

Original Research Article

Posterior extension of palatal rugae as an anatomical limitation for donor soft tissue grafts in a population of western India

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ABSTRACT

Background: Palatal soft tissue graft is a common approach for plastic surgery for oral and periodontal soft tissue augmentation procedures. If the palatal rugae are harvested within a soft tissue graft, they could cause a persistent aesthetic issue. The purpose of this study was to investigate the posterior extension of the palatal rugae bilaterally and its proximity towards the tooth among the population of western India.

Methods: 202 Maxillary dental casts from Gujarat with an age range of 20-30 years were examined. The most posterior extension of the bilateral rugae was determined by a standardized periodontal probe. Also, preferred site for soft tissue harvest was subdivided into four regions of interest and the rugae proximity towards tooth was measured.

Results: Total 154 (76.23%) and 147 (72.77%) subjects had their palatal rugae extension beyond the mesial end of the maxillary second premolar on the right and left side, respectively. There was no statistically significant association ($p>0.05$) between the posterior extension of palatal rugae and other factors such as age, gender and palatal shape. In the four regions examined, the distance from the terminal end of rugae to the gingival margin was greater on the right side compared to the left; however, this difference was not statistically significant.

Conclusions: Despite a greater percentage of palatal rugae extending beyond the mesial end of the maxillary second premolar on the right side, the rugae proximity towards tooth was less compared to the left side.

Keywords: Palatal rugae, Periodontal plastic surgery, Soft tissue autograft

INTRODUCTION

In implant and periodontal plastic surgery, soft tissue grafts play a vital role in enhancing tissue volume.¹ This approach helps in improving the dimensions of gingival tissues in the apicocoronal and buccolingual directions.² Soft tissue augmentation procedures also address the lack of keratinized tissue width and treat gingival recession.¹ These procedures commonly require the use of free gingival grafts, subepithelial connective tissue grafts, and de-epithelialized free gingival grafts, which are typically harvested from patient's own masticatory mucosa. The primary donor sites from which grafts are harvested include the hard palate and maxillary tuberosity. Among

these, the keratinized mucosa located palatal to the maxillary premolars is generally the preferred area for graft procurement.³ Notably, the posterior boundary of the palatal rugae is an important anatomic landmark, as it defines the anterior limit for graft harvesting from the hard palate during mucogingival surgical procedures.² Understanding the posterior extent of the palatal rugae is crucial for making surgical decisions.

Typically, there are three to six palatine rugae on each side, flanking the mid-palatine raphe, and located in the anterior portion of the palate, just behind the incisive papilla.^{4,5} From birth, the orientation and pattern of the palatine rugae are unique to each individual. Over time,

these patterns become more defined and remain stable throughout life. Fragmented rugae are commonly found, especially in the posterior region. The size, shape, length, width, prominence, number, and orientation of palatine rugae can vary significantly between individuals. In general, there is no bilateral symmetry in the rugae pattern.⁴

Research indicates a notable association between rugae forms and ethnic backgrounds.^{4,6-8} Various characteristics of rugae, such as their length, form, orientation, shape, and pattern of unification, display a substantial correlation with ethnicity.⁴ However, very few studies were conducted showing the impact of posterior extension of rugae on harvesting a palatal soft tissue graft.^{9,10} To the best of our knowledge, no existing evidence is available among the population in Gujarat state of Western India. Hence, this study aimed to investigate the bilateral posterior extension of the rugae and their proximity to teeth in the population of Gujarat state in western India. Furthermore, the study examined the association between the proximity of rugae and variables such as age, gender, and palatal vault form that could influence the surgical decision.

METHODS

Study design and participants

The cross-sectional study was conducted for a period of 6 months from May, 2024 to October, 2024 at Government Dental College and Hospital, Ahmedabad (GDCHA, Gujarat, India).

The study was approved by the Ethical Committee of Government Dental college and Hospital, Ahmedabad (IEC GDCH/ PER.7 /2023). A total of 202 maxillary dental casts from the department of periodontology and department of orthodontics, GDCHA were included in the study.

Maxillary dental casts of known age between 20-30 years which had full maxillary dentition (except for third molars) were included.

Exclusion criteria included (i) any developmental anomaly or any pathology of the palate, (ii) malposition or misalignment of the maxillary posterior teeth (iii) missing premolars and molars.

Data collection

The data was collected by a single examiner (TB). The investigator was trained and calibrated in the department of periodontology, GDCHA before collecting the data. Each maxillary model was numbered for identification. Outlines of the palatine rugae from the origin (near mid palatine raphe) to the terminal end were highlighted with a graphite pencil on the model with the aid of a magnification lens.

Extracting details of palatal rugae and vault form

A standardized probe (UNC-15) was used to evaluate the posterior extent of palatal rugae in relation to teeth on both right and left side of the model. The probe was placed on the line angles and mid palatal line of the tooth to analyse the posterior extent of rugae (Figure 1).



Figure 1: Evaluation of the posterior extent of rugae.



Figure 2: Determining the angle of palatal vault.

Palatal vault form was determined by measuring the angle of vault using 23-gauge wire adapted onto palate (Figure 2). The angle of different palatal vault was classified as class I- high arch or steep, class II- medium, class III- low arch or flat.¹¹

Analyzing the soft tissue donor site

To assess the rugae proximity towards tooth, a segmentation method was applied. The region palatal to maxillary premolars and molars was divided into four regions of interest (ROI). Distance between terminal end of rugae and gingival margin of tooth was measured in each ROI using divider and calibrated scale (Figure 3).

Subdivided regions of interest (ROI) (Figure 4)

ROI 1- palatal region of 1st premolar (between the mesiodistal line angles of 1st premolar).

ROI 2- palatal region of 2nd premolar (between the mesiodistal line angles of 2nd premolar).

ROI 3- palatal region of 1st molar (between the mesiodistal line angles of 1st molar).

ROI 4- palatal region of 2nd molar (between the mesiodistal line angles of 2nd molar).



Figure 3: Measuring the distance between terminal end of rugae and gingival margin of tooth.

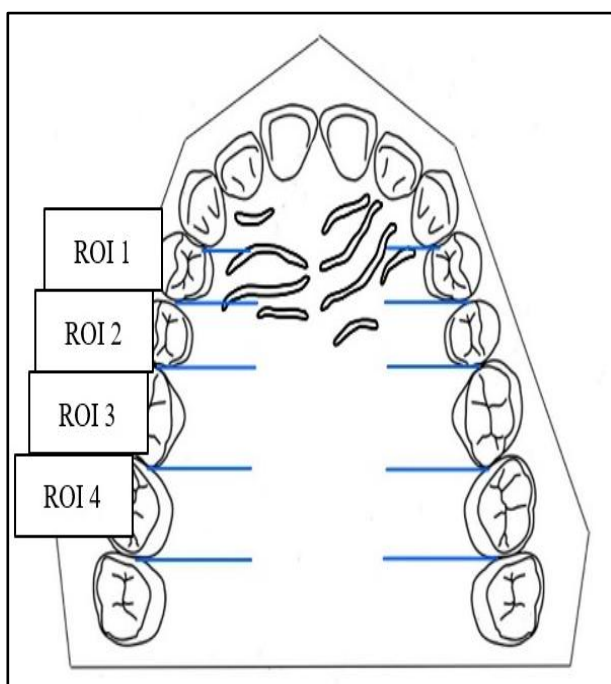


Figure 4: Subdivided regions of interest (ROI).

Statistical analysis

After collection of data, the data were coded and entered in Microsoft Excel 2019. The descriptive analysis of data includes proportions, mean, and standard deviation. The proportions were compared by using Fisher's exact test and continuity correction. Mean difference was compared by using unpaired t test and one-way ANOVA test.

Pair wise mean comparison was done by using paired t test. The "rugae extension beyond the mesial end of the maxillary 2nd premolar" was the "success" category. The proportion of subjects with rugae extensions beyond the mesial end of the 2nd premolar was estimated on both right and left sides using the normal approximation test with a 95% confidence interval (CI).

Multivariate logistic regression was done to determine the odds ratio for proximal to the mesial (success) 2nd premolar as dependent variable while age groups, gender and palatal vault form as independent variables. Statistical Package for Social Science (SPSS version 23, IBM cooperation) was used for all analyses. A p value less than 0.05 was considered as statistically significant.

RESULTS

There was total 108 (53.47%) casts of female subjects out of 202 subjects. Most of the casts belonged to <25 years of age group with mean age of 23.87±2.77 years. The high palatal vault form was the most predominant type (60.89%) followed by average vault form (38.12%) (Table 1).

Table 1 shows sidewise distribution of palatal rugae in relation to teeth and according to age, gender, and palatal form. The palatal rugae extended beyond the mesial end of the maxillary second premolar in 154 (76.23%) models on the right side of the palate and in 147 (72.77%) models on the left side of the palate. Statistically, significant difference was found when the proportion were compared for right and left side in the age group above 25 years ($p < 0.05$).

Rugae proximity on both sides were compared in Table 2 along with comparison of the mean distance according to the age, gender and palatal vault form. Although there was a greater percentage of rugae extending beyond the mesial end of the maxillary second premolar on the right side of the palate, the rugae proximity towards tooth was less on the right side compared to the left side; however, this difference was not statistically significant ($p > 0.05$).

Table 3 shows multivariate logistic regression analysis for success on right side and left-side as dependent variable. For age >25 years, on right side OR=1.03, 95% CI=0.55-1.86 and on left side OR=2.40, 95% CI=1.28-4.51. For the average palatal vault, on right side OR=0.95; 95% CI= 0.54-1.69 and on left side OR=1; 95% CI=0.56-1.79.

Table 1: Distribution of the right-side and left-side posterior extension of the palatal rugae in relation to the teeth and according to the age, gender and palatal vault form.

Posterior extension in relation to teeth			Mid-palatine of 1 st premolar	Distal of 1 st premolar	Mesial of 2 nd premolar	Mid-palatine of 2 nd premolar	Distal of 2 nd premolar	Mesial of 1 st molar	Mid-palatine of 1 st molar	P value
Age groups (years) N (%)	≤25 (n=139)	Left	1 (0.72)	7 (5.04)	23 (16.55)	33 (23.74)	37 (26.62)	31 (23.30)	7 (5.04)	0.70
		Right	0	7 (5.04)	25 (17.99)	34 (24.46)	45 (32.37)	21 (15.11)	7 (5.04)	
	>25 (n=63)	Left	0	8 (12.70)	16 (25.40)	18 (28.57)	11 (17.46)	6 (9.52)	4 (6.35)	0.04*
		Right	2 (3.17)	2 (3.17)	12 (19.05)	13 (20.63)	12 (19.05)	18 (28.57)	4 (6.35)	
Gender N (%)	Male (n=94)	Left	1 (0.72)	2 (2.13)	20 (21.28)	27 (28.72)	28 (29.79)	10 (10.64)	6 (6.38)	0.03*
		Right	2 (2.13)	3 (3.19)	11 (11.70)	22 (23.40)	20 (21.28)	27 (28.72)	9 (9.57)	
	Female (n=108)	Left	0	13 (12.04)	19 (17.59)	24 (22.22)	20 (18.52)	27 (25.0)	5 (4.63)	0.01*
		Right	0	6 (5.56)	26 (24.07)	25 (23.15)	37 (34.26)	12 (11.11)	2 (1.85)	
Palatal vault form N (%)	Low (n=2)	Left	0	0	0	1 (50.0)	0	1 (50.0)	0	0.37
		Right	0	0	0	0	1 (50.0)	1 (50.0)	0	
	Average (n=77)	Left	0	8 (10.39)	16 (20.78)	17 (22.08)	22 (28.57)	10 (12.99)	4 (5.19)	0.56
		Right	0	8 (10.39)	11 (14.29)	17 (22.08)	21 (27.27)	18 (23.38)	2 (2.60)	
	High (n=123)	Left	1 (0.81)	7 (5.69)	23 (18.70)	33 (26.83)	26 (21.14)	26 (21.14)	7 (5.69)	0.27
		Right	2 (2.13)	1 (0.81)	26 (21.14)	30 (24.39)	35 (28.46)	20 (16.26)	9 (7.32)	

Proportions were compared by Fisher's exact test, *p<0.05 significant.

Table 2: Comparison of mean distance (in mm) between terminal end of rugae and gingival margin on right and left sides according to the age, gender and palatal vault form.

Variables	ROI 1 (n=202)		ROI 2 (n=180)		ROI 3 (n=24)	
	Left (mm)	Right (mm)	Left (mm)	Right (mm)	Left (mm)	Right (mm)
	2.35±0.92	2.40±0.82	3.47±1.31	3.58±1.24	4.83±1.13	5.08±1.44
P value^a	0.47		0.35		0.42	
≤25	2.45±0.90	2.36±0.76	3.45±1.27	3.58±1.11	5.47±1.31	5.24±1.41
>25	2.13±0.92	2.48±0.95	3.45±1.36	3.64±1.62	5.30±1.06	5.32±1.25
P value^a	0.02*	0.35	0.98	0.76	0.70	0.84
Male	2.52±0.98	2.64±0.73	3.63±1.39	3.84±1.15	5.31±1.14	5.39±1.23
Female	2.20±0.84	2.19±0.84	3.28±1.18	3.39±1.36	5.50±1.32	5.00±1.56
P value^a	0.01*	<0.001**	0.07	0.01*	0.63	0.35
Low	2.0±0	2.50±0.71	3.0±0	5.50±4.95	3.0	3.0
Average	2.29±0.90	2.44±0.83	3.30±1.15	3.48±1.21	4.86±1.35	5.10±1.33
High	2.40±0.94	2.37±0.82	3.55±1.38	3.64±1.23	5.76±1.06	5.47±1.28
P value^b	0.61	0.81	0.41	0.08	0.01*	0.14

Mean compared by ^aunpaired t test; ^bone-way ANOVA, *p<0.05 significant, **p<0.001 highly significant.

Table 3: Multivariate logistic regression analysis for success on right side and left-side as dependent variable.

Variables	Right side			Left side		
	Odd ratio	P value	95% CI	Odd ratio	P value	95% CI
Age (>25 years)	1.03	0.97	0.55-1.86	2.40	0.01*	1.28-4.51
Gender (female)	1.65	0.08	0.94-2.89	0.96	0.88	0.54-1.68
Palate vault form		0.99			0.88	
Low	0	0.99	0	0.49	0.62	0.03-8.30
Average	0.95	0.87	0.54-1.69	1.00	0.99	0.56-1.79
Constant	0.70	0.16		0.87	0.59	

CI=Confidence interval, *p<0.05 significant

DISCUSSION

Many studies have explored the patterns, shape, direction, and unification of rugae in particular ethnic groups.^{4,6-8}

Presumably, this study is the first to investigate the posterior extension of palatal rugae bilaterally relative to the teeth and the rugae proximity towards teeth in the potential donor site in the Gujarat population, as it can be

an anatomical limitation for harvesting soft tissue grafts. The study also investigated the correlation between gender, age, palatal vault shape, and the distal extension of the rugae.

The use of soft tissue autografts has been a hallmark in the field of clinical periodontology over the past 50 years. While the free gingival graft (FGG) is a versatile treatment option, its limitations in terms of both quantitative (volume augmentation) and qualitative outcomes (aesthetic integration, texture, colour, and scarring) have led to its decline in the aesthetic zone. As a result, FGG is now primarily used for procedures around teeth and implants in aesthetically irrelevant areas.¹ Hence, in the recent past, subepithelial connective tissue graft (SCTG) has become a reliable treatment modality as it gives a good aesthetic result. However, the SCTG requires a thicker donor palatal tissue. According to Zucchelli et al, traditional SCTG harvesting is not recommended if palatal soft tissue is not sufficiently thick.¹² In such cases, de-epithelialized free gingival graft (DGG) was recommended. Based on the histologic and histomorphometric analyses of DGG in humans, despite the efforts to carefully remove the epithelium, results show that small remnants of epithelium were present in all samples in different proportions.¹³ Another histologic study in humans reported that epithelial remnants were found in 80% of SCTGs.¹⁴

Breault et al reported the presence of a retained palatal rugae in a free gingival graft nine years after the surgery at the recipient site.¹⁵ Regardless of the efforts to remove them, the transplanted rugae remained a permanent feature of the area. Coslet et al reported that clinical removal of palatal rugae in donor tissue does not provide a permanent correction in its topography.¹⁵ According to Karring et al, split thickness grafts of palatal or gingival tissue retain their original specificity when transplanted to the alveolar mucosa.¹⁶ Karring et al and Edel and Faccini had demonstrated that the characteristics of the gingival tissue are controlled by intrinsic mechanisms inherent to the gingival connective tissue.^{16,17}

In the current study, the maxillary casts of known age between 20 and 30 years were included, which is the most frequent age group for mucogingival surgeries.^{18,19} Evidence suggests that the posterior boundary of rugae in relation to the teeth extends up to the age of 20 hence it is considered as the lower age limit for inclusion in this study.^{4,20}

The present study showed high palatal vault form (60.89%) as the most predominant type. Evidence suggests that variation regarding palatal vault form may affect the dimensions of the donor tissue harvesting and that caution should be observed not to endanger the greater palatine artery (GPA) when dealing with a shallow palatal vault. It is reported that the average distance from the CEJ to the neurovascular bundle is 17 mm, 12 mm and 7 mm in high arch, medium arch and

low arched palate respectively. The shallower the palatal vault, the closer the palatine artery lies to the palatal gingival margin. The GPA, 7-17 mm from the CEJ, is located at 77% of the palatal height and courses close to the CEJ from the distal surface of the canine.²¹⁻²³

In the current study, the rugae extended beyond the mesial end of the maxillary second premolar on the right side of the palate in 76.23% models and on the left side of the palate in 72.77% models. This was in contrast with the previous study conducted among the Jordanian population having 90% of rugae extended up to the maxillary second premolar and 78.3% further extended beyond the mesial aspect of the premolar. However, this study did not take the right and left sides into account in their evaluation.⁹ Another study conducted in Saudi Arabia, showed that 46.25% extended beyond the maxillary second premolar's mesial end on the left side and 59.09% on the right side of the palate. This study, despite considering the rugae proximity, concluded that the left side of the palate in the sample of the Saudi Arabian population may provide reliable soft tissue grafts for aesthetic mucogingival surgery.¹⁰ A cross-sectional study to evaluate quantitative and qualitative parameters of palatal rugae in Gujarat population, reported that the fragmentary rugae (2-3 mm) count was seen more on the right side than the left side.⁵ This study could be an explanation to the less rugae proximity towards tooth on right side compared to left side in the present study.

In the present study, on the right side, although there is a greater percentage (76.23%) of rugae extending beyond the mesial end of the maxillary second premolar, the rugae proximity towards tooth was less compared to the left side. This finding reveals the importance of measuring the rugae proximity towards tooth along with the posterior extension of palatal rugae in determining the potential soft tissue graft donor site. Furthermore, a distance of 2 mm from the gingival margin, the physiological biological width, should be excluded.^{23,24} The distance from gingival margin to GPA can be disregarded as high palatal vault form is the most predominant palatal vault type. Thus, it can be deduced that palatal region of first molar on both right and left sides may provide reliable soft tissue grafts for aesthetic mucogingival surgery in population of Gujarat. However, previous literature reports that the palatal side of the maxillary first molar has the thinnest overlying mucosa.^{3,25-28}

The limitations of this study include the use of dental casts to assess palatal rugae instead of more reliable and sensitive techniques such as stereoscopy, stereophotogrammetry. The study used a divider and calibrated scale to measure the rugae proximity towards tooth that might reduce precision when compared to other devices such as the vernier calliper. The location of neurovascular bundle was not assessed due to resource limitations. The present study was conducted with cross sectional study design. To make the findings more

generalized, further large-scale study should be conducted among general population.

CONCLUSION

Within the limitations of this study, the study showed asymmetry between right and left sides regarding the posterior-most extension of the palatal rugae among the population of western India. On the right side of the palate, although a greater percentage of rugae extends beyond the mesial end of the maxillary second premolar, the rugae proximity towards tooth was less compared to the left side. Careful assessment of the extension of palatal rugae helps avoid including these ridges into grafted tissue- thereby preserving aesthetic outcomes, guiding the selection of safer donor sites, or prompting consideration of alternatives, when necessary, in mucogingival surgeries requiring soft tissue grafts. It is therefore recommended to consider the rugae proximity towards tooth as well as the posterior extension of the palatal rugae when selecting the site for harvesting a soft tissue graft.

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