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QUANTITATIVE ANALYSIS OF PALATAL BONE AT THE SUTURE AND THE SURROUNDING AREAS IN THE MAXILLA TO EVALUATE THE SUCCESS OF EXPANSION USING MARPE – A RETROSPECTIVE CBCT STUDY

Dr. Karthick Shetty[1], Dr. Sameer Narkhede[2], Dr Sushma Sonawane[3], Dr Shristi Nadar[4], Dr Nitin Gadhiya[5] & Dr Rakesh Singh[6]

[1] Professor, Department of Orthodontics, D Y Patil University, School of Dentistry, Nerul, Navi Mumbai – 400706.

[2] Professor and Head of Department of Orthodontics, D Y Patil University, School of Dentistry, Nerul, Navi Mumbai – 400706.

[3] Professor, Department of Orthodontics, D Y Patil University, School of Dentistry, Nerul, Navi Mumbai – 400706.

[4] PG student, Department of Orthodontics, D Y Patil University, School of Dentistry, Nerul, Navi Mumbai – 400706.

[5] Professor and Head of Department of Orthodontics, D Y Patil University, School of Dentistry, Nerul, Navi Mumbai – 400706.

[6] Professor and Head of Department of Orthodontics, D Y Patil University, School of Dentistry, Nerul, Navi Mumbai – 400706.

Corresponding author:

Dr Shristi Nadar, Department of Orthodontics and Dentofacial Orthopaedics, DYPU School of Dentistry, Navi Mumbai, Maharastra, India.

Abstract:

Objective: To compare the palatal bone density at the suture to determine any correlation present in the success or the failure of cases.

Method: The digital CBCT (Cone bean computed tomography) Scan of patients between the age group of 17-25 with permanent dentition is taken. Patients who had undergone mini screw assisted rapid palatal expansion were selected from the database of the Department of Orthodontics and Dentofacial Orthopaedics in D Y Patil University School of Dentistry, Navi Mumbai. This is a retrospective study depending on the previous records. CBCT's of the selected patients are checked for their bone density in grey scale units at the sutural level and classified into D1, D2, D3 and D4 to check if there is any correlation between the success and the failure of MARPE (mini screw assisted rapid palatal expansion) cases.

Result: The ROC (Receiver operating characteristic) curve shows that when the grey scale unit of the bone density is less than 610.5 there is a possibility of suture opening and more than that, there are chances for procedure failure. This is in respect to the area of the suture.

Conclusion: In miniscrew assisted rapid palatal expansion, there are various predictors to determine the success of the treatment however there is not sufficient proof to confirm a

diagnostic method as a pre requisite for the procedure. The parameter used in the study was the palatal bone density near the suture and the surrounding area. However this study has to be continued with a larger sample size with various age groups, as age also plays an important role in the suture separation as it is directly associated with the suture maturation stages.

Keywords: Maxilla, constriction, expansion, surgery, adult

INTRODUCTION

Maxillary expansion treatments have been used for more than a century to correct maxillary transverse deficiency. The earliest common cited report is that of E.C. Angell published in *Dental Cosmos* in 1860.[1] Rapid maxillary expansion, slow maxillary expansion and surgically assisted rapid maxillary expansion are the three treatments carried out. Patients age and malocclusion are important factos in choosing a treatment modality and also depends on the experience of the practitioner[2,3]. Normal palatal growth is nearly complete by age 6,[9] and increasing interdigitation of the suture makes separation difficult to achieve after puberty.[10-15] During treatment, transverse forces tip the buccal segments laterally[4] and with proper appliance design, 3rd-order moments will induce bodily translation.[5-8] If the force is strong enough, separation occurs at the maxillary suture. The clinical conditions indicating maxillary expansion include crossbites, distal molar movement, functional appliance treatment, surgical cases for instance arch coordination or bone grafts, to aid maxillary protraction and mild crowding.

The smile characteristics regarded as the most important ones are: The smile arc, dental alignment, tooth color and shape, incisal edge regularity, amount of incisor and gum display, and buccal corridor.16-18 The buccal corridor concept emerged during the 50's out of concern with ensuring natural looking dentures.19,20 This aspect of smile esthetics, also called lateral dark space, lateral negative space or "shadow tunnel," constitutes the existing dynamic space that appears, when a person smiles, between the labial surface of maxillary posterior teeth and the inner mucosa of the soft tissues that form the corners of the mouth and the cheeks.19,21,22,23 This space arises from the dark background of the mouth, and depends on the shape and width of the upper dental arch and the facial muscles responsible for the breadth of the smile.24 Although some information on the ideal buccal corridor size is available in the literature, most of it is based on clinical opinions, whereas the scientific studies that addressed this issue yielded controversial outcomes.23,25-28 Several studies showed that broad smiles with narrower buccal corridors are seen as more attractive. 26,27,29 On the other hand, other authors noted that buccal corridor width does not affect how the smile is judged from an esthetic viewpoint.21,23,25,28 Likewise, according to Isiksal et al,30 transverse characteristics seem to be of little significance in smile attractiveness. By the same token, some researchers argue that the lateral negative space influences smile esthetics only when it becomes excessively wide.28 A show of the lateral negative space is an indication for the maxillary arch expansion to attain a full smile.

Orthodontists meet two basic questions while considering rapid maxillary expansion treatment. The first one is the method of expansion (orthopedic or surgical), and the second is the type of expansion device that will be used. The other and perhaps the most important point is skeletal and dental response to the expansion.

CVM (Cervico vertebral maturation) STAGES:

In stage A, the midpalatal suture is almost a straight high-density sutural line with no or little interdigitation.[39]

In stage B, the midpalatal suture assumes an irregular shape and appears as a scalloped high-density line Patients at stage B can also have some small areas where 2 parallel, scalloped, high-density lines close to each other and separated by small low-density spaces are seen.[40]

In stage C, the midpalatal suture appears as 2 parallel, scalloped, high-density lines that are close to each other, separated by small low-density spaces in the maxillary and palatine bones (between the incisive foramen and the palatino-maxillary suture and posterior to the palatino-maxillary suture). The suture can be arranged in either a straight or an irregular pattern.

In stage D, the fusion of the midpalatal suture has occurred in the palatine bone, with maturation progressing from posterior to anterior.[41] In the palatine bone, the midpalatal suture cannot be visualized at this stage, and the parasutural bone density is increased (high-density bone) compared with the density of the maxillary parasutural bone. In the maxillary portion of the suture, fusion has not yet occurred, and the suture still can be seen as 2 high-density lines separated by small low-density spaces.

In stage E, fusion of the midpalatal suture has occurred in the maxilla. The actual suture is not visible in at least a portion of the maxilla.[42,43] The bone density is the same as in other regions of the palate.

MATERIALS AND METHODOLOGY

ETHICAL APPROVAL:

The institutional ethics committee gave its approval to the study protocol. The Department of Orthodontics & Dentofacial Orthopedics, D.Y. Patil University, School of Dentistry, Navi Mumbai, can provide the analysis's data upon request.

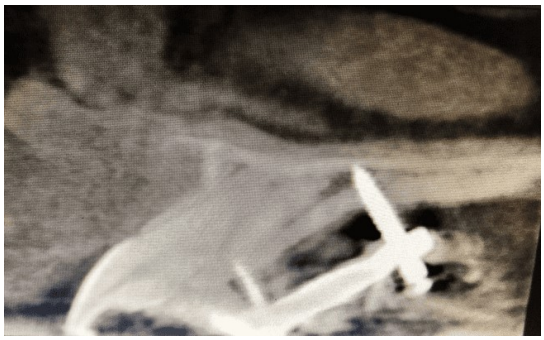
The present study was a retrospective study done at Department of Orthodontics and Dentofacial Orthopedics, D.Y. Patil University, School of Dentistry, Navi Mumbai. The study was designed to evaluate the success and failure of marpe case taking bone density into consideration.

SUBJECT AND STUDY DESIGN:

- Carestream dental CS9600 CBCT Scanner.
- Carestream 3D imaging software.

e

METHODS:



- The digital CBCT Scan of patients between the age group of 17-25 with permanent dentition is taken. Patients who had undergone mini screw assisted rapid palatal expansion were selected from the database of the Department of Orthodontics and Dentofacial Orthopaedics in D Y Patil University School of Dentistry, Navi Mumbai.
- This is a retrospective study depending on the previous records.
- CBCT's of the selected patients are checked for their bone density at the sutural level and classified into D1, D2, D3 and D4 to check if there is any correlation between the success and the failure of MARPE cases.
- The design of all cases are observed, the activation schedules are noted, to check the reason for the success and the failure of cases.
- The carestream 3D imaging software is used to read the CBCT.
- The density of the bone is measured at the sutural level by analysing the saggital view and the coronal view.
- The density is first checked at the level of the first premolar and the first molar region in the coronal view in Hounsfield units.
- Bone density at the saggital level is checked near the canine region in Hounsfield units.
- An average of all the three regions is taken as the palatal bone density and is noted in Hounsfield units.

SAMPLE:

A sample of 15 orthodontic patients who had undergone fixed orthodontic treatment at the Department of Orthodontics and Dentofacial Orthopedics, D.Y. Patil University, School of Dentistry, were selected for the study. All of the above subjects had been treated by mini screw assisted rapid palatal expansion. Cone bean computed tomography imaging was done before the treatment and after the treatment. The bone density was obtained before the treatment to avoid the superimposition with the appliance placed.

SELECTION CRITERIA:

Data were obtained from pre-treatment CBCT of 15 patients who met the following additional criteria:

A. All patients were above the age of 17 years.

B. Growth was complete in all the patient, determined using lateral cephalograms by checking the cervical vertebrae.

C. All patients exhibited maxillary constriction

D. Randomly selected mix of male and female patients.

E. No significant facial asymmetries.

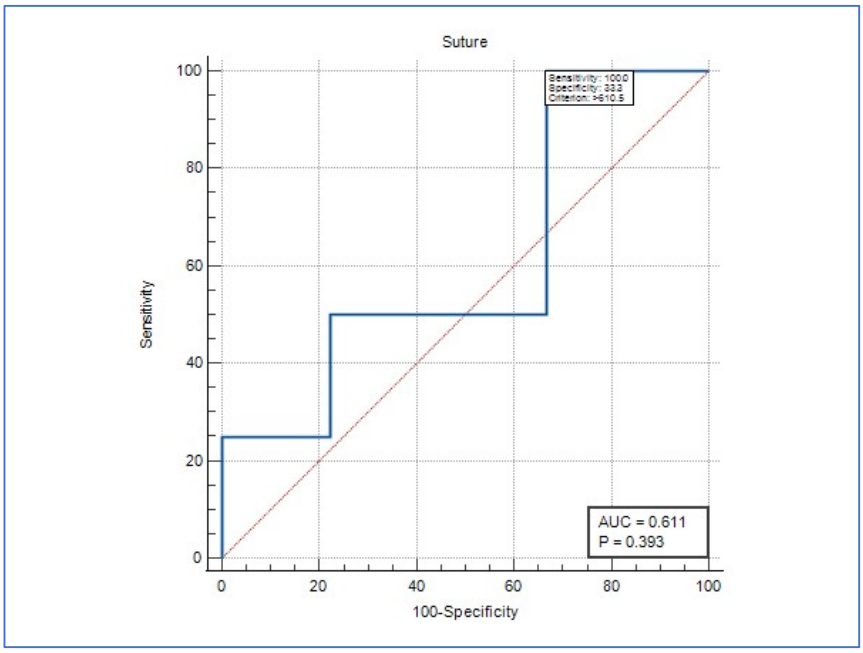
F. All patients were indicated for expansion.

SAMPLE SIZE :

30 CBCT images of treated patients with the above mentioned criteria.

RESULTS:

Graph 3: ROC curve (Suture)



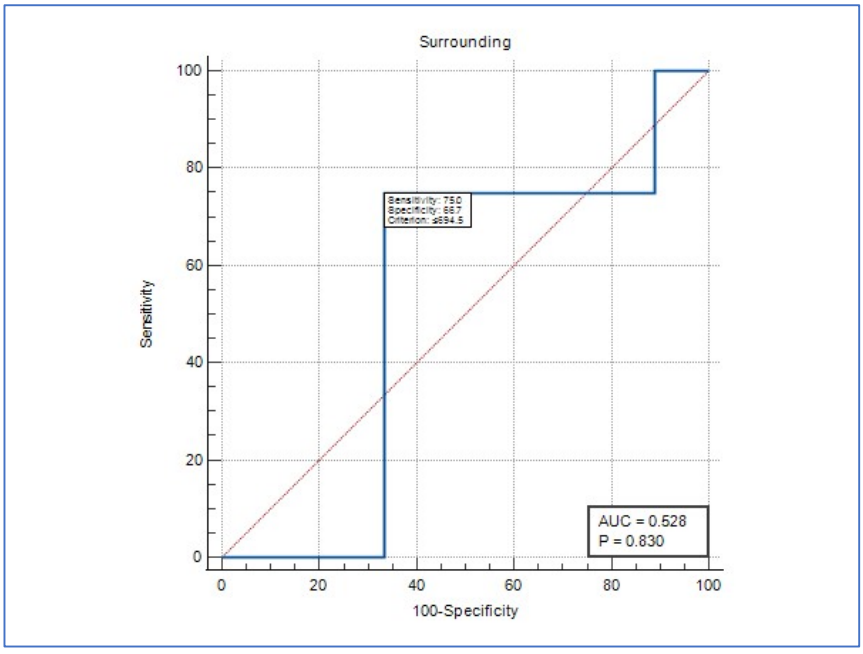


Table 3: Area under the ROC curve (AUC)

Area under the ROC curve (AUC)	0.611
Standard Error [a]	0.130
95% Confidence interval [b]	0.402 to 0.794
z statistic	0.855
Significance level P (Area=0.5)	0.3927

[a] DeLong et al., 1988

[b] Binomial exact

Youden index

Youden index J	0.3333
Associated criterion	>610.5
Sensitivity	100.00
Specificity	33.33

The ROC curve shows that when the grey scale unit of the bone density is less than 610.5 there is a possibility of suture opening and more than that, there are chances for procedure failure. This is in respect to the area of the suture.

Graph 4 : ROC curve (Surrounding)

Table 4: ROC curve (Surrounding)

Disease prevalence (%).	unknown

Area under the ROC curve (AUC)

Area under the ROC curve (AUC)	0.528
Standard Error [a]	0.130
95% Confidence interval [b]	0.324 to 0.725
z statistic	0.214
Significance level P (Area=0.5)	0.8303

[a] DeLong et al., 1988

[b] Binomial exact

Youden index

Youden index J	0.4167

Associated criterion	≤694.5
Sensitivity	75.00
Specificity	66.67

The ROC curve shows that when the grey scale unit of the bone density is less than or equal to 694.5 there is a possibility of suture opening and more than that, there are chances for procedure failure. This is in respect to the area surrounding the suture.

Pearson's Correlation: Suture Vs Surrounding (With sub-groups)

Variable Y	Suture
Variable X	Surrounding
Sample size	26
r	0.6053
95% CI	0.2847 to 0.8041
Significance level	P=0.0011

Moderate R value in correlation between the suture separation and non separation cases.

Graph 5: Scatter diagram - Suture Vs Surrounding (With sub-groups)

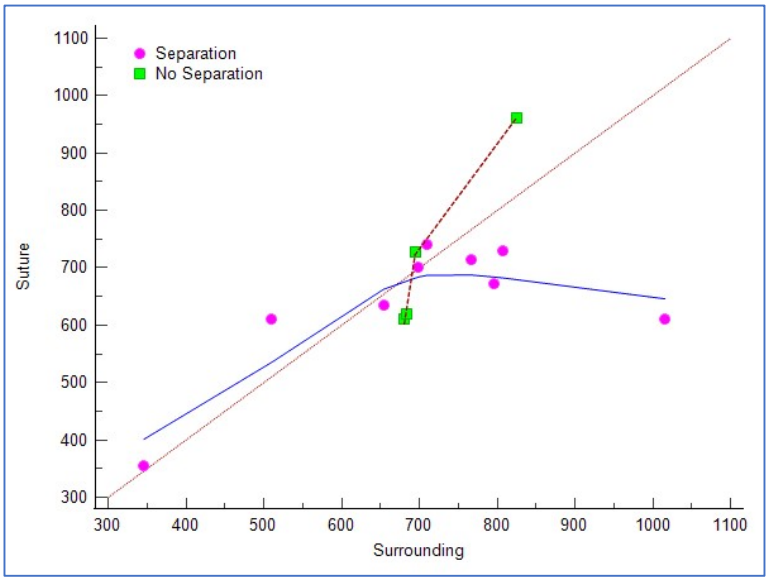


Table 5: Independent samples t-test: Suture Vs Surrounding

	Sample 1	Sample 2
Sample size	26	26

Arithmetic mean	668.4231	706.7538
95% CI for the mean	615.6547 to 721.1915	643.7553 to 769.7524
Variance	17067.9538	24327.3482
Standard deviation	130.6444	155.9723
Standard error of the mean	25.6215	30.5887

F-test for equal variances	P = 0.382

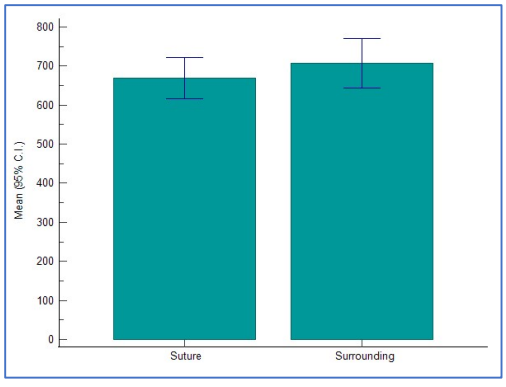
T-test (assuming equal variances)

Difference	38.3308
Pooled Standard Deviation	143.8668
Standard Error	39.9015
95% CI of difference	-41.8137 to 118.4752
Test statistic t	0.961
Degrees of Freedom (DF)	50
Two-tailed probability	P = 0.3414

Mean difference was analysed by a sample t test according to the normality of the data in correlation with the suture and the area surrounding the suture.

P value is not significant.

Graph 6: Data comparison: Suture vs surrounding



DISCUSSION:

There are various parameters to evaluate the midpalatal suture during mini screw assisted expansion. The parameters taken in previous studies were age, palatal length, MPSM stage and the palatal and the sutural bone density as predictors. (44). However this study is concentrated

on the bone density since the main aim of the MARPE is to open sutures once they are fully matured and should not depend on the age. However it was concluded in a study done by Cibele et al that there are high chances of MARPE failure after the age of 30 and success is more prevalent in young patients. Success was 100% in the B and C stages, 65% in stage D and 28% in stage E as reported by Cibele et al. This is indirectly proportional to the age as the maturation stage increases with age. The older the patient with advanced bone maturation, the lower the success rates of MARPE (94.1%, 90%, and 76% for 25, 30, and 37 years, respectively) as reported by a study done by Adriana souza. (45)

In general, as age increases, midpalatal suture interdigitation increases, with marked variations across individuals. (46,47) In addition, some studies have stated that the ossification of the midpalatal suture of each individual should be assessed by CBCT.

Activation schedule could have a possibility in determining the treatment results, MARPE is also a patient compliant procedure since expansion has to be done everyday. According to Zimring and Isaacson in 1965 two turns are given per day for the first 2 days, followed by one turn every 5 – 7 days after which one turn is given every alternate day till the expansion is complete. The reason behind the excessive force in the beginning of the procedure is to provide enough force to transfer the force directly to the bone since lesser force would also move tooth. Thus to separate the palatal suture initial excessive force is necessary. MacGinnis protocol was also followed in some cases where 2 activation was done per day. (48)

In a study done by Heinz and Andre where 27 patients from age 18 – 49 years, in this case age significantly increased the odds of complications ($p = 0.019$).

Persson and Thilander reported that midpalatal suture ossification progresses from the posterior to the anterior region. Therefore, in cases with a longer palate length, suture expansion in the anterior side will be clearly delayed. Furthermore, the result showing a statistically significant difference in the mean values of the palate length between the separation and non-separation groups supports our finding of palate length as a new predictor.(43)

Matsuyama et al mentioned that for a deeper palate, the arm strain increased and the effect of RME decreased. Modified arm shapes such as a larger diameter arm, arms connected by a diagonal wire, a straight arm, and a shorter arm efficiently expanded the maxillary dental arch. Anchor screws increased the effect of RME, generated more and closer bodily movement of the tooth, and parallel expansion of the mid-palatal suture. The model with an anchor screw without arms decreased the displacement of the teeth compared to the models with arms, so the arms are necessary for effective RME.(49)

The failure and success of MARPE cases can also depend on the design of the appliance. However more evidence is required in order to conclude a design failure since each and every case has been done with a design modification to improve the durability of the appliance and make it comfortable for the patient. It is advised to anneal the arms that extend to the premolar and the first molar region so that the force produced has a direct effect on the bone and will prevent tipping action in the molars.

There are not many studies to support that a successful expansion depends on the bone density. However the results obtained from this study showed that there is a possibility for a definitive suture opening when the bone density in grey scale units is below 611 joules at the suture area. When the bone density is more than 611 joules, there is an increased chance of MARPE failure. While checking the independent samples of the suture and the surrounding area with a t test, the p value was not significant.

CONCLUSION:

In miniscrew assisted rapid palatal expansion, there are various predictors to determine the success of the treatment however there is not sufficient proof to confirm a diagnostic method as a pre requisite for the procedure. The parameter used in the study was the palatal bone density near the suture and the surrounding area. We can conclude by saying that there is a possibility of definite suture opening below 611 joules at the area of the suture and above that there are chances of failure. However this study has to be continued with a larger sample size with various age groups, as age also plays an important role in the suture separation as it is directly associated with the suture maturation stages.

LIST OF ABBREVIATIONS

CBCT – Cone bean computed tomography
MARPE – Mini screw assisted rapid palatal expansion
ROC – Receiver operating characteristic
CVM – Cervico vertebral maturation

DECLARATIONS:

ETHICAL APPROCAL:

The institutional ethics committee gave its approval to the study protocol. The Department of Orthodontics & Dentofacial Orthopedics, D.Y. Patil University, School of Dentistry, Navi Mumbai, can provide the analysis's data upon request.

CONSENT FOR PUBLICATION

NOT APPLICABLE

AVAILABILITY OF DATA AND MATERIALS

The data was collected from the record room of Department of Orthodontics and the scanners and softwares were utilized from the Deparment of Oral medicine in D.Y.Patil University, School of Dentistry.

AVAILABILITY OF DATA AND MATERIALS:

The data was saved in the software hence a retrospective study was possible.

FUNDING:

No funding was required for this study.

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As we express our gratitude , we must never forget that the highest form of appreciation is not to utter words , but to live by them.

-John F. Keneddy

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The teacher who is indeed wise does not bid you to enter the house of his wisdom but rather leads you to the threshold of your mind.

-Khalil Gibran

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Parental love is the only love that is truly selfless unconditional and forgiving.

-Dr.T.P. Chia

Words fall short to express my gratitude towards my parents who have always hoped for and given me nothing but the best. Thank you believing that the best gift you can give a child is

good education. I am blessed to have you both in my life as my pillars of strength and constant support. Thank you for always being the calm in the storm for me. Without the inspiration, drive, and support I wouldn't be the person I am today. Thank you for always believing in me and always making me realize my true potential. I am forever indebted to you both for making me the person I am today. I hope to make you both proud one day.

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-Dr. Shristi Nadar

CONFLICT OF INTEREST

There are no conflict of interest between the authors regarding the study and its results. All authors gave their final approval and agree to be accountable for all aspects of the work.

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