

Personal Identification using Odontometry and Palatoscopy: A Pakistani Perspective

TABASSUM AHSAN QADEER¹, BEENISH FATIMA ALAM², TAUQEER BIBI³, MADEEHA ANWAR⁴

¹HOD Orthodontics, BUDC-BUHS

²Assistant Prof. Oral Biology, BUDC-BUHS

³Sr. Lecturer Periodontology, BUDC-BUHS

⁴Assistant Prof. Oral Biology, BUDC-BUHS

Correspondence to Dr. Tabassum Ahsan Qadeer, Email: ahsan.tab@gmail.com, Cell: 03218212676

ABSTRACT

Aim: To determine the most common rugae pattern and to find if it has any association with dental arch form or malocclusion.

Study Design and setting: It was a retrospective cross-sectional study conducted using the records of 200 patients visiting the Orthodontic Outpatient department of Bahria University Medical and Dental College.

Methodology: Number, size, orientation and pattern of palatal rugae were assessed on the plaster models. Dental malocclusion along with dental arch form and width were also evaluated. Descriptive statistics such as frequencies were analyzed. Chi square, Fischer exact test and One Way ANOVA was used to see the significance of differences, $p \leq 0.05$ was considered as significant.

Results: The sample comprised of class I ($n=97$), class II ($n=87$) and class III ($n=16$). 113 cases had inter-molar width >44 mm while 87 had ≤ 44 mm. Posterior orientation of the rugae, was pre-dominant for both right ($n=100$) and left ($n=122$) first rugae. The most common pattern was curved for both first rugae on right ($n=66$) and left ($n=72$) sides.

Conclusion: Our study showed that the rugae pattern, size and numbers did not show significant variation in different malocclusion classes. It can be concluded that rugae pattern do not have any significant association with malocclusion class or arch form.

Keywords: Arch form, Arch width, Forensic dentistry, Malocclusion, Palatal Rugae.

INTRODUCTION

Personal identification forms the basis of the forensic dentistry, especially in case of crimes or presence of injured bodies that have endured mutilation beyond recognition. Different methods have been identified for personal identification that includes cheiloscopy, palatoscopy, dermatoglyphics, odontometry along with utilizing different molecular techniques for DNA identification¹.

Beginning in 1889 with aiding in individual identification, palatal rugae patterns are now one of the commonly identified methods for this purpose. Transverse palatine folds or the palatine rugae are basically ridges that are composed of fibrous connective tissue that is situated within the anterior part of the hard palate behind the incisive papilla. They are formed during the 12th to 14th week of intrauterine life².

Palate is naturally well protected against damage due to presences of lips, cheeks, tongue, teeth and bones that surrounds it, hence making the palate resistant to trauma and high temperature, additionally these features plays a crucial role in forensic identification of an individual.³

Aside from protection, the rugae also help with the swallowing process and tend to improve the contact with food and helping with taste perception.⁴ Palatal rugae sustain their form throughout life, once formed their pattern remains unchanged. Though during the development process palatal length measurements may get changed, but the position of rugae remains constant throughout life.⁵ None the less exceptional circumstance like trauma or chemical attack may deform the shape of palatal rugae.

Various classifications have been developed to cognize the pattern of palatal rugae and help enhance its role within the forensic dentistry⁶. In 1911 first classification for palatal rugae was formulated by Gorla in which the rugae pattern was categorized according to number of rugae and the extension of rugal area in relation to the teeth.⁷ Thomas and Kotze have further detailed the previously classified rugae category which is now the most commonly used system⁸.

Dental arch forms can be best described as configuration of underlying bony morphology that gets influenced by the process of tooth eruption along with the impact of various muscular forces.⁹ In

1934, Chuck made the first classification for dental arch forms describing them as square, tapered and ovoid form. However, the pattern of development of dental arches varies tremendously between both the genders.

Genetic and environmental factors have shown a strong influence on the dental malocclusion. Classification proposed by Angle is the most prevalently used for dental malocclusion that is based on the assessing the relationship between maxillary and mandibular permanent first molars¹⁰.

Researches that have been conducted in Pakistan have generally focused on analysing the pattern of rugae¹¹. To the best to our knowledge none of the studies conducted here have focused on analysing the association of Palatal rugae with arch forms and widths.

Hence the aim of this study is to find an association between rugae patterns and arch forms within the Pakistani population.

MATERIALS AND METHODS

This was a retrospective cross-sectional study that was conducted using the records of 201 patients undergoing treatment at the Orthodontic outpatient department of Bahria University Medical and Dental College. Ethical approval for the study was obtained from the Ethical review committee of Bahria University Medical and Dental College (ERC 59/2020), in accordance with the declaration of Helsinki.

The study sample comprised of 200 participants was calculated by using OpenEpiTM3. Statistical conditions used were 95% confidence interval with 5% margin of error. Convenience sampling was done including clear plaster models of patients aged between 15 and 45 years having fully erupted permanent dentition up to the second permanent molars. Those having missing teeth or any soft tissue protuberances or air bubbles were removed from the study. The data was collected by a single calibrated investigator using a magnifying glass for better visualization and examination, and was recorded on a proforma for each patient. Following variables were measured on the maxillary casts:

Malocclusion: Angles classification of malocclusion was determined for each patient, based on the occlusion pattern of the first molars, as class I, II and III.

Number of Rugae: The number of rugae on the right and left sides of the median palatine raphe was recorded. The size of each

Received on 11-05-2021

Accepted on 19-10-2021

rugae was measured by using a digital caliper from one end to the other end. Based on the length, rugae were classified as:

- Primary (>5mm)
- Secondary (3-5mm)
- Fragmentary (<2mm)

Only the 3 most anterior primary rugae were noted, as they were the most clear and present in all cases. Following variables were checked on these rugae:

Shape: Shapes of the individual rugae were classified into 9 different types as described by Hauser et al¹⁵ as follows:

1. Straight – Ran Directly From Their Origin To Termination
2. Curved – Simple Crescent- Shaped With Slight Bend At The Termination Of The Rugae
3. Circular – Continuous Ring Formation
4. Wavy – Serpentine In Arrangement.
5. Cross Linked – two rugae are connected
6. Branched – rugae breaks into branches
7. Breaks – straight rugae has a sharp bend at the end
8. Divergent – the branches diverge
9. Convergent – the branches converge

Orientation: It was checked if the rugae for both right and left side were going posterior, anterior or straight towards the midline, and were named accordingly.

Arch Form: It was checked and recorded as tapered square and ovoid based on their shape posterior to the canines.

Inter- Canine and Inter-Molar Widths: It was as measured for each case.

- Inter canine width was measured as the distance between the canine tips on both the sides.
- Intermolar width was measured from the tip of mesio-buccal cusp of first molar on one side to that of the other.

Statistical Analysis:

Data was entered in SPSS v23. Descriptive statistics such as frequency and percentages have been analyzed. Test of significance was done using Chi square and Fischer exact was used to see the significance of differences, p<0.05 was considered as significant.

RESULTS

The mean inter-canine width for the entire sample was 34mm while the inter-molar width was 44.39mm. The total sample of 201 cases was divided into different malocclusions, with 97 class I cases, 88 class II and 16 class III cases. The sample displayed almost all primary rugae, only 5 secondary rugae were found on the left sides and 6 on the right.

Table 1 shows the mean inter-canine and intermolar widths for each malocclusion, the difference between the groups was statistically insignificant with a p-value of 0.28 and 0.30 for the two variables.

From the sample of 200, 113 cases had an inter-molar width of more than 44mm while 87 showed it to be ≤ 44mm. Fewer cases (n=86) had more than 34mm of inter-canine width, and 114 showed it to be less than 34mm.

Table 2: Pattern presentation of first three right and left rugae in numbers

Patterns	RR1	RR2	RR3	LR1	LR2	LR3
Straight	66	34	30	63	51	44
Curved	73	79	59	73	75	68
Wavy	7	57	72	5	37	54
Circular	2	1	0	3	0	0
cross linked	2	1	1	3	4	1
branched	14	13	12	18	13	13
broken	0	5	2	1	3	4
Divergent	10	4	3	14	9	2
Convergent	26	6	5	20	8	0
n	200	200	184	200	200	186

We checked the rugae for orientation and found it to be predominantly posterior for both right (n=100) and left (n=122) first rugae. Horizontal orientation was the most common for second rugae both on the right (n=76) and left (n=89) sides. The third rugae on the right side had mostly a posterior orientation (n=82) while horizontal was most common on the left side (n=80).

Table 2 shows the pattern of the rugae. The most common pattern was curved for both first rugae on right (n=66) and left (n=72) sides, second rugae on both sides and 3rd rugae on left side, while wavy pattern was seen as most common for the 3rd rugae on the right side.

Orientation comparison of rugae in cases showing different inter-canine widths and inter-molar widths is shown in table 3. Although the results were statistically insignificant, anterior orientation was least commonly seen. The most common orientation on the right side was posterior for first and third rugae and horizontal for second rugae in cases which had an inter canine width of ≤34mm. For cases with more inter-canine width i.e. >34mm the first rugae showed a horizontal orientation, second showed a posterior while the third showed an equally balanced horizontal and posterior orientation. For the left side horizontal orientation was most commonly seen for 2nd and 3rd rugae while posterior was most common for the first rugae and the result was same for cases showing more or less inter-canine width.

When comparing rugae patterns with inter-canine widths, curved was most commonly seen pattern for the first two rugae on right side but the third rugae showed mostly a wavy pattern. On left side it was curved for the second and third but straight for the first rugae as shown in table 4.

Orientation of rugae based on the inter-molar width is also shown in table 3. For the right side the group with narrower arches i.e. inter-molar width was ≤44mm the first three rugae all showed a posterior orientation, while for the broader arches having an inter molar of >44mm the 2nd rugae showed mostly horizontal orientation while the other two showed posterior orientation.

Table 4 shows the comparison of pattern with the inter-molar width, for the right side for the 1st and 2nd rugae were pre dominantly curved and 3rd rugae was wavy for both ≤44mm and >44mm.

On the left side the group with a narrower arch i.e. intermolar ≤44mm was predominantly curved for all the rugae. While the wider group showed a predominant straight pattern for first, curved for second and wavy for the third rugae.

Table 1: Mean and SD of Inter-canine and Inter-molar widths in different malocclusions

	Inter-canine width	SD	Inter-molar width	SD
Class I	34.4mm	±2.6	44.7mm	±2.6
Class II	33.89mm	±3.2	44.1mm	±3.39
Class III	33.4mm	±1.9	43.87mm	±3
p-value	0.28		0.3	

*p-value ≤0.05 was considered statistically significant
One way ANOVA was applied to see the significance*

Table 3: Comparison of orientation with Inter-canine width and Inter-molar width

	Horizontal			Anterior			Posterior			p-value		
	RR1	RR2	RR3	RR1	RR2	RR3	RR1	RR2	RR3	p(RR1)	p(RR2)	p(RR3)
Inter-Canine width												
≤ 34mm	43	46	33	9	30	24	62	38	50	0.1	0.6	0.4
>34mm	43	30	33	4	24	14	39	33	33			
≤ 34mm	29	49	48	12	18	17	73	46	39	0.6	0.9	0.3
>34mm	27	40	33	10	13	18	49	33	32			
Inter-Molar width												
≤44mm	38	31	24	7	23	21	42	34	38	0.6	0.6	0.2
>44mm	48	45	42	6	31	17	59	37	45			
≤44mm	23	26	33	10	11	16	54	39	33	0.8	0.3	0.8
>44mm	33	53	48	12	20	19	68	40	38			

Chi square test/ Fischer Exact test was applied to see the significance Data presented as frequencies p ≤ 0.05 was considered significant

Table 4: Comparison of different inter-canine and inter-molar widths with rugae patterns

	Straight			Curved			Wavy			Branched			Divergent			Convergent		
	RR1	RR 2	RR 3	RR 1	RR 2	RR 3	RR 1	RR 2	RR 3	RR 1	RR 2	RR 3	RR 1	RR 2	RR 3	RR 1	RR 2	RR 3
Inter-Canine width																		
≤ 34mm	40	22	17	42	44	37	6	32	40	7	4	6	5	2	0	11	4	4
> 34mm	27	12	13	30	36	23	1	24	32	7	9	6	5	2	3	15	2	1
≤ 34mm	33	30	30	45	43	36	4	19	28	10	5	5	7	5	1	12	6	0
> 34mm	31	21	14	27	32	32	1	17	26	8	8	8	7	4	1	8	2	0
Inter-Molar width																		
≤ 44mm	28	14	13	30	37	30	4	24	32	5	4	6	5	3	1	14	4	1
> 44mm	39	20	17	42	43	30	3	32	40	9	9	6	5	1	2	12	2	4
≤ 44mm	23	18	23	35	32	33	2	18	18	10	5	3	5	4	2	9	5	0
> 44mm	41	33	21	37	43	35	3	18	36	8	8	10	9	5	0	11	3	0

Data is presented as frequencies

DISCUSSION

This study was conducted to identify if any association exists between arch width and the rugae patterns. Our study proved the null hypothesis, however the results were quite interesting.

The Inter-canine width for class I, in this study, was 34.4mm while for class II and III it was 33.89mm and 33.4mm respectively. These values are more than presented by another study conducted on Pakistani population by Mushtaq N et al.¹¹ who gave the mean values for their sample as 24.1mm, 24.5mm and 23.9mm for the three malocclusion groups. The mean values in this study were greater than the maximum values of their sample. This could be due to the ethnic difference between the two samples. Ethnicity was not considered in both the studies, nonetheless theirs was conducted in KPK province while this study was in a metropolitan city having a wide variation of the ethnic backgrounds, which could be a reason for the difference. Their study however also didn't show an association between the arch widths and malocclusions. The findings of this study are similar to the studies conducted by Gurjar et al.,¹² Khateeb et al.,¹³ and Sayin et al.¹⁴ They had however, compared the differences between the genders which were not considered in this study. Another study on the same population by Ahmad I¹⁵ showed values which were closer to the values given in this study; 36.4mm, 31.6mm and 33.3mm for the three malocclusions. The results of their study however, showed a statistically significant difference in widths between the three malocclusion classes unlike this study in which the variation was not significant. The literature regarding the differences in intercanine widths in different malocclusion types is conflicting. While some studies have reported a significant difference and vice versa. This could be attributed to racial differences, gender dimorphism, geographical differences and eating habits. Future studies should include ethnic backgrounds and gender variations for comparison of the values and for establishing the norms of a population.

The mean inter-molar width for class I, II and III in this study was 44.7mm, 44.1mm and 43.97mm. Comparing the same study of Mushtaq N et al¹¹, the inter-molar values were also much less than this study showing a wider arch presentation of the sample. In accordance to this study, the difference of the inter-molar widths between the three malocclusions was insignificant. Study conducted by Ahmad I¹⁵ despite showing inter-canine values

similar to this study, showed narrower arches in the molar area in contrast to this study. Their results along with those of Ahmed N¹⁶ displayed statistically significant differences for this value between different malocclusions unlike this study.

Curved was the most common pattern of rugae as seen in the sample of this study, this was followed by straight and then wavy. The study conducted by Jadoon et al. showed a prevalence of wavy pattern.¹⁷ Studies on Egyptian population¹⁸, Australian aboriginals and Caucasians have shown a predominance of wavy pattern.

In this study the sample was divided into groups based on their inter-canine and inter-molar widths. The inter-canine widths in majority of the sample (N=114) was below the mean value of 34mm, indicating the prevalence of narrower arches in the study sample. However 57% of the sample showed a wider arch in the molar area. To the best of knowledge no study, regional or global, which mentioned the percentage of the sample showing wider or narrower arches. The values in this study however, are similar to another study conducted on Pakistani population by Wahaj A¹⁹, which showed the mean inter-canine width of their sample to be 36mm, and the mean inter-molar width of 44.2mm against ours of 44.39mm. Another study conducted on Karachi population²⁰ gave the mean inter-canine width as 39.4mm and the mean inter-molar width as 49.9mm which is much wider than ours. They also did not consider the ethnicity of the study sample, which would have shed more light on the reasons for the variations and this should be, noted in future studies being carried out.

When comparing the orientation of the rugae, the samples showed that the most common orientation was posterior for the first rugae on both the sides. However this orientation changed to horizontal in most of the second rugae and gave mixed results of posterior and horizontal, on the right and left side, in the third rugae.

Studies have shown various patterns for the rugae²¹. In this study, the examiners checked for the 8 different types as given by Thomas and Kotz and found the curved pattern was most common for the first and second rugae on both right and left sides. From the third rugae the results were very variable with wavy being more commonly seen on the right while curved was more common on the left, and these differences were even less significant from the fourth rugae onwards.

One study²² using the classification of Trobo found the most common pattern to be sinous, this pattern configures with the wavy figure as described by Hauser et al.²³ This study showed that wavy was the second most commonly seen pattern and was more frequent in the third rugae. The results agreed with the study carried out by Fatima F²⁴, who found the curved pattern as given by Hauser to be most frequently seen, along with not finding any specific pattern specific for any of the malocclusions. They however found significant differences in the number of rugae seen for different malocclusions unlike this study. However, the study conducted by Faheem et al²⁵ on the population of Karachi identified sinous as the most frequently appearing pattern.

In the current study the authors also tried to find any inter-connection between the rugae orientation and width of the palate at canine and molar regions, however the results were insignificant. The most commonly seen orientation was posterior for the overall sample and for the sample showing variable widths, the only exception being the sample having a wider intercanine width, on the right side had more horizontal pattern but the result was not statistically significant. The least common orientation was anterior. When comparing the rugae patterns with the arch widths, the curved pattern was observed most commonly. However, the sample with wider arches in molar area, for both right and left side, straight pattern was observed in the first rugae.

CONCLUSION

The current study showed that rugae pattern is not significantly different in number and patterns, for personal identification as well as for detection of malocclusion.

Conflict of interest: Nil

REFERENCES

- Bing L, Wu X-P, Feng Y, Wang Y-J, Liu H-C, Bing L, et al. Palatal rugae for the construction of forensic identification. *Int J Morphol.* 2014;32(2):546-550
- Chong JA, Mohamed AMFS, Pau A. Morphological patterns of the palatal rugae: A review. *J Oral Biosci.* 2020;62(3):249-250
- Trakanant S, Nihara J, Kawasaki M, Meguro F, Yamada A, Kawasaki K, et al. Molecular mechanisms in palatal rugae development. *J Oral Biosci.* 2020;62(1):30-5.
- Babaji P, Jalal SA, Kamalaksharappa SK. Evaluation of palatal rugae pattern in identification and sex determination in Indian children. *Pesqui Bras Odontopediatria Clin Integr.* 2018;18(1):e3944.
- Sherif AF, Hashim AA, Al Hanafy MA, Soliman EM. A pilot-cross sectional study of palatal rugae shape and direction among Egyptians and Malaysians. *Egypt J Forensic Sci.* 2018;8(1):1-9.
- Bhullar A, Kaur RP, Kamat MS. Palatal Rugea – an Aid in Clinical Dentistry. *Journal of Forensic Research.* 2011. <https://doi.org/10.4172/2157-7145.1000124>
- Sekhon HK, Sircar K, Singh S, Jawa D, Sharma P. Determination of the biometric characteristics of palatine rugae patterns in Uttar Pradesh population: a cross-sectional study. *Indian J Dent Res.* 2014;25(3):331. <https://doi.org/10.4103/0970-9290.138331>
- Omar H, Alhajrasi M, Felemban N, Hassan A. Dental arch dimensions, form and tooth size ratio among a Saudi sample. *Saudi Medical Journal.* 2018;39(1):86-91
- Tiwari A, Garg A, Virang B, Sahu S, Shah N, Verma N. Archform in orthodontics: A review. *Journal of applied dental and medical sciences.* 2018;4(1):20187.
- Gravely JF, Johnson DB. Angle's classification of malocclusion: an assessment of reliability. *British journal of orthodontics.* 1974; 1(3):79-86.
- Mushtaq N, Tajik I, Baseer S, Shakeel S. Intercanine and intermolar widths in angle class I, II and III malocclusions. *Pakistan Oral & Dental Journal.* 2014;34(1):83-86
- Gurjar A, Purohit A. Evaluation of arch width among Class I malocclusion, Class II Division 1, Class II Division 2, and Class III malocclusion in central Indian population. *Journal Of Applied Dental and Medical Sciences.* 2018;4(2).
- Al-Khateeb SN, Abu Alhajja ES. Tooth size discrepancies and arch parameters among different malocclusions in a Jordanian sample. *Angle Orthod.* 2006;76(3):459-465.
- Sayin MO, Turkkahraman H. Comparison of dental arch and alveolar widths of patients with Class II, division 1 malocclusion and subjects with Class I ideal occlusion. *Angle Orthod.* 2004;74(3):356-60
- Ahmed I, Wahaj A, Erum G. Comparison of intercanine and intermolar width among Angle's malocclusion groups. *J Pak Dent Assoc.* 2012;21(4):202-205.
- Ahmed N, Fida M. A comparison of arch dimensions among different malocclusion groups. *J Pak Dent Assoc.* 2010;19(2):94-98.
- Jadoon OK, Zaman M, uz Zaman F, Khan D, Farooq U, Seema N, et al. Analysis of palatal rugae pattern in population of Abbotabad: a forensic study. *J Ayub Med Coll Abbottabad.* 2018;30(3):428-431
- Azab SMS, Magdy R, Sharaf EL, Deen MA. Patterns of palatal rugae in the adult Egyptian population. *Egypt J Forensic Sci.* 2016;6(2):78-83. <http://dx.doi.org/10.1016/j.ejfs.2015.01.006>
- Wahaj A, Ahmed I. Comparison of intercanine and intermolar width between cleft lip palate and normal class I occlusion group. *J Coll Physicians Surg Pak.* 2015;25(11):811-4.
- Amjad A, Hussain S, Rehman A, Hassan SH. Role of palatal rugae pattern in forensic identification of individuals. *POJ.* 2016;8(2):1422-1428
- Alshahrni I. Palatal rugae characteristics and its relationship with Angle's class 1,2 & 3 malocclusions. *Int J. Morphol.* 2017;35(4). <http://dx.doi.org/10.4067/s0717-95022017000401422>
- Pramanik A, Debnath M, Debnath M. A comparative study of gender difference in palatal rugae patterns among Bengali subjects in Murshidabad. *Int J Anat Radiol Surg.* 2019;8:6-10.
- Hauser G, Daponte A, Roberts M. Palatal rugae. *J Anat.* 1989;165:237-249.
- Fatima, F., Fida, M., Shaikh, A. The association between palatal rugae pattern and dental malocclusion. *Dental Press Journal of Orthodontics.* 2019;24(1):37 e4-37 e9. https://ecommons.aku.edu/pakistan_fhs_mc_surg_dent_oral_maxillofac/101
- Faheem S, Hirani S, Maqsood S, Shaikh F, Soomro MA, Zaidi SJA. Palatal rugoscopy: Individuality and gender differences in subset of population of Karachi. *The Professional Medical Journal.* 2021;28(6):842-847.