Original Article

Prevalence of palatal rugae shapes in Karnataka and Kerala population: A cross-sectional study

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Abstract

Aims and Objectives: This study was conducted to assess the incidence and prevalence of palatal rugae shapes in the male and female populations of Karnataka and Kerala. **Materials and Methods:** This study consisted of 100 plaster models of each group, which were equally distributed between both the genders, with an age range of 17–23 years. The rugae patterns were recorded by using Thomas and Kotze classification. Correlation between the rugae shape and population as well as the rugae shape and gender were analyzed using chi-square analysis and discriminant function analysis using the Statistical Package for the Social Sciences Version 22 (IBM Corp). **Results:** Curved, straight, and wavy rugae patterns were the most common in both Kerala and Karnataka sample populations. Chi-square analysis showed significant differences between the populations for the curved pattern; discriminant function analysis showed significant differences between the populations for the curved and straight patterns. Significant gender differences were found in the curved pattern for Karnataka population and in unification patterns for both populations by Chi-square/Fischer exact test. **Conclusions:** The curved and straight rugae patterns were significantly more frequent in the Kerala population compared to the Karnataka population. Because of the limited sample size of this study, further cross-sectional studies are suggested.

Key words: *Chi-square, discriminant function, forensic odontology, palatal rugae, rugae pattern, rugoscopy*

INTRODUCTION

Identification of human bodies is a very difficult task in situations such as natural disaster, traffic accidents, acts of terrorism, and burns.[1] In such situations, examination of teeth is more reliable; however, detection by dental archives may not be conclusive because of dental treatment.[2] In some situations, where teeth may be lost because of trauma, palatal rugae are considered as an alternate method for identification.[3]

Palatal rugae are unique in their own way by forming a pattern in the anterior part of the palate. Palatal rugae and shapes vary in different populations. Because of their anatomical position, they are protected from trauma and high temperature by the lips, cheeks, tongue and buccal pad of fat, teeth, and bone. Age changes have not been demonstrated in palatal rugae.[4-6] This pattern is unique to individuals, analogous to finger prints. Shetty *et al.*[7] in their study compared palatal rugae shapes in Mysore and Tibetians. El-Fotoh and El-Sharkawy[7] in their

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study concluded that rugae patterns were unique to an individual and could be used for identification. Houser *et al*.[7] compared Swazi and Greek populations and concluded that definite differences exist between the two. Palatal rugae are very resistant to decomposition after death for a few days.[8] Therefore, rugae patterns and shapes have been used in medical and forensic identification processes.[9]

Hence, in this study, we attempted to assess the prevalence of palatal rugae shapes in Karnataka and Kerala population.

MATERIALS AND METHODS

The study involved two population groups that were randomly selected from Karnataka and Kerala. The sample was selected based on discriminant function analysis, which included 100 participants aged 17–23 years in each group, equally distributed between the genders over a period of two months. Healthy subjects with a full set of dentition without inflammation, orthodontic treatment, or trauma were selected. After obtaining ethical clearance and informed consent, impressions were made by alginate of the maxillary arch and cast was prepared by dental stone and base using Plaster of Paris.

The rugae pattern was listed according to the Thomas and Kotze classification proposed in 1983. Rugae were categorized as straight, curved, wavy, and circular [Figure 1a and b]. In addition, if rugae were having two arms, they were categorized as "unification." The margins of the rugae were traced on the casts using a sharp graphite pencil. The correlation between rugae shape and population and rugae shape and gender were tested by chi-square/Fischer exact analysis and discriminant function analysis using the Statistical Package for the Social Sciences version 22 (IBM Corp.).

RESULTS

The data collected after study were statistically analyzed by chi-square/Fischer exact test. The frequency of different rugae shapes in the population of Kerala were curved 29.4%, wavy 29.4%, straight 28.5%, circular 1.5%, unification 2.4%, unification divergent 6.5%, and unification convergent 2.4% using chi square/Fischer exact test.

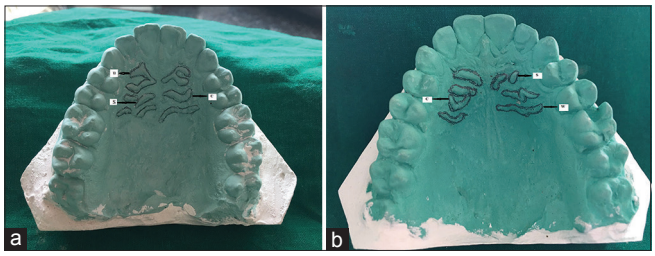

Figure 1: (a) Photograph depicting Kerala Population. (b) Photograph depicting karanataka population. Various Rugae shapes are S=Straight, W=Wavy, C=Curved, U=Unifi cation

The incidence of different rugae shapes in the population of Karnataka were curved 20.5%, wavy 22.6%, straight 44.1%, circular 0.5%, unification 6.3%, unification divergent 3.7%, and unification convergent [Table 1].

The Chi Square/Fischer exact analysis was conducted in order to asses the differences in the distribution of rugae shapes between the two study populations. The test result revealed the Kerala population had an increased percentage of curved rugae forms at 53.2% (n = 100) as compared to the Karnataka population at 46.8% (n = 88). This difference in distribution was statistically significant at P <0.001. However, the difference in distribution of other rugae forms between two study populations did not yield statistically significant difference/association [Table 2].

The Chi-square/Fischer exact analysis conducted for assessing gender distribution in Kerala and Karnataka population gave a statistical significant result for curved rugae in females belonging to the Karnataka population (P =0.03). Whereas unification rugae form

Table 1: Incidence between different rugae shapes in Karnataka and Kerala population

Rugae Shapes	Kerala			Karnataka		
	Incidence	%	Median	Incidence	%	Median
Curved	100	29.4	2	88	20.5	2
Wavy	100	29.4	3	97	22.6	2
Straight	97	28.5	2	189	44.1	2
Circular	5	1.5	1	2	0.5	1
Uni_Conv	8	2.4	1	27	6.3	1
Uni_Div	22	6.5	2	16	3.7	1.5
Uni_Comb	8	2.4	1	10	2.3	1

Table 2: Chi Square/Fischer exact analysis for analyzing the differences in rugae shapes in Kerala and Karnataka population

Rugae form	Kerala		Karnataka		c^2	P
	n	%	*n*	%		
Curved	100	53.2	88	46.8	12.766	<0.001[a]
Wavy	100	50.8	97	49.2	3.046	0.25
Straight	97	51.3	92	48.7	2.405	0.21
Circular	5	71.4	2	28.6	1.332	0.45
Unification	38	42.7	51	57.3	3.421	0.09

[a]*Differences were significant at P<0.05 level*

Table 3: Chi square/Fischer exact analysis for analyzing gender-wise differences in rugae shapes in Kerala and Karnataka population

Rugae forms	Kerala				*P*	Karnataka				*P*
	Males		Females			Males		Females		
	n	%	*n*	%		*n*	%	*n*	%	
Curved	50	50	50	50		40	45.5	48	54.5	0.03[a]
Wavy	50	50	50	50		47	48.5	50	51.5	0.24
Straight	49	50.5	48	49.5	1.00	43	46.7	49	53.3	0.06
Circular	4	80	1	20	0.36	0	0	2	100	0.49
Unification	10	26.3	28	73.7	<0.001[b]	32	62.7	19	37.3	0.02[c]

[a]Significantly higher in Karnataka females at P<0.05 level; [b]Significantly higher in Kerala females at P<0.05 level; [c]Significantly higher in Karnataka females at P<0.05 level

was statistically significant in females belonging to both Kerala and Karnataka populations (P <0.001 and P < 0.02, respectively) [Table 3].

The degree of freedom was analyzed using stepwise discriminant analysis for different rugae shapes for population detection. Curved and straight shapes are statistically significant. with a significant value of P < 0.001 [Table 4].

The standardized and unstandardized coefficients, group centroids, and structured matrix in the section point of the dicriminant function is explained in Table 5. Discriminant score higher than the sectioning point is considered as belonging to Kerala and lower than sectioning point is categorized as belonging to Karnataka.

DISCUSSION

Lysell classified palatal rugae for the first time in 1955, and Thomas and Kotze modified the classification in 1983.[10] Palatoscopy or palatal rugoscopy is the study of palatal rugae and was first put forth by a Spaniard Trobo Hermosa in 1932.[11] Kapali *et al*. included the shape of the palatal rugae in the classification, which was unique to different individuals.[12]

Rugae maintains a constant shape throughout life and may facilitate in the identification of population as it is specific for different racial groups.[7,12] Numerous classifications have been proposed. There is a need for a simple and reliable method for the classification of palatal rugae. Hence, we have considered classifying palatal rugae based on its shape in the current study, which is easier to record and is more reliable.[6]

Fischer exact test shows significant population difference for curved and straight rugae [Table 4]. However, no such differences were observed in the wavy and circular forms. Further, unification rugae pattern showed significant results in Karnataka male and female population. In a

Table 4: Step-wise discriminant function analysis of different rugae shapes for population identification

Variables entered	Wilks' Lambda				Exact *F*			
	Statistic	df1	df2	df3	Statistic	df1	df2	Sig.
Curved	0.929	1	1	173	13.256	1	173	<0.001[a]
Straight	0.904	2	1	173	9.172	2	172	<0.001[b]

[a,b]The p value for statistical significance was kept at P<0.05

comparison of Tibetans and Indians, Shetty *et al.* reported that the Indian population had a significant high number of curved rugae. On the other hand, wavy pattern was predominant in Tibetans.[7] Kapali *et al.* reported higher wavy rugae pattern among Australian Aborigines, whereas straight pattern were more common in Australian Caucasians.[13] Preethi *et al.* using jackknife test noted that 36.7% of south Indians consisted of migrated population from western India; this is attributed to migration to southern parts of India. Both western Indians and south Indians preserve distinct rugae patterns, which allows moderate level of identification. Hence, rugae patterns can be used as a good genetic marker.[14]

Measurement of rugae length and primary rugae were considered to be longer in Kerala population than that in Manipuri population, whereas secondary rugae were longer in Manipuri population. In regards to shape, the wavy pattern was higher followed by curved and straight.[12] This is in accordance with our study where straight and curved patterns were significant. Similar findings were reported by Kapali *et al.*

The study conducted by Shetty *et al.* compared palatal rugae pattern among Kodava and Malayalee population in south India.[6] The wavy pattern was highest in the Kodava population, which was statistically significant compared to the Malayalee population. Significant differences were noted between the genders for straight rugae pattern. This is in contrast to our study where unification pattern was statistically significant among Kerala and Karnataka population.

Table 5: Discriminant function coefficients for rugae shapes considered for analysis

Variables	Unstd. Coeff[a]	Str. Matrix	Std. Coeff[b]	Group Centroids		Sectioning Point[c]
				Kerala	Karnataka	
Curved	0.981	0.848	0.821	0.291	−0.362	−0.071
Straight	0.558	0.572	0.531			
(Constant)	−3.404					

[a] Unstd. discriminant function evaluated at group means; [b]Pooled among the groups correlations between discriminating variables and std. canonical discriminant function; [c] Discriminant score more than sectioning point is categorized as belonging to Kerala; less than sectioning point is considered as belonging to Karnataka

Therefore, the difference between rugae shapes among two populations may be attributed to genetic factors.[15] Palatal rugae remains constant and consistent from its development until degeneration of oral mucosa after death. Hence, palatal rugae shapes can be utilized in population detection. Because of the extremely unique nature of palatal rugae, it can be used as a supplementary method for human identification and gender determination. However, it cannot be used for postmortem identification.[16] Further studies with larger sample size may throw light on the use of palatal rugae for forensic identification.

CONCLUSION

Identification of human remains is a challenging task after natural disasters, traffic accidents, and fires. In such situations, examination of teeth is known to serve as acceptable evidence; however, when teeth are lost, the remaining soft tissues such as palatal rugae may still provide useful population-specific information. The present study found that the curved and straight rugae patterns were significantly more frequent in the Kerala population compared to the Karnataka population. Because of the limited sample size, further cross-sectional studies are suggested.

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Conflicts of interest

There are no conflicts of interest.

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