Gender Determination Using Morphological Analysis of Palatal Rugae Patterns – A Retrospective Study

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Abstract: Background: Palatal rugae are unique for an individual and remain unchanged during individual’s lifetime. Application of palatal rugae analysis as a method in gender identification needs to be confirmed with more scientific studies. The objectives of the present study were to assess the distribution of the palatal rugae patterns in Kerala population and compare the distribution of these parameters between males and females. Materials & Methods: A retrospective cross-sectional study was conducted by evaluating the casts of 100 dentate individuals, between the age of 18 and 30 years. The rugae were divided into two halves and patterns were then assessed as per Thomas and Kotze classification. Independent sample t-test was used to assess the significant difference of each type of palatal rugae between males and females.

Results: Wavy rugae (mean = 5.6 ± 0.7) was predominant among males whereas curved (mean = 4.6 ± 0.6) and circular rugae (mean = 0.9 ± 0.3) were more in females and were found to be statistically significant (p<0.05). The mean number of secondary rugae in females (1.5 ± 0.5) was greater than that of males (1.3 ± 0.4) and was found to be statistically significant (p<0.05). The diverging type was commonly found in females compared to males. Conclusion: Our findings showed statistically significant differences in the shapes and patterns of rugae between males and females among Kerala population. Thus, morphological analysis of palatal rugae can be considered as an additional aid in forensic odontology for gender differentiation.

Key Words: Palatal rugae, Gender, Forensic dentistry, Palatoscopy

Introduction: Human identification is one of the most challenging subjects that we have been confronted with since ages.[1] The most common methods of forensic identification are fingerprints, dental record comparisons, and DNA profiling when visual identification of the individual is unclear. However, these techniques have some limitations. [2-4] Constraints to the use of fingerprints occur in situations such as putrefaction, burns, severe trauma, and prolonged immersion in water.[4] Although DNA profiling is an ideal method in forensic identification, it will be expensive and time-consuming to use it in mass disasters.[2] Forensic odontological examinations have been a critical determinant in the search for identity of individual human remains. Though teeth can survive virtually intact long after many years after death, it is however not practical to employ them in identifying the edentulous persons. Palatoscopy or palatal rugoscopy i.e examination of palatal rugae pattern can be a useful identification method in these circumstances. Palatal rugae are irregular, asymmetric ridges of mucous membrane extending lateral from the incisive papilla and the anterior part of the median palatal raphe, which is just behind the maxillary central incisor teeth. The palatal rugae, like fingerprints, do not change during the life of the individual, are protected from trauma and high temperatures owing to its internal position in the oral cavity, and protected by the lips, cheeks, tongue, teeth and bone, and prosthetic devices. Even disease, trauma or chemical attack do not seem to change the shape of palatal rugae.[5] It is a well-established fact that palatal rugae are unique for an individual and remain unchanged during individual’s
These patterns are analyzed in various population and found to be differing among people of different geographical locations and gender. Several studies reported the regional variation in palatal rugae patterns in India. [8-10] However, studies on the pattern of palatal rugae in the Kerala population are very limited. Though several studies have compared the palatal rugae patterns in males and females, there exists a lack of agreement on whether the palatal rugae pattern is sufficient to discriminate between the genders. [11-14] Hence the application of palatal rugae analysis as a method in gender identification needs to be confirmed with more scientific studies. The objectives of the present study were to assess the distribution of the palatal rugae patterns in Kerala population and compare the distribution of these parameters between males and females.

Materials and Methods
A retrospective cross-sectional study was conducted on the casts of 100 dentate individuals, who visited the Outpatient Department at Azeezia College of Dental Sciences and Research, Kollam, Kerala. In this study, dental casts of 50 males and 50 females between the age of 18 and 30 years fabricated for orthodontic treatment planning were randomly selected. Approval was taken from the institutional ethics committee. Only good quality void-free dental casts with known age and sex were included in our study. Casts with severe malocclusion, congenital abnormalities, palatal asymmetries, edentulous were excluded.

Based on the published literature, accuracy in identifying gender was reported to be 71%. [15] With a relative precision of 15%, power 90% and 5 % level of significance the sample size was calculated to be 73. A total of 100 maxillary casts (50 males and 50 females) were sought. A midline was drawn using graphite pencil from the mid-palatine raphe extending from the incisive papillae to the posterior most extent of the rugae on the palate. This divided the rugae and palate in two halves. The rugae in each half were highlighted using a graphite pencil under spotlight by the examiner (Fig 1).

**Fig 1: Recorded palatal rugae pattern**

The patterns of rugae were then assessed according to Thomas and Kotze classification.[16] The palatal rugae lengths were measured using a vernier caliper in millimeters (mm). The shapes of the rugae were classified into four major types: straight, curved, circular and wavy. Based on their length, the rugae was classified into three categories: primary rugae with length of more than 5mm, secondary rugae with length between 3-5mm and fragmentary rugae with length between 2-3mm. Based on the unification pattern the rugae were divided into diverging and converging type. A diverging pattern occurs when two rugae had the same origin from the midline but immediately diverge transversely. Likewise, a converging pattern occurs when two rugae arise with different origins and converge transversely.

**Statistical analysis**

The collected data were sorted, tabulated, and subjected to statistical analysis. Statistical Program for Social Sciences (SPSS) version 16 was used for statistical analysis of data. Descriptive data was analyzed and derived in terms of mean, standard deviation and percentages. Independent sample t-test was used to assess the significant difference of each type of palatal rugae between males and females. Level of significance was fixed at p <0.05.

**Results**

A total of 100 maxillary dental casts obtained from fifty males and fifty females were included in our study. Table 1 presents the comparison of palatal rugae shapes among males and females. It was found that wavy rugae (mean – 5.6±0.7) was predominant among males whereas curved (mean – 4.6±0.6) and circular rugae (mean – 0.9±0.3) were more in females, which were found to be statistically significant (p<0.05).

**Table 1: Comparison of the Mean Number of PR shapes based on gender**

<table>
<thead>
<tr>
<th>PR Shapes</th>
<th>Gender</th>
<th>Mean ± SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight</td>
<td>Male</td>
<td>1.1 ± 0.5</td>
<td>1.21</td>
<td>0.229</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.0 ± 0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curved</td>
<td>Male</td>
<td>3.0 ± 0.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>4.6 ± 0.6</td>
<td>11.780 0.000*</td>
<td></td>
</tr>
<tr>
<td>Circular</td>
<td>Male</td>
<td>0.8 ± 0.4</td>
<td>2.21</td>
<td>0.029*</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0.9 ± 0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wavy</td>
<td>Male</td>
<td>5.6 ± 0.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>3.6 ± 0.8</td>
<td>12.740 0.000*</td>
<td></td>
</tr>
</tbody>
</table>

*: Significant at 0.05 level

Table 2 presents the distribution of rugae pattern between males and females, wherein primary rugae was predominant in both genders compared to secondary and fragmented rugae pattern. The mean number of secondary rugae in females (mean – 1.5±0.5) was greater than that of males (mean – 1.3±0.4), and was found to be statistically significant (p<0.05).

**Table 2: Comparison of the Mean Number of PR patterns based on gender**

<table>
<thead>
<tr>
<th>PR patterns</th>
<th>Gender</th>
<th>Mean ± SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>Male</td>
<td>4.8 ± 0.8</td>
<td>0</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>4.8 ± 0.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary</td>
<td>Male</td>
<td>1.3 ± 0.4</td>
<td>2.11</td>
<td>0.038*</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.5 ± 0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fragmentary</td>
<td>Male</td>
<td>0.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*: Significant at 0.05 level
The distribution of unification pattern also showed a statistically significant difference in both the genders (Table 3). The diverging type was commonly found in females compared to males. However, there was no significant gender difference in the converging type, which was found to be higher in males.

<table>
<thead>
<tr>
<th>Unification</th>
<th>Gender</th>
<th>Mean±SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Divergent</td>
<td>Male</td>
<td>1.2±0.4</td>
<td>2.9</td>
<td>0.005*</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.8±0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convergent</td>
<td>Male</td>
<td>1.7±0.4</td>
<td>1.67</td>
<td>0.101</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.0±0.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*: Significant at 0.05 level

Discussion

Palatoscopy or palatal rugoscopy is a preferred method in forensic odontology because of low utilisation cost, diagnostic sensitivity and reliability.[17] Palatoscopy can be useful in situations where fingerprints cannot be attained or when bodies are burnt or severely decomposed.[2] The uniqueness of palatal rugae patterns in forensic identification has been reported by various authors. Several studies have analyzed the palatal rugae patterns in various population and found to be differing among people of different geographical locations and gender. There exists a lack of agreement on whether the palatal rugae pattern is sufficient to discriminate between the genders. Hence the present study was carried out to assess the distribution of the palatal rugae pattern in Kerala population and compare the distribution of these parameters between males and females based on Thomas and Kotze classification. In the present study, dental casts of 100 dentate individuals were used to assess palatal rugae patterns and this permits the possibility of future comparative review, when needed. Thomas and Kotze classification was found to be the most practical and easiest to apply compared to other methods.[16] Hence we used this method for differentiating the patterns of the rugae. Lysell stated that the total number of rugae remains unchanged up to 23 years, whereas Thomas reported that palatal rugae do not undergo any changes except in length, throughout the life.[18] As there is no agreement in the findings reported on the stability of palatal rugae patterns with ageing, dental casts of individuals between the age of 18 and 30 years were considered.

Our study findings suggest that the wavy pattern was predominant, followed by curved, straight and circular. The predominant unification pattern was divergent followed by convergence. These findings were in accordance with the study conducted by Surekha et al on Manipuri and Kerala population and another study conducted by Manikya S et al on South Indian population. [19,20] This study indicated that wavy, curved and circular rugae shapes showed statistically significant differences between males and females. The results of our study were similar to the study conducted by Saraf et al, who reported difference between males and females in terms of the wavy and curved rugae shapes.[3] These results were in contrast to the study conducted by Basman R Set al, who found no difference in the rugae shapes between males and females.[21] In this study, the number of wavy rugae was significantly higher in males whereas curved and circular patterns were significantly higher in females. In agreement with our study’s findings, previous studies have reported that wavy pattern was seen commonly in males and curved pattern seen predominantly in females. [22-24] In this study the number of straight rugae was higher in males and reported a non-significant difference between genders.

The results of the present study showed that females have more secondary rugae than males and this difference was statistically significant. On the other hand, the primary rugae was predominant in both genders. A study conducted on North and South Indian population reported the occurrence of primary rugae more in males whereas secondary and tertiary rugae were more in females.[25] Palival et al. [7] and Saxena et al. [26] reported that the mean number of primary rugae was not significantly different between male and female. This finding was in agreement with the present study in which mean number of primary rugae was not significantly different between male and female. The present study observed a significant difference in divergence patterns and was found to be more common in females. In agreement with these findings, a previous study reported that females had more diverging rugae.[27] This is in contrast to the study conducted by Smriti et al and Nayak et al who reported no significant difference in convergence and divergence patterns in males and females. [8,13] A study by Manikya S et al reported more number of divergent rugae in males and convergent rugae in females.[20] Our findings showed statistically significant differences in the shapes and patterns of rugae between males and females among Kerala population. Several studies have analysed the palatal rugae patterns in Indian populations, but no studies have reported consistent findings. This regional variation in palatal rugae pattern could be due to the difference in environmental or genetic factors. This also indicates that the rugae pattern is unique to certain populations. Only a limited number of studies have been conducted in Kerala population, so direct comparison of our findings with the existing studies is not feasible. The present study was subjected to few limitations. First, the subjective nature of measurement, as the rugae patterns of the dental casts were assessed by a single examiner. In addition, samples included in this study was only limited to patients who had visited the Outpatient Department of Dental College.

Conclusion

This study demonstrated significant variations in palatal rugae patterns among males and females of Kerala population. Thus, morphological analysis of palatal rugae can be considered as an additional aid in forensic odontology for gender differentiation. However, the role of palatal rugae pattern in gender determination needs to be substantiated by the application of advanced statistical methods. Further studies on larger samples from different geographical locations are recommended to validate the findings of the present study.

References