ORIGINAL ARTICLE

Transverse changes in lateral and medial aspects of palatal rugae after mid palatal expansion: A pilot study

Priyanka Kapoor,
Ragini Miglani
Department of Orthodontics, Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India

Abstract

Introduction: Palatal rugae has established role in forensic identification of an individual due to its stability in growth as well as orthodontic treatment. However effect of orthodontic mid-palatal expansion on rugae stability still requires further investigation. Hence, this study was aimed at evaluating the stability of palatal rugae in transverse dimension in adolescent patients of mid-palatal expansion. **Materials and Methods:** The study sample consists of 14 subjects (10F,4M, age 12.4 ± 2.0 years) with transverse maxillary constriction, treated with bonded and banded rapid maxillary expansion (RME) appliance. 1st to 3rd rugae on pre- and post-expansion casts were recorded synchronously. Inter-medial and inter-lateral rugae distance were measured with digital calipers to record the transverse positional rugae changes. **Results:** There was a statistically significant ($p < 0.05$) increase in values after expansion between medial aspects of 2nd ($p = 0.002$) and 3rd rugae ($p = 0.005$) and lateral aspects of 1st ($p = 0.015$), 2nd ($p = 0.006$) and 3rd ($p = 0.001$) rugae. The transverse changes were recorded in the order of 3rd rugae >2nd rugae >1st rugae. **Conclusion:** This pilot study does not support stability of medial and lateral ruga points of 2nd and 3rd primary rugae for forensic identification in individuals treated with mid palatal expansion.

Key words: Forensic identification, mid palatal expansion, palatal rugae, stability

Address for correspondence:
*Dr. Priyanka Kapoor,
Department of Orthodontics,
Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India.
E-mail: drkapoorpriya@gmail.com*

Introduction

Forensic odontology, or forensic dentistry, was defined by Keiser-Neilsen in 1970[1] as "that branch of forensic medicine, which in the interest of justice deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of the dental findings." Thus any dental evidence, if submitted in the court of law has to be researched thoroughly for each aspect with regard to its stability and reproducibility. Of the various dental aids to establish the forensic identification of an individual for legal purposes, study of palatine rugae has proved to be a possible alternative in cases where teeth are lost due to trauma or mostly as an adjunct to already established criterion of identification. However, there is immense potential in investigating the qualitative and quantitative aspects of stability of palatine rugae during growth as well as orthodontic treatment to serve as an aid in forensic identification.

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Palatal Rugae are anatomical wrinkles or folds called "plicae palatinae", the irregular connective tissue located on the anterior third of the palate behind the incisive papilla. Palatal rugae are formed in the 3rd month in utero from the hard connective tissue covering bone. The rugae pattern and orientation is formed by about 12th to 14th week of prenatal life and remains stable until the oral mucosa degenerates after

death.[2-4] Palatine rugae are considered suitable landmarks for forensic identification are its uniqueness,[5-7] post-mortem resistance[8] and above all stability[2-4] that may be recorded through casts, tracings or digitized pattern.[3]

The pioneer for the field of palatal rugoscopy was Spanish investigator named Trobo Hermosa in 1932 and its application for personal identification was suggested by Allen in 1889. The exploration of its use in forensics has substantially increased in recent times owing to multiple mass disasters, aircraft accidents, terrorist attacks, partial incineration, fragmentation and severe decomposition.[9]

Stability in shape, direction and unification of palatal rugae throughout life have been extensively documented.[3] Although the length of anterior rugae remain stable after 10 years of age, as proved by van der Linden,[10] other longitudinal studies on growth of palate have revealed changes in length of rugae with age.[11-13] Furthermore, some orthodontic influences like extraction of first premolars have resulted in changes in length of palatal rugae[10] or direction of palatal rugae, as reported by Peavy and Kendrick.[14] Even trauma, extreme finger sucking, infancy and persistent pressure with orthodontic treatment and dentures may also be contributory to changes in rugae pattern.[15]

The qualitative and quantitative changes in the characteristic trait of stability of palatine rugae, however small in magnitude, needs to be ascertained with respect to any modification in growth or force application on the palate as done in RME. This would aid in establishing palatal rugae as primary identification guideline for forensic application.

RME is characterized by widening of mid palatal suture by forcing a lateral shift of two horizontal processes of maxilla, opening the suture in V shaped manner affecting the anterior region of the palate and hence affecting the hard connective tissue in the anterior region of palate housing the palatal rugae covering palatal bone.[16,17] Cases of skeletal maxillary constriction substantiated by presence of posterior crossbite in growing children are indicated for modification in transverse growth of maxilla, both with tooth borne Hyrax or tissue borne Hass type expanders.[18]

This pilot study was designed to evaluate whether any transverse changes occur in palatine rugae after application of orthodontic forces for midpalatal expansion in patients with maxillary constriction and hence investigate whether palatine rugae may be used in forensic identification of such patients.

Materials and Methods

This pilot study was designed on a prospective study sample of 14 adolescent patients (10 F, 4 M, age 12.4 ± 2.0 years) with transverse maxillary deficiency reporting to OPD. There were no untreated controls in the study. Sample inclusion criteria for the study included young adolescent patients with constriction of maxillary arch having posterior cross bite, no habits like tongue thrust or thumb sucking and without any history of orthodontic treatment. Written informed consent was obtained from the parents of the children prior to start of treatment. Fixed RME were used for correction of skeletal crossbite that were banded in eight cases and cemented with a modified acrylic splint in the rest of six cases.

Fabrication of appliance and activation

Pre-treatment impressions were taken with alginate and casts were poured in type III stone for study model as well as a working model. Hyrax expansion screw (Dental Morelli, São Paulo, Brazil) of size 9 or 11 mm was selected as per the requirement for expansion in the patient.

For banded hyrax, separators were inserted between maxillary premolars and molars a week prior to banding. Preformed bands (3M Unitek victory series™) were adapted to first premolars and molars and maxillary impression was made with alginate and used as working cast. Hyrax expansion screw was soldered to the bands approximately 2 mm from the palatal surface along the midpalatal suture and cemented on to the upper posterior teeth with dual-cure resin cement (Rely X; 3 M, St. Paul, Minnesota, USA) [Figure 1].

For expansion appliance with modified splint, a 0.8 mm stainless steel orthodontic wire framework (Dentaurum, Pforzheim, German) was formulated around buccal and palatal surfaces of maxillary posterior teeth, crossing the occlusal surface between the canines and lateral incisors, Hyrax expansion screw was then soldered to this wire framework between premolar or primary molars and permanent first molar teeth, approximately 2 mm from the palatal surface along the midpalatal suture. An acrylic occlusal splint extending over the occlusal and middle third of the vestibular surfaces of all teeth with thickness limiting to the freeway space and in contact with all lower teeth, was then bonded to the upper posterior teeth with dual-cure resin cement (Rely X) [Figure 2].

The activation of appliance was started 1 week after insertion of appliance with a protocol of 12 hourly activation of screw, corresponding to 0.50 mm/day (2 turns/day; 0.25 mm/turn) for 3-4 weeks with the mean treatment time recorded as 21.23 ± 8.36 days. Expansion was discontinued once the occlusal aspect of the maxillary lingual cusp of the upper first molars contacted the occlusal aspect of the facial cusp of the mandibular lower first molars incorporating additional 2-3 mm of overexpansion to compensate for relapse.

Then the expansion appliances were debanded from the arch and fresh impressions were made and casts poured to serve as post-expansion casts. Patient was then given removable retention appliance for another 6 months to retain the expansion.

Figure 1: Cementation of RME appliance (banded Hyrax): Hyrax expansion screw was soldered to the bands premolars and molars approximately 2 mm from the palatal surface along the midpalatal suture and cemented on to the upper posterior teeth

Figure 2: Cementation of RME appliance (Hyrax expansion screw with modified splint): An acrylic occlusal splint extending over the occlusal and middle third of the vestibular surfaces of all teeth with soldered hyrax expansion screw is cemented on upper posterior teeth

Cast analysis

Pre-and post-expansion casts were traced simultaneously [Figure 3a and 3b] with a 0.3 mm graphite pencil under adequate light according to the classification given by Kapali *et al*.[5] Medial and lateral points were marked on medial and lateral ends of first, second and third rugae and then traced for the whole length of primary ruga. Inter-medial and inter-lateral rugae distance was measured with the help of Vernier calipers with accuracy of 0.1 mm [Figure 4]. Points noted for measurement of inter-medial and inter-lateral distances were marked [Figure 5] and readings were recorded.

Statistical analysis

Pre- and post-expansion readings of inter-medial and inter-lateral distances for first, second and third primary rugae were subjected to statistical analysis using S*p*SS software version 16. Wilcoxon Signed ranks test was performed to determine statistical significance of transverse changes in primary rugae following expansion.

Results

Clinically, RME caused the correction of posterior crossbite with an overcorrection of approximately 2 mm with the mean treatment time recorded as 21.23 ± 8.36 days. Tracing revealed a unanimous increase in all the pre- and post-expansion inter-medial and inter-lateral distance values [Table 1]. Minimum increase in values was recorded in the inter-medial distance of first primary rugae (0.14 mm) and the maximum increase recorded in the inter-lateral distance of third primary rugae (1.42 mm). A marked increase was also seen in the inter-medial distance of third primary rugae (0.93 mm). Statistical significance of these changes was calculated by Wilcoxon Signed ranks test. There was a statistically significant ($p < 0.05$) increase in the inter-medial distance of second ($p = 0.002$) and third rugae ($p = 0.005$) whereas the inter-lateral distance recorded a statistically significant increase in first ($p = 0.015$), second ($p = 0.006$) and third ($p = 0.001$) rugae. However, the transverse changes were recorded maximum for the third rugae followed by second and least for first rugae both for inter-lateral and inter-medial distances.

Discussion

The present study has been conducted to ascertain stability of palatal rugae in transverse dimension in adolescent patients subjected to midpalatal expansion to ascertain the role of palatal rugae as primary forensic identification criterion in these patients. Our results are in accordance with already established evidence of alteration in length and positional changes in palatal rugae with growth and orthodontic treatment. Our study had no controls to monitor changes in palate due to growth in patients not undertaking any orthodontic treatment as no significant changes occurs due to growth in adolescent age group. Hence only the treatment effects were considered. The earlier studies have focused on transverse and anteroposterior changes in palatal rugae related to non-extraction orthodontic treatment planning[1] or extraction of maxillary the first premolars[1,2] or even functional and headgear mechanics.[3] Surprisingly, none of studies have concentrated on 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[16] 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.

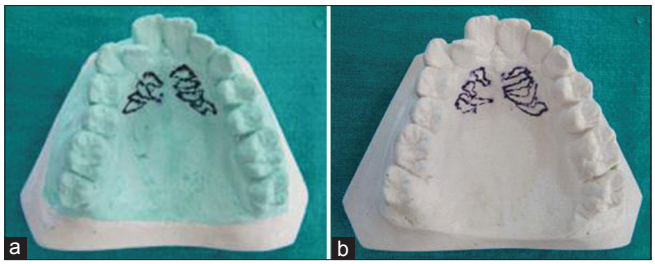

Figure 3: (a,b) Pre and post expansion casts are traced simultaneously for first, second and third primary rugae with a 0.3 mm graphite pencil under adequate light

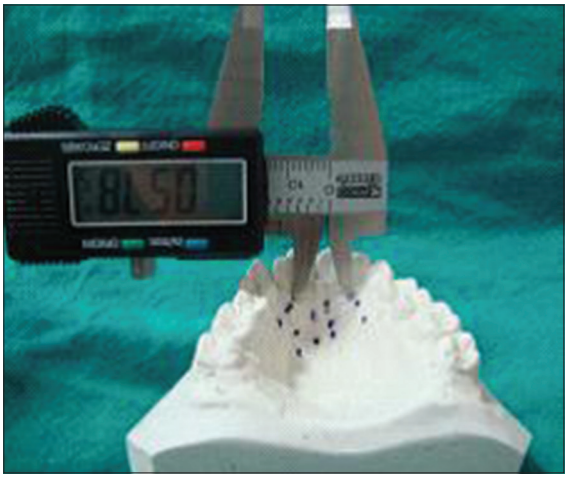

Figure 4: Intermedial and interlateral distance of first, second and third rugae are measured on pre and post expansion casts with vernier calipers with the accuracy of 0.01mm

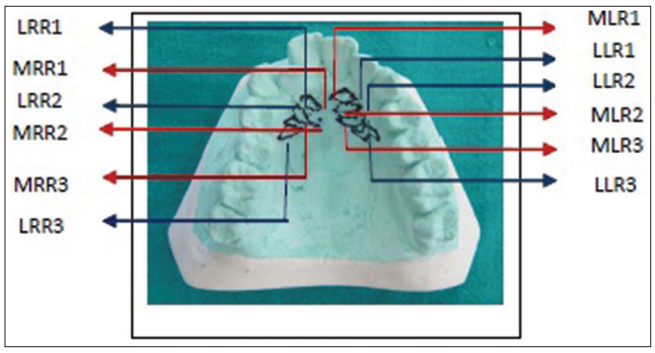

Figure 5: Points for measuring transverse changes in pre and post expansion casts: Points are indicated as 4 digit word (Eg. MLR1)where stands first digit stands for point to be measured(medial or lateral), second digit stands for side (left or right), third digit stands for ruga and last digit stands for number of ruga. Intermedial distance: Medial rugae points on first,second and third rugae from left to the right side[MRR1-MLR1, MRR2-MLR2, MRR3-MLR3] Interlateral distance: Lateral rugae points on first,second and third rugae from left to right side[LRR1-LLR1, LRR2-LLR2, LRR3-LLR3]

The results of our study recorded an increase in transverse dimensions both in intermedial and interlateral distances of all first, second and third primary rugae, with least changes shown by intermedial distance of first primary rugae. This finding is in corroboration with a study by Almeida *et al*.,[19] in 1995 where the stability of rugae during growth in early class II patients and the effect of headgear or functional appliances treatment on position of rugae was studied in a sample of 94 patients. The results revealed no significant change in transverse offsets and linear distances between medial points of the first rugae with respect to median palatal reference plane. Our study also supports this finding where the intermedial distance did not show any significant change in the context of first palatal rugae. Further, none of the groups showed any significant change in the anteroposterior distances between the medial points of the second and third rugae whereas the lateral offsets recorded significant changes in all the groups, thus concluding the medial rugae to be stable reference points.[19] In our present study also, significant changes have been recorded in the order of third palatal rugae to be highest followed by second and least in first but the values are of greater magnitude in lateral points than medial points. However, in the study by Almeida *et al*,[19] application of orthopedic forces in the headgear group illustrated an increase between the medial ruga points in addition to recording highest magnitude of changes in lateral rugae points. Hence, proving that despite the stability of medial rugae points, the orthopedic force levels support greater changes in transverse offsets in medial as well as lateral rugae points when compared all the other groups. This establishes an interesting correlation with our study where orthopedic forces brought about changes in intermedial as well as interlateral distance between rugae points.

The stability of lateral rugae points has been questioned in our study due to transverse changes in the order of third greater than second and least in first that are believed to be cumulative of growth as well as orthodontic forces. Lateral rugae changes have been reported in normally growing children[10] and also in patients undergoing orthodontic treatment with extraction of first premolars. Despite the lateral rugae changes corresponding to retraction of maxillary anterior teeth in the extraction space do not directly correlate to our study where expansion forces have been employed. However our findings are in accordance with the observations by Peavy and Kendrick and other investigators who have worked on extraction patients.[11,14,20,21] They believed that the closer the rugae are to the teeth, the more prone they are to stretch in the direction that their associated teeth move." Moreover in cases of mid palatal expansion, there is an associated buccal tipping of posterior teeth[18] hence stretching the lateral rugae points in outward direction, thus increasing the interlateral distance.

The position of lateral rugae points have also been affected in studies by van der Linden[10] and Almeida *et al*.,[19] who also observed that none of the medial points of the first rugae were affected for the transverse values. However in our study, only the first medial rugae were minimally

Table 1: Descriptive statistics of pre-expansion and post-expansion values of inter-medial and inter-lateral distances of first, second and third rugae

Rugae	Distance	*N*	Pre-expansion				Post-expansion				*P value*
			Mean	Standard deviation	Minimum	Maximum	Mean	Standard deviation	Minimum	Maximum	
1st	IM	14	3.86	0.864	3	5	4.00	0.877	3	5	$P>0.05$
2nd	IM	14	7.14	1.351	4	9	7.71	1.541	5	10	$P=0.002$
3rd	IM	14	17.93	2.303	14	21	18.86	2.070	15	22	$P=0.005$
1st	IL	14	5.64	1.447	3	8	6.36	1.646	4	9	$P=0.015$
2nd	IL	14	14.50	2.624	11	19	15.21	2.914	12	19	$P=0.006$
3rd	IL	14	20.79	2.607	14	23	22.21	2.723	15	24	$P=0.001$

affected and the remaining second and third rugae recorded significant changes with greater values for the third one, apart from an increase in interlateral distance in all the three primary rugae. This could be accounted for an expansion in the palate that is more dental than skeletal believed to occur in a fan shaped manner at the mid palatal suture.[16] Besides an increase in arch circumference may also contribute to an increase in interlateral as well as intermedial distance. This finding is partly in accordance with a study by Hausser,[22,23] who concluded that a decrease in arch circumference, affecting the anterior part of the palate brings about no significant changes in transverse values for the medial and lateral points of the second and third rugae. Another recent study by Shukla *et al*.,[15] compared pre- and post-treatment casts of extraction and non-extraction orthodontic casts and recorded instability in lateral rugae points with significant observable difference regarding lateral points of first left rugae and lateral points of second left rugae, thus corroborating with our present study. Another study by Bailey *et al*.[21] notices transverse changes more in medial rugae points in non-extraction group for first rugae and the lateral rugae points for first rugae in extraction group. Thus indicating that variation in treatment mechanics employed in orthodontics had a significant contribution toward the transverse changes recorded in orthodontic patients.

The magnitude of changes recorded in our study have showed significance even in a small sample size. Our sample comprised of adolescent patients that are believed to show greater magnitude of changes ascompared to adults, as supported by a 4 year longitudinal study on 10 adults and 13 adolescents was done by Christou and Kiliaridis[24] to measure vertical changes in rugae positions with respect to the palatal plane.

This pilot study has been able to depict transverse changes in mid palatal expansion at a small sample size and questions the stability aspect of palatal rugae to be considered as reference landmarks for forensic identification in these patients. However we recommend this study to be done on a larger sample size and in a sample of preadolescent population where skeletal component in expansion is greater to be followed longitudinally for another 6 months till the retention phase of expansion is over and recorded until the potential growth period is over. Although we have just investigated the stability aspect of palatal rugae with respect to the transverse dimension in patients undergoing mid palatal expansion, to be considered for forensic application, the vertical and anteroposterior changes also need to be considered in further studies and should be extended to different treatment mechanics in orthodontics. Our primary aim of establishing palatal rugae as primary identification source rather than an adjunct in forensics based on the availability of ante mortem data can only be ascertained, once stability of rugae in all the dimensions is studied. With the ongoing trend of mass disasters, bombings and killings, corpses with negligible identifiable remnants are on the rise and palatal rugae needs to further for stability, uniqueness and post-mortem resistance.

Conclusion

The quest for stability of medial and lateral rugae points following mid palatal expansion to be used as stable reference landmarks for forensic identification has led to the conclusion that only 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.

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