Research Article

JRAD Journal of Research and Advancement in Dentistry

J Res Adv Dent 2021;11:3:271-276.

Differentiation of Radiographic to Histomorphometric Analysis of Mid Palatal Suture Width In Caprines: A Pilot Study

Satyabrata Patnaik[1*] Swati Saraswata Acharya[2] Abhik Sinha[3] Swagatika Panda[4] Neeta Mohanty[5] Sibashis Biswas[6]

[1]Associate Professor, Department of Oral & Maxillofacial Surgery, Institute of Dental Sciences, SOA University, Bhubaneshwar, Odessa, India.
[2]Associate Professor, Department of Orthodontics, Institute of Dental Sciences, SOA University, Bhubaneshwar, Odessa, India.
[3]PG Student, Department of Orthodontics, Institute of Dental Sciences, SOA University, Bhubaneshwar, Odessa, India.
[4]MDS, Department of Oral Pathology, Institute of Dental Sciences, SOA University, Bhubaneshwar, Odessa, India.
[5]Dean, Professor and Head, Department of Oral Pathology, Institute of Dental Sciences, SOA University, Bhubaneshwar, Odessa, India.
[6]PG Student, Department of Oral & Maxillofacial Surgery, Institute of Dental Sciences, SOA University, Bhubaneshwar, Odessa, India.

ABSTRACT

Background: To conduct a pilot study and determine the potentiality of midpalatal sutural width radiographically with computed tomography in a caprine model.

Materials and Methods: Samples from the midpalatal suture of five young (16 weeks) and five old (200 weeks) *capra aegagrus hircus* were collected. The midpalatal suture width was measured radiologically and compared to respective histological preparations. Results with P < .05 were considered significant.

Results: The data obtained by radiographs and histomorphometric analysis reveal a highly significant age dependency of the measured suture width (both P <.0001), with lower suture width values in older caprine subjects compared to the younger group. The average suture widths measured in the images show a distinctively higher mean compared to the histomorphometric data with high statistical significance. The evaluated difference between both methods was almost constant.

Conclusion: Computed Tomography is a powerful tool for determining midpalatal sutural width.

Keywords: Caprine; Computed Tomography; Histomorphometric analysis; Midpalatal suture.

INTRODUCTION

Angell EC first illustrated the concept of midpalatal suture width in 1860s.[1] Rapid Maxillary Expansion (RME) has been a proven method for reducing transverse discrepancy between dental arches due to maxillary constriction.[2,3] Widening of the maxillary arch by RME corrects posterior crossbite, along with a gain in arch-perimeter in individuals with tooth/arch size discrepancies.[4-7] However, problems such as root resorption, lateral tipping, fenestration of the buccal cortex and an inability in opening the midpalatal suture may arise in those patients who are skeletally mature.[8-9] An age/function related decrease in the midpalatal suture width leads to an increased resistance against traditional rapid maxillary expansion.[10-12] Surgically assisted rapid maxillary expansion (SARME) on the other hand, is indicated in skeletally mature patients with a constricted maxillary arch. The procedure is associated with inconvenience and potential risks for the patient.[14-17] Thus, determining the extent of the maxillary expansion that requires a surgical procedure is of utmost importance.[18-20]

Received: Jan. 17, 2021: **Accepted**: Mar. 10, 2021
*Correspondence **Dr. Swati Saraswata Acharya.**
Department of Orthodontics, Institute of Dental Sciences, SOA University, Bhubaneshwar, Odessa, India.
Email: swati.acharya.tmdc@gmail.com

pISSN 2278-0076
eISSN 2321-9270

Wehrbein and Yildizhan reported that occlusal radiographs, due to their two-dimensional nature and overlapping with structures of the cranial base are not reliable in determining the suture structure.[13] Three-dimensional imaging such as Computed Tomography (CT), although limited in their use because of cost, has improved the diagnostic imaging abilities. The aim of the present pilot study was to analyze the midpalatalsutural width using Computed Tomography and compare them with their respective histological preparations in a caprine model. The ethical clearance for this study was granted by the Animal ethical committee of our university.

MATERIALS AND METHODS

Five young (16 weeks) and five old (200 weeks) *Capra aegagrushircus*were sacrificed, their maxillae were separated and the palatine mucosa was removed. After marking the necessary outlines, six cylindrical samples of bone with a diameter of 1 cm were obtained along the mid palatal suture line for each of the caprine maxillae. They were then fixed in a 4% buffered formaldehyde solution at room temperature. **(Figure 1,2,3)**The midpalatal suture width was then measured using CT scan for each of the sample and their findings were compared with their respective histological preparations. All the tomographic imaging were performed with the GE optima CT scanner, with a dimension of 20.5 X 20.5 cm and with 1024 X 1024 pixels. In order to obtain the histological samples, the specimen were placed in a KOH solution and decalcified. The thickness of the specimen were then reduced to 3 µm each and stained with H & E stains. The data sets were then run on a software, displaying them as facial slices perpendicular to the surface of the suture and palatal bone. With the point indicating cursor on the software, the points where the distance between the mid palatal sutures would be taken are marked. The distances were finally measured using the distance measurement tool of the software itself. The measurements for the histological preparation was done microscopically and comparisons were made for each sample between the two methods.

Statistical analysis

The obtained data were analyzed using SPSS software. The factors such as young and old age, and radiographic and histologic method were considered and Analysis of Variance was performed. Results with levels of $P < 0.05$ were considered significant.

RESULTS

The differences were mainly observed between the younger and the older samples in terms of suture anatomy – with a smaller suture width in the old age samples. The average suture widths measured using radiological means revealed a higher mean compared to the histological data. **(Figures 4-9)** However, the evaluated differences between the values using the two methods were found to be almost similar. The data we have obtained from the two methods have been tabulated in **table 1**.

Table 1: Comparison of Suture Width in Younger and Older age groups determined by computed tomography and histomohometry.

		Minimum,	Maximum,	
Method	Age	mm	mm	Mean
CT	Young	0.11	0.50	0.22
	Old	0.09	0.27	0.13
Histomorphometry	Young	0.08	0.61	0.16
	Old	0.01	0.27	0.10

DISCUSSION

The chronologic age cannot reliably determine the developmental status of midpalatal suture growth. Thus, establishing suitable candidates for RME without a surgical assistance becomes difficult. SARME, on the other hand, becomes necessary in adult patients. Confusion especially occurs in the borderline age group between 19 – 20 years. The Hand-wrist radiographs are not suitable for estimating the fusion of the midpalatal suture.[27,28] Hence, developing a method to individually assess the midpalatal suture became essential. The midpalatal suture matures from posterior to anterior of the oral cavity. Nguyen based on his experiments on 20 patients over 70 years of age reported that the midpalatal suture might be the only suture in the body to remain unfused even in the aged group.[11]His studies also could not find any gender differences and the closure of the midpalatal suture. Katsaroset al[7] stated that a decreased masticatory function caused by a soft diet results in

a reduced bone apposition in the sutures of similar animals.

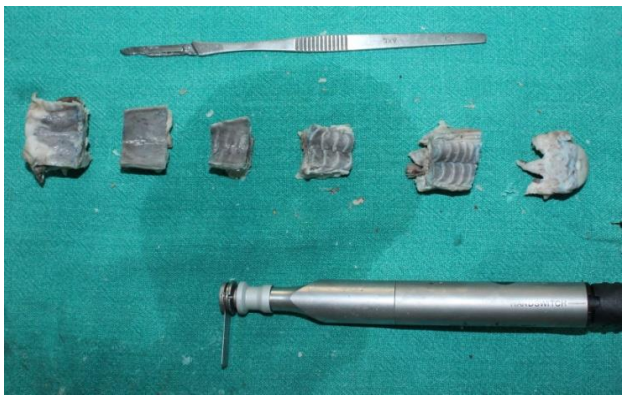
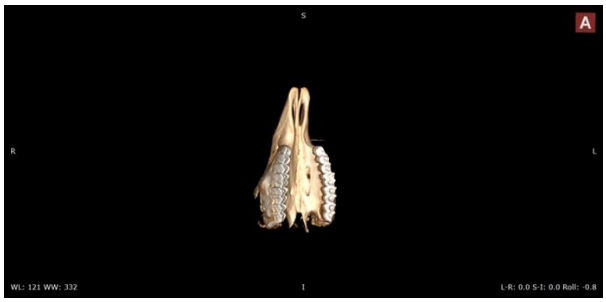
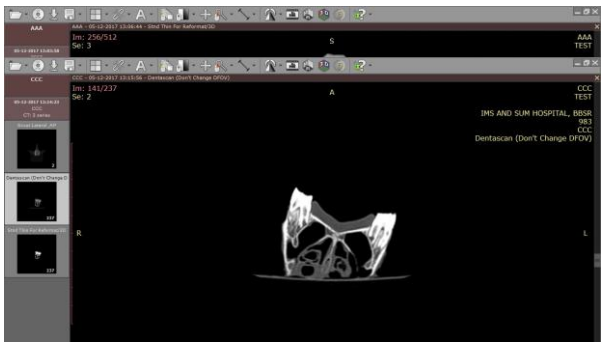


Fig 1 – 3: six cylindrical samples of bone with a diameter of 1 cm were obtained along the mid palatal suture line for each of the caprine maxillae.

Going by the sutural anatomy, humans and caprines show comparable features[37] to the point, that the data acquired from caprines in our study can be applicable for humans as well. Knaupet al[8] reported that the mean values in suture widths between younger and older caprines vary significantly. This finding correlates with the observations made in our study.





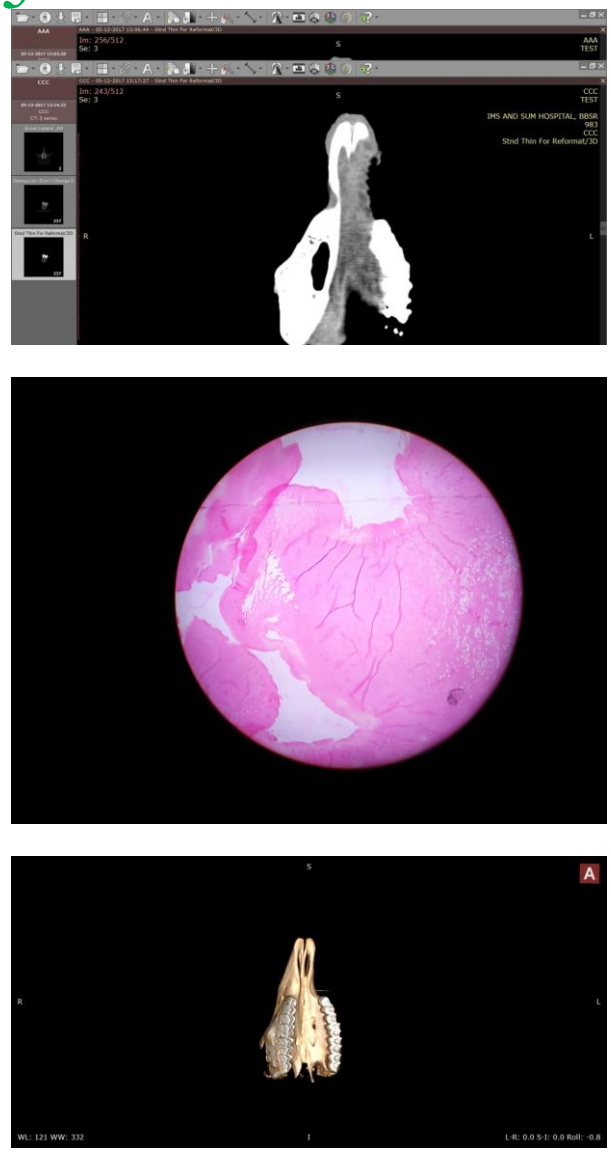


Fig 4 -9: The differences were mainly observed between the younger and the older samples in terms of suture anatomy – with a smaller suture width in the old age samples. The average suture widths measured using radiological means revealed a higher mean compared to the histological data.

In our study, the average suture widths measured using radiological means revealed a higher mean compared to the histological data. This may have occurred because the CT could not correctly depict the decreased calcification of the bony sutural borderline adjacent adjacent to the sutural lamina. The incompletely calcified regions cannot be clearly identified with CT because of a lower tissue density[44]. Another factor to be considered might be the fact that the virtual sections generated from a CT are thicker than the ones used for histological analysis. The evaluated differences between the values from both the methods were found to be almost constant. Based on the results from our pilot study, we believe that CT imaging can be used to accurately determine the degree of ossification of the midpalatal suture and hence opt for the necessary treatment while choosing between RME and SARME.

CONCLUSION

SARME is a widely established procedure in the correction of Transverse discrepancies of the maxilla in skeletally mature patients. However, the equilibrium between surgical method versus a conservative procedure with minimal complications is still inconclusive. Advances in imaging techniques have helped in this regard. Based on the findings of our pilot study, the suture width in younger and older caprinemidpalatal sutures can be reliably determined using CT. Further studies can be done with a larger sample size to consolidate the findings of our study, its degree of accuracy and the factors that could influence the results. This would, finally, assist in achieving a greater precision and help improvise the orthodontic treatment protocols.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

REFERENCES

1. Angell EC. Treatment of irregularities of permanent or adult teeth. Dental Cosmos. 1860;1:540–544.

2. DJ, Moss JP. An histological investigation into effects of rapid maxillary expansion on the teeth and their supporting tissues. Trans EurOrthod Soc. 1971:263–271.

3. Haas AJ. Rapid expansion of maxillary dental arch and nasal cavity by opening midpalatal suture. Angle Orthod. 1961;31:73–90.

4. Wertz RA. Skeletal and dental changes accompanying the rapidmidpalatal suture opening. Am J Orthod. 1970;58:41–66.

5. Mann RW, Jantz RL, Bass WM, Willey PS. Maxillary suture obliteration: a visual method for estimating the skeletal age. J Forensic Sci. 1991;36:781–791.

6. Lanigan DT, Mintz SM. Complications of surgically assisted rapid palatal expansion: review of literature and report ofa case. J Oral Maxillofac Surg. 2002;60:104–110.

7. Katsaros C, Zissis A, Bresin A, Kiliaridis S. Functional influence on sutural bone apposition in growing rat. Am J OrthodDentofacialOrthop. 2006;129:352–357.

8.Knaup B, Yildizhan F, Wehrbein H. Age-related changes in midpalatal suture. A histomorphometric study. J OrofacOrthop. 2004;65:467–474.

9.McNamara JA Jr. Maxillary transverse deficiency. Am J OrthodDentofacialOrthop. 2000;117:567–570.

10. Suri L, Taneja P. Surgically assisted rapid palatal expansion: literature review. Am J OrthodDentofacialOrthop. 2008;133:290–302.

11. Chrcanovic BR, Custodio AL. Orthodontic or surgically assisted rapid maxillary expansion. Oral Maxillofac Surg.2009;13:123–137.

12. Melsen B. Palatal growth studied on human autopsy material. A histologic micro radiographic study. Am J Orthod.1975;68:42–54.

13. Holberg C, Steinhauser S, Rudzki-Janson I. Rapid maxillary expansion in adults: cranial stress reduction depending on the extent of surgery. Eur J Orthod. 2007;29:31–36.

14. Koudstaal MJ, Wolvius EB, Schulten AJ, Hop WC, van der Wal KG. Stability, tipping and relapse of bone-borne versus tooth-borne surgically assisted rapid maxillary expansion; a prospective randomized patient trial. Int J Oral MaxillofacSurg. 2009;38:308–315.

15. Schimming R, Feller KU, Herzmann K, Eckelt U. Surgical and orthodontic rapid palatal expansion in adults using Glassman's technique: retrospective study. Br J Oral MaxillofacSurg. 2000;38:66–69.

16. Hesse KL, A˚rtun J, Joondeph DR, Kennedy DB. Changes in the condylar position and occlusion associated with maxillary expansion for correction of functional unilateral posterior crossbite. Am J OrthodDentofacialOrthop. 1997;111:410– 418.

17. McNamara JA Jr, Brudon WL. Orthodontic and Orthopedic Treatment in Mixed Dentition. Ann Arbor, Mich: Needham Press; 1993:67–93.

18. Wertz RA. Skeletal and dental changes accompanying rapid maxillary suture opening. Am J Orthod. 1980;58:41–66.

19. Wehrbein H, Yildizhan F. The mid-palatal suture in young adults. A radiological-histological investigation. Eur J Orthod. 2001;23:105–114.

20. Fuhrmann A, Schulze D, Rother U, Vesper M. Digital transversal slice imaging in the dental-maxillofacial radiology: from pantomography to digital volume tomography.Int J Comput Dent. 2003;6:129–140.

21. Habersack K, Karoglan A, Sommer B, Benner KU. High resolution multislice computerized tomography with multiplanar and 3-dimensional reformation imaging in rapid palatal expansion. Am J OrthodDentofacialOrthop. 2007;131:776–781.

22. Cheung AC, Bredella MA, Al Khalaf M, Grasruck M, Leidecker C, Gupta R. Reproducibility of trabecular structure analysis using flat-panel volume computed tomography. Skeletal Radiol. 2009;38:1003–1008.

23. Hannig C, Dullin C, Hulsmann M, Heidrich G. Three-dimensional, non-destructive visualization of the vertical root fractures using flat panel volume detector computer tomography: an ex-vivo in vitro case report. IntEndod J. 2005;38:904–913.

24. Basciftci FA, Karaman AI. Effects of a modified acrylic bonded rapid maxillary expansion appliance and vertical chin cap on dentofacial structures. Angle Orthod. 2002;72:61–71.

25. Hahn W, Fricke-Zech S, Fialka-Fricke J, et al. Imaging of midpalatal suture in a porcine model: flat-panel volume computed tomography compared with multislice computed tomography. Oral Surg Oral Med Oral Pathol Oral RadiolEndod. 2009;108:443–449.

26. Smith LG, Karagianes MT. Histological preparation of bone to study in growth into implanted materials. CalcifTissueRes. 1974;14:333–337.

27. AltugAtac AT, Karasu HA, Aytac D. Surgically assisted rapid maxillary expansion compared with the orthopedic rapid maxillary expansion. Angle Orthod. 2006;76:353–359.

28. Krebs AA. Expansion of midpalatal suture, studied by means of metallic implants. ActaOdontol Scand. 1959;17: 491–501.

29. Zimring JF, Isaacson RJ. Forces produced by rapid maxillary expansion. III. Forces present during retention. Angle Orthod. 1965;35:178–186.

30. Berlocher WC, Mueller BH, Tinaoff N. The effect of maxillary palatal expansion on primary dental circumference. Pediatr Dent. 1980;2:27–30. 12. 31. Haas AJ. Long-term post-treatment evaluation of rapid palatal expansion. Angle Orthod. 1980;50:189–218.

32. Krebs A. Midpalatal suture expansion studies by implant method over a seven year period. Trans EuropOrthod Soc. 1964;40:131–142.

33. Haas AJ. The treatment of maxillary deficiency by opening midpalatal suture. Angle Orthod. 1965;35:200–217.

34. Koudstaal MJ, Poort LJ, van der Wal KG, Wolvius EB, Prahl-Andersen B, Schulten AJ. Surgically assisted rapid maxillary expansion (SARME): a review of the literature. Int J OralMaxillofac Surg. 2005;34:709–714.

35. CapelozzaFilho L, Cardoso Neto J, da Silva Filho OG, Ursi WJ. Non-surgically assisted rapid maxillary expansion in adults. Int J Adult OrthodOrthognath Surg. 1996;11:57–66, discussion 67–70.

36. McNamara JA Jr, Baccetti T, Franchi L, Herberger TA. Rapid maxillary expansion followed by fixed appliances: a longterm evaluation of changes in arch dimensions. Angle Orthod. 2003;73:344–353.

37. Spillane LM, McNamara JA Jr. Maxillary adaptation to expansion in mixed dentition. SeminOrthod. 1995;1:176– 187.

38. Handelman CS. Nonsurgical rapid maxillary alveolar expansion in adults: a clinical evaluation. Angle Orthod. 1997;67:291–305, discussion 306–308.

39. Stuart DA, Wiltshire WA. Rapid palatal expansion in young adult: time for a paradigm shift? J Can Dent Assoc.2003;69:374–377.

40. Korbmacher H, Huck L, Merkle T, Kahl-Nieke B. Clinical profile of rapid maxillary expansion—outcome of national inquiry. J OrofacOrthop. 2005;66:455–468.

41. Obenauer S, Dullin C, Alves F, Missbach-GuentnerJ,Grabbe E, Heuser M. Flat-panel-detector-based volumetric CT: performance evaluation of imaging for skeletal structures of animals in comparison to multislice CT. ClinImaging. 2007;31:18–22.

42. Herold JS. Maxillary expansion: a retrospective study of three methods of expansion and their long-term sequelae. Br J Orthod. 1989;16:195–200.

43. Linder-Aronson A, Lindgren J. The skeletal and dental effects of rapid maxillary expansion. Br J Orthod. 1979;6:25– 29.

44. Revelo B, Fishman LS. Maturational evaluation of ossification of midpalatal suture. Am J OrthodDentofacialOrthop. 1994;105:288–292.

45. Moussa R, O'Reilly MT, Close JM. Long-term stability of rapid palatal expander treatment and edgewise mechanotherapy. Am J OrthodDentofacialOrthop. 1995;108:478– 488.

46. Korbmacher H, Schilling A, Puschel K, Amling M, Kahl-Nieke B. Age-dependent three-dimensional microcomputed tomography analysis of human midpalatal suture. J OrofacOrthop. 2007;68:364–376.

47. Stockfish H. Rapid expansion of maxilla-success and relapse. Trans EurOrthod Soc. 1969;45:469–481.

48. Haas AJ. The treatment of maxillary deficiency by opening midpalatal suture. Angle Orthod. 1965;35:200–217.

49. Pirelli P, Botti F, Ragazzoni E, Arcuri C, Cocchia D. A light microscopic investigation of human midpalatal suture. Ital J AnatEmbryol. 1999;104:11–18.

50. Lima AL, Lima Filho RM, Bolognese AM. Long-term clinical outcome of rapid maxillary expansion

as only treatment performed in Class I malocclusion. Angle Orthod. 2005;75: 416–420.