**ORIGINAL RESEARCH**

# Analysis of Various Rugae Patterns among Coastal Andhra (South Indian) Population: Digitized Method

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## ABSTRACT

**Background:** Human identification, either living or dead, is a very complex process, one of the main objectives of the forensic sciences. Palatal rugae patterns play an important role in establishing individual identity when no other traditional methods are available.

**Objectives:** (1) To see whether the rugae patterns are sufficiently individualistic to confirm the identification, (2) to record the incidence and to see whether there are gender differences in palatal rugae patterns and also to determine the predominant pattern if any, in the coastal Andhra (South Indian) population.

**Materials and methods:** Eighty individuals of age between 18 and 30 years were randomly selected for the study. Alginate impressions of maxillary arch were made and casts were poured with dental stone. Palatal rugae were highlighted with pencil. All 80 casts were photographed with a digital camera. The digitized photographs were copied to a CD and rugae patterns were analyzed by three observers as per classification given by Nayak et al. Association between rugae shape and sex was tested by descriptive and chi-square analysis using SPSS 12.0 statistical package.

**Results:** The present study showed that wavy and curved rugae patterns were predominant followed by straight rugae in males; whereas in females, wavy and straight rugae were prevalent followed by curved rugae. Unification constituted fewer than 5% in the entire sample while circular rugae were completely absent. Significant differences in rugae shapes between males and females were found in the selected population. Females showed more number of rugae compared to males in the present study.

**Conclusion:** Palatine rugae patterns vary from person to person and are highly individualistic and can be used for human identification only when the antemortem records are available. Palatine rugae shapes revealed significant differences in males and females of selected population. Observation of nonspecific rugae provides an insight to further classify and perform studies on the rugae patterns in larger samples.

## INTRODUCTION

Identifying an individual has become a difficult task for forensic, social, legal and humanitarian reasons. Most commonly employed techniques for human identification include dental, fingerprint and DNA comparison methods.[1-6] In situations, when identification of an individual by fingerprint or dental record comparison is difficult, palatal rugae patterns may be considered as an alternative source of material. Dental identification is an important method of identifying a deceased person, based on comparison of antemortem and postmortem records.

Rugoscopy, study of palatal rugae, is used for individual identification and necro identification.[2,3] The palatal rugae appear toward the third month of intrauterine life. They are asymmetrical and irregular elevations of the mucosa located in the anterior third of the palate. They are formed from the lateral membrane of the incisive papilla, arranged in transverse direction from the palatine raphe located in the midsagittal plane.[1,7,8] Development and growth of rugae are controlled by epithelial-mesenchymal interactions during intrauterine life. Palatal rugae have been shown to be highly individualistic and have consistency in shape throughout life and can be used successfully for human identification.[5,6,8-12]

Palatal rugae play an important role in medicolegal identification because their individual morphological characteristics are stable over time,[13] physiologically involved in the act of deglutition; improve the relationship between food and taste receptors, help in speech and aids in suckling in children. In addition, the rugae pattern

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appears to be specific to racial groups facilitating population identification.[4,14,15]

Rugae patterns have been studied for various purposes, mainly in the fields of anthropology, comparative anatomy, genetics, forensic odontology, prosthodontics and orthodontics.[3,14,16] Palatal rugae are advantageous over other methods of identification as in situations when identification of an individual by fingerprint or dental record comparison is difficult, when postmortem dental identification is impossible as in edentulous mouths, anatomical position inside mouth keeps them well protected from trauma and insulated against high temperatures, more resistant to decomposition and thermal effects, low utilization costs and easy reproducibility and less time, specific training is not required for rugae pattern analysis.[3,5,15,17,18]

Application of palatal rugae patterns for personal identification was first done by Allen in 1889.[17] Palatal rugoscopy was first proposed in 1932, by Trobo Hermosa.[1] Sassouni stated that no two palates were alike in their configuration and that the palatoprint does not change during growth.[3,17] Kapali et al observed denture wear, tooth malposition and palatal pathology could cause alterations in rugae patterns. Thomas et al stated that rugae are genetically determined. English et al used manual method to compare the rugae patterns. Thomas and VanWyk successfully identified a severely burned edentulous body by comparing the rugae to the pattern on victim's old denture. Carrea indicated that a rugae pattern is formed by the 12th to 14th week of prenatal life, and it remains stable throughout the person's life. In the present study, classification used for rugae shape analysis was simple and reliable. The method applied was easy to record and does not require complex instrumentation.

## AIMS AND OBJECTIVES

1. To see whether the rugae patterns are sufficiently individualistic to establish person's identity.
2. To record the incidence and to see whether there is a gender difference in palatal rugae patterns and also to determine the predominant pattern if any, in the Nellore population.

## MATERIALS AND METHODS

Alginate impressions of maxillary arch of 80 individuals (40 males, 40 females) with age 18 to 28 years were taken for the study. Informed consent was taken from all the individuals involved in the study. Casts were poured with dental stone and bases with plaster, and all the models were photographed and copied to CD and analysis of rugae patterns was done by three observers. Individuals with cleft palate, those who had undergone surgery at anterior palatal region, extraction of upper permanent teeth, those with palatal lesion, Malocclusion, orthodontic treatments were excluded from the study.

Analysis of palatal rugae was performed using Nayak et al method.

Classification of palatal rugae based on shape:
1. Straight (S), rugae which run directly from origin to termination.
2. Wavy (W) serpentine shape of rugae.
3. Curved (C) rugae appear as simple crescent shaped, curved gently.
4. Circular (A) continuous ring form of rugae.
5. Unification (U) appears when two rugae joined at their origin or termination.
6. Nonspecific rugae pattern (N) involves the rugae that did not fall in above categories.

## RESULTS

In the present study, we used Nayak et al method to assess palatal rugae patterns. During the whole study, no two palates were found identical by all the three observers. Incidence and association between rugae shape and sex were tested using Chi-square analysis and descriptive statistics.

In males (Table 1), wavy and curved rugae are prevalent followed by straight rugae (Graph 1). In females (Table 2), wavy and straight rugae are prevalent followed by curved rugae (Graph 2). Unification constituted fewer than 5% of rugae in the entire sample while circular rugae were totally absent (Graph 3). Significant differences in rugae shapes between males and females were found (Tables 3 and 4). No significant interobserver variation was ascertained for different rugae in males and females (Table 5). In present study, number of rugae was more for females (52%) than males (48%) (Graph 4).
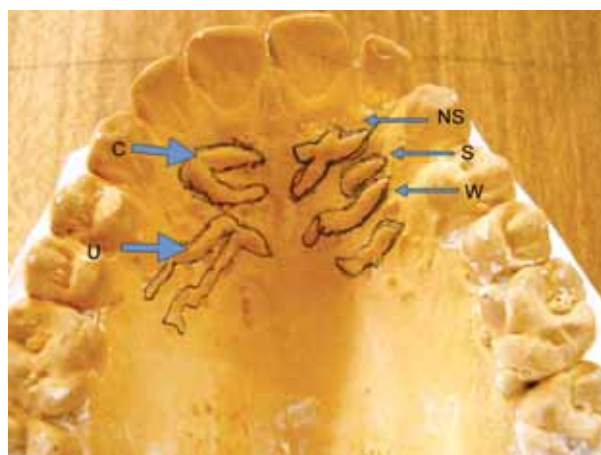


**Fig. 1:** Various shapes of rugae. C: Curved; U: Unification; S: Straight; W: Wavy; N: Nonspecific

## DISCUSSION

Establishing person's identity is a difficult task in cases of accidents or in mass disaster situations. Various classifications were introduced to assess palatal rugae. Most of the studies were done using the Silva, Carrea, Lysell, Thomas, Kotze and Kapali et al methods. Thomas and kotze highlighted the difficulties in observing, classifying and analyzing the minute variations in palatal rugae and emphasized the need to standardize the procedures in recording rugae. However, they observed that it was difficult to formulate a universally acceptable classification and

conceived that a 'single operator alone and considering his own classification can successfully apply in a comparative project, and the results derived from the comparisons are of great value than the comparison itself.[8,14] Despite the ongoing problem associated of describing the palatal rugae patterns, qualitatively and quantitatively, their uniqueness to individuals has been recognized clearly as providing a potentially reliable source of identification.[2]

Previous studies made it clear that a classification system which is simple and reliability be used in assessing rugae patterns. The purpose of the study was to record the incidence
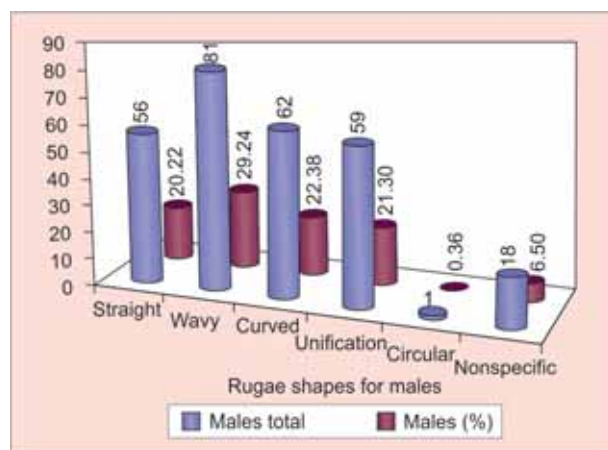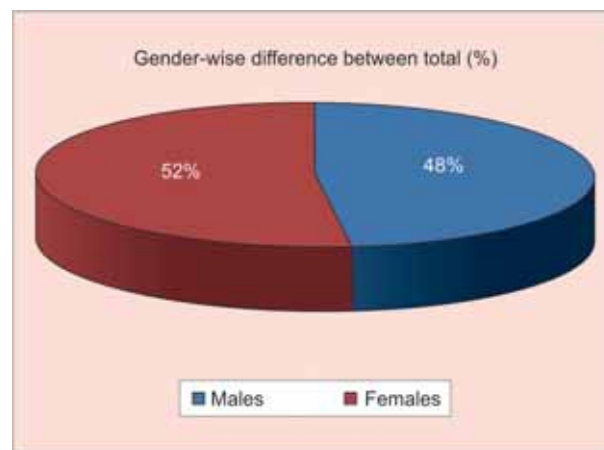


**Graph 1:** Incidence and percentage of various rugae patterns among males in entire sample
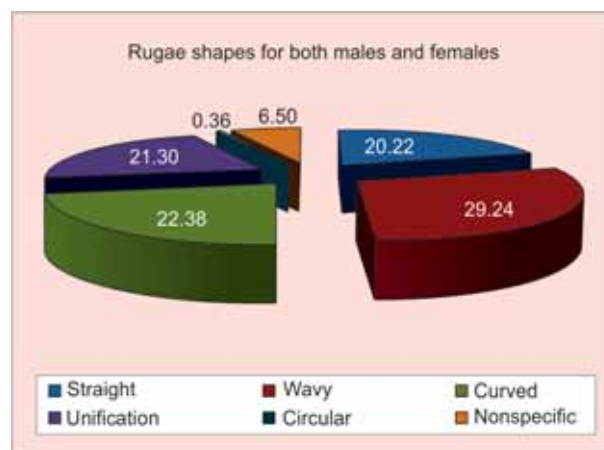


**Graph 3:** Frequency distribution of the various shapes of rugae patterns in males and females
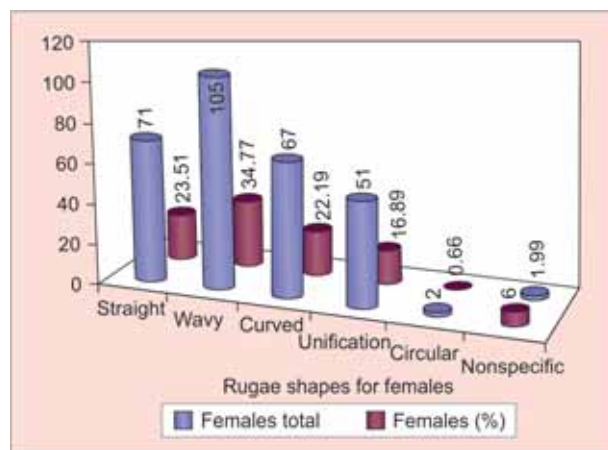


**Graph 2:** Incidence and percentage of various rugae patterns among females in entire sample



**Graph 4:** Percentage of total number of rugae among males and females in entire sample

**Table 1:** Frequency and mean of different rugae shapes in males

| Rugae shape | Incidence | Percentage | Mean | Median |
|---|---|---|---|---|
| Straight | 56 | 20.2 | 1.4 | 1 |
| Wavy | 81 | 29.2 | 2.0 | 2 |
| Curved | 62 | 22.3 | 1.5 | 1 |
| Unification | 59 | 21.3 | 1.48 | 1 |
| Circular | 1 | 0.36 | 1 | 1 |
| Nonspecific | 18 | 6.5 | 1.2 | 1 |

**Table 2:** Frequency and mean of different rugae shapes in females

| Rugae shape | Incidence | Percentage | Mean | Median |
|---|---|---|---|---|
| Straight | 71 | 23.5 | 1.78 | 2 |
| Wavy | 105 | 34.7 | 2.7 | 2 |
| Curved | 67 | 22.19 | 1.68 | 2 |
| Unification | 51 | 16.89 | 1.28 | 1 |
| Circular | 2 | 0.66 | 1 | 1 |
| Nonspecific | 6 | 2 | 1 | 1 |

**Table 3:** Chi-square analysis for assessing differences in rugae shapes in males

| | Straight (S) | Wavy (W) | Curved (C) | Unification (F) |
|---|---|---|---|---|
| Chi-square | 13.25 | 13.4 | 17.3 | 29.25 |
| Df | 4 | 5 | 5 | 4 |
| p-value[a] | 0.01 | 0.02 | 0.00 | 0.00 |

[a]Greater significant difference at $p \leq 0.05$ level

**Table 4:** Chi-square analysis for assessing differences in rugae shapes in females

| | Straight (S) | Wavy (W) | Curved (C) | Unification (F) |
|---|---|---|---|---|
| Chi-square | 22.65 | 47.85 | 10.75 | 20 |
| Df | 6 | 6 | 4 | 4 |
| p-value[a] | 0.00 | 0.00 | 0.03 | 0.00 |

[a]Greater significant difference at $p \leq 0.05$ level

**Table 5:** Chi-square analysis for assessing interobserver variation in recording different rugae shapes

| | Chi-square for entire sample | | |
|---|---|---|---|
| | Chi-square | df | p-value[a] |
| Straight | 7.81 | 7 | 0.35 |
| Wavy | 11.73 | 6 | 0.068 |
| Curved | 12.63 | 6 | 0.05 |
| Unification | 5.47 | 5 | 0.361 |

[a]None of the differences were significant at $p \leq 0.05$ level

and to determine the relation between gender and various rugae patterns in South Indians and also to confirm the individualistic nature of rugae. The method of classification that we had used in this study was a modification of Kapali et al method,[15] and it is simple, easy to apply and no advanced training is required to assess rugae patterns. While analyzing the rugae shapes throughout the study, no two individual's rugae patterns showed similar palatal print confirming that the rugae are unique, highly individualistic and help in necroidentification. No significant interobserver variations were noted in the present study.

The most common rugae shape observed in the present study were wavy and curved forms in males, wavy and straight forms in females. These findings were consistent with the study done by Kapali et al in Australian Aborigines and Caucasians[4,15,16] and Mahabalesh Shetty and Premalatha in Mangalore population[2] and M Shankar et al in Indian (Manipal) population[3] and Nayak et al in South and West Indian population and Paliwal et al in Madhya Pradesh and Kerala population. Unlike in the present study, Saraf et al[6] reported unification was greater in females, and circular rugae were more in males in his study in North Indian population. However, in the present study, unification was

few in a number and circular rugae were completely absent, similar to the study done by Preethi et al.[4] Appearance of 'some nonspecific' rugae was observed, which provides a scope to classify new rugae patterns in larger samples. Chi-square analysis showed significant sex differences in rugae shapes in males and females. However, Faisal in his study among Saudi males and females reported an increased incidence of circular shaped rugae among females than males.

In present study, numbers of rugae were more for females (52%) than males (48%) and consistent with the study done by M Shankar et al, T Bharath et al. Studies done by Faisal et al in Saudi population and Mahabalesh et al in Mangalore population did not show any significant differences in the number of rugae between males and females, whereas Shwetha et al reported that males had more rugae than females in their study of Mysore and Tibetan population.[3] This study showed that distinct patterns of rugae were associated with different gender in selected population.

## CONCLUSION

This study concludes that rugae shapes show variations in males and females of the coastal Andhra (South Indian)

population and also showed that they are unique to an individual and sufficiently characteristic of discriminate individual identification only when the antemortem records are available. As some 'nonspecific rugae' were observed, further classifications can be done to describe new rugae patterns, and it will be beneficial to conduct studies with larger samples.

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