (27.5%) female participants, while it was observed in 19 (11.9%) male participants. The difference was statistically significant (*P*-value = 0.001)**.** The convergent pattern of the palatal rugae was observed in 101 (63.1%) male participants, while no convergent pattern of

Table 1: Comparison of the number of each type of palatal rugae between males and females

Type of Palatal Rugae	Gender	Mean ± SD	Min.	Max.
Wavy	Male	2.66 ± 0.47	2	3
	Female	1.96 ± 0.30	1	3
Curved	Male	1.86 ± 0.76	0	3
	Female	3.02 ± 0.26	2	4
Circular	Male	0.12 ± 0.32	0	1
	Female	0.28 ± 0.45	0	1
Conver	Male	0.75 ± 0.65	0	2
	Female	0.00 ± 0.00	0	0
Divergent	Male	0.17 ± 0.38	0	1
	Female	0.41 ± 0.51	0	2
Straight	Male	1.17 ± 0.38	1	2
	Female	1.08 ± 0.26	1	2
Undetermined	Male	0.03 ± 0.16	0	1
	Female	0.05 ± 0.22	0	1

the palatal rugae was observed in female participants. The difference was statistically significant (*P*-value = 0.001)

The divergent pattern of the palatal rugae was observed in 65 (40.6%) female participants and in 27 (16.9%) male participants. The difference was statistically significant (*P*-value = 0.001)

The straight pattern of the palatal rugae was observed in all male and female participants. Undetermined patterns were observed in only 8 (5.0%) female participants, while an undetermined pattern was observed in only 4 (2.5%) male participants. (Table 2).

The Chi-Square test was used to compare the different pattern of the palatal rugae between male and female participants. The results revealed that there was a significant difference in circular, convergent, and divergent patterns of the palatal

Table 2: Distribution of palatal rugae between male and female study participants

Pattern of Palatal Rugae	Males	Females	*Chi-Square* value	*P*-value
Wavy	160 (100.0%)	160 (100.0%)	-	> 0.999
Curved	159 (99.4%)	160 (100.0%)	1.003	> 0.999
Circular	19 (11.9%)	44 (27.5%)	12.53	< 0.001*
Convergent	101 (63.1%)	0 (0.0%)	147.6	< 0.001*
Divergent	27 (16.9%)	65 (40.6%)	22.03	< 0.001*
Straight	160 (100.0%)	160 (100.0%)	-	
Undetermined	4 (2.5%)	8 (5.0%)	1.385	0.239

**Significant (P-value less than or equal to 0.05)*

rugae between male and female participants. The circular and divergent pattern was significantly higher in females as compared to males, while the convergent pattern was significantly higher in males as compared to females.

Discussion

The outcomes of the current study provide profound insights into the dominant patterns of palatal rugae in the Pakistani population. In males, wavy was dominant, followed by straight and curved. The most dominant patterns of palatal rugae in females were curved, followed by wavy and curved combined**.** It was observed that the common type of palatal rugae was curved in 65% males and 23% females. Circular variety is the least commonly occurring in both genders. The palatal rugae were relatively smaller in dimensions in females and larger and wider in males. Results of our study demonstrate a significant difference in circular, convergent, and divergent palatal rugae patterns between male and female participants. An Indian study, which compared palatal rugae with lip prints and tongue prints, showed that in males, the predominant type of palatal rugae was curved, and in females, it was straight.[10] A study conducted in Pakistan revealed that frequent rugae patterns occurring in the local population were sinuous and in line with divergent unification.[11] Our current study revealed that there are 3-5 rugae on each side of the palate in all individuals. A model was developed in Saudi Arabia to estimate the probability of a person's Palatal Rugae Pattern (PRP) based on the number, shape, thickness, and position of rugae, allowing for some variation. Although trained on data from 154 palates, the model is suitable for use across populations of different sizes. The findings show that PRPs are highly individual, making it extremely unlikely that two people have matching patterns; no two palates are similar in configuration, and each presents an organized pattern of rugae specific to the individual.[7,8] A local study also observed no significant difference in terms of the number of palatal rugae on both sides of the palate.[11,12]

In contrast, a recent study conducted in Riyadh found circular and backward patterns of the rugae females showed a higher incidence of backward-directed rugae (3.02 ± 2.316) compared to the males (2.49 ± 2.183).[13] On the other hand, the males had greater circular rugae (0.381 ± 0.751) than the females (0.602 ± 1.112).[13]

Hence, variation can exist among different populations. A study conducted in Iran found differences in the palatal rugae pattern among different classes of malocclusion according to Angle's classification. In addition, the orientation of some rugae was also found to be significantly different between malocclusion groups.[14] All human palates are distinct in arrangement, each displaying a structured orientation of rugae particular to every human. Variations can occur based on occlusal patterns and differences in ethnicity. Palatal rugae patterns may change due to orthodontic treatment, tooth removal, or habits like finger sucking in childhood. However, they are highly resistant to damage from disease, chemicals, fire, and trauma, and even after death, due to protection from nearby tissues such as the lips, tongue, teeth, and bone.[15] Similarly, rugae in partially edentulous and completely edentulous patients showed that female and partially edentulous arches had more numbers of rugae as compared to males and completely edentulous arches respectively.[15]According to another study, variation in ethnicities showed that the overall number of palatal rugae in the Sistani ethnicity is much lower than in the Turkmen and Fars ethnicities. In addition, the total number of palatal rugae in the Fars ethnicity was more on the left side of the palate than the right, and it was greater in women than men. Different ethnic groups have different varieties of palatal rugae patterns. Among the Iranian population, straight variety is the most common, followed by wavy and curved; in the Portuguese population, straight variety was abundant. Similarly, Egyptian, Saudi, Nepalese, and Indian populations showed different rugae patterns.[16] It can be challenging when various conditions, for example, extreme thumb sucking in infancy, orthodontic treatment causing constant stress, which allows drifting of bicuspids and tricuspids in an anteroposterior direction, resulting in movement of the lateral parts of rugae, and dental prosthesis can lead to minute differences in rugae pattern.[17] Although the format or scheme of palatal rugae is personalized for every individual, they are not usually operated in automated biometric approaches like dactyloscopy and retina scan.[18]

Therefore, patterns of rugae of the palate are exclusive, and they depict tremendous potential in providing authentic personal details that can be very productive for self-regulated systems based on biological landmarks in identifying individuals and in forensic sciences.[19,20] Orthodontic malocclusions can be associated with specific PRPS. The genetic implications of PRPs in inheritance can be explored further for prospective research. New digital methods of documenting palatal rugae should be used for better results, as the current study can have a single observer bias.

Conclusion

Our study concludes that males and females can have different varieties of palatal rugae. Wavy patterns of palatal rugae are significant in males compared to curved patterns in females.

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Author Contributions

KR: Conception and design of the work, manuscript writing for methodology design and investigation data acquisition, curation, and statistical analysis, validation of data, interpretation, and write-up of results, writing the original draft, proofreading, and approval for final submission
MSI: Manuscript writing for methodology design and investigation
SU: Validation of data, interpretation, and write-up of results
AAM: Revising, editing, and supervising for intellectual content
MH: Conception and design of the work