FREQUENCY OF DIFFERENT PALATAL RUGAE PATTERNS IN MIXED DENTITION PATIENTS

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ABSTRACT

Objective: To assess the pattern of palatal rugae in mixed dentition subjects based on Angle's classification of malocclusions.

Methodology: Pre-treatment high quality white orthodontic stone models of 102 subjects, 55 males and 47 females were selected to conduct a cross-sectional study at Peshawar. Pattern, length and orientation of palatal rugae of all subjects included in the study were assessed using the proposed method of Thomas and Kotze for classification of palatal rugae. The mean, standard deviation and percentages were measured using SPSS Version 20.0. The mean highest length of second right side rugae was recorded 7.9020mm.

Results: The study revealed significant differences in palatal rugae patterns based on gender ($\chi^2 = 6.016$, df = 5, p = .305). The orientation of horizontally directed rugae was predominant (55.9%), followed by posteriorly (26.5%) and anteriorly directed (17.6%) rugae. Furthermore, the analysis showed notable associations between malocclusion classification and primary rugae count, length, orientation, and pattern.

Conclusion: This study underscores the pivotal role of palatal rugae in accurate person identification, forensics, and dental records administration. The unique characteristics of palatal rugae hold substantial promise in forensic dentistry, enhancing our understanding of their distinct attributes and applications.

Keywords: Dentition; Finger Sucking; Malocclusion; Hard Palate

INTRODUCTION

Palatal rugae are an assembly of mucosal folds in the anterior part of the palatal incisive papillae that are unique to each individual and inalterable throughout life. These structures can be studied for several purposes, especially in forensic dentistry where they are implicated in the process of human recognition.[1] They are used as a credential mark in orthodontics because their pattern become regular after intrauterine life, its posterior patterns become lost, and the anterior patterns become more stable and prominent.[2]

Palatal rugae appear in the fetus at the end of the first trimester of embryonic life which are made of compact connective tissues covering the palatal shelves to maximum extent.[3] These structures spread from the inner part of the hard palate up to mesial side of first permanent molar and do not cross inferiorly. The palatal rugae comprises of keratinized stratified squamous epithelium and a high thickness of Merkel cells, help in tongue positioning during mastication and deglutition.[4] The length of the first palatal rugae in embryonic life is 32 mm which protrudes outside the incisive papilla.[5]

Establishing human identification by using forensic odontology is one of the most difficult tasks in postmortem scenarios. However, palatal rugae can be used as a diagnostic marker in forensic analysis because of their diversity, uniqueness, lifelong stability, and resistance to heat and harsh conditions.[6] They tend to be of great interest in those situations where no fingerprints are found like disintegrated bodies, consumed bodies, and situations where both the upper appendages are absent. It is the most important method in aeronautical mishaps to guarantee distinguishing proof of pilots utilizing antemortem information.[7] Palatal rugae are insulated by tongue and buccal fat pads from heat and protected from external trauma by their interior position in the head.[8] If rugae is harvested, using a graft of soft tissue, it can cause esthetic problems because of it tended to survive in its distinct shape.[9]

According to Sassouni's Analysis, palatal rugae remain stable throughout life and there is no similarity between the any two palates.[10] Their anatomical position in the oral cavity plays the main role in their stability. Many studies use these patterns of palatal rugae in gender identification.[11,12] Some researchers have

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reported the contribution of genetic factors to the development of malocclusion.[13] Poly-genic hereditary has been reported for Class II and Class III malocclusion expresses inheritance of autosomal dominance.[13] Since, during craniofacial development, the palatal rugae are safe structures that adhere to a single signaling pathway. Its alliance with Angle's classification of malocclusion can be considered for the forecasting of forthcoming dento-skeletal anomalies. Some previous researches suggest that there is no such difference exist in these rugae but most of the current literature suggest the difference.[3] A survey of existing literature showed that, except from few pilot studies, there is no data available on patterns of palatal rugae in mixed dentition patients. Therefore, the purpose of our study is to find out the frequency of different types of palatal rugae and orientations based on Angle's classification in mixed dentition patients.

METHODOLOGY

This retrospective cross-sectional study took place at Department of Orthodontics, Peshawar Dental College, Riphah International University Islamabad Pakistan with ethical clearance from the Institutional Review Board (IRB) of Prime Foundation, Pakistan (Prime/IRB/2022-415). Written informed consent was obtained from all participants. The study included 102 individuals (55 males and 47 females) aged 6 to 12 years in the mixed dentition stage. Participants were chosen based on specific inclusion criteria and were classified into Class I, Class II, and Class III malocclusion categories according to Angle's classification. The sample size was determined using the formula:

$$n = (Z^2 * p * (1 - p)) / (d^2).$$

Both male and female subjects within the mixed dentition stage were included, provided they had fully erupted first permanent molars, a prerequisite for Angle's classification, and complete pre-treatment records including high-quality white orthodontic stone models. Exclusion criteria encompassed individuals with asymmetry, missing or unerupted first permanent teeth, cleft lip and palate, craniofacial and dental malformations, diseases, or trauma affecting the head and neck region. Those with behaviors like thumb-sucking or tongue-thrusting were also excluded.

High-quality white orthodontic stone models (ISO type 3) were generated from alginate impressions of upper and lower dental arches. Palatal rugae were traced with a sharp graphite pencil under appropriate lighting and magnification. Dental casts were utilized for assessing Angle's classification, total rugae count, primary rugae count, unification, predominant direction, and rugae patterns. Rugae were categorized based on number, length, pattern, and orientation. Length classifications included primary (>5mm), secondary (3-5mm), and fragmentary (<3mm), determined by the greatest dimension, with lengths less than 2mm excluded. Pattern classifications comprised curved, wavy, straight, irregular, forking, and island patterns. Orientation classifications encompassed anteriorly directed, horizontally directed, and posteriorly directed rugae.

Participants were categorized into Class I, Class II, and Class III based on Angle's classification. Attributes of palatal rugae—number, length, pattern, and orientation—were documented for each category. Data analysis employed SPSS software for Windows (Version 20.0, SPSS Inc., Chicago). Descriptive statistics were used for calculating means, standard deviations, and percentages. Palatal rugae patterns were analyzed in relation to gender using chi-square analysis.

RESULTS

The study involved a comparative analysis of the average mean lengths of the first, second, and third rugae on both the right and left sides, as presented in Table 1. Notably, the second ruga on the right side exhibited the highest mean length, measuring at 7.9020mm. In contrast, the third ruga on the left side displayed the lowest mean length, measuring at 7.2543mm, on both sides.

Table 2 illuminates the observed patterns of palatal rugae among the study subjects. Among these patterns, the curved pattern emerged as the predominant choice for 24 subjects, constituting a cumulative percentage of 23.5%. Conversely, the least observed pattern was the island pattern, identified in only 5 subjects (4.9%). Notably, the p-values for the majority of rugae patterns demonstrated statistical significance (p-value < 0.05), with the exception of the third rugae on both the right and left sides (p-value > 0.05).

Examining the orientation of palatal rugae (Table 3), horizontally directed rugae emerged as the dominant orientation in 57 subjects (55.9%). Posteriorly directed rugae were observed in 27 subjects (26.5%), while anteriorly directed rugae were identified in 18 subjects (17.6%).

Furthermore, the study delved into the classification of malocclusions according to Angle's classification and correlated it with the number, length, orientation, and pattern of palatal rugae (Table 3). The data revealed noteworthy trends: the mean number of primary rugae was highest among Class III subjects in comparison to Class I and II. Additionally, the second ruga on the right side exhibited the longest mean length, measuring 9.33mm, in Class III subjects. Orientation-wise, horizontally directed rugae predominated in Class I (17), Class II (39), and Class III (3) cases. Pattern-wise, irregular and straight patterns were prevalent in Class II[15], while the wavy pattern stood out among Class I subjects.[9] The analysis of the pattern of palatal rugae by gender yielded a

Table 1: Mean length of first, second and third rugae, on both, right and left side in both genders

Gender	Total	Statistical Values	Length of first right rugae	Length of first left rugae	Length of second right rugae	Length of second left rugae	Length of 3rd right rugae	Length of 3rd left rugae
Male	55	Mean ±SD	7.44 ±1.82	7.70 ±1.82	7.90 ±2.06	7.34 ±2.23	7.46 ±2.48	7.20 ±2.50
Female	47	Mean ±SD	7.34 ±1.83	7.69 ±1.79	7.91 ±2.08	7.33 ±2.21	7.47 ±2.64	7.23 ±2.50
		t-value	1.965	1.863	1.435	1.960	1.836	1.34
		P-value	0.03	0.05	0.04	0.03	0.06	0.08

Table 2: Patterns of palatal rugae in the studied subjects.

	Frequency	Percent	Cumulative Percent
Curved	24	23.5	23.5
Straight	22	21.6	45.1
Wavy	18	17.6	62.7
Irregular	22	21.6	84.3
Forking	11	10.8	95.1
Island	5	4.9	100.0
Total	102	100.0	

Table 3: Based on Angle's Classification the numbers, length, orientation and pattern of palatal rugae.

	Class I Mean	Count	Class II Mean	Count	Class III Mean	Count
Number of Primary Right Rugae	2.86	-	2.77	-	3.17	-
Number of Secondary Left Rugae	1.75	-	1.77	-	1.83	-
Number of Tertiary Right Rugae	1.54	-	1.57	-	3.42	-
Number of Tertiary Left Rugae	1.56	-	1.68	-	3.00	-
Length of First Right Rugae	7.87	-	7.10	-	8.25	-
Length of First Left Rugae	8.07	-	7.36	-	8.92	-
Length of Second Right Rugae	7.79	-	7.82	-	9.33	-
Length of Second Left Rugae	7.32	-	7.26	-	8.25	-
Length of 3rd Right Rugae	7.36	-	7.47	-	8.00	-
Length of 3rd Left Rugae	6.97	-	7.25	-	8.00	-
Orientation of Palatal Rugae	Anteriorly Directed	6	-	12	-	0
	Horizontally Directed	16	-	38	-	3
	Posteriorly Directed	14	-	10	-	3
Pattern of Palatal Rugae	Curved	8	-	14	-	2
	Straight	5	-	15	-	2
	Wavy	9	-	9	-	0
	Irregular	5	-	15	-	2
	Forking	7	-	4	-	0
	Island	2	-	3	-	0

Table 4: Frequency of palatal rugae patterns according to gender

		Pattern of Palatal Rugae					
		Curved Count	Straight Count	Wavy Count	Irregular Count	Forking Count	Island Count
Gender	Male	14	14	12	14	4	6
	Female	12	13	8	13	9	1

chi-square value of 6.016 with 5 degrees of freedom. The resulting p-value was found to be .305, indicating that the observed pattern distribution is not statistically significant at the conventional significance level (Table 4).

DISCUSSION

Palatal rugoscopy, a nascent procedure in forensic odontology, displays considerable potential. Among identification methods, fingerprints and dental records remain steadfast. However, forensics has embraced palatal rugae's distinct attributes for identification. The investigation notably compared mean rugae lengths across genders and orientations. Table 1 highlights the second ruga's right side length, accentuating its importance. This discovery holds significance, particularly in clinical contexts. Quantifying rugae dimensions can aid patient recognition and forensic endeavors. Interestingly, the study revealed the shortest average length among all rugae was the third ruga on the left side. This prompts speculation about asymmetrical development or anatomical disparities.[14]

Diverse research conducted across populations offers conflicting findings. In alignment with our study, certain investigations report no substantial disparity in palatal rugae patterns between genders. Conversely, other studies indicate a significant differentiation among males, females, and transgender individuals as variation exists among both sexes.[15,16]

Another study by Kashima et al., delving into a comparative analysis of palatal rugae among Japanese and Indian children, signifies that Japanese children manifest a greater number of primary palatal rugae compared to their Indian counterparts. A separate investigation within the Australian population revealed that Aborigines exhibit a higher count of primary palatal rugae when contrasted with the Caucasoid population.[17]

Within this research, the examination of palatal rugae pattern distribution emerged as a significant focal point. The cumulative percentages, as displayed in Table 3, provide a lucid depiction of the prevalence of different patterns among the participants. Among these patterns, the curved pattern holds the highest prevalence, observed in approximately a quarter of the patients. In contrast, the island pattern stands as the least frequent, manifesting in a relatively limited number of individuals. These findings showcase the diverse array of rugae patterns, potentially contributing to a deeper comprehension of the genetic and developmental factors influencing their emergence.[18]

Lysell and colleagues made a noteworthy observation regarding the posterior aspect of the tongue's significance in delineating rugae patterns. Given the inherent variation in tongue positioning contingent on the specific malocclusion type, it stands to reason that disparate classes of malocclusions would yield distinct rugae patterns. In class II malocclusion, the posterior orientation of the upper side of the tongue tends to be more pronounced. In parallel, the dorsal aspect of the tongue assumes a relatively superior position in comparison to the skeletal alignment seen in class I malocclusion. This interplay between tongue posture and malocclusion classification underscores the potential influence of anatomical dynamics on the formation of rugae patterns.[19]

Fatima et al. conducted a comparative analysis of mean palatal rugae lengths across distinct malocclusions, stratified according to Angle's classification. Among these classifications, it was observed that Class III cases exhibited the most considerable length for the primary left rugae (11.94 ± 2.3), as well as for both the right (9.71 ± 2.4) and left (9.69 ± 2.4) second rugae.[3] Remarkably, these outcomes bear a notable resemblance to our study's findings, wherein Class III cases similarly displayed the highest mean lengths for the primary second and third rugae.

In our present investigation, the data presented in Table 2 illustrates that the curved pattern constitutes 24% of the sample, surpassing the proportions of both irregular and straight patterns. A similar observation pertaining to this pattern was noted by Shetty and colleagues in a student cohort from Mangalore, India. Conversely, findings reported by Faisal and associates diverge, highlighting that the circular pattern of rugae predominates across both sexes within the Saudi population.[20] In our present study, the prevailing rugae orientation was horizontally directed. Conversely, no significant trend was discernible for posteriorly and anteriorly directed rugae. This aligns with the observations made by Shwetha et al. and Shetty et al., mirroring our own findings. However, it's worth noting that the outcome reported by Faisal et al. diverged, as they identified converging rugae as the predominant orientation.[21]

In orthodontics, the Angle's classification is frequently used to evaluate malocclusions.[9] This study extended its scope by exploring potential associations with the dis-

tinct attributes of palatal rugae. Noteworthy patterns emerge from the data presented in Table 4. For instance, participants categorized under Class III displayed the highest mean number of primary rugae, suggesting a plausible connection between malocclusion and rugae development. Furthermore, certain rugae patterns and lengths exhibited a higher prevalence within specific Angle's classes, hinting at a potential correlation between the morphology of palatal rugae and dental occlusion.[22]

CONCLUSION

The current study effectively underscores the unique characteristics of palatal rugae, thus emphasizing their crucial role in dentistry for precise individual identification, forensic applications, and the management of dental records. Furthermore, this investigation highlights the distinctive attributes of palatal rugae, which hold significant promise in the realm of forensic dentistry. These findings collectively contribute to a more comprehensive understanding of the multifaceted implications of palatal rugae in the field of dental sciences.

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Author's Contribution

FS contributed in Data collection, data analysis and writing of the manuscript. SA conceived the idea, designed the study and gave final approval. ZUI, HAR and FA helped in literature review and Data Analysis and write up of the manuscript. Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflict of Interest

Authors declared no conflict of interest

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None

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.