

Original Article

TO STUDY THE CHANGES IN THE PALATINE RUGAE PATTERN DURING VARIOUS ORTHODONTIC TREATMENT

Dr. M Kulkarni, Dr. P Gore

Authors

Dr. Meena Kulkarni, Prof. & Head, Department of Oral Pathology, Rural Dental College, PIMS (DU), Loni, Maharashtra

Dr. Pratibha Gore, Resident, Department of Oral Pathology & Microbiology, Rural Dental College, PIMS (DU), Loni, Maharashtra

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Address for correspondence: Dr. Pratibha Gore, Resident,
Pravara Rural Dental College, PIMS (DU),
Loni, Maharashtra
drpratibhathoirat17@gmail.com
9970393090

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Introduction:

Palatal rugae, also called 'plicae palatinae transversae' and 'rugae palatine', refers to the ridges on the anterior part of palatal mucosa, present on each side of the median palatal raphe and behind the incisive papilla. Carrea (1937) indicated that a rugae pattern is formed by the 12th to 14th week of prenatal life, and it remains stable throughout the person's life.¹ The anatomical position of the rugae inside the mouth surrounded by cheeks, lips, tongue, buccal pad of fat, teeth and bone keeps them well-protected from trauma and high temperatures.²

Histologically, the rugae are stratified squamous (layered scales), mainly parakeratinized, epithelium on a connective tissue base, similar to the adjacent tissue of the palate. Thomas³ 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. Palatine rugae can be used as internal dental-cast reference points for quantification of tooth migration in cases of orthodontic treatment.

Sassouni⁴ 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.⁵ 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.^{6,7} Thomas and Van Wyk successfully identified burnt edentulous body by comparing the rug pattern on the victim's old denture; this indicates other things, that rugae are stable in adult life.⁸

Palatoscopy or Rugoscopy is the name given to the study of palatal rugae in order to establish a person's identity.⁷ The application of palatal rugae patterns for personal identification was first suggested by Allen' in 1889. Palatal rugoscopy was first proposed in 1932, by a Spanish investigator named Trobo Hermosa. In 1937, Carrea conducted a detailed study and established a method to classify palatal rugae. In 1983, Brinon, following the studies of Carrea, divided palatal rugae into two groups (fundamental and specific) in a similar way to that done with fingerprints.⁹

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).⁷

Very few studies have been undertaken to establish the reliability of palatal rugae pattern in individual identification which could play a very important role in forensic sciences. However, rugoscopy can be applicable for forensic identification only when there is available antemortem information for comparison such as dental casts, tracings or digitized rugae patterns. Previous studies may not have considered the effects of growth, extractions, palatal expansion, or some combination of these. The inadvertent use of other features of the cast, such as teeth, edentulous ridge morphology, muscle attachments, vestibular depth, or some combination of these, to aid in the identification, may have influenced their results.

Thus the present study will evaluate accuracy of identification by comparing the rugae patterns on pre-operative and postoperative orthodontic cast photographs overcoming these limitations. The purpose of this study is to determine if palatal rugae can be relied upon for identification of the individual and whether it can play a definite role in forensic science.

Aims & objectives:

1. To study the changes in the rugae pattern during orthodontic treatment.
2. To determine the stability of the palatine rugae pattern during orthodontic treatment.
3. To verify the accuracy rate of identification by comparing the rugae pattern on preoperative & postoperative orthodontic treatment.

Materials & Methods:

1. 90 orthodontic casts
2. 30 pre orthodontic treatment cast photographs
3. 30 post orthodontic treatment cast photographs
4. 30 randomly selected cast photographs as control.
5. Black marker, 0.5 graphite pencil, ruler, digital camera (SONY CORP.SIT-A,MODEL NO. DSC-W530,3.6 V:14.1 Mega Pixels)

90 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. The second group consisted of 30 postoperative orthodontic casts of the same patients as in the first group. The third group consisted of 30 randomly selected casts.

Out of 30 patients, 24 had history of extraction of a premolar tooth for fixed orthodontic purpose, while six 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 24 months.



Fig.1 Preoperative Orthodontic Casts Photographs

The rugae patterns 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*¹⁰.

A digital camera was placed in the horizontal plane with a spirit level at a fixed distance of 20 cm. Every cast was brought under the camera for the photograph. The aperture on the digital camera was set at maximum to achieve the best field of depth and the picture quality set at

4.0 megapixels. Photographs of all the casts were taken after delineating the rugae.

The first group of 30 preoperative cast photographs were numbered as 1-30. (Fig.1)

All the images of the casts were imported into CoralDraw® Graphics Suite. All the images of the postoperative casts & randomly selected casts were cropped, So that all areas except palatal rugae of the hard palate was 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. (Fig. 2)

After that these images (cropped) were obtained on the photo paper. 30 Postoperative cast photographs were mixed with 30 photographs of the randomly selected cast photographs. The second group consisted of postoperative cast photographs (Fig.3) and randomly selected casts photographs (Fig.4) mixed together and numbered randomly.



Fig.2: Cropped Image

16 examiners were selected as evaluators. They were professors, readers, senior lectures & PG students from the department of Oral Pathology, Prosthodontics & Orthodontics. They were instructed to match the preoperative casts photographs with other 60 photographs (30 postoperative & 30 randomly selected). The number of photographs that were correctly matched was noted. The case numbers of the preoperative casts photographs with that of the matching postoperative dental casts photographs were recorded but not revealed to the evaluators.

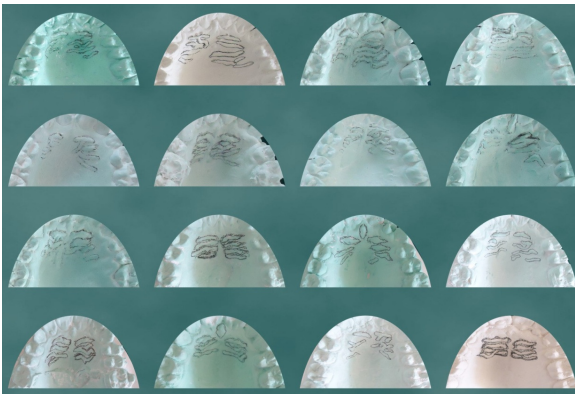


Fig. 3: Cropped postoperative orthodontic casts

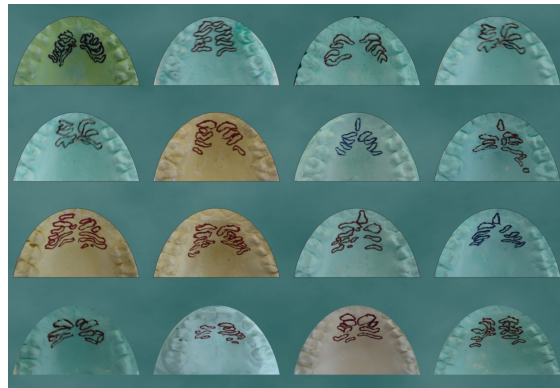


Fig.4 Cropped Randomly Selected Orthodontic Casts Photographs

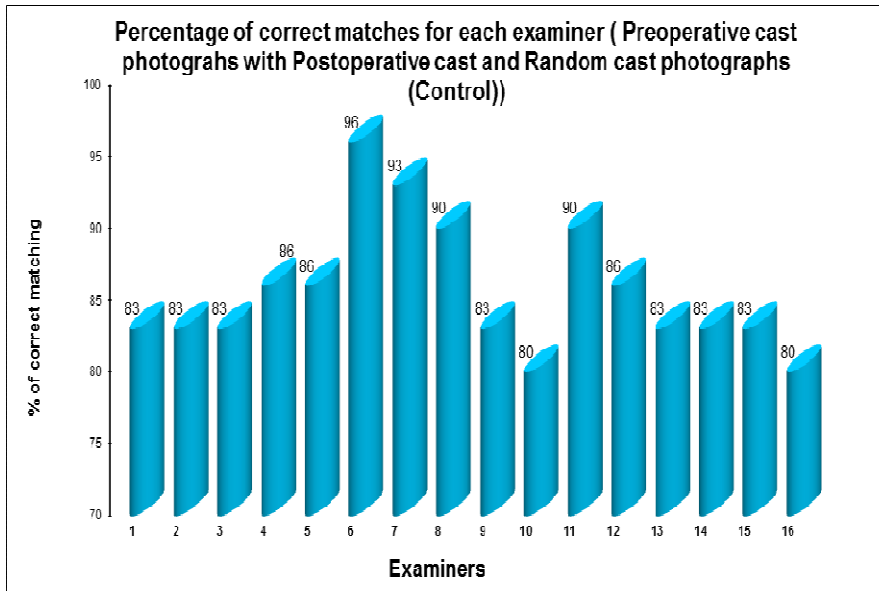
The examiners selected the closest match based on pattern of rugae. The correctness of the match for each examiner (Fig.5) & for each cast photograph (Fig.6) was calculated as the percentage of correct matches.

These photographs of the casts were kept as a permanent antemortem record in the department of oral pathology under the forensic odontology section for the future.

Discussion:

The accuracy of identification of palatal rugae patterns by four investigators & two team was reported by English et al.¹¹ to be 100%, except for one investigator who achieved only 88% correct matches. Limson & Julian¹² 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 et al who examined the accuracy rate of identification in edentulous cases, about 94%.



In the study conducted by Bansode & Kulkarni et al., 13 examiners achieved 90% correct matches. They analysed only some changes in the rugae pattern during orthodontic treatment by evaluating the preoperative and postoperative orthodontic casts

of 60 patients. They also assessed that the morphology of palatal rugae remains stable throughout life and carefully assessed rugae pattern has definite role in forensic practice.⁹

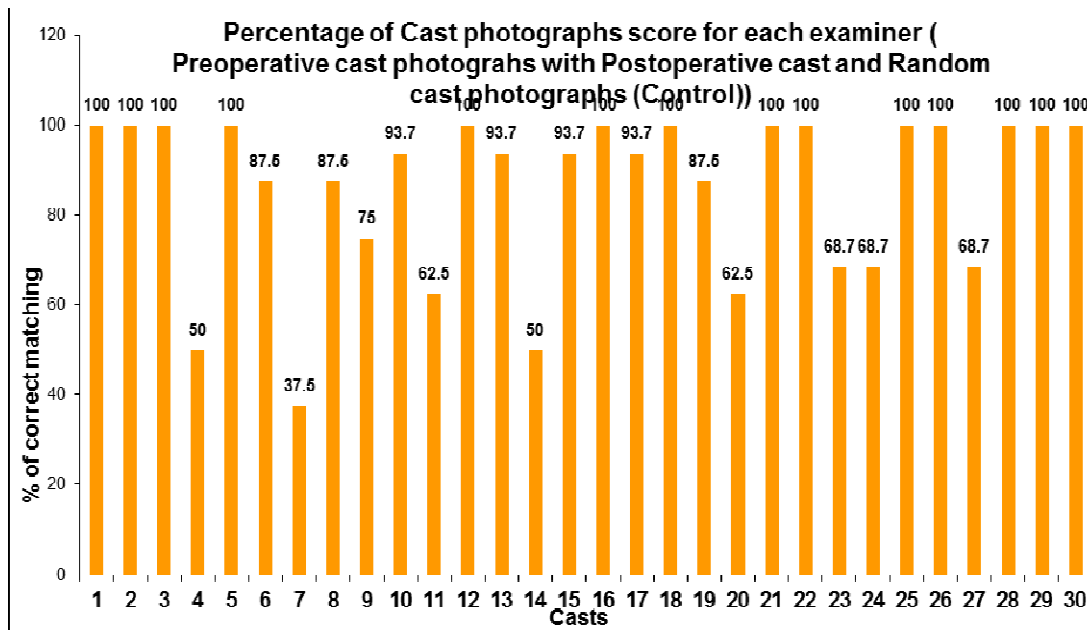


Fig.6: Percentage Of Cast Photograph Score For Each Examiner

Rugae patterns have been studied for various purposes, in the field of anthropology, comparative anatomy,¹³ genetics, forensic odontology, Prosthodontics and orthodontics.¹⁴

In the literature, the consensus of opinion is that the rugae remain fairly stable in number & morphology except when there is trauma, such as loss of tooth, persistent pressure, extreme finger sucking, orthodontic tooth movement which may modify the alignment.¹⁵

Various investigators have implied that palatal rugae are unique to each individual and they can be used successfully in human identification.



Fig.7: Non Specific Rugae Pattern

The importance of dental identification is on the rise year after year. With the passage of time, the role of forensic odontology has increased as very often teeth and dental restorations are the only means of identification.¹⁶ However, researchers have disagreed as to whether or not legal identification could be based solely on palatal rugae. Controversy also exists about the stability of quantitative and qualitative characteristics of rugae during growth.

English et al¹¹ and Peavy and Kendrick¹⁷ noted that the characteristic pattern of the palatal rugae did not change as a result of growth, remaining stable from the time of development until the oral mucosa degenerated at death. Van der Linden proved that the anterior rugae do not increase in length after 10 years of age. Also the qualitative characteristics such as shape, direction and unification remain stable throughout life. However, Hauser et al have suggested that the mean rugae count changes moderately in adolescence and then increases markedly from the age of 35 to 40 years. In contrast, Lysell considered that the number of rugae decreased from 23 years of age onwards.⁹ Some events can contribute to changes in rugae pattern, including trauma, extreme finger sucking in infancy, and persistent pressure with orthodontic treatment and dentures.⁹ It has been suggested that changes in the length of rugae with age result from underlying palatal growth.⁸⁻¹⁰ Furthermore, Bailey et al, Almeida et al and Abdel-Aziz et al concluded that movement of teeth may change the position of the rugae points.⁶

Dental casts are three dimensional (3-D) records of malocclusion that have been used successfully during diagnosis and treatment planning for orthodontic patients. The palatine rugae are unique to each patient and are reasonably stable during the patient's growth thus, they may serve as suitable reference points from which the clinician can derive the reference planes necessary for longitudinal cast analysis. Positional changes of posterior teeth in the antero-posterior direction are relevant to the diagnosis and correction of sagittal occlusal abnormalities and arch length discrepancies. Hauser observed orthodontically treated patients and concluded that the lateral edges of the rugae moved forward about one-half the distance of the migration of the adjacent teeth, while the medial rugae were not affected. In a study of changes occurring in 14 patients who underwent extraction of four premolars, Peavy and Kendrick reported that the lateral ends of the rugae that terminated close to the teeth followed the movement of the teeth in the sagittal plane, but not in the transverse plane.¹⁸

In the present study 16 examiners with the help of cast photographs of the palatal rugae studied the changes occurring during the various orthodontic treatment. The accuracy rate of identification by comparing the rugae patterns from the cast photographs observed & noted.

The matching of preoperative and postoperative orthodontic casts photographs demonstrates that the changes occurring following extractions and tooth movement do not significantly alter the pattern of rugae. In the 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. However, some examiners did have problems during matching, which may have been due to non-specific rugae patterns, (FIG.7) overlapping of rugae, and poorly demarcated rugae. Because of which some casts had difficulty in matching.

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.

This method of identification can be used only when an ante-mortem record of the palatal rugae is available. This could simply consist of dental cast photographs. However, other methods of recording the rugae pattern are possible for identification purpose, which might include, palatal prints, or computerized tomography of the rugae pattern. In future there is need to conduct study using other means & large data.

Conclusion:

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

The collected data can be used as a antemortem data in the department under the section of forensic odontology for the future in personal identification when the other means of identifications are lost or cannot be used.

Results:

Table 1 shows the percentage of correct matches for all 16 examiners; this ranges from 80% to 96%, with a mean of 85.5 % (SD \pm 4.57) and a median of 83% .(FIG.4)

Table 2 shows the percentage of correct matches for each case, this ranges from 37.5% to 100 % with mean of 86.03 % (SD + 18.62) and a median of 93.7.(FIG.5)

By applying Wilcoxon Matched Pairs Signed Rank Test the **median** of the differences of Percentage of correct matches from Preoperative cast with Postoperative cast and Preoperative cast with Postoperative cast and Random cast (Control) differ significantly.

Non-parametric Spearman correlation coefficient i.e. value of $r = 0.8835$, $p < 0.001$

Thus effective matching results in a significant correlation between Postoperative cast and Preoperative cast with Postoperative cast and Random cast (Control). That is the matching appears to be effective.

Statistical analysis:

Statistical analysis were done by computing descriptive statistics i.e. mean, median, standard deviation, percentage, 95% and 99% confidence intervals. The Non parametric test Wilcoxon Matched Pairs Signed Rank Test and Non-parametric Spearman correlation coefficient were applied for matching of Percentage of correct matches and cast score for each examiner.

The probability value (i.e. p , 0.05) considered as significant. The statistical analysis software **SYSTAT version 12** (Cranes Software, Bangalore, India) were used to analyze the data in this study.

Examiner score:

Table No.1: Percentage of correct matches for each examiner (Preoperative cast photographs with Postoperative cast photographs and Random cast photographs (Control))

Examiners	Percentage of correct matches
1	83
2	83
3	83
4	86
5	86
6	96
7	93
8	90
9	83
10	80
11	90
12	86
13	83
14	83
15	83
16	80
Mean ± SD	85.50±4.57
Range	80-96
Median	83
95% CI	88.168
99% CI	87.93

Cast score

Table No. 2: Percentage of Cast photograph score for each examiner Preoperative cast photographs with Postoperative cast photographs and Random cast photographs (Control):

Casts	Percentage of correct matches by examiner
1	100
2	100
3	100
4	50
5	100
6	87.5
7	37.5
8	87.5
9	75
10	93.7
11	62.5
12	100
13	93.7
14	50
15	93.7
16	100
17	93.7
18	100
19	87.5
20	62.5
21	100
22	100
23	68.7
24	68.7
25	100
26	100
27	68.7
28	100
29	100
30	100
Mean ± SD	86.03 ± 18.62
Range	37.5-100
Median	93.7
95% CI	79.08
99% CI	92.98

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