ORIGINAL ARTICLE

Importance of palatal rugae in individual identification

Shriram C Bansode,
Meena M Kulkarni
Department of Oral Pathology, M.G.V. Dental College, Nashik, India

Abstract

Background: Rugae are anatomical folds or wrinkles, the irregular fibrous connective tissue located on the anterior third of the palate, behind the incisive papilla. They are also called 'plica palatine.' These rugae patterns are studied for various purposes, mainly in the fields of anthropology, genetics, orthodontics, prosthodontics, and forensic science. **Objective:** To determine the stability of the palatal rugae during fixed orthodontic treatment and to verify the accuracy rate of identification by comparing the rugae patterns on preoperative and postoperative orthodontic casts. **Materials and Methods:** Thirty preoperative and postoperative dental casts were selected. Thirty casts were randomly selected for the present study. The postoperative and the randomly selected casts were trimmed so that all areas except the rugae area of the hard palate were removed. The 30 postoperative casts were mixed with the 30 randomly selected casts. Thirteen examiners were selected as evaluators. They were instructed to match the 30 preoperative dental casts with the 60 dental casts (30 postoperative and 30 randomly selected casts). The case numbers of those that were correctly matched were noted. **Results:** During fixed orthodontic treatment, dental changes and sometimes bony changes occurred, but no changes occurred in the rugae pattern. The 13 examiners achieved 90% correct matches, which is the median in the present study. We used kappa statistics to assess the agreement between evaluators for matching preoperative with postoperative casts. **Conclusion:** Palatal rugae patterns are unique to an individual, and can therefore be used for individual identification in forensic odontology.

Key words: Individual identification, orthodontic casts, palatal rugae, rugae pattern

Address for correspondence:
Dr. Shriram Bansode, Department of Oral Pathology, M.G.V. Dental College, Mumbai-Agra Road, Panchavati, Nashik - 03, India.
E-mail: drshriram148@gmail.com

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Introduction

Among the common methods used in the forensic sciences for confirming the identity of a person are fingerprinting, DNA analysis, and dental comparison.[1] Visual identification is the most common method; because most deaths do not occur under unusual circumstances, the remains are usually visually identifiable. However, in complex identification, visual means of identification is the least desirable method because of emotional stress in the identifier and lack of objective assessment at the time of identification.[2] As Morlang[3] has stated, fingerprints have long been the standard for identification, but this form of identification is not possible if there are no antemortem records. Also, postmortem fingerprints are often unavailable, especially in cases involving fire, decomposition, and massive trauma.

In forensic dentistry, the oral cavity plays a very important role because of the unique anatomy of the teeth. In certain situations, if teeth are lost due to any reason, the most common of which is trauma, then the use of human palatal rugae has been suggested as an alternative method for identification. Palatal rugae are formed in the third month in utero from the hard connective tissue covering bone. The pattern orientation is formed by about 12th to 14th week of prenatal life and remains stable until the oral mucosa degenerates after death. The palatine rugae possess unique characteristics that can be used in circumstances when it is difficult to identify a dead person through fingerprints or dental

records.[4,5]

Histologically, the rugae are stratified squamous (layered scales), mainly parakeratinized, epithelium on a connective tissue base, similar to the adjacent tissue of the palate. Thomas[6] reported differences in the rugae cores taken from human embryos of over 20 weeks. He found the reticulin fiber content to be very delicate and the fibroblasts to be different in amount and size from that in adjacent palatal tissue. Many researchers have studied the morphology of palatal rugae and the racial differences, but very few have studied the individuality of palatal rugae.

Rugae are protected from trauma by their internal position in the head, and from heat by the tongue and the buccal pad of fat. Sassouni[7] have stated that no two palates are alike in their configuration and that the palatoprint does not change during growth. They are considered to be stable throughout life (following completion of growth), although there is considerable debate on the matter.[8] Once formed, they do not undergo any changes except in length (due to normal growth) and remain in the same position throughout a person's entire life.[1,9]

Thomas and Van Wyk[10] successfully identified a severely burnt edentulous body by comparing the rugae to the pattern on the victim's old denture; this indicates, among other things, that rugae are stable in adult life. Thus, palatal rugae appear to possess the features of an ideal forensic identification parameter, i.e., uniqueness, postmortem resistance, and stability. Palatoscopy or palatal rugoscopy is the name given to the study of palatal rugae in order to establish a person's identity.[1]

The application of palatal rugae patterns for personal identification was first suggested by Allen[11] in 1889. Palatal rugoscopy was first proposed in 1932, by a Spanish investigator named Trobo Hermosa.[12] In 1937, Carrea[13] conducted a detailed study and established a method to classify palatal rugae. In 1983, Brinon,[13] following the studies of Carrea, divided palatal rugae into two groups (fundamental and specific) in a similar way to that done with fingerprints.[12,13] In this manner, dactyloscopy (study of fingerprints) and palatoscopy (study of palatal prints) were united as similar methods based on the same scientific basis. The two systems are sometimes complementary: for instance, palatoscopy can be of special interest in those cases where there are no fingers to be studied (burned bodies or bodies in severe decomposition).

The present study was conducted to evaluate accuracy of identification established by comparison of the rugae patterns on preoperative and postoperative orthodontic casts.

Materials and Methods

Ninety orthodontic casts of patients were obtained from the Department of Orthodontics for this study. These 90 casts were divided into three groups. The first group consisted of 30 preoperative orthodontic casts [Figure 1]. The second group consisted of 30 postoperative orthodontic casts of the same patients as in the first group; these 30 casts were mixed with 30 randomly selected casts. Out of 30 patients, 25 had history of extraction of a premolar tooth for fixed orthodontic purpose, while five patients had no history of extraction. Four patients had history of dento-alveolar expansion (from 3 mm to 8 mm); 24 patients had history of proclination (from 3 mm to 10 mm) which had been treated with edgewise therapy. The duration of treatment varied from 8 months to 26 months.

Thirty postoperative orthodontic treatment casts and the 30 randomly selected casts were trimmed by an orthodontic cast trimmer in a standardized manner so that the base was parallel to the occlusal plane. The posterior part of the casts were trimmed perpendicular to the base until the cast measured 2½ cm from the incisive papilla; this technique was originally described by English *et al*.[2] Finally, the remaining borders were trimmed perpendicular to the base, following the form until all teeth and edentulous ridges were removed. This step ensured that the teeth, the edentulous area, and the vestibule would not have any influence and that only the palate would be used in the identification process [Figure 2].

The rugae pattern on all the casts were delineated using a sharp graphite pencil under adequate light and magnification according to the classification given by Kapali *et al*.[14] The first group of 30 preoperative casts were given a random number; the second group consisted of postoperative casts and randomly selected casts mixed together and numbered randomly. The case numbers of the preoperative casts with that of the matching postoperative dental casts were recorded but not revealed to the evaluators. Thirteen examiners were selected as evaluators; they included one professor, one reader, two lecturers, four postgraduate students, three interns, and two clerical staff from the Department of Oral Pathology. The examiners selected the closest match based on pattern of rugae [Figure 3]. The correctness of the match for each examiner was calculated as the percentage of correct matches.

Results

Table 1 shows the percentage of correct matches for all 13 examiners; this ranges from 76.66 to 96.66%, with a mean of 89.69% and a median of 90%. Figure 4 shows the percentage of correct matches for each case, which ranges from 72.72 to 100% with a mean of 90.71 (S.D ± 11.05) and a median of 100% and confidence interval ranges from 86.76 to 94.66%.

Figure 1: Preoperative orthodontic casts

Figure 2: Trimmed postoperative orthodontic casts

Figure 3: Matching preoperative casts with trimmed postoperative casts

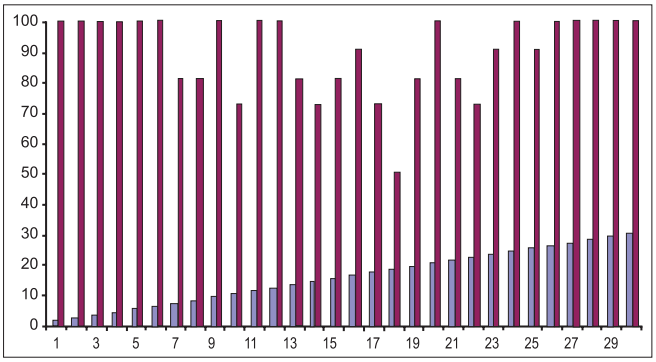

Figure 4: Percentage of correct matches for each case

Table 1: Percentage of correct matches for each examiner

Examiner	Percentage of correct matches
1	93.33
2	83.33
3	96.66
4	90
5	90
6	96.66
7	93.33
8	90
9	90
10	86.33
11	93.33
12	76.66
13	86.37

The mean percentage of correct matches among dental staff examiners was 91.17%, (SD ± 4.057), and median is 90%. The mean percentage of correct matches among non-dental examiners was 80.490%, (SD ± 4.0093) and median was 80.49%. To evaluate the accuracy of identification, Fleiss' kappa statistics was performed for dental staff examiners and the score was 0.61, which indicates that there is substantial agreement between the evaluators for correctly matching preoperative casts with the postoperative casts.

To compare the accuracy of assessment of rugae patterns between dentist and non-dentist examiners, we compared the results of two dental lecturers with that of the two non-dental examiners using Cohen's kappa statistics, which showed that dental examiners have a better ability in this

Figure 5: Complex rugae pattern

evaluation than non-dental examiners.

Discussion

The accuracy of identification of palatal rugae patterns by four investigators and two teams was reported by English *et al*., to be 100%, except for one investigator who achieved only 88% correct matches.[2] Limsons and Julian[15] who compared some points of the rugae patterns using computer software reported that the percentage of correct matches ranged from 92% to 97%. Maki Ohtani[16] *et al*. who examined the accuracy rate of identification in edentulous cases, which should not be considered to be significantly different from that in dentate cases, achieved 94% correct matches. In the present study, two examiners who correctly matched 29 out of 30 cases, had knowledge of dental anatomy and rugae but no training in forensic science identification techniques. Other examiners also matched the casts with high accuracy. This suggests that the ability to match the preoperative and postoperative casts may not require special training or knowledge.

According to the present study, dental staff have better ability in this form of evaluation than non-dental staff. However, some examiners did have problems during matching, which may have been due to complex rugae patterns [Figure 5], overlapping of rugae, and poorly demarcated rugae.

The matching of preoperative and postoperative orthodontic casts also demonstrates that the changes occurring following extractions and tooth movement do not significantly alter the pattern of rugae. In the four cases where arch expansion was undertaken, the morphology of the rugae was not altered, though there was a definite increase in the length of the rugae. A common concern about palatal rugae voiced by many researchers is the possibility of rugae patterns changing with age and other outside influences. Orthodontic movement, extraction of teeth, cleft palate surgery, periodontal surgery, and eruption of an impacted canine are only some of the concerns. Most dental identification is based on comparison of teeth and associated restoration, but identification based on rugal characteristics is not always possible. Instances could occur in which the palate remains intact due to its position, while most other anatomical structures are destroyed, burned, or dehydrated. Therefore, anatomical structures such as palatal rugae may assume more importance in the future.[2]

This method of identification can be used only when an ante-mortem record of the palatal rugae is available. This could simply consist of existing dental casts. However, other methods of recording the rugae pattern are possible for identification purpose, which might include photography, palatal prints, or computerized tomography of the rugae pattern.

Conclusion

It appears that the pattern of palatal rugae is unique to each individual and that it can therefore be used for establishing identity. Although some changes do occur in the rugae during orthodontic treatment, the morphology of palatal rugae remains stable throughout life and carefuly assessed rugae pattern has definite role in forensic practice.

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