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The Association between Palatal Rugae Pattern and Different Dent Malocclusion

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Abstract:

Background: *Palatal rugae complete its development during early intrauterine life, whereas dental malocclusions in permanent dentition establishes several years into the post-natal life.*

Objective: *The objective of present study was to determine association between the palatal rugae pattern and Angle's classes of malocclusion.*

Methods: *A cross-sectional study was conducted on pretreatment dental casts of 368 patients at Bolan Medical College/SPH Quetta from Oct 2021 to May 2022. The sample was divided into the following groups: Class I, Class II div. 1, Class II div. 2, and Class III. The number of palatal rugae was recorded, bilaterally. The length, pattern and orientation of three anterior-most primary rugae on both sides were recorded.*

Results: *The mean age of the study sample was 17.8 ± 5.4 years. The mean number of the palatal rugae was 11.18 ± 2.5, with significant differences among different malocclusion groups. The length of the first rugae on left side and third rugae on both sides varied significantly among the groups ($p < 0.05$). Similarly, the pattern of palatal rugae was also found to be significantly different among the malocclusion groups. The right sided rugae did not have any significant difference in the orientation in different malocclusion groups; however, the left sided rugae showed significant differences among the four malocclusion groups ($p < 0.001$).*

Conclusions: *The current study showed subtle differences in the palatal rugae pattern among the Angle's classes of malocclusion. Similarly, the length and orientation of some rugae were also found to be significantly different between malocclusion groups.*

Keywords: Rugae, Malocclusion, Palate

INTRODUCTION

The palatal rugae are unique structures that remain fixed in their position and pattern throughout an individual's life. This gives them a significant role in forensic Dentistry, as they can potentially aid in the process of human identification. [1-3]

In Orthodontics, they serve as stable reference points for comparing pre-treatment and post-treatment cephalometric tracings.[4] Palatal rugae develop during

the third month of intrauterine life and cover a major portion of the palatal shelves. These structures create a series of folds on the front part of the palatal mucosa, located behind the incisive papilla on both sides of the median palatal raphe.[5]

The range of numbers on each side fluctuates between 4 and 6, appearing prior to the fusion of the palatine shelves. The growth and development of these structures are regulated by the interaction between epithelial and mesenchymal cells. As intrauterine life progresses, the pattern becomes irregular, with the disappearance of the posterior ones and an increase in prominence of the anterior ones.[6-8]

These structures are shielded by the surrounding soft and hard tissues, such as lips, cheeks, tongue, teeth, and bone, providing protection against trauma and high temperatures. While their involvement in deglutition and oral sensation is well-established, their exact role in sensorineural function remains not fully comprehended.[9-10]

The growth and development of the craniofacial region are influenced by the intricate interplay between fibroblast growth factors and Hedgehog signaling pathways.[11-13] Some research studies have highlighted the significant role of genetic factors in predisposing individuals to malocclusion.[14,15] It has been noted that Class II subdivision 1 malocclusion exhibits polygenic inheritance, while Class II subdivision 2 and Class III malocclusion show autosomal dominant inheritance patterns. Recent scientific publications have delved into the genetic pathways and molecular mechanisms involved in the formation of palatal rugae.[3,11,13,19]

Malocclusion not only raises aesthetic concerns but also leads to functional impairments that can have long-term effects on psychological well-being. Early diagnosis is crucial as it allows for timely preventive or interceptive treatments, potentially reducing the burden of disease and treatment duration.[20] Given that palatal rugae are stable structures that follow common signaling pathways during craniofacial development, their correlation with Angle's classes of malocclusion could aid in predicting future dentoskeletal abnormalities. A review of relevant literature revealed a lack of data on the association between palatal rugae and various malocclusion traits, except for a preliminary investigation.[15] Therefore, the aim of this study was to explore whether there is a link between the morphological characteristics of palatal rugae and Angle's classes of malocclusion.

METHODOLOGY:

A cross-sectional study was conducted on pretreatment dental casts of 368 patients at Bolan Medical College/SPH Quetta from Oct 2021 to May 2022.. The dental records of 5,000 subjects were reviewed, and those who met the inclusion criteria were selected. Prior to data collection, ethical clearance was obtained from the ethical review committee. The sample size was determined based on a previous study by Gandikota et al, which reported the average length of primary palatal rugae in Angle's Class I and Class II as 20.54 ± 2.46 mm and 19.11 ± 1.78 mm, respectively. The study had a power of 80% and an alpha level of 0.05. The sample was divided into four equal groups, with 46 subjects in each group, based on molar and incisor relationships (Class I, Class II division 1, Class II division 2, and Class III).

Only patients with good quality dental casts from the Pakistani population, as confirmed by their National identity card, were included. The patients were between the ages of 12-30 years, had permanent dentition, established molar and incisor

relationships, and a normal vertical growth pattern. Patients with specific malocclusions, such as quarter or half-cusp molar relation, subdivision and asymmetric cases, and complex cases with unmatched molar and incisor relations, were excluded. Additionally, patients with a history of extraction or previous orthodontic treatment, cleft lip and palate, craniofacial and dental anomalies, pathology or trauma involving the head and neck region, habits such as tongue thrusting or thumb sucking, and carious or missing molars and incisors were also excluded from the study.

A research study was carried out on the dental stone models of superior pretreatment quality. (white orthodontic stone, ISO type 3) derived from the alginate impressions of upper and lower dental arches. The palatal rugae were outlined with a sharp HB pencil under suitable light, and magnification. The most medial and distal ends of the palatal rugae were marked on dental cast and linear distances were measured using digital vernier calipers (0-150 mm ME00183, Dentaurum, Pforzheim, Germany)

Based on length, the rugae were categorized as primary (> 5 mm), secondary (3 – 5 mm), and fragmentary type (< 3 mm). 8 The total number of rugae was recorded for both right and left sides. The three anterior-most primary rugae (labelled as ruga 1, 2 and 3) were observed for the length, pattern and orientation. For the assessment of pattern and orientation, the rugae were classified according to the method described by Hauser et al.[5]

Data were analyzed using SPSS for Windows (version 20.0, SPSS Inc. Chicago). The Shapiro Wilk test was applied to test the normality of data, which showed a non-normal distribution; hence non-parametric test was applied. The Mann-Whitney U test was applied to compare the study parameters between genders. Descriptive statistics for the palatal rugae lengths, i.e. means and standard deviations (SD), were calculated. The Kruskal-Wallis test was used to compare the mean differences in the palatal rugae number and length among the four malocclusion groups.

The pattern and orientation were compared across the four groups using the Chi-square test. To rule out any error in measurement, 30 dental casts were reevaluated by the main investigator using intraclass correlation coefficient for quantitative variables and Kappa statistics for the qualitative variables. A p-value $\leq$ 0.05 was considered as statistically significant.

RESULTS

The measurement error was evaluated and the results showed fair to excellent agreement between the two sets of reading in the assessment of rugae number and length, whereas pattern and orientation assessment showed moderate to excellent agreement (Tables 1 and 2).

The comparison between sexes, regarding number of palatal rugae, and length, pattern and orientation of primary rugae, showed insignificant differences; therefore, further statistical analyses were not performed separately. Statistically significant differences were found in the number of rugae among malocclusion groups (Table 3).

The mean lengths of the primary rugae are shown in Table 4. There were significant differences in mean lengths among the groups in ruga 1 on left side ($p < 0.001$) and rugae 3 on both right ($p = 0.03$) and left ($p < 0.001$) sides. Curved pattern

was predominant and significant differences were found among the groups ($p < 0.05$); however, the results did not show any specific pattern peculiar to any malocclusion type. The distribution of different rugae pattern is shown in Table 5.

There was no significant differences for the orientation among the groups on right side; however, left side showed significant differences for the ruga 1 ($p = 0.001$), ruga 2 ($p = 0.004$) and ruga 3 ($p = 0.013$). The distribution of orientation of the rugae among the malocclusion groups is shown in Table 6.

DISCUSSION

Palatal rugae characteristics are distinctive to each person. Discrepancies can be observed between genders, although conflicting findings are evident in the literature across different demographics. While certain research has indicated minimal sexual dimorphism in rugae patterns, other studies have highlighted notable distinctions among males, females, and transgender individuals.[2,22-25]

However, the current investigation revealed no notable disparities between the male and female cohorts in terms of the quantity of palatal rugae, as well as the length, pattern, and orientation of primary palatal rugae. The dissimilarities observed in the outcomes might be attributed to ethnic diversity. Moreover, the average count of primary rugae in this study closely aligned with the findings of previous research, indicating a consistency of approximately three rugae.[6,26]

The mean number of palatal rugae was observed to be greatest in Class I subjects, and the mean lengths of primary rugae were found to be comparable among the four malocclusion groups. In contrast, Kapoor et al [6] reported the highest number of palatal rugae in Class II division 2 group and shorter length of first, second and third rugae in Class II division 1, as compared to Class I group, in an Indian population. However they conducted a pilot study and the subjects were not evenly distributed in the malocclusion groups, whereas the present study was conducted on an adequate sample with comparable number of subjects in each group.

The role of palatal rugae in mastication, deglutition and speech has been reported in literature. [9,10] Lysell [8] reported that the dorsal surface of tongue is an important determinant of rugae pattern. Tongue position may vary with type of malocclusion 27; therefore, the pattern of rugae is expected to vary in different malocclusion classes. In Class II malocclusion, the tip of tongue is positioned more posterior, and dorsal portion is postured more superiorly, as compared to skeletal Class I malocclusion. [28]

Furthermore, individuals with Class III malocclusion exhibited a notably lower tongue posture in posterior regions compared to those with Class I malocclusion. The study findings also revealed significant variations in the primary rugae pattern among the different groups. However, it is worth noting that Kapoor et al.[6] reported conflicting results, potentially attributed to the limited sample size in their study, which hindered the detection of such differences.[29]

There have been reports indicating a significant genetic predisposition in the quantity, configuration, and alignment of palatal rugae.29-35 Studies have shown that the orientation of the main palatal rugae exhibits notable variations on the left side, and the initial primary rugae are more commonly directed towards the posterior in individuals belonging to the Class II division 2 groups. Previous study reported insignificant differences in the orientation of primary palatal rugae.[7] The conflicting

outcomes may have arisen from the asymmetrical nature of rugae and the limited understanding of their development and formation mechanisms.[30-35] These findings indicate a potential interconnection between the developments of various structures within the orofacial complex, possibly influenced by comparable epigenetic changes affecting their characteristics. Delving deeper into genetic variances at the molecular level could serve as the definitive method to confirm this correlation.

CONCLUSIONS

The present research discovered a correlation between the capacity of palatal rugae and the configuration of primary rugae with the Angle's classes of malocclusion. Nevertheless, the length and orientation of the primary palatal rugae exhibited diverse outcomes.

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Table 1:- evaluation of the reliability of measurements

	Palatal Rugae	Mean ± SD			Intraclass Correlation Coefficient
		Engle	First Reading	Second Reading	
Rugae Numbers	Primary	Right	4.27 ± 9.8	4.13 ± 1.1	0.8
		Left	4.50 ± 1.1	4.63 ± 1.2	0.7
	Secondary	Right	1.27 ± 9.4	1.60 ± 1.0	0.7
		Left	1.13 ± 1.0	1.33 ± 0.9	0.7
	Fragmentary	Right	0.43 ± 0.6	0.93 ± 0.8	0.6
		Left	0.50 ± 0.8	0.90 ± 0.9	0.6
Rugae Primary Lenth (mm)	First	Right	8.51 ± 1.2	8.69 ± 1.4	0.8
		Left	8.20 ± 1.4	8.19 ± 2.0	0.8
	Second	Right	8.44 ± 2.0	8.77 ± 2.0	0.8
		Left	8.82 ± 1.9	8.99 ± 2.3	0.8
	Third	Right	10.14 ± 2.5	10.06 ± 2.5	0.8
		Left	9.17 ± 2.5	9.31 ± 2.4	0.8

Table 2:- Evaluation of the reliability of measurements.

	Palatal Rugae	R/L	P-Value
Primary Rugae Pattern	First	Right	0.00
		Left	0.00
	Second	Right	0.00
		Left	0.00
	Third	Right	0.00
		Left	0.00
Primary Rugae Orientation	First	Right	0.00
		Left	0.00
	Second	Right	0.00
		Left	0.00
	Third	Right	0.00
		Left	0.00

Table No 3- Mean No. of palatal rugae among malocclusion groups.

No. of Rugae		Molar Class				P-Value
		Engle	Class I	Class II/1	Class II/2	
Rugae Numbers	Primary	Right	4.33 ± 1.0	3.87 ± 1.0	4.02 ± 0.7	0.5
		Left	4.37 ± 1.0	3.71 ± 0.6	4.06 ± 0.8	0.001
	Secondary	Right	1.07 ± 0.9	1.26 ± 0.8	0.07 ± 0.9	0.001
		Left	1.21 ± 0.8	1.28 ± 0.8	0.87 ± 1.0	0.002
	Fragmentary	Right	0.29 ± 0.6	0.45 ± 0.8	0.57 ± 1.0	0.001
		Left	0.45 ± 0.7	0.55 ± 0.9	0.68 ± 1.0	0.002

Table No 4- Mean lengths of palatal rugae among malocclusion groups.

No. of Rugae	Molar Class			
	Engle	Class I	Class II/1	Class II/2
Primary	Right	8.64 ± 1.3	8.27 ± 1.5	8.58 ± 1.1
	Left	8.35 ± 1.7	7.69 ± 2.1	8.99 ± 1.3
Secondary	Right	9.06 ± 1.8	9.36 ± 2.1	9.70 ± 2.6
	Left	9.06 ± 1.2	8.33 ± 2.2	9.71 ± 2.7
Fragmentary	Right	9.64 ± 2.7	11.00 ± 1.3	11.64 ± 2.3
	Left	9.64 ± 2.3	9.99 ± 1.9	12.00 ± 2.6

Table 5 - Comparison of pattern of primary palatal rugae among malocclusion groups.

Primary Rugae			Molar Class			
			Class 1	Class2/1	Class 2/2	Class 3
1st	Right	Curved	28	29	20	27
		Straight	21	12	9	18
		Wavy	2	0	0	0
		Irregular	0	0	0	0
		Forking	11	18	20	12
		Island	0	0	0	8
	Left	Curved	29	29	27	21
		Straight	18	9	9	19
		Wavy	0	0	0	0
		Irregular	0	0	0	0
		Forking	11	19	25	20
		Island	2	0	0	8
2nd	Right	Curved	45	31	38	28
		Straight	8	11	11	9
		Wavy	0	4	14	12
		Irregular	0	0	0	0
		Forking	0	19	14	21
		Island	0	0	0	0
	Left	Curved	35	29	45	41
		Straight	19	14	8	9
		Wavy	12	8	8	9
		Irregular	0	0	0	0
		Forking	0	18	8	8
		Island	0	0	0	0
3rd	Right	Curved	42	45	49	36
		Straight	12	6	0	8
		Wavy	9	4	9	4
		Irregular	0	0	0	0
		Forking	0	14	10	19
		Island	0	0	0	0
	Left	Curved	35	45	45	35
		Straight	15	2	9	7
		Wavy	20	4	10	12
		Irregular	0	0	0	0
		Forking	2	8	0	4
		Island	0	0	0	0

Table No. 6 Orientation of Promary Palatal Rugae Malocclusion Group Comparison

Primary Rugae			Molar Class				
			Class 1	Class2/1	Class 2/2	Class 3	P-Value
1st	Right	Posteriorly directed	28	29	41	39	0.15
		Horizontal	6	10	7	7	
		Anteriorly directed	19	15	8	15	
	Left	Posteriorly directed	20	38	51	39	0.001
		Horizontal	19	5	4	12	
		Anteriorly directed	16	20	6	6	
2nd	Right	Posteriorly directed	14	18	18	21	0.11
		Horizontal	18	10	14	4	
		Anteriorly directed	35	28	28	32	
	Left	Posteriorly directed	30	21	31	35	0.004
		Horizontal	20	10	12	12	
		Anteriorly directed	30	29	16	18	
3rd	Right	Posteriorly directed	18	20	25	15	0.15
		Horizontal	4	2	0	2	
		Anteriorly directed	41	39	31	38	
	Left	Posteriorly directed	21	29	39	41	0.013
		Horizontal	16	6	14	6	
		Anteriorly directed	38	40	28	28	