IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 21, Issue 12 Ser.1 (December. 2022), PP 59-68
www.iosrjournals.org

Assessment of relationship between palatal rugae pattern and dental malocclusion

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Abstract:
Background*: Early diagnosis may provide an advantage of preventive or interceptive treatment that may reduce disease burden and treatment duration. Since, the palatal rugae are stable structures and follow common signaling pathway during craniofacial development, its association with Angle's classes of malocclusion can be helpful for the prediction of forthcoming dentoskeletal aberrations. There were only few studies available describing association of palatal rugae with various malocclusions traits. The studies comparing Angle`s classes of malocclusion and palatal rugae characteristics were rare in Kerala population.*
Aim &objective*: Primary objective of the study was to compare pattern of palatal rugae among different Angle`s classes of malocclusion. Secondary objective was to compare the length of palatal rugae among different Angle`s classes of malocclusion.*
Materials and Methods*: 120 pretreatment cast were selected from records of patients who presented to the department of orthodontics in PSM Dental College. The sample consisted of pretreatment casts of both sex, between the age group of 12-30 years. According to Angle's class I, class II, class III malocclusion, 40 casts each fulfilling the inclusion criteria were considered. Dental stone models (white orthodontic stone, ISO type 3) were derived from the alginate impressions of upper and lower dental arches of subjects. The palatal rugae were outlined with a sharp HB pencil of 0.5mm size. The most medial and distal ends of the palatal rugae were marked on dental cast and linear distances were measured using digital vernier calipers (ISC Aerospace Digimatic Digital Caliper, 0- 150mm). The pattern of palatal rugae was assessed visually. The length and pattern of three anterior-most primary rugae (labelled as ruga 1, 2 and 3) were observed. For the assessment of pattern the rugae were classified according to the method described by Hauser et al. The pattern was compared across the three groups using the Chi-square test. The mean differences in the palatal rugae length between the three groups were compared with the ANOVA test.*
Results*: The current study showed that the first primary rugae on both sides is longest in Class III malocclusion group, the second primary rugae on left side is longest in Class II group and the third primary rugae on left side is longest in Class III group. Irregular pattern was observed more in Class I malocclusion group in first rugae on right and left sides and second rugae on right and left sides. Forking pattern was observed more in Class II malocclusion group in first and second rugae on right side and third rugae in both sides. Wavy pattern was observed more in Class III group in first rugae on both sides and in second pattern on left side.*
Conclusion: *Palatal rugae length has definite co-relation with Class II and Class III malocclusion. Palatal rugae pattern has definite co-relation with all three Angles classes of malocclusion. Thus the study showed that the palatal rugae characteristics can be used to differentiate the different Angle's classes of malocclusion.*
Key Word*: Rugoscopy; Palatal rugae; Angle`s classes of malocclusion.*

Date of Submission: 25-11-2022 Date of Acceptance: 08-12-2022

I. Introduction

Palatal rugae (PR) or transverse palatine folds are asymmetrical and irregular elevations of the mucosa located in the anterior third of the palate, made from the lateral membrane of the incisive papilla, arranged in transverse direction from palatine raphe located in the midsagittal plane.[1] Palatal rugae appear during the third month of intrauterine life and occupy most of the length of palatal shelves. They are unique structures that are inalterable in their position and pattern throughout the life of an individual. This gives them a special role in

forensic dentistry, having potential implications in the process of human identification. They form a series of anatomical folds on the anterior part of the palatal mucosa, behind the incisive papilla on each side of the median palatal raphe. The number of palatal rugae varies from 4 to 6 on each side. Their growth and development is controlled by the complex interaction between epithelial and mesenchymal cells which is inturn controlled by the group of homeobox genes. Studies have proved that the position of the dorsal surface of the tongue plays a vital role in the developmental stage of the palatal rugae. The tongue position in turn varies with different types of malocclusion. The pattern, length, orientation and number of palatal rugae has correlation with various dental malocclusions.[2]

For the assessment of pattern and orientation, the rugae can be classified according to the method described by Hauser et al[3]. Orientation or direction of palatal rugae are classified as:

a. Posteriorly directed rugae (associated with negative angles)
b. Horizontal/perpendicular rugae (associated with angles of zero degrees)
c. Anteriorly directed rugae (associated with positive angle).

Shape/Pattern of palatal rugae are divided as:

a. Curved (has a simple crescent shape which curves gently)
b. Straight (run straight directly from their origin to termination)
c. Wavy (if there is a slight curve at the origin or termination of curved rugae)
d. Forking (unification occurs when two rugae are joined at their origin or termination).
e. Irregular (broken, irregular pattern of rugae)
f. Island (rugae displaying continuous ring formation at the termination)

Based on length, according to Lysell the rugae can be categorized as :

a. Primary (5 mm or more)
b. Secondary (3 – 5 mm)
c. Fragmentary type (< 3 mm).[4]

According to Hauser, strength of palatal rugae can be classified on the basis of thickness of first, second and third primary rugae as:

a. Strong
b. Medium
c. Weak.[4]

The palatine rugae have importance in dentistry not only because of their typical pattern of orientation but also because of their usefulness as a reference landmark in various dental treatment modalities. As they are a stable landmark, the palatine rugae also can play a significant role in clinical dentistry. In addition, clinicians can use the palatine rugae to assess the amount of anteroposterior tooth movement, because they remain stable during a person's life.[5]

The orientation pattern of rugae is formed by about 12th to 14th week of prenatal life and remains stable until the oral mucosa degenerates after death. The prominence of palatal rugae diminishes from prenatal period to adolescence but the shape remains unaltered. Although, some habits like finger sucking or persistent pressure from orthodontic treatment or dentures and orthodontic extractions may bring about local changes in palatal rugae, the stability in shape of rugae has been routinely exploited for dental cast superimposition to monitor tooth movement in orthodontics. Besides, an appreciable hereditary component of palatal rugae has also been suggested in various twin and family studies, but this varies in extent and characteristics in different investigations.[4] There is a significant constriction of the palatal rugae in class II div 1 individuals as compared to class I individuals, for the same intermolar widths.[6] There is difference in ruga in normal and oligodontia cases due to shared pathways of development of rugae and teeth.[7] The stability and hereditary inclination exhibited by palatal rugae leds to formulation of hypothesis that various occlusal characteristics that display a strong genetic basis may display a correlation with rugae. This in turn may serve as a diagnostic appurtenance for malocclusions very early in life and aid in preventive or interceptive measures to alleviate forthcoming dento-skeletal aberrations.[4] The palatal rugae are stable structures and follow common signaling pathway during craniofacial development, its association with Angle's classes of malocclusion can be helpful for the prediction of forthcoming dentoskeletal aberrations. Establishing a co-relation between palatal rugae characteristics, including number, length, pattern and orientation with Angle`s classes of malocclusion helps to intercept the malocclusion long before it is established in the oral cavity.

II. Material And Methods

Palatal rugae form a series of anatomical folds on the anterior part of the palatal mucosa, behind the incisive papilla on each side of the median palatal raphe. The number of palatal rugae varies from 4 to 6 on each side. The pattern, length, orientation and number of palatal rugae which has correlation with various dental malocclusions were assessed in this study.

Study design: cross sectional study.
Study Location: Kerala
Sample size: 120
Sample Size Calculation:
Simple random sampling was used to select dental casts in each Angle's classes of malocclusion (class I, class II, class III). Sampling was done using SPSS Software.
The sample size was calculated using the formula :

$$n = \frac{(Z\alpha+Z\beta)^2 pq \times 2}{d^2}$$

Where $Z\alpha = 1.96$
$Z\beta = 0.84$
p = % of forking pattern
q = 100 - p
d = effect size
SD = Standard deviation
As per the study by Farheen Fatima et al[1], the standard deviation (SD) of forking pattern of palatal rugae is 25. To detect a difference of d = 25, the sample size required was

$$n = \frac{(1.96+0.84)^2 \times 25 \times 80 \times 2}{25^2} = 40$$

Therefore, 40 specimens from each Angle's classes malocclusion (Class I, Class II, Class III) were considered for the study. So overall 120 samples were evaluated.
Subjects & Selection Method: 120 pretreatment casts were selected from records of patients who presented to the department of orthodontics in PSM Dental College. The sample consisted of pretreatment casts of both sex, between the age group of 12-30 years. According to Angle's class I, class II, class III malocclusion, 40 casts each fulfilling the inclusion criteria were considered.
Inclusion Criteria:
1) Age range of 12-30 years
2) Permanent dentition with fully erupted 1st molars
3) Well-established molar and incisor relationships
Exclusion Criteria:
1. History of previous orthodontic or prosthodontic treatment, maxillofacial or plastic surgery.
2. Individuals having any facial asymmetry
3. Craniofacial trauma
4. Congenital anomalies
5. Missing, grossly decayed or impacted teeth
6. Mixed dentition.

Procedure Methodology

Dental stone models (white orthodontic stone, ISO type 3) were derived from the alginate impressions of upper and lower dental arches of subjects. The palatal rugae were outlined with a sharp HB pencil of 0.5mm size (Figure 1). The most medial and distal ends of the palatal rugae were marked on dental cast and linear distances were measured using digital vernier calipers (ISC Aerospace Digimatic Digital Caliper, 0- 150mm) (Figure 2).

All information collected from the subject was strictly confidential. An informed consent was obtained from all participants. Socio - demographic data and measurements were collected from the subjects of the study and study models respectively. (Figure 3).

Measurements:
Based on length, the rugae were categorized as :
1) Primary (5mm or more)
2) Secondary (3–5 mm)
3) Fragmentary type (<3mm).
The length and pattern of three anterior-most primary rugae (labelled as ruga 1, 2 and 3) were observed.[2] For the assessment of pattern, the rugae were classified according to the method described by Hauser et al[3] (Figure 4).

Statistical Analysis:
Quantitative variables were summarised as mean/standard deviation. Descriptive statistics for the palatal rugae lengths, i.e. means and standard deviations (SD), were calculated. The pattern was compared across the three groups using the Chi-square test. The mean differences in the palatal rugae length between the three groups

were compared with the ANOVA test. Comparison of pattern of rugae was done with Chi-square test. A p-value ≤ 0.05 was considered as statistically significant.

Figure 1: Outlining Palatal Rugae

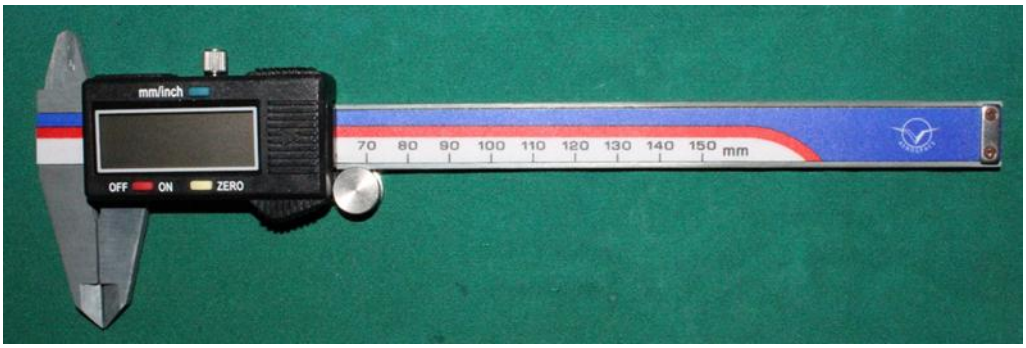

Figure 2: Vernier caliper

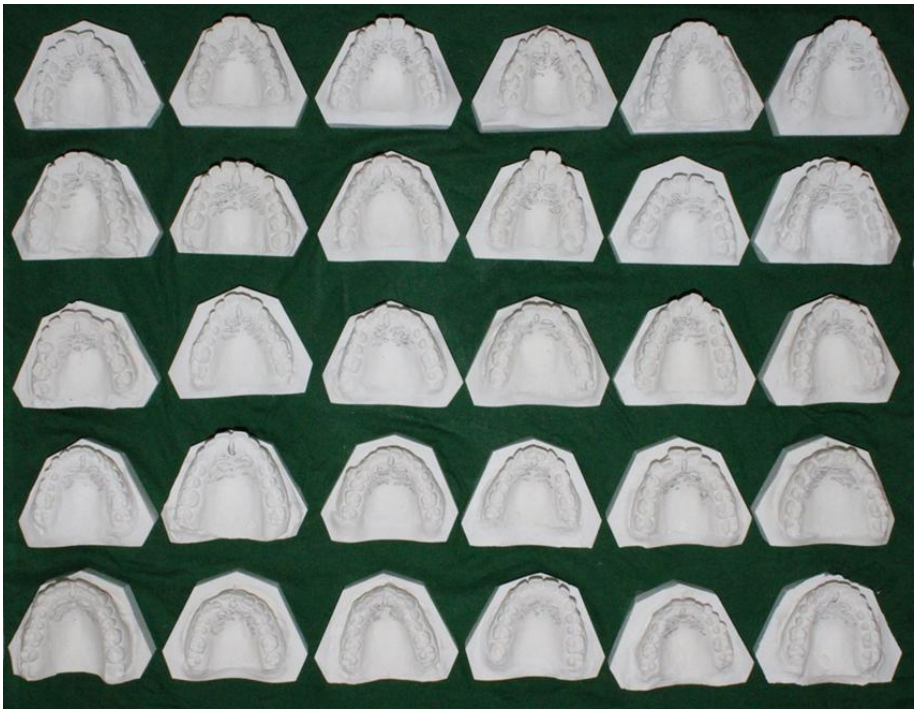

Figure 3: Study Models

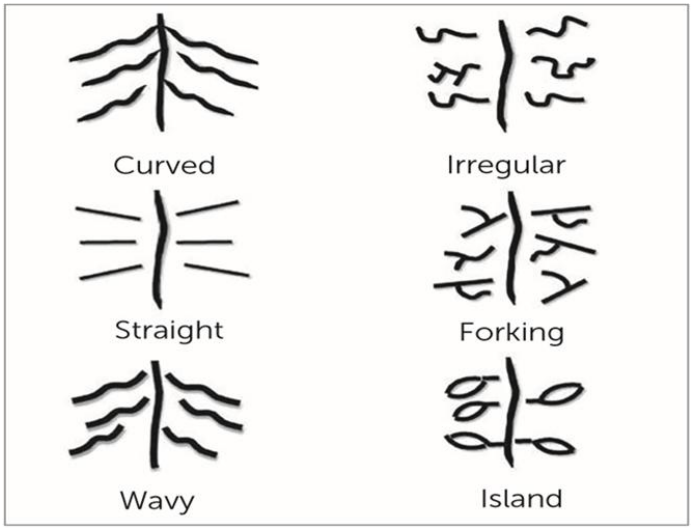

Figure 4: Rugae Pattern

III. Result

This study was done to investigate whether an association exists between morphological features of palatal rugae and Angle's classes of malocclusion. The study compared the pattern of palatal rugae among different Angle`s classes of malocclusion and the mean lengths of primary palatal rugae among different Angle`s classes of malocclusion. Dental stone models (white orthodontic stone, ISO type 3) were derived from the alginate impressions of upper and lower dental arches of subjects.

The palatal rugae were outlined with a sharp HB pencil of 0.5mm size (Figure 1). The most medial and distal ends of the palatal rugae were marked on dental cast and linear distances were measured using digital vernier calipers (ISC Aerospace Digimatic Digital Caliper, 0- 150mm) (Figure 2). The pattern was assessed visually. The length and pattern of three anterior-most primary rugae (labelled as ruga 1, 2 and 3) were observed.

The values for different parameters have been tabulated. The results are expressed as mean and standard deviation. ANOVA was used to calculate any significant differences in length of rugae on right and left sides in different classes of malocclusion. Fisher's exact test was performed in order to calculate any significant differences in pattern of rugae on right and left sides in different classes of malocclusion. A p-value ≤ 0.05 was considered as statistically significant.

The mean age of the subjects was 20.71 + 3.894. Out of 120 subjects, 7.5% were of age <15 years, 40% of age 16-20, 47% of age 21-25 and 16% of age >26. The percentage of male and female subjects were 38.3 and 61.7 respectively. (Table 1, table 2, table 3)

The number of primary and fragmentary palatal rugae on both sides and secondary rugae on right side showed no significant difference among the malocclusion groups ($p>0.05$). The number of secondary rugae on left side showed significant difference among the malocclusion groups ($p<0.05$). The number of secondary rugae on left side is highest in Class II malocclusion and lowest in Class I malocclusion. (Table 4)

The primary first palatal rugae on right side, second rugae on left side showed highly significant difference in length among the malocclusion groups ($p= 0.0001$). The primary first and second rugae on left side showed significant difference in length among the malocclusion groups ($p<0.05$).The length of second and third primary rugae on right side showed no significant difference among the malocclusion groups ($p>0.05$). The number of secondary rugae on left side is highest in Class II malocclusion and lowest in Class I malocclusion. The first primary rugae on both sides is longest in Class III malocclusion group. The second primary rugae on left side is longest in Class II group. The third primary rugae on left side is longest in Class III group. (Table 5)

The pattern of palatal rugae was found to be significantly different among the malocclusion groups ($p < 0.05$) except the third primary rugae on left side. Curved pattern was predominant and island pattern was rare in all malocclusion groups. Irregular pattern was observed more in Class I malocclusion group in first rugae on right and left sides and second rugae on right and left sides. Forking pattern was observed more in Class II malocclusion group in first and second rugae on right side and third rugae in both sides. Wavy pattern was observed more in Class III group in first rugae on both sides and in second rugae on left side. (Table 6)

The orientation of palatal rugae was found to be significantly different among the malocclusion groups ($p < 0.05$) in the second and third primary rugae on left side. Anterior orientation was predominant and horizontal orientation was rare in all malocclusion groups. Anterior orientation was observed more in Class III

malocclusion group in second and third rugae left side. Horizontal orientation was not observed in Class III group. (Table 7)

This study was done to investigate whether an association exists between morphological features of palatal rugae and Angle's classes of malocclusion. The study compared the pattern of palatal rugae among different Angle`s classes of malocclusion, the mean number of palatal rugae among different Angle`s classes of malocclusion, orientation of primary palatal rugae among different Angle`s classes of malocclusion and the mean lengths of primary palatal rugae among different Angle`s classes of malocclusion. Dental stone models (white orthodontic stone, ISO type 3) were derived from the alginate impressions of upper and lower dental arches of subjects.

The palatal rugae were outlined with a sharp HB pencil of 0.5mm size (Figure 1). The most medial and distal ends of the palatal rugae were marked on dental cast and linear distances were measured using digital vernier calipers (ISC Aerospace Digimatic Digital Caliper, 0- 150mm) (Figure 2). The pattern, orientation and number of palatal rugae were assessed visually. The total number of rugae were recorded for both right and left sides. The length, pattern and orientation of three anterior-most primary rugae (labelled as ruga 1, 2 and 3) were observed.

The values for different parameters have been tabulated. The results are expressed as mean and standard deviation. ANOVA and Kruskal Wallis test were performed in order to calculate any significant differences in number of rugae on right and left sides in different classes of malocclusion. ANOVA was used to calculate any significant differences in length of rugae on right and left sides in different classes of malocclusion. Fisher's exact test was performed in order to calculate any significant differences in pattern of rugae on right and left sides in different classes of malocclusion. Chi square test and Fisher's exact test were performed in order to calculate any significant differences in orientation of rugae on right and left sides in different classes of malocclusion. A p-value ≤ 0.05 was considered as statistically significant.

The mean age of the subjects was 20.71 + 3.894. Out of 120 subjects, 7.5% were of age <15 years, 40% of age 16-20, 47% of age 21-25 and 16% of age >26. The percentage of male and female subjects were 38.3 and 61.7 respectively. (Table 1, table 2, table 3)

The primary first palatal rugae on right side, second rugae on left side showed highly significant difference in length among the malocclusion groups (p= 0.0001). The primary first and second rugae on left side showed significant difference in length among the malocclusion groups (p<0.05).The length of second and third primary rugae on right side showed no significant difference among the malocclusion groups (p>0.05). (Table 4, Table 5, Table 6)

The pattern of palatal rugae was found to be significantly different among the malocclusion groups (p < 0.05) except the third primary rugae on left side. Curved pattern was predominant and island pattern was rare in all malocclusion groups. Irregular pattern was observed more in Class I malocclusion group in first rugae on right and left sides and second rugae on right and left sides. Forking pattern was observed more in Class II malocclusion group in first and second rugae on right side and third rugae in both sides. Wavy pattern was observed more in Class III group in first rugae on both sides and in second rugae on left side. (Table 7, Table 8, table 9)

	Mean	Std. Deviation
Age	20.71	3.894

Table 1: Mean age

Age	Frequency	Percent
≤15	9	7.5
16-20	48	40.0
21-25	47	39.2
≥26	16	13.3
Total	120	100.0

Table 2: Age frequency

Sex	Frequency	Percent
Female	74	61.7
Male	46	38.3
Total	120	100.0

Table 3: Gender frequency

LENGTH OF 1ST PRIMARY	Angle Class	Mean	Std. Deviation	P value(ANOVA)
RIGHT	I	9.053	1.120	0.0001
	II	9.199	1.277	
	III	10.038	0.814	
LEFT	I	9.723	1.652	0.018
	II	9.214	1.387	

	III	10.314	2.005	

Table 4: Length of 1st primary rugae

LENGTH OF 2ND PRIMARY	Angle Class	Mean	Std. Deviation	P value(ANOVA)
RIGHT	I	8.842	2.319	0.153
	II	7.834	2.054	
	III	8.559	2.723	
LEFT	I	9.707	2.113	0.0001
	II	9.720	1.930	
	III	7.934	2.171	

Table 5: Length of 2nd primary rugae

LENGTH OF 3RD PRIMARY	Angle Class	Mean	Std. Deviation	P value(ANOVA)
RIGHT	I	10.105	3.241	0.719
	II	9.644	2.441	
	III	9.659	2.897	
LEFT	I	10.534	2.429	0.028
	II	9.605	2.098	
	III	11.113	2.935	

Table 6: Length of 3rd primary rugae

1ST PATTERN	PATTERN	ANGLE CLASS			TOTAL	P value (Fisher`s exact test)
		I	II	III		
RIGHT	C	29	26	24	79	0.002
	F	2	12	8	22	
	IR	4	0	0	4	
	IS	1	0	0	1	
	S	4	1	4	9	
	W	0	1	4	5	
LEFT	C	25	32	26	83	0.033
	F	11	4	4	19	
	IR	2	0	0	2	
	IS	0	1	0	1	
	S	1	1	4	6	
	W	1	2	6	9	

Table 7: Pattern of 1st primary rugae

2ND PATTERN	PATTERN	ANGLES CLASS			TOTAL	P value(fisher`s exact test
		I	II	III		
RIGHT	C	18	12	28	58	0.001
	F	2	4	0	6	
	IR	6	4	4	14	
	S	6	4	6	16	
	W	8	16	2	26	
LEFT	C	28	16	28	72	0.0001
	F	5	20	0	25	
	IR	2	0	0	2	
	S	3	2	8	13	
	W	2	2	4	8	

Table 8: Pattern of 2nd primary rugae

3RD PATTERN	PATTERN	ANGLE CLASS			TOTAL	P value (Fisher`s exact test)
		I	II	III		
RIGHT	C	23	28	28	79	0.001
	F	4	8	0	12	
	IR	3	4	2	9	
	IS	0	0	1	1	
	S	1	0	1	2	
	W	9	0	8	17	
LEFT	C	17	26	24	67	0.187
	F	5	1	4	10	
	IR	4	4	4	12	
	IS	1	1	0	2	
	S	3	0	0	3	
	W	10	8	8	26	

Table 9: Pattern of 3rd primary rugae

IV. Discussion

Palatal rugae are the ridges situated in the anterior part of the palatal mucosa on each side of the median palatal raphe and behind the incisive papilla. Goria[8] defined the rugae as the ridges that extend at least one-half the distance from the median palatal raphe to the dental arch. The palatal rugae appear toward the 3rd month of intrauterine life, from the covering connective tissue in the palatine process of maxillary bone. Its

development and growth is mutually controlled by epithelial–mesenchymal interactions. Specific extracellular matrix molecules are expressed at their specific sites during development. Once formed, they may experience changes in their size due to growth of the palate, but their shape is maintained. Physiologically, the palatal rugae are involved in swallowing and help to improve the relationship between food and the taste receptors in the dorsal surface of the tongue. They also participate in speech and in suction in children.

Malocclusion causes aesthetic concerns and functional impairment that may result in long term impact on the psychological health. An emphasis has been placed on the early diagnosis, as this may provide an advantage of preventive or interceptive treatment that may reduce disease burden and treatment duration. Since the palatal rugae are stable structures and follow common signaling pathway during craniofacial development, its association with Angle's classes of malocclusion can be helpful for the prediction of forthcoming dentoskeletal aberrations.

Fathima F[2] evaluated the association between the length of palatal rugae with the Angle's classes of malocclusion. There were significant differences in mean lengths among the groups in rugae on left side and third rugae on both right and left sides. The first rugae on left side and third rugae on right side is longest in Class II div 2 and shortest in class I. Third rugae on left side is longest in Class III and shortest in Class I. In the present study the primary first palatal rugae on right side, second rugae on left side showed highly significant difference in length among the malocclusion groups. The primary first and second rugae on left side showed significant difference in length among the malocclusion groups. The length of second and third primary rugae on right side showed no significant difference among the malocclusion groups. The first primary rugae on both sides is longest in Class III malocclusion group. The second primary rugae on left side is longest in Class II group. The third primary rugae on left side is longest in Class III group. The results of the current study contrasts with the study conducted by Fathima F[2].

Chandrasekhar Gandikota[6] showed significant difference in palatal rugae length in Angle's classes of malocclusion. The first palatal rugae were shorter in class II div 1 patients than in class I patients by 1.43 mm and this difference was statistically significant. The second palatal rugae were shorter in class II div 1 patients than in class I patients by 3.1 mm. The third palatal rugae were evidently shorter in class II div 1 patients than in class I patients by 4.24 mm. In the present study the primary first palatal rugae on right side, primary first and second rugae on left side showed highly significant difference in length among the malocclusion groups. The first primary rugae on both sides is longest in Class III malocclusion group. The second and third primary rugae on left side is longest in Class II and Class III group respectively.

Amy Moran[7] compared palatal rugae length in a study in individuals with oligodontia and normal individuals. There was no significant difference in the mean length of rugae between the affected and unaffected subjects. The palatal rugae length difference in individuals with missing teeth were not evaluated in the present study as the condition may alter the palatal rugae characteristics in such individuals.

Lysell[9] reported that the dorsal surface of tongue is an important determinant of rugae pattern. Tongue position may vary with type of malocclusion; therefore, the pattern of rugae is expected to vary in different malocclusion classes. In Class II malocclusion, the tip of tongue is positioned more posteriorly, and dorsal portion is postured more superiorly, as compared to skeletal Class I malocclusion. Moreover, the tongue posture in posterior regions was found to be significantly lower in subjects with Class III malocclusion, as compared to Class I subjects.

Jasmina Primozic[10] showed that skeletal Class III subjects have a significantly lower tongue posture as compared to Class I subjects. The lower tongue posture has also been associated with greater values of the parameters (surface area and volume) describing the mandibular alveolar morphology, while the transverse widths of the dental arches appear not to be influenced. Fatih Yilmaz[11] showed that the dentofacial morphology affects the position and movements of the tongue during deglutition, and adaptive changes occur in the tip, dorsum, and root of the tongue. Deglutitive tongue movements in patients with a skeletal Class II relationship are different from those with a skeletal Class I relationship.

The association of food and taste receptors in the dorsal surface of tongue has been considered responsible for particular configurations and prominence of rugae. And as tongue posture is variant in Class II and Class III patients, it was expected to influence the palatal rugae pattern in different categories of malocclusion. In Class II malocclusion groups, contact of anterior portion of the tongue with rugae area of hard palate has been shown to be decreased as compared to the control group. While in Class III malocclusion, tongue-to-palate distances were found to be generally greater and tongue posture lower as compared to controls. The variability of tongue posture was not evaluated in the present study.

The study conducted by Fathima F[2] showed that curved pattern was predominant and significant differences were found among the groups. However, the results did not show any specific pattern peculiar to any malocclusion type. The present study showed that the pattern of palatal rugae was found to be significantly different among the malocclusion groups, except the third primary rugae on left side. Curved pattern was predominant and island pattern was rare in all malocclusion groups. Irregular pattern was observed more in

Class I malocclusion group in first rugae on right and left sides and second rugae on right and left sides. Forking pattern was observed more in Class II malocclusion group in first and second rugae on right side and third rugae in both sides. Wavy pattern was observed more in Class III group in first rugae on both sides and in second rugae pattern on left side.

Priyanka Kapoor[4] in an in vitro pilot study on relation of palatal rugae pattern with Angle`s classes of malocclusion revealed that no particular pattern for a particular malocclusion. Curved pattern was the most predominant and irregular pattern was the least observed. However, the most predominant pattern for first, second and third primary rugae was curved with forking-diverging, being most common in first primary rugae of left side in Class I and Class III malocclusions. The present study showed that the pattern of palatal rugae was found to be significantly different among the malocclusion groups, except the third primary rugae on left side. Curved pattern was predominant and island pattern was rare in all malocclusion groups. Irregular pattern was observed more in Class I malocclusion group in first rugae on right and left sides and second rugae on right and left sides. Forking pattern was observed more in Class II malocclusion group in first and second rugae on right side and third rugae in both sides. Wavy pattern was observed more in Class III group in first rugae on both sides and in second pattern on left side.

In a study Crystal Runa Soans[12] in an in vitro study to evaluate the structural morphology of palatal rugae in Kerala orthodontic subjects with varying sagittal skeletal malocclusions (Class I, Class II, Class III) showed that Wavy and curved types were the most common types of rugae pattern in all skeletal dysplasia groups followed by straight pattern. Skeletal Class III had the highest number of straight rugae among the three groups which was statistically significant. Skeletal Class III had the highest number of straight rugae among the three groups which was statistically significant. The present study showed that curved pattern was predominant and island pattern was rare in all malocclusion groups. Palatal rugae pattern difference in skeletal classes were not compared in the present study.

The study conducted by Amy Moran et al[7] compared palatal rugae number in individuals with oligodontia and normal individuals. There were no significant differences between the samples for right-sided rugae; however, on the left side, there was a statistically significant difference between the samples in shape frequency associated with second palatal rugae. Specifically, a curved shape was identified more frequently in second palatal rugae of the oligodontia group. In addition, a wavy shape was more frequently associated with left third palatal rugae in the control group, although this only approached significance. The palatal rugae pattern difference in individuals with missing teeth are not evaluated in the present study as this may alter the palatal rugae characteristics in such individuals.

In a study Ekrem Oral[13] showed that wavy and curved types were the most common types of rugae pattern in all groups (Class I, Class II, Class III). Aparna Paliwal[14] showed in the study that straight rugae pattern on the right side of the palate in the male subjects was found to be significantly predominant in the Madhya Pradesh population, whereas wavy shape was predominant in Keralites. In the present study curved pattern was predominant and island pattern was rare in all malocclusion groups. Irregular pattern was observed more in Class I malocclusion group in first rugae on right and left sides and second rugae on right and left sides. Forking pattern was observed more in Class II malocclusion group in first and second rugae on right side and third rugae in both sides. Wavy pattern was observed more in Class III group in first rugae on both sides and in second pattern on left side.

Comparative studies performed amongst geographically diverse populations belonging to Indian regions such as Karnataka and Kerala and Manipur and Kerala, have demonstrated important differences in rugae pattern. Savita[15] compared two groups of Indian population (Kerala and Karnataka) showed that the predominant palatal rugae pattern in both populations are curved and straight. A study conducted by R Surekha[16] comparing two groups of Indian population (southern Indians and western Indians) predominantly showed the prevalence of wavy and curved rugae forms followed by straight rugae pattern. In the present study only Kerala population was considered for evaluation.

V. Conclusion

The study was conducted primarily to compare pattern of palatal rugae among different Angle`s classes of malocclusion. Secondary objectives were to compare the number, length and orientation of palatal rugae among different Angle`s classes of malocclusion. The first primary rugae on both sides is longest in Class III malocclusion group. The second primary rugae on left side is longest in Class II group. The third primary rugae on left side is longest in Class III group. Irregular pattern was observed more in Class I malocclusion group in first rugae on right and left sides and second rugae on right and left sides. Forking pattern was observed more in Class II malocclusion group in first and second rugae on right side and third rugae in both sides. Wavy pattern was observed more in Class III group in first rugae on both sides and in second pattern on left side. The current study showed Palatal rugae length has definite co-relation with Class II and Class III malocclusion. Palatal rugae pattern has definite co-relation with all three Angles classes of malocclusion.

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Dr. Lijo K jose, et. al. "Assessment of relationship between palatal rugae pattern and dental malocclusion." *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, 21(12), 2022, pp. 59-68.