

Assessment of palatal rugae pattern and their reproducibility for application in forensic analysis

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Introduction

Visual identification is the most common method applied in forensic sciences. However, in certain incidences where hard tissues (teeth) of the oral cavity are lost due to any reasons such as trauma, visual means of identification is significant in non-mutilated palatal tissues.^[1] Thus, in forensic dentistry, the unique characteristic pattern of palatal rugae can be used as an identification tool.^[2]

Palatal rugae (Plica Palatinae Transversae) refer to a series of

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Abstract

Background: Rugae are the anatomical folds that are located on the anterior third of palate behind the incisive papillae. They are also known as “Plica palatine,” and the study of these patterns is called palatoscopy. It can be used in various fields such as sex determination, orthodontics and forensic odontology. **Objective:** To investigate palatal rugae patterns in females and males and to evaluate the stability of these patterns in pre- and post-operative orthodontic cases. **Materials and Methods:** Fifty patients were selected for this study (25 males and 25 females). From the above sample, 10 males and 10 females had undergone orthodontic treatment and their casts were retrieved for sex determination analysis and stability of rugae patterns pre- and post-treatment. **Results:** Changes occur in bony structures during fixed orthodontic treatment but rugae patterns remain stable. Kappa stats and Chi square test were used to analyze agreement between the two evaluators, and 95% correct matches were achieved. **Conclusion:** Palatal rugae are unique to every individual and can be used as an indicator in forensic odontology.

Key words: Forensic odontology, orthodontics, palatoscopy, rugae

transverse ridges on the anterior part of the palatal mucosa. These rugae are present on each side of the median palatal raphe and behind the incisive papillae.^[3]

Palatoscopy/rugoscopy is the study of palatal rugae that helps in sex determination. The advantage of palatal rugae is its internal position, which leads to stability and perenity. Palatal design and structure is not altered during growth and it is protected from external trauma.

Application of palatal rugae patterns for personal identification was suggested by Allen in 1889. The term “Palatal rugoscopy” was first proposed by the Spanish investigator Trobo Hermosa.^[4] Identification of palatal rugae pattern is based on classification by Thomas *et al.* This classification includes number, length, shape and identification pattern of rugae. By determining the length of all rugae, three categories are identified.^[5]

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

The shape of individual rugae are classified into four major types

1. Straight – Runs directly from origin to termination
2. Curvy – Simple crescent shape that was curved gently
3. Circular – Definite, continuous ring formation, diameter from origin to termination is considered
4. Wavy – Serpentine form.

The unification pattern is further subdivided into diverging and converging types.^[6,7]

Diverging pattern occurs when two rugae begin from the same origin but diverge transversely.^[8,9]

Converging pattern occurs when two rugae arise from different regions and converge transversely.^[6,7]

The objective of the present study was to investigate sex variation in palatal rugae patterns and evaluate the reliability of these patterns in human identification by studying pre- and post-operative orthodontic cases.

Materials and Methods

The present study was conducted at I.T.S. Centre for Dental Studies and Research, Ghaziabad, India. All individuals of the study belong to the same geographical population from Western Uttar Pradesh. The study sample consisted of casts of 50 patients, of which 25 were males and 25 were females. From the above sample, 10 males and 10 females had undergone orthodontic treatment. All the casts were in the age group of 15-30 years. All casts were of healthy patients free from any diagnosed congenital abnormalities, inflammation and trauma. All selected casts from the individuals were free of air bubbles or voids, especially in the anterior one-third of the palate. In patients who had undergone orthodontic treatment, their pre and post-operative casts were visualized and compared to find the closest match that is required for the stability of rugae pattern. Rugae patterns on the study models were delineated using pencil under adequate light and magnification using a hand lens.

A double-blind study was conducted on orthodontic casts of patients who underwent orthodontic treatment in the Department of Orthodontics. The casts were distributed randomly among two observers for determination of sex and stability of rugae pattern. The two observers were not informed whether the casts belong to the same patient, and the casts of the pre-operative orthodontic treatment were then matched with multiple post-treatment casts. The individual observer's analyses were also not disclosed to the other observer. The selection of cast for the study was on a random basis without informing the observer on what kind of study was being performed; this could have brought a selection bias for the study. Data or cases were

collected from the Department of Orthodontics in patients whose treatment was completed. For identification of sex, the classification given by Thomas *et al.* was used. In addition, the unification pattern was also used. To achieve stability during analyses, each of the observers randomly took one pre-operative cast of a patient who underwent orthodontic treatment and this was matched with multiple post-operative casts on the basis of palatal rugae, and the closest match was selected. Correctness of the match for each examiner was calculated as the percentage. Sample size was determined by statistically analyzing the data from which results would be obtained.

Results

The results of the study showed that females have slightly more rugae than males. These sex-wise distribution modes of unification pattern of rugae showed a statistically significant difference. Diverging pattern was found more commonly in females compared with males, who predominantly showed converging patterns [Table 1]. This can probably substantiate the increase in rugae pattern in females.

The use of pre- and post-orthodontic cases also demonstrates that the changes occurring with extractions and tooth movement or any other orthodontic treatment do not significantly alter the pattern of the palatal rugae. Variables in length and shape of palatal rugae also showed statistically significant results and thus could be used as a discriminant in sex determination [Table 2].

The overall percentage of correct matches by observers

Table 1: Gender-wise distribution of mode of unification of rugae

	Total no. of samples	No. of unification patterns	Percentage	P value
Converging				
Males	25	15	60	0.04
Females	25	9	36	
Diverging				
Males	25	10	40	0.04
Females	25	16	64	

*Significance: <0.05

Table 2: Variables in length and shape of palatal rugae

Variable	N	Mean	SD	Student's t-test
Primary rugae	50	3.6	1.12	16.08
Secondary rugae	50	1.85	0.94	8.20
Fragmentary rugae	50	1.11	0.99	5.61
Straight	50	1.91	1.07	8.98
Wavy	50	2.39	0.97	12.34
Curved	50	0.76	0.73	5.23
Circular	50	1.05	1.07	4.66

*P value-aPr >|t| < 0.0001

in palatal rugae pattern between the casts of pre- and post-operative orthodontic patients was 88.6% and 95.7%, respectively, with a mean of 90.2% and median of 90%. The percentage of correct matches for each case was 74.2% and 100%, respectively, with a mean of 90.32%.

To evaluate the accuracy of identification, kappa stats was performed between the observers and the score was 0.61, which indicates an agreement between observers for correctly matching pre-operative and post-operative casts.

This study found that palatal rugae are sufficiently characteristic to indicate identity through discrimination. This gave the evidence that palatal rugae may be used for identification purposes and was proved to be stable in the population under study [Figure 1a and b].

Discussion

Many attempts have been made in order to find out safe means for human identification that may allow recognition, avoidance or detection of errors and simultaneously preclude changes or alterations of numbers or individuals.^[10,11] It is widely acknowledged that there are limitations in identification by fingerprints, dental records and DNA in some forensic situations, and the palatal rugae pattern of an individual may be considered as a useful adjunct for identification purposes.^[12,13]

Our study also emphasized the advantage of palatoscopy in accordance to the previous literature. The present study was carried out to study the rugae pattern and to compare the patterns between the males and the females in a Western UP population. We also aimed to evaluate the reliability of palatal rugae as a forensic tool and to assess its stability in a particular regional and ethnic group, as there tends to be variation in various groups. This study found that palatal rugae are sufficiently characteristic to indicate identity through discrimination and gave evidence that palatal rugae may be used for identification purpose sand was proven to be stable in the population under study [Figure 1a and b]. The average number of rugae in females was slightly higher in comparison with that in males, and the diverging pattern

was found more commonly in females compared with males.

Souza Lima^[13] conducted a study and concluded that there are no changes in the morphology or arrangement of palatal rugae. Individuals submitted to surgery exhibited a mild reduction of space among the rugae or even shortening or elongation depending on the extent of the intervention performed. There was no remarkable damage in any such case. However, it should be highlighted that the palatal rugae may be changed by different factors, such as wearing complete dentures, procedures that may cause trauma, cleft palate, fibrous tissue and “calluses”; however, these factors do not impair identification. In our study also, the rugae pattern remained unchanged after the intervention.

English *et al.*^[11] conducted a study to identify individuals undergoing orthodontic treatment. They concluded that the palatal rugae pattern is characteristic enough to differentiate among individuals.

Hauser *et al.*^[11] investigated 117 dental casts of individuals from Swaziland aged 12-60 years. Prominent rugae were observed on the dental casts of this population; the palatal rugae patterns were very similar as this population is highly homogenous.

Dental casts have also been used by Limsom.^[8] Utilization of dental casts presents the advantages of simple analysis, reduced cost and easy achievement in any laboratory; this corroborates the routine work of Brazilian forensic medical institutes, which do not have many resources available to buy sophisticated equipments and materials.

The use of pre- and post-orthodontic cases [Figures 2 and 3] also demonstrates that the changes occurring with extractions and tooth movement or any other orthodontic treatment do not significantly alter the pattern of the palatal rugae. Average number of rugae in females was slightly higher in comparison with that in males, and the diverging pattern was found more commonly in females as compared with males. Therefore, anatomical structures such as palatal rugae may have greater importance in the future and could serve as a potential forensic tool as it remains unchanged after the surgical intervention.

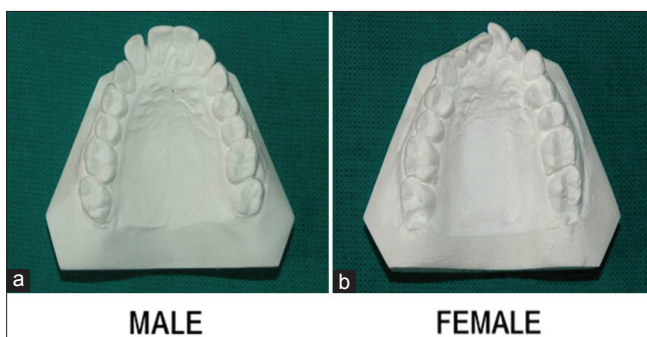


Figure 1: Palatal rugae pattern in males and females

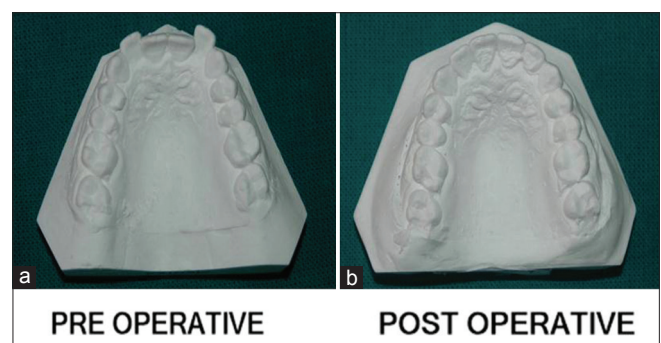


Figure 2: Pre and post-operative orthodontic casts showing palatal rugae pattern

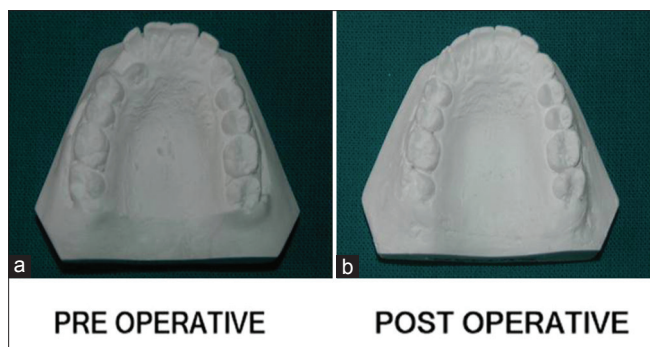


Figure 3: Pre and post-operative orthodontic casts showing palatal rugae pattern

Conclusion

The present study has clearly highlighted the patterns of rugae architecture that are highly specific for the female and male populations. The average number of rugae in females was slightly higher in comparison with that in males and the diverging pattern was found more commonly in females compared with males. The study also highlighted the consistency of rugae pattern in pre- and post-treated dental patients (orthodontically treated). Likewise, further studies need to be explored on varying population.

The rugae morphological pattern may be useful in forensic science in case of mutilation when compared with other parts of the body. Palatal rugae form an intrinsic and integral pattern for every single individual and can also help in sex determination. The ease of reproducibility and lower level of variation makes palatal rugae a potential tool in forensic odontology.

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