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Study of Palatal Rugae Pattern For Gender Identification

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ABSTRACT

In this project the variations in male and female rugae patterns are studied. It opted for ten dental cast models in all, five of whom were male and five of whom were female, and they were all in the 18–25 age range. The palatal rugae's size, shape, number, and symmetry were all studied in these samples.

This study wanted to identify how much the patterns of male and female rugae varies in any evident ways. Both forensic dentistry and personal identification may benefit from this. Rugae are dependable for forensic use because they are protected inside the mouth and do not change much over time.

In an attempt to figure out which rugae types were more commonly encountered in males and females, comparison of the shapes of rugae, including straight, curved, wavy, and circular were done. The findings demonstrated that although some patterns were similar, some types—such as wavy rugae—were more frequently observed in females and curved rugae in males. These variations may lend credence to rugoscopy's function in gender differentiation.

Keywords: *Palatal Rugae, Rugae pattern, Rugoscopy, Gender, Forensic Odontology.*

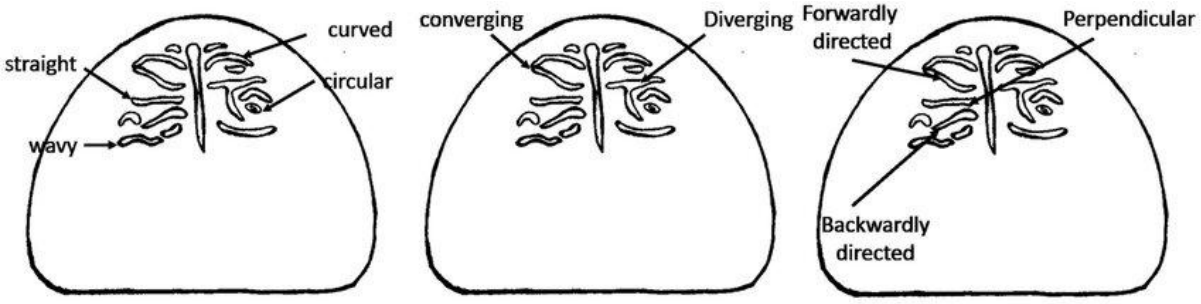
1. INTRODUCTION

Rugae are the small, irregular ridges located on the roof of the mouth, just behind the front teeth. These ridges are found in the anterior third of the hard palate and are called palatal rugae. The pattern formed by these ridges is referred to as the rugae pattern. Each individual has a unique rugae pattern, which remains unchanged throughout life and can be used for personal identification. These rugae develop during foetal life, usually between the 12th and 14th weeks of pregnancy. They are made of connective tissue and are covered by a thin mucosal layer. Despite their small size, rugae are well protected inside the mouth and do not change significantly over time, even after death or in accidents like burns. Table 1 describes the various types of rugae pattern.

Based on Size	
1. Primary Rugae	Longer than 5 mm
2. Secondary Rugae	Between 3–5 mm
3. Fragmentary Rugae	Less than 3 mm
Based on Shape of Rugae	
1. Straight	Run directly outwards from the midline
2. Curved	Slightly bent, like a bow
3. Wavy	Appear like gentle waves or zigzags
4. Circular	Form loop-like or complete ring shapes
5. Unified	Two rugae joining at either end (origin or end)

Based on Direction

1. Some rugae point forward (anterior)
2. Some point backward (posterior)
3. Others run almost perpendicular to the centreline of the palate.



Types of rugae based on shapes | Types of rugae based on unification | Types of rugae based on direction

Importance of Rugae pattern

Since every person has a unique rugae pattern, it helps in identifying unknown human remains, especially when other means like fingerprints are not available. In orthodontics and denture-making, the rugae serve as reference points to track movement or position teeth and ensure proper fit of dental appliances. Rugae patterns can differ based on gender and ethnic group, making them useful in population studies and tracing human ancestry.

Significance of Rugae Pattern in Forensic Science

Palatal rugae patterns hold valuable forensic significance due to their unique, stable, and protected nature. Here's a detailed explanation of their importance in forensic investigations:

1. Personal Identification

Palatal rugae are unique to each person, similar to fingerprints. No two individuals, including identical twins, have the same rugae pattern. Because they do not change much over time, they can be used to:

- Identify unknown bodies
- Verify identity in criminal cases
- Re-establish identity in mass disasters (e.g., airplane crashes, building fires)

2. Resistance to Post-mortem Changes

One major forensic advantage is their resistance to decomposition, fire, and trauma. In cases where fingerprints are destroyed due to burns or decomposition, the rugae—being located inside the mouth and protected by tissues and bones—often remain intact and can be examined for identification.

3. Gender and Ethnicity Clues

Studies have shown that rugae patterns may differ based on sex and racial background, making them helpful for:

- Estimating gender of unknown remains
- Contributing to the biological profile of a deceased person
- Narrowing down possible identities

4. Comparative Analysis

If ante-mortem dental records, casts, or photographs of palatal rugae exist, they can be compared with post-mortem findings. Dentists or forensic experts use casts, digital scans, or photographs of the palate to match the patterns.

5. Non-invasive and Cost-effective

Recording palatal rugae is simple, painless, and affordable. It only requires dental impressions or digital scanning, making it an easy and accessible tool in forensic odontology, especially in regions with limited forensic resources.

6. Use in Mass Disasters

In situations involving many victims (e.g., natural disasters, plane crashes), dental identification using rugae can be one of the fastest methods to identify people when other means are unavailable or destroyed.

In this project the variations in male and female rugae patterns are studied. It opted for ten dental cast models in all, five of whom were male and five of whom were female, and they were all in the 20–24 age range. The palatal rugae's size, shape, number, and symmetry were all studied in these samples. The objective of the present study is to-

1. To identify palatal rugae patterns (in terms of number and shape) in males and females.
2. To compare the palatal rugae patterns in males and females.

2. MATERIALS AND METHODS

A total number of 10 (5 males, and 5 female) irreversible hydrocolloid (alginate) impressions of the maxillary arch were made. The students were randomly chosen having aged between 18-25yrs who were devoid of any history of orthodontic treatment, surgery involving the palate, or congenital defects. The samples were chosen based on the clarity of the palatal region, ensuring that the rugae were well-preserved and easily identifiable. A convenience sampling technique was used for data collection.

Maxillary impressions were recorded using irreversible hydrocolloid material and perforated dentulous stock trays of suitable dimension. The impression was then poured using dental stone. The stone models were free of voids or discrepancy especially in the anterior two-third of hard palate. The base of the stone model was trimmed parallel to the occlusal plane. The palates examined in these studies were shallow with U-shaped arch frame.

Method of Identification

A midline was drawn coinciding with that of the mid palatine raphae extending from the incisive papillae to the posterior most extent of the rugae on the palate. This divided the rugae in two halves and the rugae in each half were highlighted using a lead pencil and were observed under suitable light and magnification (figure 1)

The pattern of rugae was determined using Thomas and Kotze classification ref (Figure 2). It classifies the rugae pattern into straight, wavy, circular, curved, and unification. The shape, number, and length of rugae pattern were studied. The length of each rugae was measured using Vernier callipers in millimetres (mm). The rugae were marked as follows- Initial rugae, the most anterior one was represented by numbers. The identified shapes were classified as curved, wavy, straight and circular. The unification was grouped either as converged or diverged. Converged are those where two rugae originated away from the centre and united towards it. While diverged ones are those rugae which originated from the centre and diverged away from it.

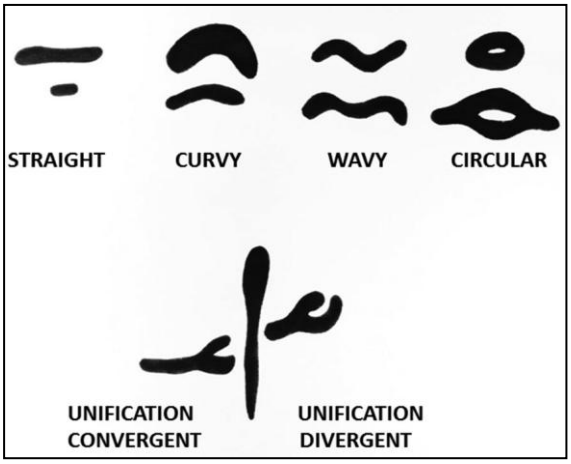


Figure 1. Thomas and kotze classification of Rugae pattern

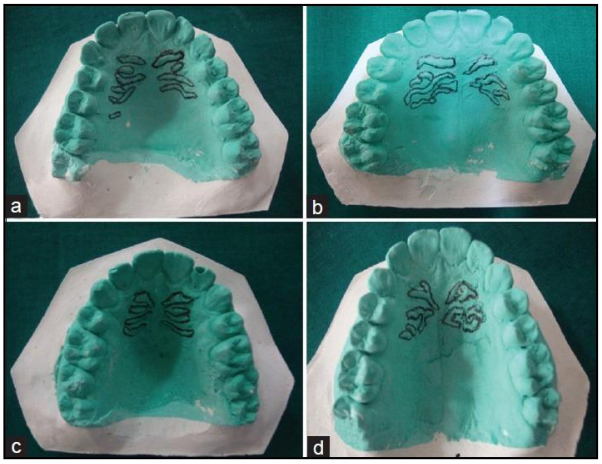


Figure 2. Rugae pattern highlighted using lead pencil

Statistical Analysis

Chi-square test and t-test were used for comparison between the desired parameters. A significance level of data was analysed by using Graph-Pad prism 10.4.1.

3. RESULTS AND DISCUSSION

1. Total number of rugae Isolated

A total of 96 rugae were found in 10 individuals. Out of these, 49 (51%) were found in male and 47 (49%) in females as depicted in Figure 3, with their descriptive statistical analysis in Table 1. Even though the number of rugae in males was greater than that found in females, it was not statistically significant (p=0.81). Similar results have been reported in the studies done by Gadicherla et al., 2017.

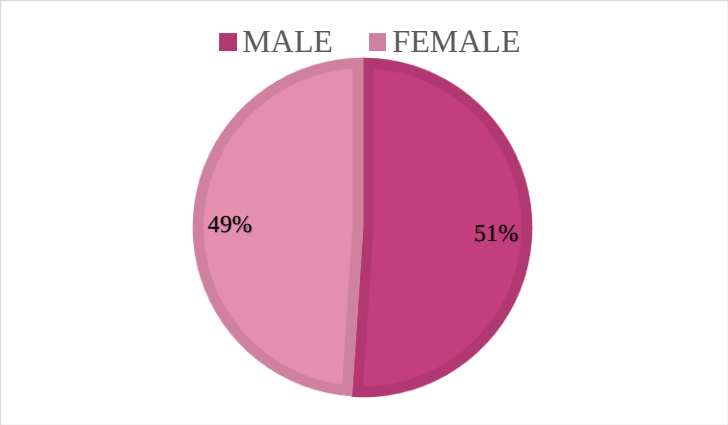


Figure 3. Total number of rugae in male and female

Table 1. Association of mean number of palatal rugae and gender

	Gender	N	Mean± SD	P value
Number of palatal rugae	Male	5	9.8± 2.04	0.81
	Female	5	9.4± 3.26	

***SD- standard deviation**

2. Specific pattern-wise distribution of rugae

In the total 96 rugae found, 40 (41.6%) were straight type. 37 (38.5%) curvy types followed by 18 (18.75%) wavy. Straight pattern was found to be the most predominant type. Unification convergent and divergent types were found in relatively lesser number respectively. In our study, only one circular rugae was isolated (Figure 4). Similar findings were reported by Madhankumar, 2013 in their study.

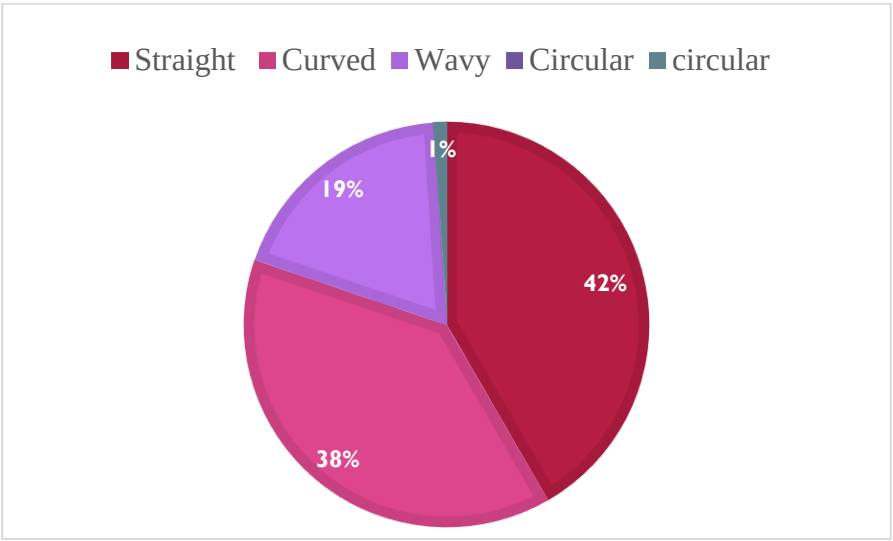


Figure 4. Specific pattern-wise distribution of rugae

3. Gender-wise distribution of specific rugae patterns

In male samples, the most commonly observed rugae shape was curved, accounting for around 42% of the total male rugae. This was followed closely by straight rugae, which made up 40% of the male rugae. Wavy rugae were less frequent in males, observed in 14% of cases, while circular rugae were the least common, seen in only one male sample (2%). In contrast, in female samples, straight rugae were slightly more common than in males, making up approximately 42.6% of the total female rugae. Curved rugae were present in about 34% of the rugae observed in females. Interestingly, wavy rugae were more frequent in females compared to males, appearing in about 23.4% of the cases. No circular rugae were observed in any of the female samples as shown in figure 5, and its descriptive statistical analysis is depicted in Table 2

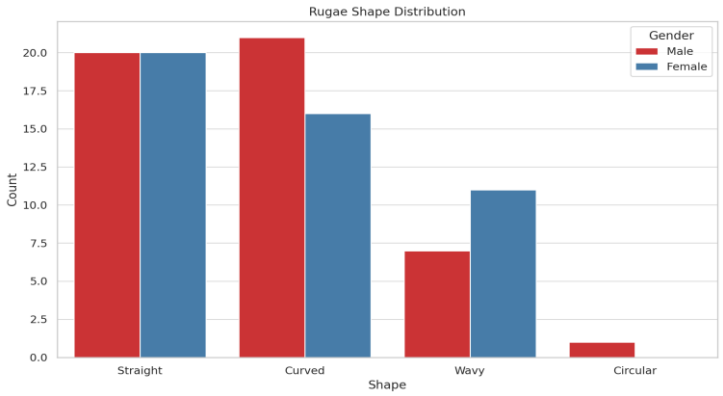


Figure 5. Gender-wise distribution of specific rugae patterns

Table 2. Association of mean of palatal rugae pattern and gender

Rugae pattern	Gender	N	Mean± SD	P value
Straight	Male	5	4± 2	1.0
	Female	5	4± 1.5	
Curved	Male	5	4.2±1.3	0.35
	Female	5	3.2±1.9	
Wavy	Male	5	1.4±0.89	0.17
	Female	5	2.2±0.83	
Circular	Male	5	0.2±0.44	0.33
	Female	5	0±0	

***SD- standard deviation**

Our study is in agreement with the results conducted by Smriti et al., 2017 on south Indian population, wherein they have tested palatal rugae for sex determination, it was seen that females showed a higher prevalence of circular and backward-directed rugae, contrary to our study. Also, males had more forward-directed and straight rugae. The shape of the rugae exhibited gender prediction accuracy up-to 60% based on linear regression analysis. Another study done by Gautum et al., 2017 on gender identification using palatal rugae shows the similar findings of the present study. Their study shows that the straight rugae pattern was the most common in both the genders. They also study the length of the palatal rugae of both male and female and find out the mean length of palatal rugae was significantly greater in males (6.25 ± 1.15 mm) than in females (5.16 ± 1.40 mm). Their study concluded that palatal rugae patterns exhibit sexual dimorphism and can aid in gender identification. The study done by Balgi et al., 2014 were in consistent with the present study findings. Their study also shows that the straight pattern of rugae were commonly observed in females and the average length of rugae was greater in males (13.63 mm) than in females (11.66). Their study found significant differences in rugae length and shape between genders, suggesting its utility in gender determination. Similar study done by pappu et al, 2018 also points that the straight rugae pattern was found to be more common in both men and women, with averages of 2.32 ± 0.12 in men and 1.98 ± 0.02 in women, showing insignificant association between the different rugae patterns and gender. The straight rugae pattern is the most prevalent in both groups.

4. CONCLUSION

The analysis suggests that palatal rugae patterns show subtle but consistent variations between males and females, particularly in shape and distribution. Males tend to have more curved rugae, while straight and wavy rugae are more common in females. Although the total number and side-wise distribution of rugae were similar across genders, the shape and pattern differences may hold forensic significance. While rugae length (with primary rugae being dominant) does not show significant sex-based variation, unification patterns such as converging or diverging rugae are uncommon but have been observed sporadically in both males and female. Overall, this study supports the idea that palatal rugae can be a useful, non-invasive tool for gender differentiation in forensic identification, especially when traditional methods like fingerprints or DNA are unavailable.

This study shows that palatal rugae patterns can vary between males and females and can play a helpful role in forensic identification. Rugoscopy is a reliable and non-invasive method, especially useful when other means of identification (like fingerprints or DNA) are not available.

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