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Evaluation and comparative study of palatal rugae, arch length, and arch width with its predictive accuracy for Gender Identification

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ABSTRACT

Aim: The aim of this study was to evaluate and correlate variation in the palatal rugae pattern, maxillary arch length, and maxillary arch width in males and females visiting dental college along with its predictive accuracy in gender differentiation.

Materials and methods: 100 preorthodontic maxillary dental stone casts, including 50 males and 50 females in age range of 18–30 years, were studied for different rugae pattern, arch length, and arch width. Thomas and Kotze classification was adopted for assessing rugae pattern. The arch length was measured by using the Lavelle's method and arch width by measuring intermolar distance. The data were analyzed using independent *t*-test and discriminant function analysis by SPSS 19 Statistical Package.

Results: The study revealed that females had higher curved and diverging type of rugae while males had higher circular and converging type of rugae, which were found to be statistically significant ($P < 0.05$). The arch length and width at all dimensions were higher for males than females, which were found to be statistically significant ($P < 0.05$). Association between rugae pattern and arch dimension was computed using discriminant function analysis, which permitted gender differentiation in this population with an accuracy of 83%.

Conclusion: The rugae pattern, arch length, and arch width can be used for gender differentiation in the human population. However, further research work on a larger population and use of other methods is necessary to validate its use in forensics science.

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1. Introduction

Forensic odontology is a branch of dentistry dealing with appropriate handling and inspection of dental evidence, and with proper evaluation and presentation of dental findings in the interest of justice.[1] Identifying a person is crucial for individual and community purpose as well as for death certification. Human identification is centered on the scientific principles, primarily including dental records, DNA evaluations, and fingerprints.[2]

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The term palatoscopy or palatal rugoscopy is given to the study of palatal rugae conducted for establishing a person's individuality.[3] The rugae are shielded from elevated temperatures and trauma by their location inside the oral cavity, protected and enclosed by soft tissues like tongue, cheeks, and lips as well as hard tissues like teeth and bone. Once formed, they alter only in their length, owing to normal growth, and are remaining in the same location throughout the lifetime of an individual. Additionally, palatal rugae can withstand decay for up to 7 days after the person's death.[1,2]

Dental arch length and arch width also show variation with different races and gender. Many studies have been conducted to identify gender using palatal rugae pattern,[4–6] arch length,[7] and arch width[8,9] as three separate parameters. Also, few studies are known to combine rugae and arch length.[10,11] However, this is the first study to combine all three parameters together for gender identification.

The aim of this study was to evaluate and correlate variations in the palatal rugae pattern, maxillary arch length, and maxillary arch width in males and females visiting dental college along with its predictive accuracy in gender differentiation.

2. Materials and methods

The study sample consists of 100 preorthodontic maxillary dental stone casts retrieved from the Department of Orthodontics of the Dental College, which included 50 males and 50 females in the age group of 18–30 years.

2.1. *Inclusion criteria*

- Individuals without braces, and removable or fixed partial dentures.
- Fully erupted teeth up to first permanent maxillary molars.
- No dental anomalies or interproximal caries.

2.2. *Exclusion criteria*

- Individuals with lip and palate abnormalities like cleft lip and cleft palate.
- Individuals with partial dentures and braces, and dental anomalies.
- Clinically apparent interproximal dental caries.
- Change in the shape or number of the teeth.

Thomas and Kotze classification[12] was used for interpretation of palatal rugae on the casts. The rugae were outlined by sharp pencil and were measured by using digital Vernier Caliper (Fig. 1).

The rugae are classified based on their length as the following: primary (>5 mm), secondary (3–5 mm), and fragmentary (<3 mm). Rugae less than 3 mm are disregarded. The rugae are divided into four types based on their shape as curved, wavy, straight, and circular (Fig. 2). Based on their unification pattern, rugae are classified as follows: converging and diverging (Fig. 2).

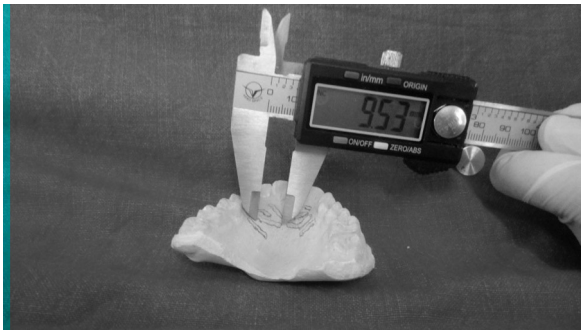


Fig. 1 – Measurement of palatal rugae.

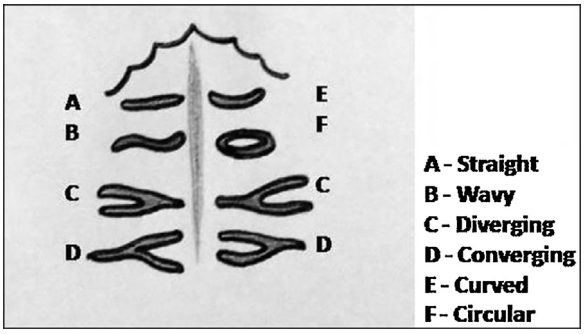


Fig. 2 – Representation of various types of rugae.

Lavelle et al.[13] method was used for measurement of dental arch length. The measurements were performed on maxillary casts using digital Vernier Caliper of 0.01 calibrations. The dental arch length was measured between the most mesial aspect of anterior teeth (maxillary central incisor) and the most distal aspect of posterior teeth (maxillary first molar). The dimensions measured were from 11 to 16 (Fig. 3).

Arch width was measured using maxillary intermolar width while its reference point was selected as distance between mesial fossa of first permanent molars (Fig. 4).[14] All

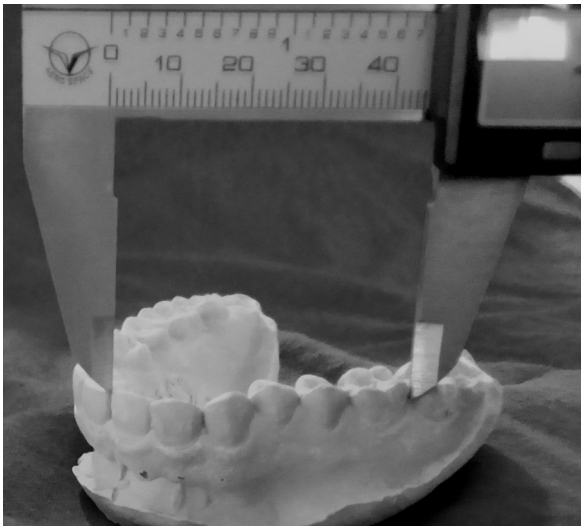


Fig. 3 – Measurement of arch length.



Fig. 4 – Measurement of arch width.

the identification and measurements were done by a single examiner and reading was repeated three times for each cast and then the average was calculated.

2.3. *Statistical analysis*

The statistical analysis was done using independent *t*-test and discriminant function analysis using the SPSS 19 Statistical Package.

3. Results

The present study includes 100 preorthodontic casts retrieved from Department of Orthodontics. Evaluation of rugae patterns was done by Thomas and Kotze classification, which states that the curved and wavy rugae are the most prevalent shapes in all the groups, followed by straight rugae. The mean of circular and converging rugae was more in males and the curved and diverging rugae pattern was more in females, which were found to be statistically significant ($P < 0.05$). The mean value of primary rugae was more as compared to secondary rugae, which was not statistically significant [Graph 1, Table 1].

Similarly, differences in arch length were calculated using Lavelle's method, and differences in arch width were measured using maxillary intermolar widths, which showed that the mean values of arch length and width have statistically significant values wherein males have higher dimensions than that of females ($P < 0.05$) [Graph 2, Table 2].

Unstandardized coefficients were calculated by discriminant function analysis of the study groups [Table 3]. An equation was constructed using these values to determine the gender of an unidentified person wherein the value of the rugae and arch dimensions is multiplied with their respective unstandardized coefficients and then added to the constant, and the predictive accuracy was calculated.[15,16] Hence, the unidentified gender calculated using palatal rugae pattern individually is $G = -1.755 + 0.756$ (curved rugae pattern) $-$ 0.603 (circular rugae pattern) $-$ 0.459 (convergent rugae pattern) + 0.531 (divergent rugae pattern) [applying this formula, the accuracy in determining gender is 71%].

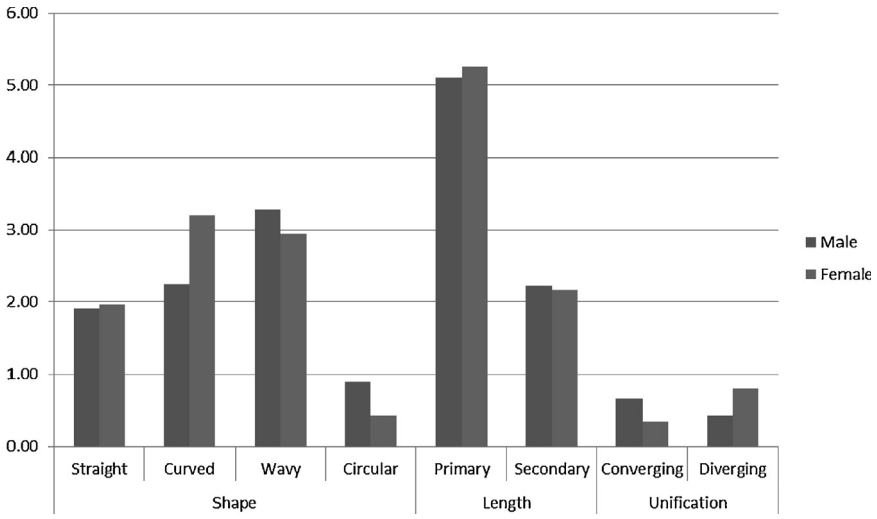
Similarly, for arch length it is $G = -21.229 + 0.453$ [accuracy is 70%]. And, for arch width it is $G = -17.39 + 0.356$ [accuracy is 64%].

Finally, the unidentified gender calculated using rugae pattern, arch length, and arch width combined is $G = -20.034 - 0.697$ (curved rugae pattern) + 0.402 (circular rugae pattern) + 0.319 (arch length) + 0.137(arch width) [accuracy is 83%].

4. Discussion

The current study evaluated and correlated the variations in the palatal rugae pattern, maxillary arch length, and maxillary arch width in males and females (18–30 years) visiting dental college along with its predictive accuracy in gender differentiation.

It is widely known that there are limits in identification by fingerprints and DNA in some forensic circumstances, and the palatal rugae pattern of a person may be considered as a beneficial adjunct for identification purpose.[6] The most



Graph 1 – Distribution of rugae pattern according to gender. *Note*: All parameters measured on *Y*-axis are mean value of total number of rugae.

Table 1 – t-Test of significance for difference between palatal rugae pattern in male and female.

Different types of rugae	Gender	N	Mean	Standard deviation	Standard error mean	P value
Shape						
Straight	Male	50	1.90	1.3887	0.1963	0.824
	Female	50	1.96	1.3086	0.1850	
Curved	Male	50	2.24	1.0796	0.1526	0.000
	Female	50	3.20	0.9035	0.1277	
Wavy	Male	50	3.28	1.5124	0.2139	0.208
	Female	50	2.94	1.1501	0.1626	
Circular	Male	50	0.90	0.8864	0.1253	0.002
	Female	50	0.42	0.6727	0.0951	
Length						
Primary	Male	50	5.10	1.4742	0.2084	0.620
	Female	50	5.26	1.7356	0.2454	
Secondary	Male	50	2.22	1.0554	0.1492	0.784
	Female	50	2.16	1.1313	0.1600	
Unification						
Converging	Male	50	0.66	0.8478	0.1198	0.037
	Female	50	0.34	0.6580	0.0930	
Diverging	Male	50	0.42	0.7024	0.0993	0.013
	Female	50	0.80	0.8081	0.1142	

Table 2 – t-Test of significance for the difference between the mean arch lengths and widths in males and females.

Dental arch dimensions	Gender	N	Mean	Standard deviation	Standard error mean	P value
Arch length	Male	50	47.94	1.9733	0.2790	0.000
	Female	50	45.72	2.4162	0.3417	
Arch width	Male	50	49.76	2.9524	0.4175	0.000
	Female	50	47.80	2.6496	0.3474	

prevalent shapes of palatal rugae were curved and wavy rugae followed by straight rugae, which is consistent with results of Nayak et al.[3] Also, it agrees with the study conducted by Surekha et al.[17] and Kumar et al.[18] Only circular and curved rugae shapes presented statistically significant differences in gender. The circular rugae were found to be statistically higher in males than in females, and curved rugae were higher in females than in males.

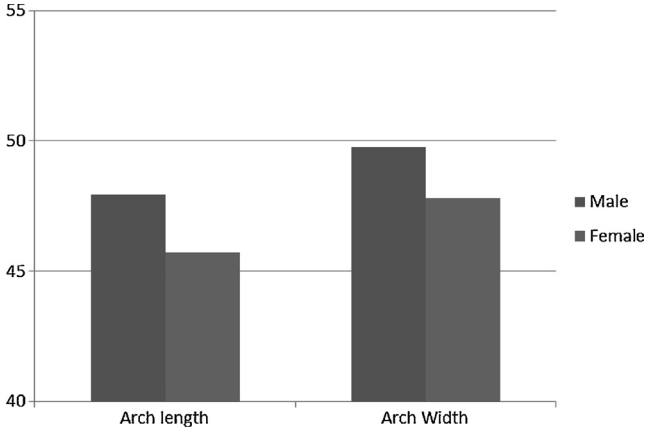
The primary rugae were more as compared to secondary rugae, but the findings were not statistically significant. The divergent rugae were higher in females and the converging rugae were higher in males, which were analogous to the findings of Swetha.[19]

The study showed that arch length of the males in all dimensions was greater than those of the females, which was consistent with the findings of Shrestha and Bhattarai[7] and Barrett et al.[20] The arch width of the males was greater than those of the females, and this is consistent with the study of Jindal et al.[8]

This is the first comparative cross-sectional study to use rugae pattern, arch length, and arch width in combination for gender determination. The predictive accuracy was higher for

Table 3 – Discriminant function coefficients for rugae and arch length that entered analysis – gender.

Type	Variable	Unstandardized coefficient	Male	Female	Sectioning point
Discriminant analysis done for rugae pattern alone	Curved rugae pattern	0.756	−0.682	0.682	0.000
	Circular rugae pattern	−0.603			
	Convergent rugae pattern	−0.459			
	Divergent rugae pattern	0.531			
	(Constant)	−1.755			
Discriminant analysis done for arch length alone	Arch length	0.453	0.503	−0.503	0.000
	(Constant)	−21.229			
Discriminant analysis done for arch width alone	Arch width	0.356	0.349	−0.349	0.000
	(Constant)	−17.390			
Discriminant analysis done for rugae pattern, arch length, and width combined	Curved rugae pattern	−0.697	0.920	−0.920	0.000
	Circular rugae pattern	0.402			
	Arch length	0.319			
	Arch width	0.137			
	(Constant)	−20.034			



Graph 2 – Distribution of arch length and arch width according to gender. *Note*: All the parameters on Y-axis are dimensions of arch length and width in mm.

the combination (83%) when compared with the separate parameters (71% for rugae pattern, 70% for arch length, or 64% for arch width). However, these conclusions are obtained from limited sample size, and therefore, further research work on larger samples and use of other methods are necessary to validate its use in forensic science.

5. Conclusion

This is the first study conducted using discriminant function analysis on palatal rugae pattern, maxillary arch length, and maxillary arch width in combination for gender identification. Discriminant function analysis showed that gender determination was more accurate for combination than individual parameters. Hence, the palatal rugae pattern, maxillary arch length, and maxillary arch width can be used for identifying gender in the human population.

Conflicts of interest

The authors have none to declare.

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