Digital Anthropometric Analysis of Palatal Rugae Pattern in Qassim Population, Saudi Arabia

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Authors' contributions

This work was carried out in collaboration between both authors. Author RE designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Author ME prepared the sample, wrote the proposal and revised the analyses of the study. Both authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Background: Palatal rugae are asymmetric irregularity in anterior part of palate with unique configuration and different forms in different populations.
Aims: To digitally determine the number and pattern of palatal rugae in Qassim population.
Study Design: Cross sectional descriptive study.
Place and Duration of Study: Sample: They were selected from dental lab in Qassim University Dental Clinic, Saudi Arabia, between March and May 2017.
Methodology: Using Microsoft surface pen, 109 images of models of adult patients in Qassim were digital traced. The palatal rugae pattern was assessed on the basis of number, shape, direction, and unification.
Results: The mean number of palatal rugae were 9.38 in males and 8.85 in females. The most common shape of palatal rugae was the wavy 39.1% of study population.
Conclusion: Wavy and straight shape palatal rugae are the most common shape of rugae with no statistically significant difference between males and females.

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1. INTRODUCTION

In forensic identification, the mouth allows for a myriad of possibilities [1]. One of them is the characteristic pattern of palatal rugae. Palatal rugae (PR) are irregular asymmetric ridges of the mucous membrane extending laterally from the incisive papilla and the anterior part of the medial palatal raphe mucosal elevations seen on the anterior third of palate [2].

The clinical significance of the palatine rugae is widely considered to be stable landmarks even during orthodontic treatment [3], so their use for forensic identification has been well established [4-6].

Although teeth are more durable than other parts of the body, identification via dental records is not reliable because dental treatment might have been performed between the creation of a dental record and the person's death [7]. While the rugae pattern is as unique to a human as are his or her fingerprints [4,8] and it retains its shape throughout life [9-11].

The scientific literature on palatoscopy has been documented since the 19th century. Many researchers have introduced different methods of classification and analysis of palatal rugae since then [4,7]. Thomas and Kotze, [12] have categorized two-armed rugae as 'branches' or 'unification' depending on the length of their origin; unifications have further been classified as converging or diverging, depending on the type of origin. Based on the length, three categories were formed; Primary rugae: (5 mm or more), secondary rugae: 3–5 mm and Fragmentary rugae: less than 3 mm. Then, a classification was given by Kapali et al. [10] which was less specific and categorized rugae shape as straight, wavy, curve and circular.

A significant association of palatal rugae in various populations as palatal rugae patterns are highly variable among different genders and ethnicities [12-14]. The difference extending to the number, length, shape, direction, and unification of rugae [10,15-16].

The aim of the current study was to determine the number and pattern of palatal rugae in Qassim population and digitally detect the predominant pattern of palatal rugae.

2. MATERIALS AND METHODS

All subjects of the study belonged to Qassim province. They were selected from dental lab in Qassim University Dental Clinic, Saudi Arabia. The usage of dental casts for research purposes was included in the consent form signed by all patients before starting their treatment. Duplication of the original casts was taken using rubber base impression materials and cast using hard dental stone. The study received ethical approval from the research ethics committee in college of dentistry, Qassim University.

The study sample consisted of casts of 109 patients, of which 56 were males and 53 were females. The ages of the study individuals were taken from their registration file. All the casts were belonging to patients aged 18-35 years. All casts were of healthy patients free from any diagnosed congenital abnormalities, inflammation and trauma based on the patients' records in clinics database. All selected casts from the individuals were free of air bubbles or voids, especially in the anterior one-third of the palate.

The casts were photographed focusing on the palatal area using SLR digital camera (Canon 500D EOS Digital Camera). The photographs were standardized using tripod with fixed position in relation to the cast till all pictures were taken. All casts were photographed and the digital images were imported to Microsoft Surface pro 4. Each image was then resized to a 1:1 ratio using Adobe Photoshop CC 2015 (Adobe Systems Software Ltd)

Rugae patterns on the study models were traced using Microsoft pen for Microsoft surface pro 4 tab (Fig. 1). The images were distributed randomly among two observers for tracing and determining the rugae pattern. The two observers were not informed about the age and sex of patients. The selection of cast for the study was on a single blinded random basis without informing the observer on what kind of study was being performed; this could have brought a selection bias for the study.

The strengths of the Palatal rugae were digitally measured using Adobe Photoshop cc 2015 and recorded at the maximum thickness of the palatal rugae.
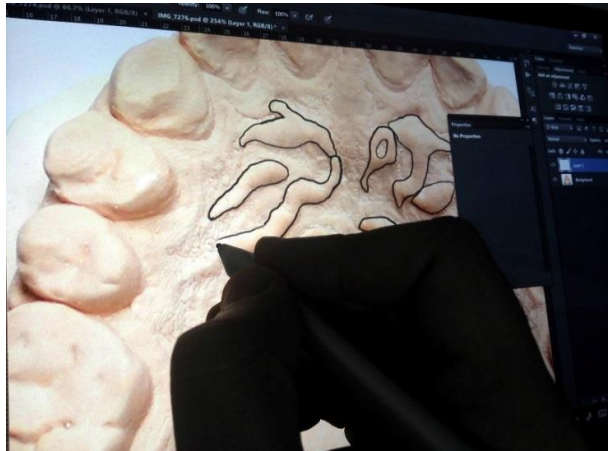
Fig. 1. Digital tracing of palatal rugae using microsoft surface pen

Fig. 2. Rugae pattern traced as a layer on the digital image of the model

2.1 Method of Identification

The classification used to describe the rugae patterns was based on those described by Thomas and Kotze, [11]. Classification of Rugae following the descriptions of Thomas and Kotze. Having determined the length of all the rugae, three categories were formed:

Primary rugae: (5 mm or more), secondary rugae: 3–5 mm and Fragmentary rugae: less than 3 mm. Further on, the fragmented rugae were not considered for any of the categorizations.

The shapes of individual ruga were classified into six major types: straight, curved, wavy, circular and unification (diverging and converging) (Fig. 3).

Straight types ran directly from their origin to termination. The curved type had a simple crescent shape that curved gently. Evidence of even the slightest bend at the termination or origin of a rugae led to a classification as curved. The basic shape of the wavy rugae was serpentine; however, if there was a slight curve at the origin or termination of curved rugae, it was classified as wavy. To be classified as circular, a rugae needed to display a definite continuous ring formation. Unifications in which two rugae began from the same origin but immediately diverged were classified as diverging. Rugae with different origins which joined on their lateral portions were classified as converging.

Right side rugae were marked first in an anteroposterior direction followed by the left side.

Fragmentary Rugae that were vague on the image were discarded.

2.2 Statistical Analysis

Data were analyzed and tabulated using SPSS version 21 for windows. The numbers of rugae were displayed in the form of mean and standard deviation and comparison between the study groups using Student's t-test for independent varaiables. The patterns of rugae were recorded individually and patterns were displayed in the form of frequency and percentages. Association between rugae shape and gender was tested using Chi-square. Statistical comparisons were performed at statistically significant level p<0.05 with Bonferroni's adjustments for multiple comparisons.

3. RESULTS AND DISCUSSION

3.1 Results

The total number of rugae in the study sample was ranged from 8.85 ± 1.41 in females and 9.38 ± 1.13 in males with a statistically significant difference between the two groups (p=0.034. The males have statistically significant more rugae on the right side than the left side (5.04 ± 0.79 and 4.58 ± 0.97. While the left side has no statistically significant difference with mean 4.34 ±. 0.86 rugae in males and 4.26 ± 0.92 in females (Table 1).

The Most common rugae distribution in the Qassim population was wavy 39.1% followed by straight in 26.9% and curved in 26.7%. Unification was less common among the Qassim population with 3.3% diverging and 2.1% converging. The least common distribution was for the circular pattern in only 1.9% of palatal rugae of the study sample (Fig. 4). No statistically significant difference was found between males and females in the frequency of pattern distribution (Table 2).

3.2 Discussion

The palatal rugae are like fingerprints, do not change during the life of the individual. They are protected from trauma and high temperatures because of their internal position in the oral
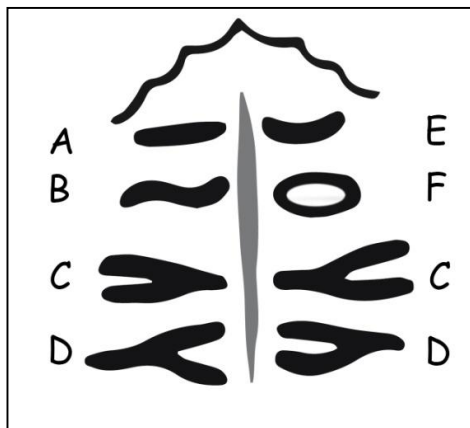

Fig. 3. Different palatal ruga pattern: A: Straight, B: Wavy, C: Diverging, D: Converging, E: Curved and F: Circular

Table 1. Distribution of the mean numbers of palatal rugae among study population

	Gender				df	T (p)
	Male		**Female**			
	Mean	**SD**	**Mean**	**SD**		
Right	5.04	0.79	4.58	0.97	107	2.674 (0.01*)
Left	4.34	0.86	4.26	0.92	107	0.440 (0.66)
Total	9.38	1.13	8.85	1.41	107	2.153 (0.03*)

t: for student's t-test
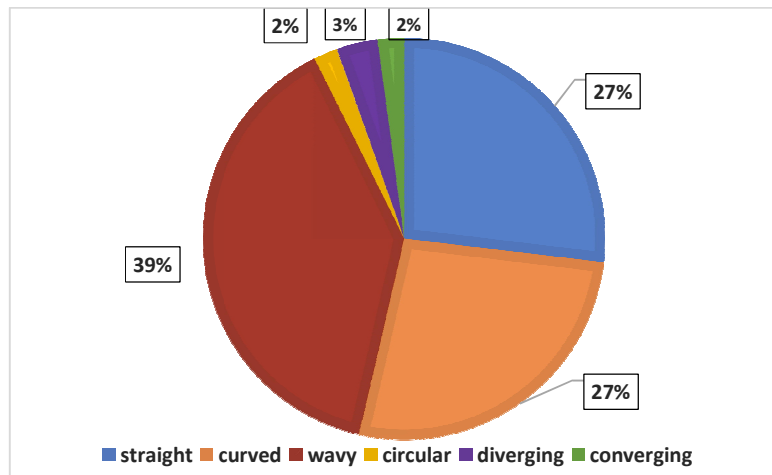**: significant at p<0.05*

Fig. 4. Percentages of different palatal rugae shapes

Table 2. Distribution of rugae characteristics among the study population

| | Gender | | | | | | X^2 (p) |
| | Male | | Female | | Total | | |
	No.	%	No.	%	No.	%	
Straight	145	27.6%	122	26.0%	267	26.9%	7.3 (0.19)
Curved	153	29.1%	112	23.9%	265	26.7%	
Wavy	191	36.4%	198	42.2%	389	39.1%	
Circular	9	1.7%	10	2.1%	19	1.9%	
Diverging	14	2.7%	19	4.1%	33	3.3%	
Converging	13	2.5%	8	1.7%	21	2.1%	

p: for chi-square test
*: significant at p<0.05

cavity, surrounded and protected by lips, cheeks, tongue, teeth, and bone [17]. Palatine rugae exhibit some variations in race and gender but they are not subjected to gross changes except in the length while the person is growing [4,17].

The present study aims at illustrating a novel method of palatal rugae superimposition by digital tracing using Microsoft pen for Microsoft surface pro 4 tab which seems to be reliable and extremely user-friendly.

The selected ages of the sample were from 18-35 years in Qassim population. At this age range, there are no changes characterize the general craniofacial growth area consequently, the rugae region with no differential growth of the underlying bone [18].

Recording of the rugae shape was done according to the classification given by Thomas and Kotze, [12] with the exclusion of fragmentary rugae as it is more simple with fewer observer

errors [9]. The classification includes straight, wavy, curved and circular shapes were considered, in addition, unification; diverging or converging were also included. This classification had been used in several other studies [19,20].

In the present study the mean total number of rugae in Qassim of males was (9.38 ± 1.13) rugae more than females (mean= 8.85 ± 1.41) with a significant statistical difference, which was in accordance with the study conducted by Syed et al. [19] in Abha in Saudi Arabia which showed more rugae in the population (13.4 rugae in males and 11.25 rugae in females). While other studies showed no gender difference in the number of rugae Kumar et al. [21] and Rajan et al. [22] on an Indian population and Ahmed and Hamid, [23] on a Sudanese population.

The most common rugae shapes observed in the present study were wavy forms, accounting 39.1% of the sample population. This is consistent with the previous study in Riyadh by Fahmi et al. [24]; it was found in about 44% of

their sample and Kapali et al. [10] results where 55.8% of Aborigines and 40.6% of Caucasians have wavy rugae. While circular type of rugae in Qassim population was the less common rugae type (1.9%), This finding is in agreement with Fahmi et al. [24] study in Riyadh, Saxena et al. [25] in Bahopal with the results of Venegas et al. [26] in Chile, and consistent with the results of two Indian populations [27], that showed respectable and considerably high percentage of straight rugae similar to the results of this study (26.9% in Qassim).

This study revealed the presence of the unification rugae pattern in the Saudi population with the diverge form more prevalent than the converging form (3.3% and 2.1% respectively). This coincides with the findings reported by Abdellatif et al. [28] who compared unification forms of palatal rugae between the Egyptian and Saudi children and reported that converging rugae were more frequent in Egyptians (4.07%) while diverging rugae were more frequent in the Saudi children (4.84%).

The results of the present study confirm that there are genetic differences and environmental changes in different rugae patterns of different populations. Thomas and Kotze, [29] in their study in South Africa considered it is unlikely that environmental factors affect the formation of rugae and believe rugae shape is genetically controlled. It is plausible that certain, but unidentified, genes influence the orientation of the collagen fibers during embryogenesis and govern rugae pattern in different populations [28]. And thus further studies with larger sample sizes and based on genetic considerations may be needed to substantiate the findings of the present study.

4. CONCLUSION

The rugae pattern in an individual showed a promising uniqueness. The males show significant more rugae than the females especially on the right side with the most common pattern of palatal rugae is the wavy shape then straight and curved pattern. No statistically significant difference in palatal rugae pattern between males and females was revealed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bajpai M, Mishra N, Yadav P, Kumar S. Efficacy of lip prints for determination of sex and inter observer variability. Eur J Exp Biol. 2011;1(4):81-6.
2. Pillai J, Banker A, Bhattacharya A, Gandhi R, Patel N, Parikh S. Quantitative and qualitative analysis of palatal rugae patterns in Gujarati population: A retrospective, cross-sectional study. J Forensic Dent Sci. 2016;8(3):126-34.
3. van der Linden FPGM, Duterloo HS, Zelders T, Peters KA, Raaben JH. Changes in the position of posterior teeth in relation to ruga points. Am J Orthod. 1978;74(2):142-61.
4. Caldas IM, Magalhães T, Afonso A. Establishing identity using cheiloscopy and palatoscopy. Forensic Sci Int. 2007;165(1):1-9.
5. Kogon S, Arnold J, Wood R, Merner L. Integrating dental data in missing persons and unidentified remains investigations: The resolve initiative and DIP3. Forensic Sci Int. 2010;197(1-3):e31-e35.
6. Limson KS, Julian R. Computerized recording of the palatal rugae pattern and an evaluation of its application in forensic identification. J Forensic Odontostomatol. 2004;22(1):1-4.
7. Patil MS, Patil SB, Acharya AB. Palatine rugae and their significance in clinical dentistry: A review of the literature. J Am Dent Assoc. 2008;139(11):1471-8.
8. Buchner A. The identification of human remains. Int Dent J. 1985;35(4):307-11.
9. Nayak P, Acharya AB, Padmini AT, Kaveri H. Differences in the palatal rugae shape in two populations of India. Arch Oral Biol. 2007;52(10):977-82.
10. Kapali S, Townsend G, Richards L, Parish T. Palatal rugae patterns in Australian aborigines and Caucasians. Aust Dent J. 1997;42(2):129-33.
11. Lysell L. Plicae palatinae transversae and papilla incisiva in man; a morphologic and genetic study. Acta Odontol Scand. 1955;13(Suppl. 18):5-137.
12. Thomas CJ, Kotze TJ, Van der Merwe CA. An improved statistical method for the racial classification of man by means of palatal rugae. Arch Oral Biol. 1987;32(4):315-7.
13. Thomas CJ, van Wyk CW. The palatal rugae in an identification. J Forensic Odontostomatol. 1988;6(1):21-7.

14. Buchtová M, Tichý F, Putnová I, Míšek I. The development of palatal rugae in the European pine vole, Microtus subterraneus (Arvicolidae, Rodentia). Folia Zool. 2003;52(2):127-36.

15. Kashima K. Comparative study of the palatal rugae and shape of the hard palatal in Japanese and Indian children. Aichi Gakuin Daigaku Shigakkai Shi. 1990;28: 295-320.

16. Shetty SK, Kalia S, Patil K, Mahima VG. Palatal rugae pattern in Mysorean and Tibetan populations. Indian J Dent Res. 2005;16(2):51-5.

17. VN, Ugrappa S, MNJ, Ch L, Maloth KN, Kodangal S. Cheiloscopy, palatoscopy and odontometrics in sex prediction and discrimination - a comparative study. Open Dent J. 2014;8:269-79.

18. Simmons JD, Moore RN, Erickson LC. A longitudinal study of anteroposterior growth changes in the palatine rugae. J Dent Res. 1987;66(9):1512-5.

19. Kim HK, Moon SC, Lee SJ, Park YS. Three-dimensional biometric study of palatine rugae in children with a mixed-model analysis: A 9-year longitudinal study. Am J Orthod Dentofac Orthop. 2012;141(5):590-7.

20. Syed S, Alshahrani I, Alshahrani A, Togoo RA, Luqman M, Dawasaz AA. Conversion of palatal rugae pattern to scanable quick response code in an Arabian population. J Dent Sci. 2016;11(3):253-60.

21. Kumar G, Dhanapal R, Saraswathi T, Bharath S. Sex determination by discriminant function analysis of palatal rugae from a population of coastal Andhra. J Forensic Dent Sci. 2011;3(2):58.

22. Rajan VP, John JB, Stalin A, Priya G, Abuthagir AKS. Morphology of palatal rugae patterns among 5-15 years old children. J Pharm Bioallied Sci. 2013;5(Suppl 1):S43-7.

23. Ahmed AA, Hamid A. Morphological study of palatal rugae in a Sudanese population. Int J Dent. 2015;2015:1-8.

24. Fahmi FM, AlShamrani SM, Talic YF. Rugae pattern in a Saudi population sample of males and females. Saudi Dent J. 2001;13(2):92-5.

25. Saxena E, Chandrashekhar BR, Hongal S, Torwane N, Goel P, Mishra P. A study of the palatal rugae pattern among male female and transgender population of Bhopal city. J Forensic Dent Sci. 2015;7(2):142-7.

26. Hermosilla Venegas V, San Pedro Valenzuela J, Cantín López M, Suazo Galdames IC. Palatal rugae: Systematic analysis of its shape and dimensions for use in human identification. Int J Morphol. 2009;27(3).

27. Paliwal A, Wanjari S, Parwani R. Palatal rugoscopy: Establishing identity. J Forensic Dent Sci. 2010;2(1):27.

28. Abdellatif AM, Awad SM, Hammad SM. Comparative study of palatal rugae shape in two samples of Egyptian and Saudi children. Pediatr Dent J. 2011;21(2):123-8.

29. Thomas CJ, Kotze TJ. The palatal ruga pattern in six southern African human populations. Part I: A description of the populations an a method for its investigation. J Dent Assoc S Afr. 1983;38(3):158-65.

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