

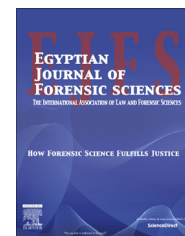
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ORIGINAL ARTICLE

Patterns of palatal rugae in the adult Egyptian population

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Abstract: Rugoscopy refers to the study of palatal rugae in order to establish a personal identity. A significant association has been found between rugae forms and ethnicity which may represent a valuable finding in forensic medicine. The present study was aimed to analyze the pattern of palatal rugae in the adult Egyptian population and to examine for any sex differences. A total of 108 pre-orthodontic dental casts were enrolled in this study (54 males and 54 females) in the age group of 18–35 years. The pattern of palatal rugae regarding the number, size and shape of rugae was identified according to the classification made by Kapali et al. Primary rugae type showed the highest frequency while the most frequent shape was the wavy shape, followed by the straight shape. The predominant direction of palatal rugae was the forward direction. Also, the converging form of unification was found to be more prevalent than the diverging form. No significant difference was found between males and females except for the curved shape that was significantly greater among females. This study showed a specific rugae pattern in the studied adult Egyptian population when compared to other populations' patterns that are reported in the literature.

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1. Introduction

Personal identification represents one of the major issues in forensic odontology since dental identification can be used as

the sole method for postmortem identification due to the high resistance of dental tissue to adverse conditions such as fire, trauma and decomposition.¹

Palatal rugae are irregular transverse ridges of the mucosa in the anterior third of the palate, radiating from the palatine raphae behind the incisive papillae.² They are formed in the early intrauterine life during the period from 12th to 14th week and remain stable throughout the person's life,³ not undergoing any changes, except for increase in the length as a process of normal growth.⁴ Physiologically, they are involved in the oral swallowing and improve the relationship between food and taste receptors on the dorsal surface of the tongue.⁵

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Palatal rugae are found to be stable in shape and structure during the life of an individual and are not changed by disease, trauma, chemicals or heat.⁵⁻⁷ Once formed, they remain in the same position and even if they are destroyed, are reproduced exactly at their original site.^{5,6} Their stability is due to their anatomical position inside the oral cavity which make them protected by the lips, cheeks, tongue, teeth and bone and prosthetic devices. Also, they are found to withstand thermal effects in burn victims⁸ and decomposition changes for up to seven days after death.⁹

Therefore, palatal rugae have been used in medicolegal identification processes and they have been equated with fingerprints due to their stability and uniqueness to individuals.¹⁰ Palatoscopy (palatal rugoscopy) refers to the study of palatal rugae in order to establish a person's identity.^{3,11} Palatoscopy can be of special value in certain conditions as cases of severe burn or decomposition when examination of finger prints is impossible. Furthermore, palatal rugae can be used for identification of edentulous subjects when other odontological methods cannot be used.¹² Many attempts have been done in this field to improve recording and analysis of data in order to develop an easy and reliable way for personal identification.¹³

Several studies reported a significant association between rugae forms and ethnicity¹⁴⁻¹⁶ which may represent a valuable finding in forensic investigations especially in disasters.¹⁷ Studies on the pattern of palatal rugae in the Egyptian population are very limited. Therefore, this study aimed to analyze the pattern of palatal rugae in the adult Egyptian population and to examine for any differences that could be found between males and females.

2. Materials and methods

The study sample consisted of 108 pre-orthodontic dental casts which included 54 males and 54 females in the age group of 18-35 years from the Department of Orthodontics, Faculty of Dentistry, Ain shams University, Cairo, Egypt. All selected casts were free of air bubbles or voids, especially at the anterior third of the palate. They belonged to individuals who were free of any diagnosed congenital abnormalities, inflammation, trauma, malocclusions, palatal asymmetries or orthodontic treatment. Ethical clearance was not applicable.

The rugae were delineated using a sharp graphite pencil under adequate light and magnification using hand lens to enhance the visualization of the palatal rugae on these casts and were analyzed macroscopically.

Subsequently, the pattern of palatal rugae was identified according to the classification made by Kapali et al.¹⁸, who classified palatal rugae according to their length, shape, direction and unification form.

Rugae length: measurements were made directly from the cast using a digital slide caliper with an accuracy of 0.02 mm from the origin near the mid-palatine raphe to the terminal end transversely. According to Kapali et al., three categories were identified:

1. Primary rugae: (A:-5-10 mm; B:-10 mm or more).
2. Secondary rugae: 3-5 mm.
3. Fragmentary rugae: Less than 3 mm.

All rugae were considered for the study irrespective of their length.

The shapes of individual rugae were classified into four major types: curved, wavy, straight and circular (Fig. 1):

- 1) Straight: They run directly from their origin to the termination.
- 2) Curved: They had a crescent shape and curved gently.
- 3) Wavy: There was a slight curve at the origin or termination of the curved rugae.
- 4) Circular: Rugae that form a definite continuous ring were classified as circular.

The direction of the rugae was determined by measuring the angle formed by the line joining its origin and termination and the line perpendicular to the median raphe. Based on the direction, rugae were classified as:

- 1) Forwardly directed rugae – associated with positive angles.
- 2) Backwardly directed rugae – associated with negative angles.
- 3) Perpendicular rugae – associated with angles of zero degrees.

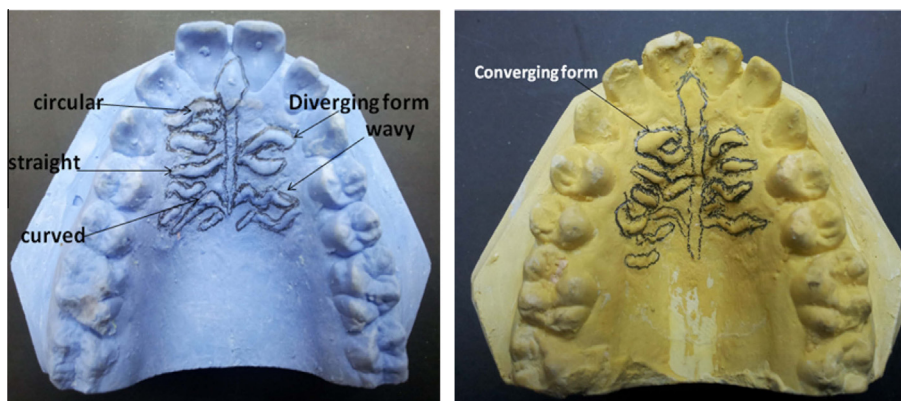


Figure 1 Patterns of palatal rugae as marked and analyzed on the casts.

Unification occurs when two rugae are joined at their origin or termination. Accordingly, rugae are classified into:

- 1) Diverging – If two rugae had the same origin from the midline but immediately branched.
- 2) Converging – Rugae with different origins from the midline, but which joined on their lateral portions.

Rugae description was repeated by each examiner on a set of 10 randomly selected casts (after 2 weeks) to test for possible intra-or/and inter-observer reliability.

2.1. Statistical analysis

The data were tabulated using the Microsoft excel and statistically analyzed using the SPSS 19.0 statistical package. Kappa was used to test intra/inter examiner reliability. Since the distribution of the rugae patterns was not normal, differences of the frequencies of rugae patterns were assessed by Kruskal–Wallis test (between variable groups) and Mann–Whitney test (between two groups). All reported *P* values are two-sided (*P* > 0.05: non-significant, *P* < 0.05: significant).

3. Results

In the present study, there was no significant intra-/or inter-observer error. Table 1 shows the descriptive statistics of different types of palatal rugae. By comparison, there were significant differences in the frequencies of palatal rugae types. Regarding the length, primary rugae was the most frequent category. The most frequent shape was the wavy shape, followed by the straight, curved and circular shape.

The predominant direction of palatal rugae was the forward direction since it showed a significant difference when compared with backward and perpendicular directions. Converging palatal rugae showed a significantly higher incidence than diverging rugae.

Table 2 shows the detailed distribution of palatal rugae characteristics among females and males with their descriptive statistics and tests of significance. There were no significant

differences either in the total number of rugae or in the frequency of different categories of the length between males and females. The median of the total number of rugae was 10 in both sexes. Also, there were no significant differences between both groups in the incidences of the unification forms and the directions of the palatal rugae. Regarding the shape of palatal rugae, the frequency of the curved shape was significantly greater among the females while all other shapes showed similar frequencies in both groups.

4. Discussion

Palatal rugae represent an important biometric feature that can be used for personal identification. This is due to their stability, uniqueness to individuals and postmortem resistance.¹⁹ Palatal rugae were found to retain their stability even during orthodontic treatment^{20,21} and extraction of teeth.²² Therefore, they have been equated with fingerprints.²³

Several studies reported inter-racial differences in palatal rugae even in relatively similar population groups which may help to identify the population especially in disasters.^{18,24} Differences between males and females have also been studied with no definite conclusion which indicates the need for more studies.⁶ Hence, this study aimed to analyze the palatal rugae patterns in the adult Egyptian population and to examine for any differences that could be related to sex.

This study found that, the primary rugae were the most frequent type of rugae length in the adult Egyptian population. Differences in palatal rugae length patterns between different populations are reported by previous studies. Kashima et al.²⁵ compared the palatine rugae and shape of the hard palate among the Japanese and Indian children and reported that Japanese children had more primary rugae than the Indian children and the palatal raphe of the Japanese children were wider than those of the Indian children. Kapali et al.¹⁸ reported that the Australian Aborigines had more primary rugae than the Caucasoids.

The present study found that, the wavy shape was the predominant shape followed by the straight shape. These findings are similar to those reported by Abdellatif et al.¹⁵

Table 1 Descriptive statistics of palatal rugae characteristics with tests of significance.

Rugae characteristics	Mean ± SD	Range	Median	<i>P</i> value	
Length	Primary (> 10 cm)	2.87 ± 2.09	(0–9)	3	< 0.001*
	Primary (5:10 cm)	4.72 ± 2.13	(0–10)	4	
	Secondary	1.32 ± 1.41	(0–7)	1	
	Fragmentary	1.02 ± 1.36	(0–5)	0	
Shape	Straight	2.24 ± 2.16	(0–10)	2	< 0.001*
	Curved	1.85 ± 1.28	(0–6)	2	
	Wavy	3.21 ± 1.78	(0–8)	3	
	Circular	1.44 ± 1.68	(0–7)	1	
Direction	Forward	5.04 ± 2.92	(0–11)	5	< 0.001*
	Backward	1.8 ± 1.86	(0–8)	1.5	
	Perpendicular	1.94 ± 1.57	(0–7)	2	
Unification	Diverging	0.63 ± 0.77	(0–3)	0	< 0.001†
	Converging	1.49 ± 1.56	(0–6)	1	

* Significant by Kruskal–Wallis test.

† Significant by Mann–Whitney test.

Table 2 Descriptive statistics of the palatal rugae characteristics among females and males with test of significance.

Rugae characteristics		Females			Males			P
		Mean \pm SD	Range	Median	Mean \pm SD	Range	Median	
Length	Primary (> 10 cm)	3.02 \pm 2.3	(0–9)	3	2.72 \pm 1.87	(0–8)	2.5	0.6
	Primary (5:10 cm)	4.80 \pm 2.32	(0–10)	5	4.65 \pm 1.94	(1–10)	4	0.76
	Secondary	1.26 \pm 1.29	(0–6)	1	1.39 \pm 1.52	(0–7)	1	0.7
	Fragmentary	0.8 \pm 1.12	(0–4)	0	1.24 \pm 1.54	(0–5)	0	0.23
	Total number	9.28 \pm 3.65	(2–18)	10	8.26 \pm 3.13	(5–16)	10	0.57
Shape	Straight	2.37 \pm 2.07	(0–10)	2	2.11 \pm 2.25	(0–7)	1	0.19
	Curved	2.13 \pm 1.37	(0–6)	2	1.57 \pm 1.13	(0–3)	2	0.04*
	Wavy	3.45 \pm 1.82	(0–8)	3	2.98 \pm 1.7	(0–7)	3	0.21
	Circular	1.43 \pm 1.58	(0–6)	1	1.46 \pm 1.78	(0–7)	1	0.94
Direction	Forward	5.28 \pm 2.99	(0–11)	5	4.8 \pm 2.84	(0–10)	4	0.43
	Backward	2.04 \pm 1.95	(0–8)	2	1.56 \pm 1.75	(0–6)	1	0.15
	Perpend.	1.96 \pm 1.45	(0–7)	2	1.91 \pm 1.7	(0–6)	2	0.66
Unification	Diverging	0.59 \pm 0.76	(0–3)	0	0.67 \pm 0.78	(0–2)	0	0.59
	Converging	1.50 \pm 1.69	(0–6)	1	1.48 \pm 1.42	(0–4)	1	0.81

* Significant by Mann–Whitney test.

who investigated the palatine rugae pattern in the Egyptian and Saudi children. They found that the most common rugae shape in Egyptians was wavy shape while the curved shape was most common rugae shape in Saudi children, followed by straight rugae in both the groups. Also, previous studies on other populations found wavy shape as the predominant shape in Caucasian, Aboriginal Australians¹⁸, Indian population^{1,26,27} and Chilean population.²⁸ This was found in contrast to what was reported by Eboh²⁹ who found that the straight shape was the commonest palatal rugae shape followed by wavy shape among the Nigerian population.

This study found that, forward direction was the predominant direction of palatal rugae. This was also found in contrast to the Indian population where backward direction was reported to be the predominant direction.³⁰

This study revealed the presence of the unification rugae pattern in the Egyptian population with the converging form more prevalent than the diverging form. This coincides with the findings reported by Abdellatif et al.¹⁵ who compared unification forms of palatal rugae between the Egyptian and Saudi children and reported that, converging rugae were more frequent in Egyptians while diverging rugae were more frequent in the Saudi children.

Contrary to these findings are those found by previous studies on the Indian population as they found unification rugae pattern to be very rare.^{1,31} Also, comparison of rugae patterns in the African and European populations revealed that Africans had significantly greater numbers of unifications and circular rugae.³²

This study found no significant differences between males and females in rugae pattern. This agrees with previous studies which reported no significant differences between both sexes in the palatal rugae pattern among the adult Egyptian population.^{15,33} These findings were reported also by previous studies on other populations such as the Saudi population¹⁵, Australian Aborigines¹⁸ and Portuguese population.¹⁶

In contrast, other studies revealed a difference between males and females. Dohke and Osato³⁴ reported that among the Japanese, the females had fewer rugae than males. Fahmi

et al.³⁵ studied the rugae patterns in Saudi males and females and reported that females showed a significantly greater number of converging type while males had a significantly greater number of circular type.

While some studies on the Indian population reported no significant differences between both sexes in the palatal rugae pattern^{27,31} other studies showed gender differences. Shetty and Premalatha³⁶ and Manjunath et al.³⁷ found that the incidence of curved, straight and forwardly directed rugae was more among females than males, while wavy, perpendicular and backwardly directed rugae were more among males.

Babu et al.¹⁷ found no significant difference between males and females in the length and shape of palatal rugae, but females were found to have greater number of rugae than males. Also, they reported that, the converging pattern was more frequent in males while diverging pattern was more frequent in females which was consistent with the finding of other studies on Indians.^{38,39}

Population differences of rugae patterns have been reported by several comparative studies. This raises the question about the role of genetic differences and environmental effects on racial differences. Previous studies reported that, environmental factors are unlikely to affect formation of rugae and rugae shape is genetically controlled. This was enforced by subsequent twin studies which have revealed that rugae pattern has an underlying genetic basis.⁴⁰

Palatal rugae develop as localized regions of epithelial proliferation and thickening during the early intrauterine life even before elevation of palatal shelves. Subsequently, fibroblast and collagen fibers accumulate in the connective tissue beneath the thickened epithelium and assume a unique orientation. Palatal rugae orientation is achieved by running of collagen fibers antero-posteriorly within the curve and in concentric curves across the base of each rugae. Therefore, prominent rugae occupy most of the length of the palatal shelves at the time of their elevation in human embryos.⁴¹ This process is believed to be affected by genes during embryogenesis and postnatal growth which may result in differences in rugae pattern between different populations.³¹

5. Conclusions

This study showed a specific rugae pattern in the studied adult Egyptian population when compared to the patterns in other populations that were reported in the literature. This may indicate an association between the palatal rugae pattern, ethnic group and regional variation which can aid as an additional tool in forensic identification procedures. Further studies on a larger sample size involving people from different Governorates in Egypt are recommended in order to validate the findings of the present study.

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Conflict of interest

None declared.

Ethical approval

Necessary ethical approval was obtained from the university ethics committee.

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