Original Article

Study of the Shape of Palatal Rugae to Determine the Gender of a Person

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Abstract

Background: Medico-legal cases constitute a significant burden on healthcare systems and represent an important public health concern within any region. Proper assessment, documentation, and classification of these cases are essential for identifying regional patterns and trends. Such categorization provides valuable information to authorities and policymakers, enabling them to develop appropriate preventive strategies and regulations aimed at reducing morbidity and mortality associated with medico-legal incidents. Among the various aspects of medico-legal investigation, sex determination plays a crucial role in the identification of individuals, particularly in cases involving unknown or decomposed remains. Palatal rugae, the anatomical ridges present on the anterior part of the palate, have been reported to exhibit sexual dimorphism in several studies. To further evaluate their usefulness in sex determination, the present study was conducted at SSIMS & RC, Davangere, Karnataka. A total of 250 maxillary casts obtained from individuals aged 12–25 years, comprising 125 males and 125 females, were subjected to detailed analysis. The morphology and characteristics of palatal rugae were examined and compared between the sexes. The findings demonstrated distinct gender-specific variations in palatal rugae patterns, supporting their potential utility as a reliable adjunct in forensic sex determination.

Keywords: Medico-legal; identification; sex determination; palatal rugae; sexual dimorphism.

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Introduction

Identification is the determination of a person's individual uniqueness by analyzing specific physical characteristics.[1] In forensic science, establishing a person's identity is essential in both civil disputes and criminal investigations. It may pertain to living individuals, dead bodies, or isolated human remains. Identification is classified as either complete or partial. Complete identification implies the definitive confirmation of individuality. In contrast, partial identification refers to assessing specific characteristics such as race, sex, age, or stature, with the overall identity remaining unresolved.[2]

Determining human identity remains one of forensic investigation's most critical yet challenging aspects. Several approaches are employed, including visual recognition, fingerprint analysis, footprint examination, dental profiling, and DNA fingerprinting. However, these methods may be limited in reliability or conclusiveness in certain situations. The most widely practiced method is visual identification, primarily because in a large proportion of cases the body retains sufficient features to allow recognition. Dental evidence also serves as a valuable tool in identification; nevertheless, its applicability may be restricted when teeth are absent due to trauma, thermal damage, or pre-existing edentulism in the victim.[3]

Palatal rugae have been regarded as highly individualistic structures, comparable to fingerprints in their uniqueness.[4] Despite increasing interest in their forensic application, literature from India remains relatively scarce. The current study evaluated and compared the palatal rugae patterns between males and females, focusing on parameters such as number, shape, size, and spacing. By highlighting the predominant patterns in each sex, the study aims to reinforce the role of palatal rugae as a practical and dependable method for personal identification in medico-legal contexts.

Materials and Methods

Source of data: This study included 250 participants (125 males and 125 females) aged between 12 and 25 years, from whom maxillary casts were obtained. The study group comprised medical students, dental patients from S.S. Institute of Medical Sciences & Research Centre, Davangere, and students from Ram Nagar Government School, Bapuji Dental College, and Nutun PU College, Davangere, Karnataka.

Inclusion criteria:

1. Age group of 12 to 25 years.
2. Both male and female.

Exclusion criteria:

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1. Age group below 12 and above 25 years.
2. Students with cleft lip and cleft palate.
3. Students with any inflammation, trauma, or oral cavity tumors.

Method of data collection and sampling procedure: Institutional approval was obtained, and informed written consent was secured from all participants. Maxillary impressions were taken under aseptic precautions using alginate impression material, and positive casts were prepared with dental stone. These casts were analyzed in the Department of Forensic Medicine and Toxicology, S.S. Institute of Medical Sciences & Research Center, Davangere. Palatal rugae were outlined with a graphite pencil or marker to aid visualisation and examined under magnification. Classification was performed according to Thomas and Kotze, based on rugae shape. Measurements were recorded with a vernier calliper, and data were documented separately for the right and left sides of the palate.

Data analysis

The data was analyzed using SPSS 18 (Trial Version), USA, Chicago. Microsoft Word and Excel were used to generate graphs, tables, etc. Step-wise discriminant analysis was done to compare the shapes of rugae patterns.

Results

Table 1: Show the incidence and percentage of curved rugae in males and females on right and left side.

Right side	Female		Male		Left side	Female		Male	
	count	%	count	%		count	%	count	%
0	21	16.8	15	12.0	0	22	17.6	25	20
1	59	47.2	76	60.8	1	44	35.2	54	43.2
2	34	27.2	29	23.2	2	42	33.6	33	26.4
3	9	7.2	5	4.0	3	17	13.6	12	9.6
4	2	1.6	0	0.0	4	0	0	1	0.8
total	125	100	125	100	total	125	100	125	100

Table 2: Show the incidence and percentage of wavy rugae in males and females on right side.

Right side	Female		Male		Left side	Female		Male	
	count	%	count	%		count	%	count	%
0	5	4.0	3	2.4	0	6	4.8	0	0
1	49	39.2	35	28.0	1	60	48.0	35	28.0
2	50	40.0	58	46.4	2	41	32.8	50	40.0
3	19	15.2	24	19.2	3	14	11.2	36	28.8
4	2	1.6	5	4.0	4	4	3.2	4	3.2
total	125	100	125	100	total	125	100	125	100

Table 3: Show the incidence and percentage of straight rugae in males and females on right side.

Right side	Female		Male		Left side	Female		Male	
	count	%	count	%		count	%	count	%
0	29	23.2	44	35.2	0	54	43.2	50	40.0
1	83	66.4	67	53.6	1	63	50.4	55	44.0
2	10	8.0	14	11.2	2	7	5.6	18	14.4
3	2	1.6	0	0.0	3	1	0.8	2	1.6
4	1	0.8	0	0.0	4	125	100	125	100
total	125	100	125	100	total	54	43.2	50	40.0

Table 4: Show the incidence and percentage of convergent rugae in males and females on right side.

Right side	Female		Male		Left side	Female		Male	
	count	%	Count	%		count	%	count	%
0	117	93.6	115	92	0	113	90.4	115	92.0
1	8	6.4	10	8	1	12	9.6	10	8.0
Total	125	100	125	100	Total	125	100	125	100

Table 5: Show the incidence and percentage of divergent rugae in males and females on right side.

Right side	Female		Male		Left side	Female		Male	
	count	%	count	%		count	%	count	%
0	125	100	118	94.4	0	119	95.2	112	97.6
1	0	0	7	5.6	1	6	4.8	3	2.4
Total	125	100	125	100	Total	125	100	125	100

Table 6: Show the incidence and percentage of nonspecific rugae in males and females on right side.

Right side	Female		Male		Left side	Female		Male	
	count	%	count	%		count	%	count	%
0	118	94.4	121	96.8	0	117	93.6	118	94.4
1	07	5.6	4	3.2	1	8	6.4	7	5.6
Total	125	100	125	100	Total	125	100	125	100

Table 7: Show the incidence and percentage of circular rugae in males and females on right side.

Right side	Female		Male		Left side	Female		Male	
	count	%	count	%		count	%	count	%
0	125	100	119	95.2	0	123	98.4	112	97.6
1	0	0	6	4.8	1	2	1.6	3	2.4
Total	125	100	125	100	Total	125	100	125	100

Table 8: Show the incidence and percentage of pointed rugae in males and females on right side.

Right side	Female		Male		Left side	Female		Male	
	count	%	count	%		count	%	count	%
0	125	100	125	100	0	125	100	123	98.4
1	0	0	0	0	1	0	0.0	2	1.6
Total	125	100	125	100	Total	125	100	125	100

Table 9: Show the incidence, percentage and significance of each type of rugae in males and females on left side.

	Left side						Right side					
	Females		Males		P- value	RCC*	Females		Males		p-value	RCC*
	Count	%	Count	%			Count	%	Count	%		
Curved	180	17.2	163	15.6	0.800	0.834	165	16.1	155	15.1	0.063	0.173
Wavy	211	20.2	259	24.8	0.002	1.562	216	21.0	243	23.7	0.029	0.537
Straight	80	7.7	99	9.5	0.213	1.191	110	10.7	97	9.4	0.672	-0.292
Convergent	12	1.1	10	1.0	0.010	1.599	8	0.8	10	1.0	0.879	0.788
Divergent	6	0.6	3	0.3	0.660	0.335	0	0.0	7	0.7	0.408	0.421
Circular	2	0.2	3	0.3	0.880	1.119	0	0.0	5	0.5	0.648	0.4027
Point	0	0.0	2	0.2	0.959	3.551	0	0.0	0	0.0	0.000	0.000
Non-specific	8	0.8	7	0.7	0.953	1.096	7	0.7	4	0.4	0.020	0.198

*Raw canonical coefficient - RCC

The results indicate that wavy rugae on the left side are the most common type in both sexes, with a statistically significant male predominance. Convergent rugae were more frequently observed in females and showed a significant difference. On the right side, wavy rugae again emerged as the predominant type, with significant male predominance, while the non-specific form was significantly more frequent in females.

From the above table, the following equations are deduced:

Equation- 1: For right side rugae based on shape:

Gender = [0.173(curved) + 0.537(wavy) + 0.788(convergent) + 0.421(divergent) + 0.198(nonspecific) + 0.4027(circular) - 0.292(straight)]-1.229.

If the value falls near 0.254, it is male; if it is less than or near -0.271, it is female.

Equation- 2: For the left side rugae based on shape:

Gender = [0.834(curved) + 1.562(wavy) + 1.191(straight) +1.599(convergent) + 0.335(divergent) + 1.096(nonspecific) + 1.119(circular)] -5.107.

If the value falls near 0.252, it is male; if it is less than or near -0.269, it is female.

Discussion

Based on the classification proposed by Thomas and Kotze,[5] palatal rugae are categorized into seven distinct forms: curved, wavy, straight, convergent, divergent, circular, and point. Those that do not conform to these groups are considered non-specific. In the present study, the wavy pattern emerged as the predominant form in both sexes, followed by curved and straight types.

Among females, the left side of the palate revealed wavy rugae in 20.2%, curved in 17.2%, straight in 7.7%, convergent in 1.1%, non-specific in 0.8%, divergent in 0.6%, and circular in 0.2%, with no point-shaped rugae observed. On the right side, wavy (22.0%) and curved (16.1%) types predominated, while straight (10.7%), convergent (0.8%), and non-specific (0.7%) patterns were less frequent; no divergent, circular, or point forms were detected.

In males, the wavy type also predominated on both sides of the palate. On the left side, wavy rugae accounted for 24.8%, followed by curved (15.6%), straight (9.5%), convergent (1.0%), non-specific (0.7%), divergent and circular (0.3% each), and point (0.2%). On the right side, wavy (23.7%) and curved (15.1%) were again most common, followed by straight (9.4%), convergent (1.0%), non-specific (0.7%), and circular (0.5%); no point rugae were observed.

These findings are in close agreement with previous studies. Venegas et al,[4] reported the predominance of sinuous (43%) and curved (27%) rugae. In comparison, Gondivkar et al,[6] observed sinusoidal (71%) as the most common form, followed by wavy (19%), curved (6.6%), point (1.5%), and circular (1.2%). Similarly, Shetty DK et al,[7] found wavy patterns to be most frequent, followed by curved and straight, with other forms being less frequent (5–10%).

Concerning sex-based variation, Shetty M et al,[8] and Manjunath S et al,[9] reported a male predominance of wavy rugae, with statistically significant differences—findings consistent with the present study (P = 0.029 and P = 0.002 for right and left sides, respectively). In contrast, Verma et al. documented a higher prevalence of wavy patterns in females with statistical significance, thereby contradicting our observations.

Curved rugae demonstrated a female predominance in our study without statistical significance. This aligns with the reports of Shetty M,[8] Verma R,[10] and Gondivkar SM,[6] while Chopra A et al,[11] documented a significant female association. Conversely, Sharma P et al. found curved rugae to be more

common in males, contradicting our results and most published literature.

In the present study, straight rugae showed overall male predominance. However, when analyzed sidewise, the right palate exhibited a higher frequency in females, consistent with the findings of Fahim MF,[13] and Shetty M,[8] In contrast, the left palate showed a male predominance similar to that reported by Verma R,[10] Chopra A et al,[11] who found no significant gender difference and reported a similar distribution in both sexes. Importantly, none of these studies—including the current one—demonstrated statistical significance about straight rugae.

Convergent Pattern- In the present study, the overall frequency of convergent rugae was equal in both sexes. However, side-wise analysis revealed a statistically significant difference on the left side (P = 0.010), where females showed a higher prevalence, while the right side demonstrated male predominance without significance. Most earlier studies have reported results without side-by-side distribution. Fahim MF et al.[13] observed a significantly higher prevalence of convergent rugae in females, which supports the current study's findings on the left side. Similarly, Verma R et al.[10] documented female predominance but without statistical significance. In contrast, Chopra et al.[11] reported a male predominance with significant differences, differing from our observations.

Divergent Pattern- The divergent type of rugae demonstrated male predominance in the present study. On side-wise comparison, females showed higher prevalence on the left side, whereas males were predominant on the right; however, these differences were not statistically significant. Conversely, Verma R et al.[10] and Chopra A et al,[11] reported divergent rugae as more common in females, though without statistical significance, which contradicts our results.

Circular Pattern- Circular rugae in this study were more common in males, both overall and on side-wise evaluation, though the differences were not statistically significant. These results are consistent with the observations of Fahim MF et al,[13] Verma R et al,[10] and Chopra A et al,[11] who reported male predominance with statistically significant values. Venegas VH et al,[4] and Shetty M et al,[8] also observed a greater frequency in males, though their findings did not reach statistical significance.

Conclusion

The non-specific rugae pattern demonstrated overall female predominance. On side-wise analysis, this predominance was statistically significant on the right side (P = 0.020), whereas the left side showed higher frequency in females without statistical significance.

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Conflicts of interest

There are no conflicts of interest.

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