Palatal rugoscopy as an adjunct for sex determination in forensic odontology (Sri Ganganagar population): A cross-sectional study of 100 subjects

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Abstract

Introduction: Palatorugoscopy is the term used to study the rugae patterns. The word rugae came from the Greek word seam. Moreover, it relates the crisscrossing or joining or stitching of the parts of two biological structures during fetal differentiation. The aim of this study is to determine the gender difference in rugae pattern with regard to length, number, shape, unification and direction in the population of Sri Ganganagar, Rajasthan.

Objective: The objective is to determine the gender difference in rugae pattern with regard to length, number, shape, unification and direction; to investigate the difference in division of rugae in males and females and to compare rugae pattern in males and females of different age group.

Materials and Methods: This study included 100 subjects, in which 50 were males (Group A) and other 50 were females (Group B). After the formation of primary cast, all quantitative as well as qualitative characteristics of palatal rugae patterns were recorded. Mainly, two classifications were used in this study, Thomas et al. and Kapali et al.

Statistical Analysis: Student t-test was used, and “P” value of <0.05 was considered statistically significant.

Results: A statistically significant value was found in left-sided palatal rugae patterns depending upon the size, where we found that primary rugae were more in males. On comparing the angulation of palatal rugae patterns of left-sided rugae, a statistically significant value was found among the negative angulation which was higher in male subjects. Next, while comparing the angulation of palatal rugae of right side, we found a statistically significant value among zero (perpendicular rugae), which was more in male population. On comparing the unification of right-sided rugae patterns, we found that divergent rugae were more in male subjects.

Conclusion: Palatal rugae patterns act as individualistic, and are unique patterns, and are helpful in determining the human gender. Further, more studies are required on palatal rugae patterns used in forensics on large population scale.

Keywords: Kapali et al., palatal rugae, Thomas et al., Vernier caliper

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INTRODUCTION

According to the Federation Dentaire Internationale, forensic dentistry is the branch of dentistry which works for exact assessment and inspection of dental proofs, and helps in conservation and detection of records for proper fairness in decision.[1]

The study of palatal rugae for evaluating human specification and naming is defined as palatoscopy.[2] The word rugae came from the Greek word seam. Moreover, it relates the crisscrossing or stitching of the parts of two biological structures during fetal differentiation.[3] Design and placement of palatal rugae patterns are organized between the 12th and 14th weeks of intrauterine phase, and this alignment lasts for whole life unless the soft tissue decays afterward decease.[4]

Epithelial–mesenchymal interchange is the factor which controls and expands the dimensions of rugae patterns, and along with this, some molecules are also identified during growing.[5] Acids, chemicals, injuries, wounds, eruption and dropping of teeth or life-threatening conditions do not alter or affect the configuration of palatal rugae patterns.[6] Rugae are useful in recognition methods due to their simplicity, accuracy and cost-effectiveness.[7] Hence, with these features, palatal rugae patterns are one of the specific postmortem proofs.

The present study is conducted to determine the gender difference in rugae pattern with regard to length, number, shape, unification and direction in the population of Sri Ganganagar, Rajasthan.

MATERIALS AND METHODS

Candidates were selected from the Outpatient Department of Maharaja Ganga Singh Dental College and Research Centre, Sri Ganganagar, Rajasthan. This study included 100 subjects, in which 50 were males (Group A) and other 50 were females (Group B). Sample size was correctly distributed within the age group 30–70 years.

After the settlement of the patient on the dental chair, mixing of alginate impression material was carried out. Measured amount of powder and water was added into the bowl and mixed in the figure-of-eight motion up to 1 min. Quickly after mixing of alginate material, maxillary impression tray was filled with the material and instantly inserted into the patient's mouth. Impression tray was stationary and immobile during the setting of impression material. After taking maxillary impression, suddenly primary cast was made with the use of dental stone.

After the formation of primary cast, all quantitative as well as qualitative characteristics of palatal rugae patterns were recorded.

Mainly, two classifications were used in this study, Thomas et al. and Kapali et al.[8]

Parameters are as follows [Figure 1]:
- Length of palatal rugae was measured with the use of manual Vernier caliper (primary rugae, secondary rugae and fragmental rugae)
- Unification: Meeting point of two different rugae patterns at the same place may be at starting or terminal point of rugae (convergent and divergent rugae)
- Shape: Curved, wavy, straight and circular
- Angulation or direction: Angle formed between the line joining starting and terminal portion of palatal rugae and it must be perpendicular to the median raphe (forwardly directed, backwardly directed and perpendicular rugae)
- Number of palatal rugae was evaluated.

Statistical analysis

Findings were recorded, tabulated and subjected to statistical analysis.

Student's \(t\)-test was used. “\(P\)” value of < 0.05 was considered statistically significant.

RESULTS

1. In our study, we found statistically significant value in left-sided palatal rugae patterns depending upon the size, where we found the mean value of primary rugae size (length) in male participants to be higher \(3.62 \pm 0.67\) as compared to female participants \(3.1 \pm 0.77\) [Table 1]

2. On comparing the angulation of palatal rugae patterns of left-sided rugae, a statistically significant value was found among the negative angulation which was having higher mean value in male subjects \(1.36 \pm 1.17\) than females \(0.9 \pm 0.83\) [Table 2]
3. Next, while comparing the angulation of palatal rugae of right side, we found a statistically significant value with respect to zero angulation (perpendicular rugae), with mean value more in females (0.92 ± 0.82) than males (0.56 ± 0.61) [Table 3]

4. On comparing the unification of right-sided rugae patterns, we found divergent rugae of higher mean value in males (0.56 ± 0.64) than females (0.3 ± 0.46) with statistically significant value [Table 4]

5. In addition, on comparing the variables between males and females in general (taking left- and right-sided palatal rugae simultaneously), we found statistically significant values for size (length) of primary rugae (mean value in males 3.57 ± 0.08 higher than females 3.32 ± 0.81) and size of secondary rugae (mean value in males 1.83 ± 1.98 higher than females 0.19 ± 0.44), shape (straight; mean value in females 0.36 ± 0.68 higher than males 0.20 ± 0.42) and divergent unification (mean value in males 0.49 ± 0.57 higher than females 0.29 ± 0.45) [Table 5].

**DISCUSSION**

In human-made as well as in natural disasters (mass casualties), dental records are highly useful for human identification, as finger records are not precise in each condition. The philosophy behind this is that postmortem dental records can be compared with the same person's antemortem record for identification along with the use of models and photographic views. Various methods are available for the recognition of humans such as determination of gender, blood grouping, age estimation, weighting, dental records, dactyloscopy and anthropometry. A palatal rugae pattern study (palatorugoscopy) is one of them as palatal rugae patterns are extremely distinctive and isolated in each and every human being.\(^8\)

These patterns do not undergo any positional, locational and functional change in complete lifespan of person. The utilization of patterns in forensic odontology is because of its cost-effective and convenient procedure for analysis, along with other profitable points of rugae.\(^9\)

In our study, we examined and studied the rugae length, number, shape, size, unification and direction on both the sides (left and right) of midpalatal suture of both male and female groups. Many differences were present between both the genders.

On comparing the length of palatal rugae patterns on left side (primary, secondary and fragmentary) in both male and female groups, we noticed that in the male population, the length (primary rugae) \(P = 0.001\) was more as compared to female population. Furthermore, length primary rugae \(P = 0.020\) and secondary rugae \(P = 0.000\) were more in males than females when compared in general that is taking left- and right-sided palatal rugae simultaneously.

**Table 1: The comparison of size among male and female participants on the basis of primary, secondary and fragmentary (left-sided palatal rugae patterns)**

| Group     | N  | Mean±SD | T   | P     |
|-----------|----|---------|-----|-------|
| Primary   |    |         |     |       |
| Female    | 50 | 3.1±0.67| −3.560| 0.001*|
| Male      | 50 | 3.62±0.77|       |       |
| Secondary |    |         |     |       |
| Female    | 50 | 0.24±0.47| 1.31 | 0.261 |
| Male      | 50 | 0.14±0.40|       |       |
| Fragmentary |   |         |     |       |
| Female    | 50 | 0.0±0.00 |       |       |
| Male      | 50 | 0.0±0.00 |       |       |

*Statistically significant \((P<0.05)\). n: Number of participants, SD: Standard deviation, t: Student t-test

**Table 2: Comparison of angulation among males and females on the basis of positive, negative and zero (left-sided palatal rugae patterns)**

| Group | N  | Mean±SD | T   | P     |
|-------|----|---------|-----|-------|
| Positive |    |         |     |       |
| Female | 50 | 1.42±0.97| 0.090| 0.928 |
| Male   | 50 | 1.36±1.25|       |       |
| Negative |   |         |     |       |
| Female | 50 | 0.9±0.83 | −2.254| 0.026*|
| Male   | 50 | 1.36±1.17|       |       |
| Zero   |    |         |     |       |
| Female | 50 | 1.14±1.03| 0.623| 0.535 |
| Male   | 50 | 1.02±0.89|       |       |

*Statistically significant. n: Number of participants, SD: Standard deviation, t: Student t-test

**Table 3: Comparison of angulation among males and females on the basis of angulation (right-sided palatal rugae patterns)**

| Group | N  | Mean±SD | T   | P     |
|-------|----|---------|-----|-------|
| Positive |    |         |     |       |
| Female | 50 | 1.08±0.87| −0.738| 0.463 |
| Male   | 50 | 1.22±1.01|       |       |
| Negative |   |         |     |       |
| Female | 50 | 1.6±1.17| −0.533| 0.595 |
| Male   | 50 | 1.72±1.06|       |       |
| Zero   |    |         |     |       |
| Female | 50 | 0.92±0.82| 2.471| 0.015*|
| Male   | 50 | 0.5±0.61 |       |       |

*Statistically significant. n: Number of participants, SD: Standard deviation, t: Student t-test

**Table 4: Comparison among the male and female participants on the basis of unification (right-sided palatal rugae patterns)**

| Group | n  | Mean±SD | t   | P     |
|-------|----|---------|-----|-------|
| Convergent |    |         |     |       |
| Female | 50 | 0.04±0.1979| 0.581| 0.563 |
| Male   | 50 | 0.02±0.1442|       |       |
| Divergent |   |         |     |       |
| Female | 50 | 0.3000±0.46291| −2.318| 0.023*|
| Male   | 50 | 0.5600±0.64397|       |       |

*Statistically significant. n: Number of participants, SD: Standard deviation, t: Student t-test
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Table 5: Comparison of variables among males and females

| Variables | Groups   | Mean±SD    | t     | Significant |
|-----------|----------|------------|-------|-------------|
| Number    | Female   | 3.5100±0.88186 | -1.117 | 0.265       |
|           | Male     | 3.6400±0.75905 |       |             |
| Size      | Primary  | Female     | 3.3200±0.81501 | -2.348 | 0.020*      |
|           |          | Male       | 3.5700±0.68542 |       |             |
|           | Secondary| Female     | 0.9900±0.42556 | -8.102 | 0.000*      |
|           |          | Male       | 1.8367±1.98288 |       |             |
|           | Fragmental| Female   | 0.0000±0.00000 |       |             |
|           |          | Male       | 0.0000±0.00000 |       |             |
| Angulation| Positive | Female     | 1.4100±1.10184 | 0.699  | 0.485       |
|           |          | Male       | 1.3000±1.12367 |       |             |
|           | Negative | Female     | 1.2500±1.07661 | -1.856 | 0.065       |
|           |          | Male       | 1.5400±1.13191 |       |             |
|           | Zero     | Female     | 0.9500±0.84537 | 1.379  | 0.170       |
|           |          | Male       | 0.7900±0.79512 |       |             |
| Shape     | Curved   | Female     | 1.7800±1.01085 | 0.215  | 0.830       |
|           |          | Male       | 1.7500±0.95743 |       |             |
|           | Wavy     | Female     | 1.0900±0.81767 | -0.765 | 0.445       |
|           |          | Male       | 1.1800±0.84543 |       |             |
|           | Straight | Female     | 0.3600±0.68931 | 1.974  | 0.050*      |
|           |          | Male       | 0.2000±0.42640 |       |             |
|           | Circular | Female     | 0.0100±0.10000 | -0.579 | 0.563       |
|           |          | Male       | 0.0200±0.14071 |       |             |
| Unification| Convergent| Female    | 0.0300±0.17145 | 0.451  | 0.653       |
|           |          | Male       | 0.0200±0.14071 |       |             |
|           | Divergent| Female     | 0.2900±0.45605 | -2.719 | 0.007*      |
|           |          | Male       | 0.4900±0.57726 |       |             |

*Statistically significant. SD: Standard deviation, t: Student t-test

Zero angulated rugae are those which have perpendicular directions. Moreover, this may be because, during the development of human embryo, the palatal rugae which are thick and leading occupy the large dimension of palatal structure. The inclination, orientation and direction of palatal rugae are established in intrauterine life by the accumulation of running fibers (collagen fibers) over the foundation of palatal rugae patterns in the direction of anteroposterior turns and in concentric loops. Moreover, in embroyogenesis, several variations also occur because of genetical factors.18

On comparing the unification of rugae patterns among both genders (male and female) of right side, divergent unification was more in males than females (P = 0.023). Furthermore, divergent unification was found to be more in males than females when taking into consideration both right- and left-sided palatal rugae simultaneously. Similar results were obtained by Thabitha et al. in 2015, Kalyani et al. in 2016, Bharath et al. in 2011 and Dr. Nagrale et al. in 2021 in their study.

This may be attributed as, in the embryo of mice, it has been demonstrated that on the fibroblast growth factor (FGF) and Sonic hedgehog signaling, activator–inhibitor system is dependent, in turn which further results in systematic generation of palatal rugae patterns in the specified growth areas in the growing palate. In mice, the absence of palatal rugae occurs, if loss of role related with FGF-10 or FGF-2. On the other side, in humans, the morphology of palatal rugae patterns is more complex than mouse, and the foundational mechanisms are probably to be maintained at the level of molecular genetics.

On comparing the shape of palatal rugae patterns between the males and females taking into consideration both right- and left-sided rugae simultaneously, straight-shaped rugae were found more in females than males (P = 0.050), curved and wavy rugae more in males (P < 0.05) which is in accordance with studies done by Nallamilli et al. in 2015, Azab et al. in 2016 and Selvamani et al. in 2019.
Discrepancy in shapes of palatal rugae with respect to gender differentiation may be precisely studied by considering larger sample size.

CONCLUSION

In our study, we found a statistically significant value in left-sided palatal rugae patterns depending upon the size, where we found that primary rugae were more in males. However, on comparing the angulation of palatal rugae patterns of left-sided rugae, a statistically significant value was found among the negative angulation which was higher in male subjects. Next, while comparing the angulation of palatal rugae of right side, we found a statistically significant value among zero (perpendicular rugae), which was more in male population. On comparing the unification of right-sided rugae patterns, we found that divergent rugae were more in male subjects. With these findings, we can conclude that palatal rugae patterns act as individualistic, and are unique patterns, and are helpful in determining the human gender.

Further, more studies are required on palatal rugae patterns used in forensics on large population scale.

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Conflicts of interest
There are no conflicts of interest.

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