

# Characteristics of Palatal Rugae Patterns in West Godavari Population of India

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## ABSTRACT

Palatal rugae refer to the ridges on the anterior part of the palatal mucosa, each side of the median palatal raphe and behind the incisive papilla. Various studies on different populations have reported unique rugal patterns within each population.

**Aim:** To study, analyse and report the significant palatal rugae patterns among West Godavari District population and compare with the patterns reported in the literature, which can aid as an additional method of identification in cases of crime or mass disasters.

**Material and Methods:** Pre-orthodontic casts of 100 samples (50 males and 50 females) were selected. The method of identification of the rugae pattern used was that of Thomas et al (1983) which includes the number, shape and unification patterns of rugae. The different types of rugae between males

and females were statistically analyzed and compared with other population studies in the literature.

**Results:** A statistically insignificant ( $p > 0.05$ ) higher mean primary rugae scores was found in males ( $7.48 \pm 2.45$ ) while secondary ( $3.38 \pm 2.02$ ) and tertiary ( $2.56 \pm 1.84$ ) rugae were more among females. Both genders showed predominance in wavy (males =  $4.82 \pm 1.91$  and females =  $4.74 \pm 1.98$ ) type of distribution. Commonly observed pattern in the mode of unification was converging (58%) in males and diverging pattern (62%) among females which was statistically significant ( $p = 0.04$ ).

**Conclusions:** The findings showed a specific rugae pattern in this group when compared to other populations reported in the literature. Palatal rugae patterns are definitely associated with regional variation and can aid as an additional tool in forensic identification procedures.

**Key words:** Forensic, Mass disaster, Palatal rugae, Population characteristics, West Godavari

## INTRODUCTION

Human identification is one of the major fields of study and research in forensic science because it deals with the human remains and aims at establishing the identity. Importance of dental investigation in human identification remains one of the most reliable and frequently applied methods by forensic odontologist, predominantly by the comparison of ante-mortem and post-mortem records. Forensic dental identification mainly involves determining gender, age, ethnic background, community etc of the individual [1].

Palatal Rugoscopy i.e study of palatal rugae is one of the simple technique used by a forensic odontologist in human identification [2]. Palatal rugae also called as rugae palatinae or plicae palatinae transversae refers to a series of transverse ridges on the anterior part of the palatal mucosa on each side of the median palatal raphe and behind the incisive papillae. In mice it has been noted that, palatal rugae develop in the third month of intrauterine life as localized areas of epithelial proliferation even before the elevation of the palatal shelves [3]. Beneath the epithelial thickening condensation of fibroblasts accumulate in the connective tissue giving a distinctive rugal pattern [4]. The anatomic position of these transverse ridges aid in oral swallowing, suction in children, taste perception and participate in speech specially 's' and 'sh' phonemes [5].

In clinical dentistry due to the stable nature of the palatal rugae it aids as a landmark during orthodontic treatment [6], during cleft palate surgeries, [7] palatal prosthesis [8] and medicolegal identification [9]. It is a well established fact that the rugae pattern is as unique to a human as his or her fingerprints [10]. It is one of the tool used by an forensic odontologist in human identification because of its internal position, stable in nature, perenity, [11] uniqueness and low utilization costs. Rugal length and transverse palatal rugal region width increases with age in both genders and stops once the somatic growth stops [12]. Also, there seem to be a significant association between rugae forms and ethnicity

as various authors reported the palatal rugae patterns which were unique to that particular community. In a forensic context, it is required to provide an evaluation of ethnic group as an aid in personal identification.

During our previous study on palatal rugae we observed a distinct population characteristic pattern, now using the same methodology we conducted a study to assess the palatal rugae patterns and report the significant rugae patterns in West Godavari District population, which can aid as an additional method of identification in cases of crime or mass disasters.

## MATERIAL AND METHODS

The material for this study consisted of 100 pre orthodontic dental casts 50 males and 50 females between the age group of 15-30 years from the Department of Orthodontics, Vishnu Dental College, Bhimavaram, West Godavari District, Andhra Pradesh, India. All subjects were healthy individuals free of congenital abnormalities, inflammation, trauma or orthodontic treatment. All casts were free of air bubbles or voids specially at the anterior third of the palate.

The classification system of Thomas et al., (1983) was followed for rugae identification [11]. This includes the study of number, length, shape, and unification patterns of rugae. Rugae patterns were outlined using sharp graphite pencil.

### Measurement of length of the rugae

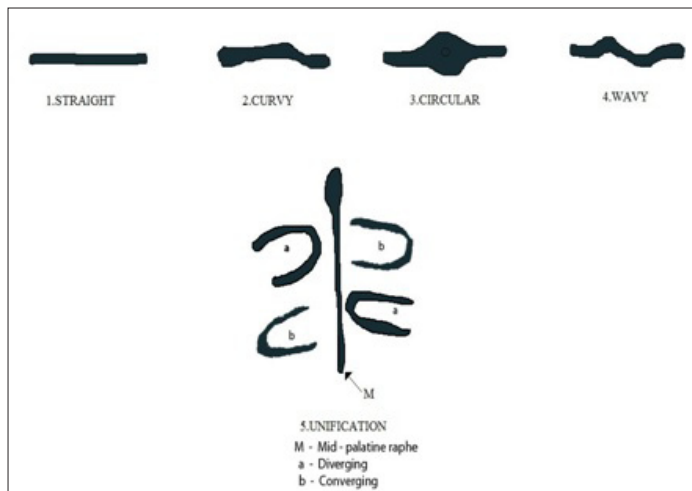
Rugae length was recorded from the starting point of rugae at mid palatine raphe to the end point of rugae transversely and in case of circular shape rugae the maximum diameter was taken into consideration. All measurements were made under magnification using a slide calliper to an accuracy of 0.05mm. Having determined the length of all rugae, three patterns were formed:

- 1) Primary rugae (5-10 mm).
- 2) Secondary rugae (3-5mm).
- 3) Fragmentary rugae (less than 3 mm).

## Measurement of shape of the rugae

Shape of individual rugae were classified as follows: [Table/ Fig-1].

1. STRAIGHT- ran directly from the origin i.e mid-palatine raphe to termination 2. CURVY- a simple crescent shape which was curved gently 3. CIRCULAR- a definite continuous ring formation 4. WAVY- in the form of serpentine 5. UNIFICATION- when rugae has two



[Table/Fig-1]: Different shapes of individual palatal rugae patterns

Gender	Number			Shape			
	Primary	Secondary	Tertiary	Straight	Wavy	Curved	Circular
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Males (n=50)	374 (7.48±2.45)	138(2.76±2.45)	93(1.86±2.05)	195(3.9±2.35)	241(4.82±1.91)	76(1.58±1.67)	93(1.86±2.06)
Females (n=50)	355(6.94±1.74)	169(3.38±2.02)	128(2.56±1.84)	192(3.76±1.91)	239(4.74±1.98)	74(1.46±1.22)	147(2.16±2.26)

[Table/Fig-2]: Mean distribution of the study sample based on the number and shape of palatal rugae according to gender

Test applied: Unpaired t- test; Statistical significance is considered at  $p < 0.05$ ; For number of rugae  $p = 0.27$  and for shape of rugae  $p = 0.14$

Gender	Unification pattern	Unification within gender n (%)	p-value
Males (n=50)	Converging	29 (58)	0.04*
	Diverging	21 (42)	
Females (n=50)	Converging	19 (38)	
	Diverging	31 (62)	

[Table/Fig-3]: Analysis of unification pattern in males and females

Test applied: Chi-square test; \* indicates statistical significance at  $p < 0.05$

arms which are joined either at their origin or termination which may be diverging and converging type. Diverging occurs when two arms of the rugae begin from the same origin and bifurcates transversely similarly converging occurs when two arms of rugae arise with different origins and converge transversely.

The readings were reported for each study cast and observations were tabulated.

## STATISTICAL ANALYSIS

The recorded data was compiled and entered in a spreadsheet computer program (Microsoft Excel 2007) and then exported to data editor of SPSS version 15.0 (SPSS Inc., Chicago, Illinois, USA). Unpaired t test and Chi square tests were used for comparison of mean and relationship between the attributes. For all the tests, confidence interval and p-value were set at 95% and  $\leq 0.05$  respectively.

## RESULTS

The total number of rugae in the study sample was 605 in males and 653 in females. Mean primary rugae was more in males (7.48±2.45) whereas secondary (3.38±2.02) and tertiary (2.56±1.84) rugae were more among females but the results were statistically insignificant ( $p > 0.05$ ). Based on the shape of palatal

rugae both genders showed wavy type (males = 4.82±1.91 and females = 4.74±1.98) followed with straight (males = 3.9±2.35 and females = 3.76±1.91) type of distribution. However, these observations were statistically insignificant ( $p > 0.05$ ) [Table/Fig-2].

Gender-wise distribution of mode of unification of the rugae showed predominant covering pattern (58%) in males and diverging pattern (62%) among females with a p value of 0.04 which shows that difference is statistically significant [Table/Fig-3].

## DISCUSSION

Forensic identification of human as alive or dead includes determination of various parameters like age, sex, race or geographical area. Palatal rugoscopy is one such tool employed successfully in identifying an individual based on the rugae pattern analysis as it is proved to be unique in shape, length, width, prominence, number and orientation considerably among individuals. Variation also exists in the right and left sides of the same person i.e., no bilateral symmetry exists in the rugae pattern [13]. Therefore, rugae patterns can be used in individual identification by comparing the postmortem rugae details with the antemortem records. Thomas and Van Wyk in 1987 reported identification of a severely charred edentulous body with the help of plaster casts made from the dentures in the victims mouth and compared with another set found in that individual's home [14]. Use of palatal rugae in forensics is not only due to its uniqueness but also due to its postmortem resistance,

overall stability and additionally low utilization cost, making it an ideal forensic identification parameter. Muthusubramanian et al., performed an analysis of rugae in burn victims and cadavers to simulate rugae identification in cases of incineration and decomposition. They reported that 93 percent of palatine rugae were normal and 77 percent of palatine rugae showed no colour change among subjects with third degree panfacial burns when examined after 72 hours stored in a mortuary at 5 degrees with 30 to 40 percent relative humidity [15].

Pre-orthodontic stone casts were used in our study for the analysis of rugae patterns as these present an advantage of simulating the oral cavity in the forensic laboratory, easy to handle, simple analysis, reduced cost and easy fabrication. Sognnaes advocated the use of casts made from jaws rather than from dentures for a more reliable result [16]. Various studies have shown the use of photographs taken by digital cameras, their transfer to the hard disk of the computer and later these images were analysed using a software programme [11,17]. Nevertheless, this process can conserve the physical space consumed in storing the stone casts, this process is complex as it involves specific photography skills in attaining the perfect photograph and includes complex data analysis and interpretation as the examiner must be well versed in photography and its software application and its execution.

Palatal rugoscopy was first proposed in 1932 by a Spanish investigator, Trobo Hermosa [18]. Since then various classifications were proposed by many researchers like Silva in [19] Carrea in [20]. Lysell in [21] Basauri in [22] Lima in [23] Caruso in [24] Tzatscheva and Jordanov in [25] Thomas in [26] Kotze in [27] and many more. Each classification had its own merits and demerits in practical application. Thomas and Kotze [26-28] in all their articles emphasised the necessity for standardizing the procedure

in observing, classifying and interpreting the variations of palatal rugae patterns. They also suggested that "a single operator alone(eliminating inter-observer error), using his own classification can very successfully apply it in a comparative project and that the results of the comparisons and not the classification itself are important." In our study Thomas et al., [26-28]. classification was used in observing and interpreting the palatal rugae patterns. This classification was chosen because it is simple as no complex instrumentation is required, practically easy to apply and covers most of variables like total number, length, shape and unification patterns of the palatal rugae.

On deriving the association of palatal rugae and ethnicity various classifications were employed and each author claiming their classification method employed was most accepted. Whatever may be the classification system employed in various population studies, a definite significant variation among population and among ethnic group exists [Table/Fig-3].

Dohke and Osato reported that among the Japanese, the females had fewer rugae than males [29]. Kapali et al., in 1997 through their longitudinal and cross-sectional approaches aimed to investigate changes of rugae patterns with age in Australian Aborigines and compared the patterns between Australian Aborigines and Caucasians. They employed classification described by Lysell [21] and Thomas and Kotze [26-28]. Authors analysed the number, length, shape, direction and unification of rugae and concluded that mean number of primary rugae in Australian Aborigines was higher than that of Caucasians and the most common shapes in both the ethnic group were wavy and curved while straight and circular were least common [30] Fahmi et al., studied the rugae patterns in Saudi males and females. Authors employed classification of Thomas et al., [26-28]. and reported that females showed a significant difference in the converge type and males had a significant difference in the circular type and concluded that the rugae patterns can be an additional method of differentiation between Saudi males and females in conjunction with the other methods such as visual, fingerprints and dental characteristics in forensic sciences [31].

Nayak et al., in 2007 examined the possible difference in rugae shape between Southern Indians and Western Indians and also the effectiveness of rugae shape in identifying the populations using discriminant function analysis. Authors recorded according to the classification given by Kapali et al., They reported low incidence of unifications and absence of circular rugae indicating that these two Indian populations were characterised by fewer types of rugae shape and also significant difference between two populations were observed in straight and curved rugae as they were seen in more number among Southern and Western Indians respectively. On discriminant function analysis moderate differentiation of the populations were possible with an attributed accuracy of 70% and concluded that discrete variables such as rugae shape are better suited for the purpose of discrimination than continuous variables like rugae length [32].

Paliwal et al., in 2010 determined the number and pattern of palatal rugae among Madhya Pradesh and Kerala populations of India and reported that straight rugae pattern on the right side of the palate among males were significantly predominant when compared to Madhya Pradesh population [33]. Kashima et al., compared the palatine rugae and shape of the hard palate among Japanese and Indians children and reported that Japanese children had more primary rugae than Indian children and the palatal raphe of Japanese children were wider than those of the Indian children [34]. In a comparative study between Indians and Tibetan population by Shetty et al., it was reported that Indian males had more primary rugae on the left side as compared to females and vice versa for the Tibetan population. Also, Indian males had more number of curved rugae on both right and left sides than Tibetan males and

Tibetan females had more wavy rugae on right and left sides than Indian females [35].

In our study of Palatal rugae pattern of West Godavari District population we observed unique features. There was a significant difference in the average number of rugae, females showing increased number of rugae when compared to males. Unification pattern among males and females showed increased converging pattern in males and increased diverging pattern in females. No significant difference was found in gender-wise comparison of length and shape of palatal rugae of study sample [Table/Fig-4].

Further research should be indicated with a larger sample size in order to validate our findings. Comparison with other geographical populations would give better understanding of population variations. Databank for storing the palatal rugae pattern must be established as these patterns may serve as ante-mortem record, which could be utilized in identification procedures of forensic odontology.

Comparison within population		
Authors	Population Studied	Observations made
Dohke and Osato in [29]	Japanese	<ul style="list-style-type: none"> <li>Females had fewer rugae than males.</li> </ul>
Fahmi et al., in [31]	Saudi	<ul style="list-style-type: none"> <li>Females showed difference in the converge type</li> <li>Males showed difference in the circular type.</li> </ul>
Suresh et al., in 2012*	West Godavari District	<ul style="list-style-type: none"> <li>Females showed increased number of rugae than males.</li> <li>Unification pattern: increased converging pattern in males increased diverging pattern in females.</li> </ul>
Comparison between populations		
Authors	Population Studied	Observations made
Kashima et al., in [34]	Japanese and Indians children	<ul style="list-style-type: none"> <li>Japanese children had more primary rugae than Indian children.</li> <li>Palatal raphe of Japanese children were wider than those of the Indian children.</li> </ul>
Kapali et al., in [30]	Australian Aborigines and Caucasians	<ul style="list-style-type: none"> <li>Mean number of primary rugae in Australian Aborigines was higher than Caucasians.</li> </ul>
Shetty et al., in [35]	Indians and Tibetan	<ul style="list-style-type: none"> <li>Indian males had more primary rugae on the left side as compared to females</li> <li>Indian males had more number of curved rugae on both right and left sides than Tibetan males.</li> <li>Tibetan females had more wavy rugae on right and left sides than Indian females.</li> </ul>
Nayak et al., in [32]	Southern Indians and Western Indians	<ul style="list-style-type: none"> <li>Southern Indians showed more number of straight and curved rugae than Western Indians.</li> </ul>
Paliwal et al., in [33]	Madhya Pradesh and Kerala	<ul style="list-style-type: none"> <li>Kerala population showed predominant straight rugae pattern on the right side of the palate among males when compared to Madhya Pradesh population.</li> </ul>

**[Table/Fig-4]:** Population characteristics of Palatal rugae pattern 2012\* -The present study

## CONCLUSION

We observed the existence of a specific rugae pattern in West Godavari population when compared to other populations reported in the literature. Thus, this study highlights that palatal rugae pattern could be used as one of the adjunct in comparative identification process of forensic odontology. Due to the regional variation of rugae pattern in different populations, rugae databank

needs to be established which will serve as a forensic reference centre.

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