

Various Methods for Assessing Palatal Rugae Pattern

Venkata Naidu^{1*} Salman² Sameer Ahmed³ Sanagamesh B⁴

¹Senior Lecturer, Department of Orthodontics, Ame Dental College, Raichur, Karnataka, India.

²PG Student, Department of Orthodontics, Ame Dental College, Raichur, Karnataka, India.

³Reader, Department of Orthodontics, Ame Dental College, Raichur, Karnataka, India.

⁴Professor and Head, Department of Orthodontics, Ame Dental College, Raichur, Karnataka, India.

ABSTRACT

Background: Palatal rugae are ridges or striations in the anterior part of hard palate behind the incisive papilla. They are formed during third month of intrauterine life and these ridges are distributed on both sides of the median palatal raphe. At birth, the palatal rugae are complete, with the typical shape, length, width, prominence, position, and orientation creating a unique pattern for each person. Palatal rugae are utilized as reference points to measure teeth migration during orthodontic therapy. These rugae are important parameters in the assessment of stability during and after orthodontic treatment. Palatal rugae provides us a reference plane necessary for model analysis and in mini implant placement procedures.

Keywords: Palatal rugae, Stability, Palatal rugae morphology.

INTRODUCTION

Palatal rugae are formed during third month of intrauterine life and undergo few morphological changes in their anatomical pattern, in length as a result of normal palatal growth.¹ Transverse palatine folds or palatal rugae are asymmetrical and irregular elevations of the mucosa in the anterior third of the palate, arranged in a transverse direction from the palatine raphe located in the mid-sagittal plane. At birth, the palatal rugae are complete, with the typical shape, length, width, prominence, position, and orientation creating a unique pattern for each person. Its development and growth are mutually controlled by epithelial mesenchymal interactions, where specific extra extracellular matrix molecules are spatiotemporally expressed during development.² These ridges are distributed on both sides of the median palatal raphe.

MATERIALS & METHODS

A detailed search in the data base of PubMed, Cochrane Library and Medline was done. The search terms included were palatal rugae/ rugae/

reliable/stable/analysis in various combinations. The data was scrutinized and structured chronologically and hierarchy of methods of analysing rugae has been described.

DISCUSSION

Anatomy of palatal Rugae

Palatal rugae are also referred as 'plicae palatinae'.³ The first rugae are distinguished in human embryos of 32mm Crown rump length(CRL) next to the incisive papilla and in pre natal stage they are relative prominent. Physiologically, the palatal rugae are involved in swallowing and help to improve the relationship between food and taste receptors in the dorsal surface of the tongue. Form, layout and characteristics are not affected by the eruption of teeth or their losses. ⁴ Palatal rugae forms elevations more or less prominent and take various configurations. Its design and structure are unchanged and are not altered by chemicals, heat, disease or trauma. Even if palatal rugae are destroyed, they are reproduced on same site (Almedia et al 1995). ⁵ As early as 1955, Lysell suggested that the palatine rugae might possess

Received: Dec. 6, 2018; Accepted: Jan. 28, 2019

*Correspondence Dr. Venkata Naidu.

Department of Orthodontics, Ame Dental College, Raichur, Karnataka, India.

Email: ameortho2003@gmail.com

unique characteristics that could be used in paternity identification. The number of rugae on each side of the palate varies between three to five per side. The palatine rugae does not extend beyond the anterior half of the hard palate, and they never crosses the midline

Various Patterns of Palatal Rugae:

DA silva ²⁵ classification for rugae pattern **Table 1**

Table 1; Showing different types of rugae pattern.

Types	Rugae types	
Type 1	Line	/
Type 2	Curve	~
Type 3	Angle	1
Type 4	Circle	o
Type 5	Wavy	~
Type 6	Point	.

Various anatomic landmarks used to assess the palatal rugae. (**Fig 1**)

a)Antero-posterior measurement of rugae

The antero-posterior distance between 1st and 2nd , 2nd and 3rd palatal rugae are measured of both right and left side.

b) Median palatal raphe to number of rugae

The number of rugae present either side of the midplane are measured.

c) Transverse width of the rugae

The bilateral transverse width of the rugae is measured for each palatal rugae's.

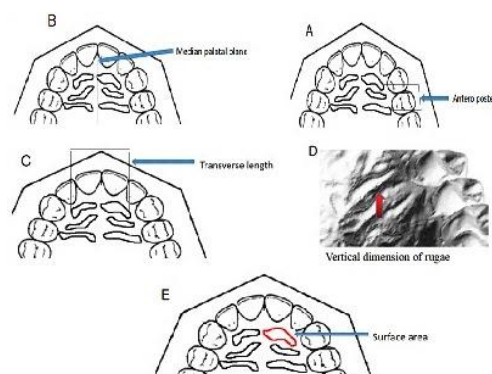
d) Vertical dimension of the rugae

The vertical dimension of each palatal rugae is measured of both right and left side of the median palatal plane.

e) Area of the rugae

The surface area of each palatal rugae is measured of both right and left side of the median palatal plane

Fig 1: Various anatomic landmarks used to assess the palatal rugae



Analysis of Palatal Rugae

There are various methods used for assessing palatal rugae pattern. Based on pattern a) Antero-posterior measurement of rugae, b) Median palatal raphe to number of rugae, c) Transverse width of the rugae, d) Vertical dimension of the rugae and f) Area of the rugae. These parameters can be assessed by both manually and digitally by various methods.

Photographic assessment

Intra oral photographs were taken with dslr digital camera. The custom made external attachment was attached to camera to standardize all photographs. softwares like (PRCS-Palatal rugae comparison software) can be used for analyzing rugae pattern.

Other photographic methods like dental casts were numbered and then photographed using a standard digital camera. Photographs were taken ensuring that the camera was perpendicular to the dental casts and that the distance between the camera and the dental casts was always the same; furthermore, two rulers were placed on each side of the casts, to check for possible distortions The first, second and third rugae in both sides of the palate were analysed and measurements are done.

Tracing of palatal rugae and assessment in AUTOCAD and Image analyzer softwares.

The rugae patterns on the models are traced with 0.3mm lead pencil with matte acetate sheets and overlapped with graph sheets, scanned in flatbed scanner and measured in autocad or image analyzer softwares.

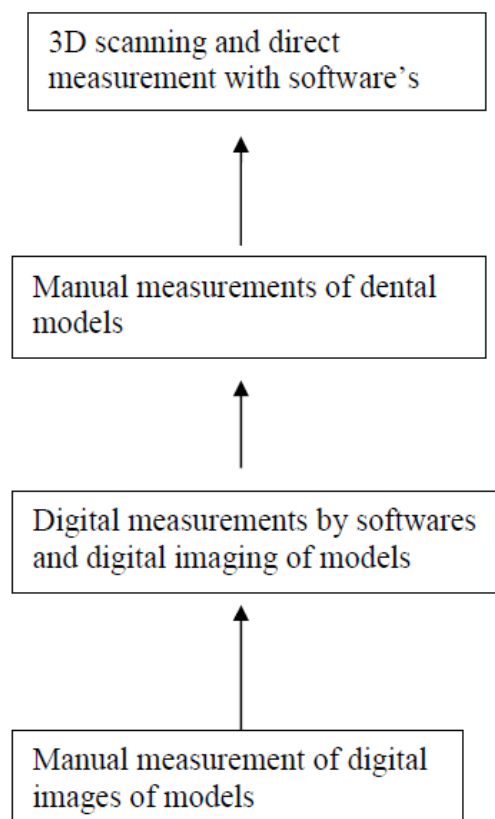
3D scanning of the palatal rugae

Various 3D scanning methods like OrthoCAD™, Ortho Insight 3D™, iTero® scans, is used for scanning of models and measuring the palatal rugae.

Superimpositions of dental models on digital imaging

The lateral cephalograms of each subject were scanned in a flatbed scanner. Maxillary casts of each subject were scanned with a 3-dimensional laser scanner. Directly on the dental casts the first, second, and third right rugae from the incisal edge of the maxillary right central incisor were measured with a pair of compasses and transferred to the contour of the median palatal plane of the digital casts, and then we superimposed this contour with the marked rugae on the palatal contour of the scanned lateral cephalogram.

Hierachy of Methods for Palatal Rugae Analysis



Significance of Palatal Rugae

Palatal rugae are utilized as reference points to measure teeth migration during orthodontic therapy⁶. These rugae are important parameters in the assessment of stability during and after orthodontic treatment.⁷ Palatal rugae provide us a reference plane necessary for model analysis and in mini implant placement procedures.⁸ Summary of studies present till now were scrutinized and arranged chronologically in **Table 2**.

Table 2: Summary of studies showing significance of Palatal rugae.

Author	Study	Conclusion
Marco Antonio Almedia et.al.,1995 ⁵	Stability of rugae patterns in normal and patients treated with headgear or functional appliances	The third medial rugae appeared to be suitable anatomic points for the construction of stable reference planes for longitudinal cast analysis.
L'Tanya J. Bailey et.al.,1996 ⁷	Stability of palatal rugae in extraction and non-extraction cases of orthodontic treated patients	Transverse width of the third rugae appear to be stable landmarks for the construction of anatomic reference points in longitudinal cast analysis.
Brent R. Hoggan et.al., 2001 ⁹	Assessed palatal rugae during antero-posterior tooth movements by cephalometric	Rugae landmarks can be used reliably as cephalometric superimpositions to assess antero-posterior molar movements.

	superimpositions	
Abdel-Aziz HM, et.al.,2001 ¹⁰	Stability of the palatal rugae before and after orthodontic treatment in adult egyptian patients	The lateral third rugae points can be used as reference points for cast superimposition.
Janalt Damstra et.al.,2009 ¹²	The antero-posterior transverse changes in the positions of the palatal rugae after rapid maxillary expansion	The medial aspect of the third rugae cannot be considered as stable reference landmark when RME is performed.
D. Shukla et.al.,2011 ²	The stability of palatal rugae before and after orthodontic treatment	Third palatal rugae were the most immutable overs the persons life and hence could be used as a reference to evaluate the changes in teeth positions during orthodontic treatment.
Jan Hourfar et.al., 2014 ⁸	The stability of the most distal (third) palatal rugae and bone availability, for safe insertion of orthodontic mini-implants (OMIs) in the anterior palate.	The position of the third palatal rugae remained stable during orthodontic treatment and bone availability also remained adequate.
V Deepak et.al·2014 ¹⁶	Palatal rugae pattern in orthodontic treated cases	Orthodontic treatment has impact on the stability of palatal rugae so investigator should be aware of that fact when analyzing for identification reasons
Susana Braga et.al., 2015 ¹	The palatal rugae patterns pre and post orthodontic treatment.	That the first right rugae had significant differences in size before and after the treatment suggesting that, in females, palatal rugae morphology is a better marker that palatal rugae length.
Priyanka Kapoor and Ragini Miglani ¹⁷	Stability of palatal rugae in transverse dimension in adolescent patients with mid-palatal expansion	That there study does not support stability of medial and lateral rugae points of 2nd and 3rd primary rugae for forensic identification in individuals treated with mid palatal expansion.
Ayman G. Mustafa et.al·2015 ¹⁸	Morphometric changes that occur in palatal rugae during orthodontic treatment	Orthodontic treatment induces various morphometric changes in the palatal rugae patterns.
Alka Banker et.al·2016 ¹⁹	The quantitative and transverse changes in the position of palatal rugae after palatal expansion	There is stability of the palatal rugae with its respect to its number but not with respect to its position.
Xiu-Ping W et.al., 2017 ³	The accuracy of a digital image system in matching palatal rugae before and after orthodontic treatment	The palatal rugae are morphologically diverse, but these changes do not greatly influence the individual identification.
Jonathan Sandler et.al., 2017 ⁶	To test the precision of the 3D scanner and to compare it with measurements from cephalometric	The medial end of the third rugae and the palatal vault was the most stable points from which tooth movement can be

	radiographs	measured
Maria Saadeh et.al., 2017 ²⁰	The instability of palatal rugae following rapid maxillary expansion.	Palatal rugae were altered by RME in all dimensions in both linear and angular measurements, almost equally on right and left sides and average linear changes were about 1 mm.
Jagadish Hosmani ²¹	Comparision of palatal rugae pattern Indian and Tibetan population	They found difference among two population in palatal rugae pattern
Mahnaz Sheikhj ²²	Assessment of palatal rugae pattern for sex and ethnicity identification in an iranain population	Palatal rugoscopy was not a reliable method to classify the sex of an individual and to differentiate between different racial subsets
Sonya M.S. Azab ²³	Patterns of palatal rugae in the adult Egyptian Population	There study showed a specific rugae pattern in adult Egyptian population when compared to the patterns in other populations.
Surekha R, Koneru Anila ²⁴	Assessment of palatal rugae patterns in Manipuri and Kerala population,	They found statistically significant association between the shape of the rugae and population.

CONCLUSION

The first and second rugae are not stable or reliable. The transverse dimensions of the third palatal rugae are stable and reliable landmarks in extractions cases but medial points of third rugae are not stable in rapid maxillary expansion cases. There is significant difference in rugae pattern among various populations. Also the treatment rendered alters the rugae pattern hence there is need for further area and volumetric assessment/evaluation of the palatal rugae pattern.

CONFLICT OF INTEREST

No potential academic conflict of interest relevant to the above article was reported.

REFERENCES

1. Susana Braga & Inês Morais Caldas, Study of palatal rugae pattern following orthodontic treatment. Australian Journal of Forensic Sciences. 2015, 305-311
2. D. shukla, A. Chowdhry, Bablani, P. Jain, R. Thapar. Establishing the reliability of palatal rugae pattern in individual identification (following orthodontic treatment). J Forensic Odontostomatol. 2011 Jul 1; 29(1): 20-9
3. Xiu-Ping, W.; Jian-Ning, H.; Pan, F.; Yu-Jin, W. & LI, B. Analysis of palatal rugae morphology before and after orthodontic treatment by a digital image recognition system. Int. J. Morphol., 35(2): 420-424, 2017.
4. Shivaraj A. Sinificance of palatal ruage in orthodontics. J Orofac Res 2013; 3(3): 202-209
5. Almeida MA, Phillips C, Kula K, Tulloch C. Stability of the palatal rugae as landmarks for analysis of dental cast. Angle Orthod. 1995; 65(1): 43-8.
6. Sandler J., Thiruvengkatachari B, Gutierrez R. Measuring molar movement: A reliable technique. APOS Trends Orthod 2017; 7: 63-8.
7. L'Tanya J. Bailey, DDS, MS; Abbas Esmailnejad, DDS; Macro Antonio Almeida, DDS, MSD. Stability of the palatal rugae as landmarks for analysis of

- dental casts in extraction and non extraction cases. *Angle Orthod* 1996;66(1);73-78
8. Jan Hourfar, Björn Ludwig, Dirk Bister, Anna Braunand Georgios Kanavakis, The most distal palatal ruga for placement of orthodontic mini-implants. *Eur J Orthod*. 2015 Aug;37(4):373-8
 9. Brent R. Hoggan, DDS, MS, and Cyril Sadowsky, BDS ,MS. The use of palatal rugae for the assessment of anterior tooth movements. *Am J Orthod Dentofacial Orthop* 2001;119:482-8.
 10. Abdel-Aziz HM, Sabet NE. Palatal rugae area: a landmark for analysis of pre-and post-orthodontically treated adult Egyptian patients. *East Mediterr Health J*. 2001 Jan-Mar
 11. Panagiotis christou, Stavros Kiliaridis. Vertical growth related changes in position of palatal rugae and maxillary incisors. *Am j Ortho Dentofacial orthod*.2007.07.009
 12. Janalt Damstra, Dharmesh Mistry, Claudia Cruz and YijinRen. Anterio-posterior and transverse changes in the positions of palatal rugae after rapid maxillary expansion. *Eur J Orthod*. 2009 Jun;31(3):327-32
 13. Insan Janga; Motohiro Tanakab; Yoshiyuki Kogac; Seiko Iijimab; Joseph H. Yozgatiand; Bong Kuen Chae; Noriaki Yoshidaf. A Novel Method for the Assessment of Three-Dimensional Tooth Movement during Orthodontic Treatment. *Angle Orthod*. 2009 May;79(3):447-53
 14. M Hemanth, M vidya, Nandaprasad shetty and Bhavana V Karkera. Identification of individuals using palatal rugae: computerised method. *J Forensic Dent Sci*. 2010 Jul-Dec;2(2): 86-90.
 15. Gandikota C, Venkata YP, Challa P, Juvvadi SR, Mathur A. Comparative study of palatal rugae pattern in class II div 1 and class1 individuals. *J pharm Bioall Sci* 2012;4:358-63
 16. V Deepak, Nikhil I Malgaonkar, Nishit Kumar Shah, Azzeghaiby Saleh Nasser, Kapil Dagrus, Tarakji Bassle. Palatal Rugae Patterns in Orthodontically Treated Cases, Are They a Reliable Forensic Marker? *J Int Oral Health*. 2014 Sep-Oct;6(5): 89-95.
 17. Priyanka Kapoor and Ragini Miglani. Transverse changes in lateral and medial aspects of palatal rugae after mid palatal expansion: A pilot study. *J Forensic Dent Sci*. 2015 Jan-Apr; 7(1): 8-13.
 18. Ayman G. Mustafa, Mohammed Z. Allouh , Rawan M, Alshehab. Morphological changes in palatal rugae patterns following orthodontic treatment. *J Forensic Leg Med*. 2015.
 19. Banker A, Patel KD, Trivedi I, Patel R, Pillai Jp Quantitative and Transverse Changes in the position of Palatal Rugae after Palatal Expansion. *Dentistry* 2016, 6:387.
 20. Maria Saadeh, Anthony Macari, Ramzi Haddad, Joseph Ghafari, Instability of palatal rugae following rapid maxillary expansion. *Eur J Orthod*. 2017 Oct 1;39(5):474-481
 21. Hosmani J, Gadekar NB, Kotrashetti VS, Nayak R, Babji D, Mishra S. Comparison of palatal rugae pattern among Indian and Tibetan population. *J Forensic Dent Sci* 2018;10:40-4.
 22. Sheikhi M, Zandi M, Ghazizadeh M. Assessment of palatal rugae pattern for sex and ethnicity identification in an Iranian population. *Dent Res J* 2018;15:50-6.
 23. Azab, Sonya & Magdy, Reham & A. Sharaf El Deen, Mohamed. (2015). Patterns of palatal rugae among adult Egyptian population. *Egyptian Journal of Forensic Sciences*. 5. 10.1016/j.ejfs.2015.01.006.
 24. Surekha R, Anila K, Reddy VS, Hunasgi S, Ravikumar S, Ramesh N. Assessment of palatal rugae patterns in Manipuri and Kerala population. *J Forensic Dent Sci* 2012;4:93-6.
 25. Prahalad Hunsigi, text book of Forensic odontology (First edition 2016).