

## Palatal rugae: Stable or variable

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### Abstract

Forensics has always considered Palatal rugae as a stable landmark for identification in cases of mishap which needs forensic intervention. Many previous studies have claimed that palatal design and structure is not altered during growth as its position protects it from external trauma. But this theory can now be challenged with studies showing otherwise as a number of people are undergoing Orthodontic treatment to enhance their aesthetics. The question that now arises is that can palatal rugae be actually considered a stable landmark? How orthodontic treatment alters the structure of rugal area and how tooth movement affects the stability of rugae. This article throws light on significant effects of tooth movement on palatal rugae reported by various studies.

**Keywords:** Palatal rugae, Orthodontic treatment, Stability, Variability, Landmark.

### Introduction

Palatal rugae or plica palatinae transversae refers to a series of 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. Up until now there are studies which claim the palatal design and structure is not altered during growth as its position protects it from external trauma.<sup>1</sup> This may be because seldom did people undergo orthodontic treatment in that era. But with increase in demand for facial aesthetics and introduction of ceramic brackets and lingual orthodontics more people readily accept undergoing treatment.

Application of palatal rugae patterns for personal identification was proposed by Allen in 1889. Since then forensic sciences have considered palatal rugae to be stable throughout life, it's said that after 5yrs of age there is no change in the rugae area of a person. Palatal rugae are permanent and never changes by disease, trauma or chemical corrosion. When other tissue structures are damaged or burning, palatal rugae within the mouth retains complete according to previous literatures.

Due to unique and diverse features, human palatal rugae attract increasing attention as a new marker in the forensics. Thomas and Kotze<sup>2</sup> studies showed that palatal rugae pattern is different among each individual, even between the twins, recent studies in palatoscopy have shown researchers that rugae cannot be considered stable after all. Especially, after a patient undergoes orthodontic treatment.

Winslow<sup>3</sup> in 1753 was first to actually mention about palatal rugae in his article. It was Allen<sup>4</sup> and Wood<sup>5</sup> who suggested relationship between rugae and teeth, according to them these landmarks on the surface of the palate could be utilized for orientation and measurement of tooth position. Bernklau related the rugae to the teeth by using a symmetroscope, and stated that the movements of the marginal ends of the palatine

rugae could be observed as an additional diagnosis of the direction of tooth movement. Carrea<sup>6</sup> indicated that a rugae pattern had been formed by the twelfth to fourteenth week of intrauterine life, and he thought that it remained stable from this time throughout life. He stated that the rugae never change as a result of orthodontic treatment, and that loss of teeth has no effect on the shape of the rugae. Leontinis<sup>7</sup> states that rugae is stable throughout life until the oral mucosa degenerates at death. Hausser<sup>8</sup> felt that the amount of tooth movement in a sagittal direction could be related to the rugae. Friel<sup>9</sup> demonstrated by a serial study that the teeth move forward in relation to the rugae in conjunction with growth of the jaws. He showed that the posterior limit of the rugae in relation to the teeth tends to move backward until the age of twenty.

A number of these studies points out to the fact that until now the concept of rugae being a stable landmark for identification in cases of mishap which needs forensic intervention is faulty. Though palatine rugae is considered important, their relation to teeth have been neglected in dental literature.

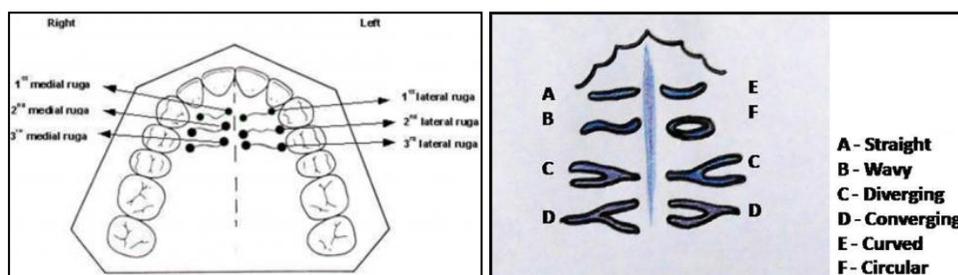
**Anatomical Aspects:** Palatal rugae are located on the anterior one-third of the palate behind the incisive papilla. Palatal rugae develops in the 3rd month in utero from the bone lined by hard connective tissue and the alignment and pattern of palatal rugae are generated in the 12<sup>th</sup> and 14<sup>th</sup> week which remains stable throughout life. Palatine rugae are considered suitable landmarks for forensic identification because of its uniqueness, post-mortem resistance and above all stability that may be recorded through casts, tracings or digitized pattern, Van der Linden<sup>10</sup> proved that the anterior rugae do not increase in length after 10 years of age. The palatine rugae do not extend posteriorly they are present just on the anterior part of the hard palate. Furthermore, some orthodontic influences like extraction of first premolars have resulted in changes in length of palatal rugae or

direction of palatal rugae, as reported by Peavy and Kendrick.<sup>11</sup>

Changes in rugae pattern are multifactorial with underlying cause being trauma, extreme finger sucking, infancy and persistent pressure with orthodontic treatment and dentures. It has been suggested that changes in the length of rugae with age result from underlying palatal growth. The anterior rugae are more prominent than the posterior rugae. The orientation, length, shape, width and number vary considerably among people. A study done on Australian Aborigines and Caucasians showed that with age there is change in the length of palatal rugae, 32 percent of rugae showed changes in shape, while 28 per cent displayed a change in orientation. In contrast to studies suggesting that rugae move forward with age, the majority of Aboriginal rugae that changed direction moved posteriorly. Changes in rugae patterns have been assumed to result from palatal growth but the study

showed that alterations in pattern were observed in the Aboriginal sample even after palatal growth had ceased.<sup>12</sup> Variation also exists in between the right and left sides of rugae in same person.

The palatal rugae due to presence of gustatory and tactile receptors they contribute to the perception of taste, the texture of food qualities and maintaining tongue position. Generally there is no bilateral symmetry in the number of primary rugae or in their distribution from the midline. Studies done by English<sup>13</sup> indicate that palatal rugae can withstand even in extreme circumstances and can still be used for identification. But the question is what about patients who undergo orthodontic treatment? Can an individual still have a stable landmark post treatment? Certain authors point out the first rugae to be more stable others conclude the third palatal rugae pair as more stable reference.



**Fig. 1: Anatomical aspects of palatal rugae**

**Palatal Rugae after Mid-palatal Expansion:** There was very less concern to notice the changes with palatal rugae after expansion initially but now many orthodontists agree to the fact that increase in width can affect the stability of palatal rugae points as a stable landmark. Growth modification or force application on

palate may bring about qualitative or quantitative changes on palatal rugae. Priyanka Kapoor et al<sup>4</sup> in her study on effects of RME evaluated transverse changes in palatine rugae after mid-palatal expansion. The figure (2) below shows the expansion device used by the author for her study.



**Fig 2: Appliance used for expansion**

Hyrax expansion screw was the appliance of choice after correction of posterior crossbite the results revealed a unanimous increase in all the pre and post expansion inter-medial and inter-lateral distance values according to this study. The author's recorded minimal inter-medial distance of 1<sup>st</sup> primary rugae and maximum increase in inter lateral distance of third primary rugae. A marked increase was also noted in

inter-mesial distance of third primary rugae. The author's results are in accordance with already established evidence of alteration in length and positional changes in palatal rugae with growth and orthodontic treatment. Maxillary mid palatal expansion that might have a significant direct bearing on palatal rugae in transverse dimension as mid palatal expansion opens the palatal suture in a V-shaped manner significantly affecting the anterior palatal vault and in

turn affecting the connective tissue covering of palatal rugae. Thus, whether they can be considered as stable reference landmarks for establishing distinctiveness in growing individuals having undergone mid palatal expansion, still needs to be explored. Reference landmarks for forensic identification has led to the conclusion that the medial aspect of first primary rugae is a stable reference landmark while the medial and distal aspects of the 2nd and 3rd rugae are liable to changes in transverse dimension. Hence, the application of palatal rugae for forensic identification in patients having undergone mid palatal expansion still remains questionable.

Cotton et al<sup>15</sup> correlated the tendency of relapse in maxillary teeth to stretched fibres of the attached palatal mucosa after treatment. Janalt Damstra et al<sup>16</sup> studied the stability of medial aspects of the rugae in patients where rapid maxillary expansion was performed in addition to fixed appliance therapy and stated that The addition of RME to fixed appliance therapy caused a change in transverse measurements between the medial aspects of the rugae bilaterally. Another interesting fact noticed in the study was the shape of expansion of palatal rugae, a V-shape expansion of the medial aspects of the rugae would be expected but instead the transverse changes were more marked for the third, less for the second, and least for the first rugae. The medial aspects of the rugae expanded in a 'Λ'-shape pattern when RME was performed in addition to fixed appliance therapy. Suggesting that the palatal mucosa may not follow the underlying separation of the palatal shelves and that the stretched fibres in the hard palate may have an effect on rugae movement. This can be

one of the reasons for relapse causing the maxillary teeth to return to their original position after RME.

#### Stability of Palatal Rugae in Extraction and Non Extraction cases:

There are quite a few number of studies conducted on the effects of extraction and non extraction cases. Peavy and Kendrick<sup>11</sup> evaluated the changes in 15 patients treated with extraction of four premolars and found that lateral ends of the rugae terminate close to the teeth and tend to follow the movement of teeth in the saggital plane but not in transverse plane. Authors concluded that the amount of tooth movement seems to have some influence on the stability of palatal rugae. The extraction of one or two premolars creates a large space for distal retraction of the maxillary anterior teeth which changes the positions of lateral points of the first rugae and this in turn changes the transverse offset and linear values.

Previously some casts studies done reported stability of palatal rugae as reference points in pre and post treatment comparisons on stone cast. One of the study performed by Brent R Hoggan and Cyril Sadowsky<sup>17</sup> in which they studied on palatal rugae taken as reference points for the measurements of tooth movement comparable with cephalometrics in 33 patients evaluating the parameters on pre and post treatment casts. Statistically no significant difference was found between the mean molar movement that was measured cephalometrically and the mean molar movement that was relative to the medial and lateral ends of the first and second palatal rugae or relative to the medial end of the third palatal rugae.

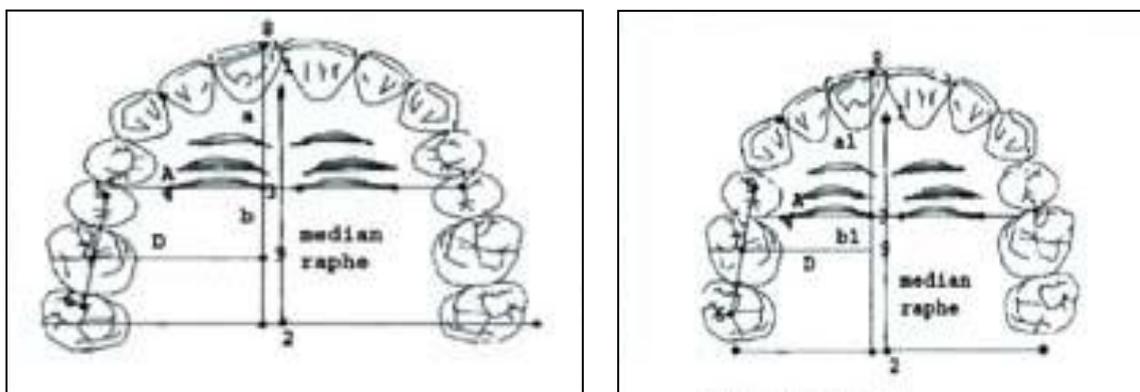


Fig. 3: Palatal landmarks in Pre & Post cast of premolar extraction case

Another benchmark study was done by Peavy on effects of tooth movement on palatine rugae. He related rugae to select zones of teeth to study their tooth movement as compared with movement of the teeth. Both the pre and post treatment casts were analyzed. The study reported that rugae associated with the cuspid followed the tooth in a sagittal direction in nearly every instance (92 %); while positive relation with the second premolar was 50 per cent. Some rugae moved in the

opposite direction than their associated tooth. Little association of rugae-tooth movements was found in the transversal direction.

The authors further reported that quantitative comparisons between pre-treatment and post-treatment casts showed the terminations of specific rugae to be greatly affected by the posterior movement of the anterior teeth. Rugae 1 and 2, terminating in the cuspid zones, were very unstable; while changes in the

termination of the rugae in the posterior part of the hard palate were slight. The study concludes the rugae appear to be of limited benefit in determining direction or magnitude of tooth movement. They may have their greatest value as an aid in orientation of the Bernklau symmetrograph on the midsagittal plane of the raphae, when determining symmetry, or evaluating the directions of certain tooth movements in a serial study but even then these uses would be possible if those rugae originate in a stable part of the palate are to be selected.

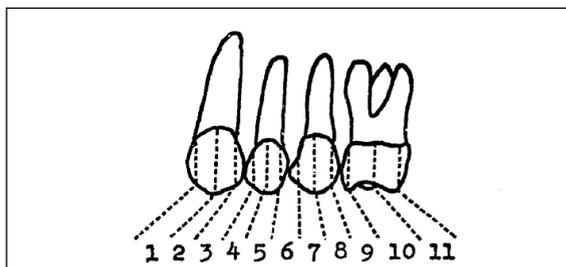


Fig. 4: Peavy's selected zones

Hausser's thinking that the cuspids and premolars moved in a sagittal direction twice as far as the ends of their related rugae was found to be true only in the cuspid region (zones 2 and 3). The longer rugae associated with the second premolars did not terminate laterally as close to these teeth as with the cuspids. Thus, the rugae were less subject to tooth movement in the region of the second premolars. The mucous membrane containing the rugae is tightly fixed to the underlying periosteum and around the neck of the teeth. The thinner less pronounced rugae are more likely to be stretched as a result of tooth movement than are the wider, heavier ones. The ends of some rugae were observed to have moved in an opposite direction than their related teeth.<sup>8</sup>

It was found in a study done by Shukla et al<sup>19</sup> that anteroposterior changes were significantly different for distances between lateral points of the first and second left rugae, between second and third left rugae and between the medial points of first and second right rugae thus suggesting that that space closure has some effect on the stability of the rugae.

**Stability of Palatal Rugae on Headgear or Functional Treatment:** Almedia et al<sup>1</sup> using the reflex metrograph to digitize dental casts in three dimensions conducted a study to determine if the palatal rugae are affected by treatment with headgear or functional appliances as compared with an untreated control group. Changes were found in the lateral points of the rugae, particularly in the headgear group. The medial rugae were found to be anatomically suitable landmarks for construction of stable analysis. According to this study only the headgear group showed a tendency for an increase in medial points of the rugae. The average lateral distance between the first and second rugae of

both sides in the headgear group and between second and third left rugae in functional group was significantly increased. The author concluded that functional and headgear appliance does not alter the transverse measurements of medial rugae points. Their results suggest that transverse offsets and distances between medial rugae points were stable particularly for the first rugae. The study also noted that there was a significant change between the medial points of second and third rugae in headgear group. The lateral rugae was deemed unstable. The results concurred with those of Moyers et al.<sup>21</sup>

**Vertical Growth and Position of Palatal Rugae:** Panagiotis Christoua et al<sup>22</sup> had done a longitudinal study on effects of vertical growth on the palatine rugae and position of incisors with 3 Dimensional scanning. The study was done using pre and post treatment dental casts and cephalograms of the patients. The aim of this study was to assess the long-term stability of the palatal rugae in the vertical dimension, relate them to possible maxillary incisor post-eruptive movements, and validate them by using lateral cephalograms as references for the evaluation of longitudinal dental changes. The study reported that during the 4 year observational period the rugae in both adolescents and adults changed positions in the vertical and anteroposterior dimensions. The study claims the sagittal changes of the rugae can be attributed to the mesial migration of all teeth of the dentoalveolar complex. Their findings also implied on the fact that the medial point of the third palatal rugae as stable point can be used as a reference to identify dental changes, preferably in a short period.

The authors also point out to the fact that many secondary changes in rugae position are related to secondary incisor eruption, which is greater in young subjects so use of it for a long-term study is not beneficial. They finally reported that the vertical changes in the position of the first rugae are associated with changes in the vertical position of the maxillary incisors and the increase in lower anterior facial height. Moreover, vertical changes are more marked for the first rugae (closest to the incisors), less for the second, and even less for the third rugae in both adolescents and adults. Thus, concluding that the third rugae is the most reliable and can be used as a reference for short-term observations

## Conclusion

"The closer the rugae are to the teeth, the more prone they are to stretch in the direction that their associated teeth move" holds true. Investigators have concluded that orthodontic treatment and tooth movement have a significant effect on the stability of first and second palatal rugae. The most reliable points which can be used as a reference point also are the medial and lateral third rugae points. Certain literature still point out to the fact that there is not much clinical

significance by the amount of change in the rugae so can be used for clinical purpose.<sup>23</sup> But orthodontic studies prove otherwise. To evaluate the dental movements, more studies with greater sample size and use of new 3D technologies is suggested for better understanding of the relationship of palatal rugae, tooth movement and related stability.

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