



RESEARCH ARTICLE

PALATAL RUGAE PATTERN IN CENTRAL INDIAN POPULATION

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ABSTRACT

Introduction: Identification of humans is a prime requisite for certification of death, for personal, social and legal reasons in forensic sciences. Palatal rugae considered as an important tool in individual's identification when other methods are not feasible or available.

Objectives: To analyze the various palatal rugae patterns among adult central Indian population and to evaluate for any differences that could be related to gender identification in central Indian population.

Material and method: Total 300 individuals (150 males and 150 females) were selected from rural and urban areas ranging in age from 17-25 years and evaluated for different rugae patterns by using Thomas and Kotze classification.

Results: The total number and pattern of rugae were not significantly associated with gender. Whereas significant difference in rugae length was linked in both gender. According to length, the primary type of rugae was dominant and according to shape circular patterns of rugae were the most common, in both males and females.

Conclusion: Our findings concluded that the palatal rugae patterns of an individual are uniquely structured and specific, 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 various forensic identification procedures.

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INTRODUCTION

Forensic odontology can be defined as a branch of dentistry which deals with appropriate handling and examination of dental evidence and with proper evaluation and presentation of dental findings in the interest of justice (Dayal and Srinivasan, 1998). Human identification is a very difficult process either live or dead, and one of the main aspects in forensic medicine, especially in cases of massive disasters. Fingerprints, DNA

analysis & dental details are the most commonly used scientific methods of forensic identification (Whittakar, 1994). The limitation to the use of fingerprints occurs where the hands are charred or mutilated. As teeth are more durable, the identification using dental records may also prove to be inconclusive since many records may be inaccurate or incomplete, contain fraudulent data or additional dental treatment might have been done in the time interval between the creations of the dental record of the individual (Chester, 2002). So, palatal rugae pattern may be an alternative source of material when identification of an individual by fingerprint and dental records comparison is becomes difficult.

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Palatal rugae pattern formation begins by 12th to 14th week of prenatal life, and it remains stable throughout the individual's life (Carrea, 1937). Later, fibroblasts and collagen fibers accumulate beneath the thickened epithelium and attain a distinctive orientation (Hauser *et al.*, 1989; Kapali *et al.*, 1997). It is shown that palatal rugae are highly individual and consistent in shape throughout life. The anatomical position of the rugae surrounded by cheek, lips, tongue and the buccal pad of fat protects it in cases of trauma or incineration (Lysell, 1955). Studies carried out in different populations did not reveal any significant differences in the number of primary rugae between Aboriginal males and females (Kapali *et al.*, 1997). However, it is indicated that among the Japanese, the females had fewer rugae than males (Dohke and Osato, 1994). Study on palatal rugae pattern in two different populations of India has been done, who reported lack of sex dimorphism in their sample (Nayak *et al.*, 2007). Considering that there are differences in rugae patterns in specific populations, therefore, it is necessary to establish certain rugae parameters so that identification would be more reliable. At present no such standards have been determined for the Central Indian population. Therefore, this study was an attempt to determine the number, length and predominant pattern of rugae in the Central Indian male and female population and compare the patterns between the two groups, which may assist with differentiating the sexes.

MATERIAL AND METHODS

Ours is a prospective study and met approval of the institutional ethics committee. A total 300 individuals (150 males and 150 females) ranging in age from 17-25 years, were selected from rural and urban localities visiting Dental College and Hospital. All the subjects were from Central India, healthy, free of any congenital abnormality, inflammation, trauma, orthodontic treatment, swelling, neoplasm and palatal tori. Detailed history and informed consent was obtained from every patient. After clinical examination, alginate hydrocolloid impression of the maxillary jaw was made using perforated metal trays and plaster casts were poured. To avoid any bias, gender of every patient was unknown to the investigators during evaluation of the casts. All the subjects were studied for total number of palatal rugae, variability of palatal rugae pattern, distribution of the length of rugae and to determine the peculiarities of pattern between males and females. The palatal rugae pattern was classified according to the classification given by Thomas and Kotze, 1983. Rugae lengths were measured using digital vernier caliper (Forbes Gokak Ltd. Model no. 111-322) to an accuracy of 0.05 mm following the description of Thomas and Kotze, 1983.

According to the length of rugae, three categories were formed.

- Primary rugae: 5 to 10 mm or more
- Secondary rugae: 3-5 mm
- Fragmentary rugae: less than 3 mm

The shapes of individual rugae were classified as follows (Bajracharya *et al.*, 2013):

- Curved
- Wavy
- Straight

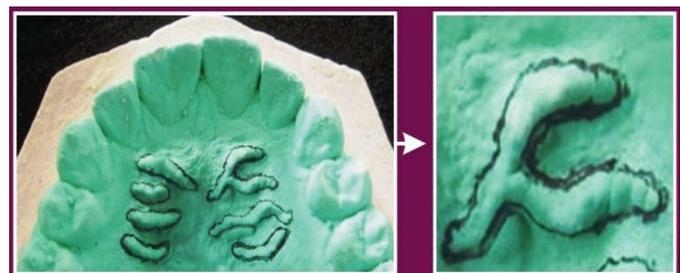
- Circular
- Diverging
- Converging
- The curved type had a simple crescent shape which curved gently (Fig.-3)
- The basic shape of the wavy rugae was serpentine; however, if there was a slight curve at the origin or termination of curved rugae it was classified as wavy. (Fig.-4)
- Straight types ran directly from their origin to termination. (Fig. 5)
- To be classified as circular- display a definite continuous ring formation. (Fig. 6)
- Unification occurs when two rugae are joined at their origin or termination. Unifications in which two rugae began from the same origin but immediately diverged were classified as diverging (Type-5/ Fig. 1). Rugae with different origins which joined on their lateral portions were classified as converging (Type-6/ Fig. 2)

The casts were compared based on classification by Thomas *et al* to find the individuality and stability of palatine rugae.



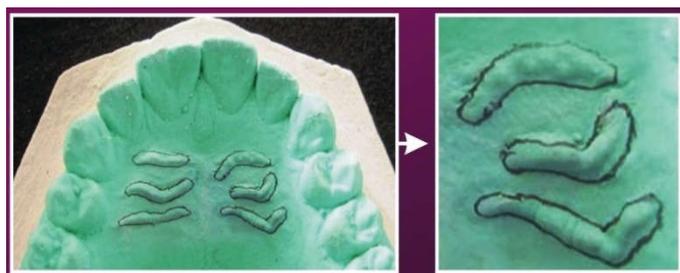
(A) Complete cast view (B) Rugae view after 8x zoom

Figure 1. Diverging Type of palatal rugae



(A) Complete cast view (B) Rugae view after 8x zoom

Figures 2. Converging Type of palatal rugae



(A) Complete cast view (B) Rugae view after 8x zoom

Figures 3. Curved Type of palatal rugae



(A) Complete cast view (B) Rugae view after 8x zoom

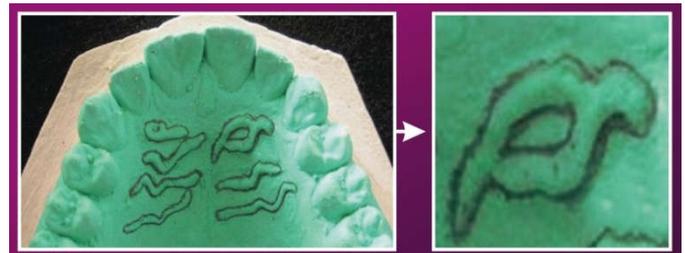
Figure 4. Wavy Type of palatal rugae



(A) Complete cast view (B) Rugae view after 8x zoom

Figure 5. Straight Type of palatal rugae

All the identification and measurements were done by one examiner and the readings were repeated three times for each cast.



(A) Complete cast view (B) Rugae view after 8x zoom

Figure 6. Circular Type of palatal rugae

Statistical Analysis

Statistical analysis was done using statistical software SPSS 14.0[©] (statistical package for social science). Chi-square test was applied to the total frequency of different palatal rugae patterns and comparison of difference was compared with 'Z' test between males and females. A significance level of 5% was considered as critical value.

Table 1. Distribution of different patterns of palatal rugae in entire study Population

| Gender | | Type I | Type II | Type III | Type IV | Type V | Type VI | Total |
|--------|---|--------|---------|----------|---------|--------|---------|-------|
| Male | F | 9 | 57 | 400 | 497 | 142 | 15 | 1120 |
| | % | 0.80% | 5.09% | 35.71% | 44.38% | 12.68% | 1.34% | 100% |
| Female | F | 18 | 42 | 618 | 681 | 109 | 16 | 1484 |
| | % | 1.21% | 2.83% | 41.64% | 45.89% | 7.35% | 1.08% | 100% |
| Total | F | 27 | 99 | 1018 | 1178 | 251 | 31 | 2604 |
| | % | 1.04% | 3.80% | 39.09% | 45.23% | 9.64% | 1.19% | 100% |

(F = i.e. frequency)

Table 2. Descriptive statistics of percentage of different types of Palatal rugae pattern Categorized by gender

| Type | Sex | N | Mean | SD | z-value | Significance |
|------|--------|-----|------|------|---------|--------------|
| I | Male | 150 | 1.12 | 0.35 | 0.83 | 0.41 |
| | Female | 150 | 1.28 | 0.46 | | |
| II | Male | 150 | 1.35 | 0.48 | 0.02 | 0.98 |
| | Female | 150 | 1.35 | 0.48 | | |
| III | Male | 150 | 3.33 | 1.11 | 1.89 | 0.06 |
| | Female | 150 | 3.70 | 1.90 | | |
| IV | Male | 150 | 4.57 | 1.55 | 1.87 | 0.06 |
| | Female | 150 | 4.20 | 1.79 | | |
| V | Male | 150 | 2.08 | 1.10 | 1.22 | 0.22 |
| | Female | 150 | 2.39 | 1.54 | | |
| VI | Male | 150 | 1.36 | 0.50 | 0.24 | 0.80 |
| | Female | 150 | 1.41 | 0.51 | | |

Z-test for significance *Level of significance = 5% # p>0.05, (N = No. of subject)

Table 3. Comparison of total number of palatal rugae present on right and left side

| Side | Groups | N | Mean | Std deviation | z-value | Significance |
|-------|--------|-----|------|---------------|---------|--------------|
| Right | Male | 550 | 4.20 | 0.83 | 0.32 | 0.74 |
| | Female | 734 | 4.17 | 0.94 | | |
| Left | Male | 570 | 4.51 | 0.84 | 0.06 | 0.94 |
| | Female | 750 | 4.50 | 0.89 | | |

Z-test for significance *Level of significance = 5% # p>0.05, (N = No. of subject)

Table 4. Distributions of length of Palatal rugae in males and females

| | | <3 mm | 3-5 mm | 5-10 mm or >10 mm | Total |
|--------|------------|--------|--------|-------------------|-------|
| Male | Frequency | 355 | 375 | 390 | 1120 |
| | Percentage | 31.70% | 33.48% | 34.82% | 100% |
| Female | Frequency | 457 | 472 | 555 | 1484 |
| | Percentage | 30.80% | 31.81% | 37.40% | 100% |
| Total | Frequency | 812 | 847 | 945 | 2604 |
| | Percentage | 31.18% | 32.53% | 36.29% | 100% |

RESULTS

The total number of palatal rugae pattern among male and female populations: Among males, circular -type IV pattern was predominant constituting 44.38% of all patterns. This was followed in occurrence by straight- type III (35.71%), diverging- type V (12.68%), wavy-type II (5.09%), converging-type VI (1.34%) and curved- type I (0.80%) respectively. Females also showed predominance of circular-type IV pattern constituting 45.89% of all patterns. This was followed in occurrence by straight- type III (41.64%), diverging- type V (7.35%), wavy-type II (2.83%), curved-type I (1.21%) and converging-type VI (1.08%) respectively. There was no significant ($P > 0.05$) difference found in the total number of different types of palatal rugae pattern between males and females (Table 1 & 2).

Right and left distribution of palatal rugae: The mean number of palatal rugae was more in males as compared to females (right as well as left side) and the mean number of palatal rugae pattern present on left side was more as compared to right side. There was no statistically significant difference found in the total number of palatal rugae present on right and left side between males and females as shown in (Table 3).

Length of palatal rugae: Distribution of length of palatal rugae between males and females was compared using chi -square test and was found to be stastically significant ($P < 0.05$) (Table 4 & 5).

Table 5. Descriptive statistics of difference in the rugae length in mm between Males and females

| Type | Sex | Mean | SD | z-value | Significance |
|-------------------|--------|------|------|---------|--------------|
| <3 mm | Male | 2.48 | 1.01 | 5.46 | 0.017 |
| | Female | 3.08 | 0.86 | | |
| 3-5 mm | Male | 2.55 | 0.86 | 6.30 | 0.008 |
| | Female | 3.18 | 0.87 | | |
| 5-10 mm or >10 mm | Male | 2.65 | 0.90 | 10.14 | 0.013 |
| | Female | 3.72 | 0.91 | | |

Z-test for significance *Level of significance = 5%

DISCUSSION

Palatal rugae have been studied for various reasons, the most important one being for personal identification in the field of forensic odontology. Several studies reported inter-racial differences in palatal rugae even in relatively similar population groups which may help to identify the population especially in disasters (Kapali *et al.*, 1997). Differences between genders have also been studied with no definite conclusion which indicates the need for more studies (Bharath *et al.*, 2011; Caldas *et al.*, 2007). Hence, this study aimed to analyze the palatal rugae patterns among adult central Indian population and to examine for any differences that could be related to gender. In the present study the commonest palatal rugae shapes were circular; these findings are in contrast with Eboh DE, who reported straight shape was the commonest palatal rugae shape followed by wavy shape among Nigerian population (Eboh, 2012). Abdellatif *et al.* found that the most common rugae shape in Egyptians was wavy shape while curved shape is most common in Saudi children, followed by straight rugae in both groups (Abdellatif *et al.*, 2011). Many other studies also found wavy shape as the predominant shape

like in Caucasian, Aboriginal Australians (Carrea, 1937) and Chileans (Hermosilla *et al.*, 2009).

Authors studied the different rugae pattern in different Indian population and found wavy pattern to be the most predominant pattern followed by curved and straight pattern in both male and female patients (Kumar *et al.*, 2012; Nayak *et al.*, 2007). Comparisons between the converging & diverging types did not show any specific trend. This study revealed higher prevalence of diverging type of rugae than converging type rugae in male as well as female. This is in contradiction with Saraf who found a higher prevalence of converging type in Indian females (Saraf *et al.*, 2011). Abdellatif *et al* compared unification forms of palatal rugae between Egyptian and Saudi children and reported that converging rugae were more frequent in Egyptians children (Abdellatif *et al.*, 2011). Our study found no significant differences between males and females in terms of rugae pattern. This is in accordance with the work of Kumar and Faisal (Kumar *et al.*, 2012; Faisal *et al.*, 2001) who did not notice any statistical difference in palatal rugae patterns of males and females and suggest that palatoscopy may not be an efficient tool for sex determination, though Mohammed RB (Mohammed *et al.*, 2014) found significant differences in Andhra coastal (South indian) population. Saxena studied the palatal rugae pattern among males, females and transgender population of Bhopal city and found significant difference (Saxena *et al.*, 2015). In South Indian population, higher incidence of curved rugae pattern was observed in females than in males (Manjunath *et al.*, 2012; Shetty and Premalatha, 2011).

In our study the total number of rugae are non-significant in male and female, which is in accordance with the findings of Ibeachu PC in Nigerian population and Bharath *et al*, Saraf A *et al* and Shetty M and Premalatha K in Indian population (Ibeachu *et al.*, 2014; Bharath *et al.*, 2011; Saraf *et al.*, 2011; Shetty and Premalatha 2011). However, our study findings are contradictory with those of Saxena in Bhopal city, and Madankumar and Nayak who reported significant difference in the number of rugae between the genders among various Indian populations (Saxena *et al.*, 2015; Madhankumar *et al.*, 2013; Nayak *et al.*, 2007). These variable observations can be attributed to genetic or ethnic variation in different Indian populations. The total number of palatal rugae on left side were more than right side and statistically non significant. This is in agreement with the study done by Surekha *et al* and Dohke and Osato who also proved that the left side of palatal rugae is dominant, and explained it to be the phenomenon of regressive evolution (Surekha *et al.*, 2012; Dohke and Osato, 1994).

The primary type of palatal rugae is most commonly found in male as well as female and we observed significant difference in the length of palatal rugae between the sexes; this finding is contradictory with previous studies which reported no significant differences in the length of palatal rugae between both sexes by Saraf and Babu among Indian population, and Ibeachu in Nigerian and and Faisal in Saudi population (Saraf *et al.*, 2011; Babu *et al.*, 2013; Ibeachu *et al.*, 2014; Faisal *et al.*, 2001). Previous studies reported that, environmental factors are unlikely to affect formation of rugae and rugae shape since it is genetically controlled. This was enforced by subsequent twin studies which have revealed that rugae pattern has an underlying genetic basis (Gaurav, 2013).

Conclusion

We conclude that changes in length of palatal rugae can be attributed to genetic, environmental or geographical variation. The findings showed a specific rugae pattern in this group when compared with the results from other studies. After results of this study, it is clear that palatal rugae patterns are definitely uniquely associated with regional variation and can be used as an additional tool in forensic identification procedures of individuals. Therefore, due to the regional variation of rugae pattern in different populations, rugae databank needs to be established in future which will serve as a forensic reference centre.

Recommendations

Further studies on a larger population and different geographical areas in India are recommended in order to validate these findings.

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