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Original Research Article

Comparative Evaluation of Maturation of Mid Palatal Suture in Adolescents and Young Adults Using Cone-Beam Computed Tomography (CBCT)

Pramod Kumar[1], Padmaja Katiyar[2], Richa Angik[3]

[1]Senior Resident, Department of Dentistry, Jawaharlal Nehru Medical College and Hospital, Bhagalpur, Bihar.

[2]MDS, Department of Preventive and Pediatric Dentistry, Ghaziabad, U.P.

[3]Associate Professor, Department of Dentistry, Jawaharlal Nehru Medical College and Hospital, Bhagalpur, Bihar.

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Corresponding author: Dr. Pramod Kumar

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Abstract

Background and Aim: This study evaluated the midpalatal suture maturation stages in adolescents and young adults using cone-beam computed tomography (CBCT).

Methods: 200 CBCT scans of individuals between the ages of 10 and 25 were included in the sample. (95 men and 105 females). Young adults (n = 100), post-adolescents (n = 52), and adolescents (n = 48) were divided into these three groups. Using Planmeca ProMax 3D software, a cross-sectional axial slice was used to assess the midpalatal suture maturation stage in accordance with Angieleri's technique. Two previously calibrated examiners analysed the images and divided them into five unique maturational stages. Stages D and E were not taken into account with an open midpalatal suture, but phases A, B, and C were. Association tests were conducted using chi-square tests, and a binary logistic regression was evaluated ($P< 0.05$).

Results: In subjects aged 10 to 15 years, the likelihood of finding an open midpalatal suture was 70.8%; in subjects aged 16 to 20 and 21 to 25 years, the odds were 21.2% and 17%, respectively. Furthermore, males were more likely than females to experience this possibility at the older age of 16 years.

Conclusion: Postadolescents and young adults have a higher chance of having an open midpalatal suture than orthodontists did decades ago. Men are also more likely to discover the midpalatal suture opening. When maxillary expansion is required, the orthodontists may take these consequences into account. Additionally, the middle palatal suture's ossification is highly variable, hence CBCT may be advised to rule out this possibility.

Keywords: Midpalatal Suture Maturation Stages, CBCT, Palatal Expansion Technique.

Introduction

Numerous problems, which affect both the muscular function and aesthetics, are associated with transverse maxillary constriction, including posterior crossbite (dental and/or skeletal), dental crowding, occlusal disharmony, narrowing of the

pharyngeal airway, changes in tongue posture, and mouth breathing[1-3].

Strong forces are required during the orthopaedic procedure known as rapid maxillary expansion (RME) in order to facilitate the midpalatal suture's separation. (MPS). With a true increase in transversal breadth, this technique corrects the transverse maxillary constriction by extending collagenous fibres and forming new bone locally [4]. For patients with an MPS opening, this technique has been applied extensively in orthodontic therapy over the years.

On the other hand, patients with a full MPS ossification have been suggested surgically assisted rapid maxillary expansion (SARME) to minimise the resistance to the disjunction[5,6]. However, it is not quite obvious when a person can go from RME to SARME, particularly in late adolescence and early adults [7,8]. RME should be advised before puberty, notwithstanding the findings of multiple research [9,10]. Other reports of necropsy specimens have demonstrated that patients at ages 27, 32, 54, and even 71 have no evidence of this suture fusing[11–13]. Because of this, the chronological age is a poor metric for assessing the MPS's developmental condition during growth [13,14].

Cone-beam computed tomography (CBCT) was suggested by Angelieri *et al*. in 2013 [15] as a way of evaluating MPS maturation on an individual basis. In order to provide more trustworthy clinical data when choosing between RME alone and SARME for adolescents and young adults patients, these authors identified five maturational stages (A, B, C, D, and E). This suggests that patients in stages A and B would experience RME's skeletal effects more strongly and with less resistance than those in stage C.

SARME was advised for individuals who were in stages D and E. Three years later, Angelieri *et al*. [16] proved that maxilla widening orthopedically without surgical intervention is still feasible despite increased sutural resistance to traditional RME at stage C.

Recently, Tonello *et al*. [17] examined the MPS maturation stage in Brazilian teenagers between the ages of 11 and 15 using the same Angelieri's technique. These authors claim that there were no differences in the maturation stages between boys and girls and that stage C was the most prevalent in this particular age group.

By applying the same methods, Ladewing *et al*.[18] determined that stages C, D, and We were the most prevalent among post-adolescents aged 16 to 20, proving that stage C was more prevalent in both sexes. These findings demonstrated the potential for significant variation in the calcification phases of the middle palatal suture with respect to the potential for maxillary disjunction and chronological age. Additionally, the outcomes may vary depending on the racial group.

Material and Methods

This descriptive and retrospective study was conducted at Department of Dentistry, Jawaharlal Nehru Medical College and Hospital, Bhagalpur, Bihar. In a private dental diagnostic imaging facility, 200 CBCT scans of children (n = 48), adolescents (n = 52), and young adults (n = 100) between the ages of 10 and 25 were included in the sample. (Bhagalpur). Each patient signed the donation form. The sample size was determined by applying the algorithm to predict one proportion (possibility to find midpalatal suture opening in adults) with a 95% confidence level, the precision of 5% and 10% of this possibility. (data from a previous pilot test). The bare minimum sample size required was 163 CBCTs.

Patients between the ages of 10 and 25 of both sexes who had CBCT imaging for the diagnosis of impacted teeth and skeletal malocclusion between November 2021 and October 2022 were selected based on the inclusion criteria. Exclusion criteria for study participants were those having a history of orthodontic treatment or the use of any appliances, maxillofacial trauma, odontogenic diseases, cleft lip and palate, syndromic disorders, and noisy or blurry images on the CBCT scans.

All of the CBCT pictures examined in the current analysis were created by the Planmeca ProMax 3D Mid scanner (Helsinki, Finland). Field of view of at least 11 cm, 90 kV, 10 mA, voxel size of 0.2 to 0.3 mm, and exposure time of 13.68 s were the settings used. Pictures from the CBCT were evaluated using Planmeca Romexis®. The patient's head was adjusted in the three planes of space in accordance with the previously described method [15], and the slice that would be utilised to evaluate the MPS maturational phases was selected.

The images were taken in a standardised way. First, in both the coronal (Fig. 1a) and axial (Fig. 1b) views, the patient's midsagittal plane was selected as the location for the image analysis software's cursor. Next, the sagittal picture of the patient's head was altered so that the horizontal reference line connected with the cancellous bone between the upper and lower cortical bones, which is the median region of the palate. (Fig. 1c).

Then, in the axial CBCT segment, the method created by Angelieri *et al*.[15] was used to image and classify the MPS's stage of skeletal maturation. Two axial cross-sectional slices were used for a more precise assessment when patients had a thick or curved palate, in accordance with past recommendations[15,17,18]. Two previously calibrated examiners analysed the images and divided them into five unique maturational stages. Stages D and E were not deemed to have an open midpalatal suture, although Stages A, B, and C did. (Fig. 2).

50 CBCT slices of adolescents and post-adolescents of both genders aged 10 to 25 years were utilised for the training and calibration by an experienced and trained orthodontist (LEAG). An in-depth explanation of the morphologic traits of each MPS growth stage was given to the observer (LMJV) in a PowerPoint presentation with 50 CBCT axial slices produced by Microsoft, Redmond, Washington, USA. The observer was instructed on the MPS maturation stage and was able to recognise the MPS method by using the precise figures and legends provided by Angelieri *et al*.[15]. Only codes might be used to identify the photographs. The observer was also provided a printed handout with a written description of the radiographic features of each MPS development stage.

The calibration was done twice with a four-week washout period. Recorded data were transmitted to the agreement analysis to check for inter-examiner errors. The observer was also asked to re-observe the slices to rule out any intra-examiner errors. The weighted kappa coefficient was used for both investigations. Constantly dim lighting was used to observe the 200 CBCT sagittal slices.

The examiner was retrained in the MPS maturation stage four weeks after the initial observation and asked to re-observe the slices after receiving the images in a different random order.

All statistical procedures were conducted with SPSS version 24 (SPSS) software for windows. By age groups, the chance of finding an open midpalatal suture was examined using the chi-square test. Last but not least, a binary logistic regression model was run with the MPS maturation stage as the output variable. The predictor factors included sex and age (in years). (the codes

were 0 and 1 for females and males, respectively). Each factor's influence on the outcome variable was represented by an OR along with a 95% confidence interval (CI). P <0.05 was used to determine statistical significance for all statistical tests.

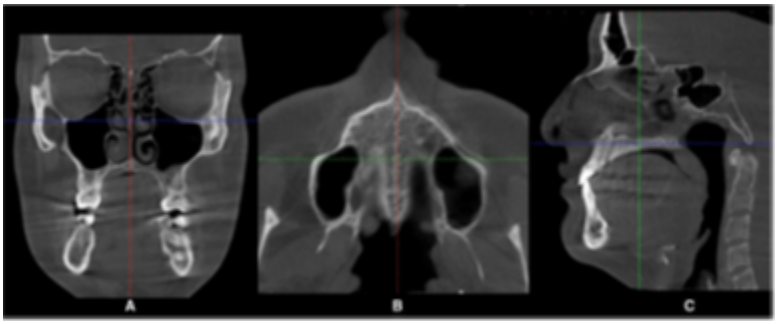

Figure 1: Procedures to measure the midpalatal suture in the CBCT sections. a view from above. The axial view. c Sagittal view; see how the blue line runs across the middle of the hard palate in this image.

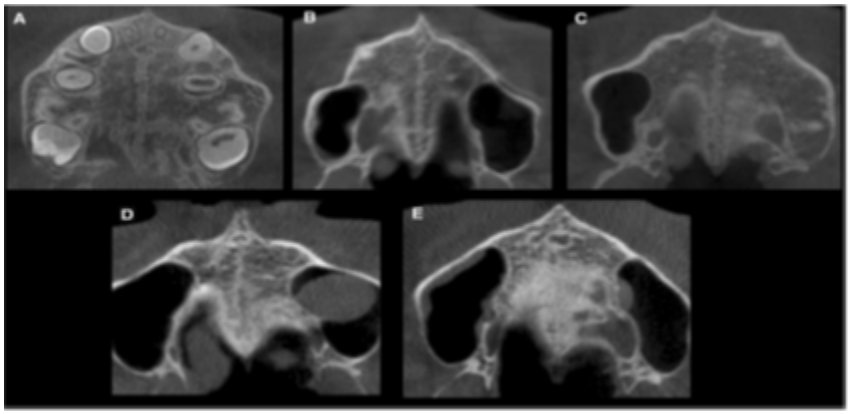

Figure 2: CBCT technique of Angieleri *et al*. [15]. A radiopaque line that is largely straight can be identified as the midpalatal suture. B. The midpalatal suture is seen as a scalloped, dense line. C. Low radiographic density regions divide two radiopaque, parallel, scalloped lines. D. The palatine bones become more radiopaque, and the suture is only visible in the midline of the palate bone as two scalloped high-density lines. E. The suture between the maxillary and palatine bones can no longer be seen, indicating fusion; fusion has occurred in the maxilla.

Results

Stage E (39.5%) had the highest incidence in the study population (Table 1), followed by stages D (29%), C (22.5%), B (8%), and A (1%). The MPS was not fused in 63 of 200 patients (31.5% of the total sample with phases A, B, or C). Stage C had a prevalence of 45.2% and was more prevalent in females (10 to 15 years old). The stage C decreased from 45.2% (14 subjects) in the younger group to 9.4% (5 subjects) in the older group. In the older age group (21 to 25 years), the frequencies of stages D and E were higher than those in the 16 to 20-year-old age group, as was expected. However, no stage A subject was observed in the group of individuals aged 21 to 25. However, stage B was present in two subjects who were between the ages of 21 and 25.

Table 1 : Age and sex-based distribution of the MPS maturational stages

Age (years)	Sex	Stage										Total
		A		B		C		D		E		
		n	%	n	%	n	%	n	%	n	%	
10-15	F	1	3.2	6	19.4	14	45.2	7	22.6	3	9.7	31
	M	1	5.9	7	41.2	6	35.3	2	11.8	1	5.9	17
	F+M	2	9.1	13	60.6	20	80.5	9	34.4	4	15.6	48
16-20	F	0	0	1	4.8	3	14.3	8	38.1	9	42.9	21
	M	0	0	0	0	7	22.6	13	41.9	11	35.5	31
	F+M	0	0	1	4.8	10	36.9	21	80	20	78.4	52
21-25	F	0	0	0	0	5	9.4	16	30.2	32	60.4	53
	M	0	0	2	4.3	10	21.3	12	25.5	23	48.9	47
	F+M	0	0	2	4.3	15	30.7	28	55.7	55	109.3	100
Total		2	1	16	8	45	22.5	28	29	79	39.5	200

F= female, M =male

Table 2 demonstrates that, when all groups were included, an open midpalatal suture could be verified in 70.8% of instances in children aged 10 to 15 years, 21.2% in instances in which children aged 16 to 20 years, and 17% in instances in which children aged 21 to 25 years. Additionally, the findings show that in the age ranges of 16 to 20 and 21 to 25, men are more likely than women to have a midpalatal suture opening.

Table 2: Age and sex differences in the MPS maturational stages and the likelihood of locating the midpalatal suture opening

Midpalatal suture opening							
Age (years)	Sex	Possibility		No possibility			p-value
		n	%	n	%	Total	
10-15	F	20	41.6	11	22.9	31	0.320
	M	14	29.2	3	6.3	17	
	F+M	34	70.8	14	29.2	48	
16-20	F	4	7.7	17	32.7	21	1.000
	M	7	13.5	24	46.1	31	
	F+M	11	21.2	41	78.8	52	
21-25	F	5	5.0	48	48.0	53	0.037*
	M	12	12.0	35	35.0	47	
	F+M	17	17.0	83	83.3	100	

F =female, M =male

**Chi-square test: P < 0.05, significant*

There is a comparison of the stages of sex-specific maturation in (Table 3). It shows that stage E has a higher occurrence in both sexes, with females experiencing it more frequently (41.9%). Stage E is then followed by stage D (29.5%). Twenty-nine percent of patients had Stage C. Females were 1% more likely to experience stages A and B, with a prevalence of 6.7% being the lowest. Men (36.6%) exhibited stage E more than stage D. (28.4). Stage A was observed in 1.1% of cases, stage B in 9.5%, and stage C in 24.2%.

Table 3: MPS maturational phases distribution and sex comparison in 10 to 25 year old participants

Sex	Stage										Total
	A		B		C		D		E		
	n	%	n	%	n	%	n	%	n	%	
Female	1	1.0	7	6.7	22	20.9	31	29.5	44	41.9	105
Male	1	1.1	9	9.5	23	24.2	27	28.4	35	36.8	95

Chi-square test: P = 0.898, not significant

The results of logistic regression (Table 4) show that women have midpalatal suture openings at a rate that is 51.1% lower than that of men. For every year that one gets older, there is a 24% lower likelihood of finding a midpalatal suture opening.

Table 4: Results of a logistic regression model with the phases of development of the midpalatal suture as the outcome variable and age and sex as predictors

Variable	p	OR	95% CI	
			Lower	Upper
Sex	0.049	0.489	0.239	0.998
Age (years)	<0.001	0.760	0.695	0.831
Constant	<0.001	111.891		

r2 Cox y Snell = 21%
r2 Nagelkerke = 30%

Discussion

The earliest age at which palatal expansion can reliably occur is debatable in the literature, hence treating transverse maxillary constriction in patients is a crucial topic for orthodontists. Patients who are early or late teenagers or adults find this challenging. Up until a few years ago, the maxillary disjunction and midpalatal suture opening were thought to be accessible at the age of 16. Excruciating pain, gingival recession, palatal mucosa ulceration or necrosis, buccal tilting of the back teeth, decreased buccal bone thickness, alveolar bone bending, buccal root resorption, and buccal cortical fenestration are further negative symptoms of RME that may be experienced by elderly people. On the other hand, SARME contends that unnecessary procedures may raise risk, expense, morbidity, and the number of recovery days required for patients[28].

Recent studies have demonstrated that this chance[11–13] is much higher in young adult patients and that RME is possible up to age 20.

As a result, patients as young as 24 to 26 years old have been described as having success with the miniscrew-assisted rapid palatal expansion operation (MARPE) [29–31]. However, there are few studies that quantify this proportion till age 25, and knowing this information is important for orthodontists who, knowing this rate, may consider the RME as a possibility if the case justifies and not only a dental expansion (Fig. 3).

The therapeutic choice to repair a posterior crossbite is often supported by the patient's chronological age due to the scientific literature's support for RME in growing patients[27]. There is debate regarding the decision between RME and SARME; some authors[32] advocate individuals older than 25 years to get SARME, while other sources like Epker and Wolford[6] advise those older

than 16 years. The vast range of reasons for different age groups and the absence of precise therapeutic recommendations for the length of treatment for maxillary expansion were the driving forces for this investigation. This study intends to assess if maxillary disjunction may be accomplished in adolescent, postadolescent, and young adult patients using a midpalatal suture opening as a less invasive alternative to SARME.

The morphology of the MPS was evaluated using CBCTs through a cross section in the middle of the palate in accordance with the Angieleri *et al*.[15] phases of maturity. This procedure identifies the five MPS maturation phases. It was determined that phases A, B, and C were more likely to result in the midpalatal suture opening, with step C being the most significant. In spite of the interincisal opening in the maxillary bone section, a clinical experiment on maxillary expansion discovered that RME under D maturation stage is not viable to the posterior region, resulting in the failure of the RME surgery. They contend that because the suture has fused partially or completely, preventing the RME forces from opening the suture, the treatment of surgically assisted RME would be preferable in stages D and E. (Fig. 2).

Stage A appeared in early infancy between the ages of 5 and 11, while stage B predominated between the ages of 13 and 15, according to Angieleri *et al*.[15]. These results are in line with those of our study, which discovered that youngsters between the ages of 10-15 experienced phases A and B. (Table 1). The MPS was shown to be fused in people under the age of 15, which is quite similar to the findings of Angieleri *et al*.[16], who said that the MPS was fused in people between the ages of 11 and 14. Women's MPS mature earlier men's, as seen by the prevalence of stage C in females between the ages of 10 and 15 years. It's interesting to note that these results support clinical observations of RME failure in late adolescence, primarily in females and adults.

Stages D and E were present in 29% and 39.5% of our sample, respectively, in contrast to Ladewig *et al*'s study[18], which shows that stage C was prevalent in both sexes. In our study, a high prevalence was also seen in the group of people aged 21 to 25. The results of other research, which included patients older than 18 years, indicated that stages D and E were present in 84.4% and 60%, respectively[16,18], are similar to this one, but they were different. This disparity might be explained by the sample's environmental and genetic variables that were studied. It does, however, imply that RME treatment for young adult patients may always be an option [29–31].

Age and gender play a significant role in determining the midpalatal suture opening, but they are not significant decision-making criteria since, according to the research, they are not reliable indications of whether or not the MPS is merged[11]. Men are more likely than women to have a midpalatal suture opening than vice versa. (Table 2). An extra 80% success rate for RME in patients without growth is reported by Capelozza Filho *et al*.[23]. An interincisal maxillary diastema was considered evidence that the RME was effective[22]. Despite the fact that the MARPE procedure already produces intriguing results in patients around the age of 25[29-31], these results support the possibility of performing RME on young people. However, additional research would be necessary to evaluate the CBCT scans of the maxilla and then retroactively forecast the risk of RME in people who received RME treatment.

Similar findings were made by Angieleri *et al*. [16], who found that 12% of adult patients lacked fusion of the middle palatal suture. Contrary to our findings, we found that adults over 20 may find a midpalatal suture opening

that varies by gender (24.5% of men and 9.6% of women). With this knowledge, the orthodontist may be better able to describe to the patient a probable treatment plan that will subsequently be verified by an auxiliary examination. (occlusal radiographs or CBCT). This study also shows that the RME protocol, particularly in young adults, may benefit from the use of CBCT to confirm the MPS's ossification status and help decide whether to perform a conventional RME (if the MPS is clearly open) or use microimplants (MARPE protocol) if the suture is closing, or ultimately whether the SARME protocol would be preferable if the suture was fully closed.

If it is possible to estimate a person's MPS ossification status using other biological indicators, a tomographic test should be avoided to reduce the patient's exposure to ionising radiation. Caution is necessary in this situation.

Conclusion

Contrary to what orthodontists previously believed, there is a 20% possibility of finding a midpalatal suture opening in postadolescents and early adults. Additionally, men are more likely than women to have an opening in the midpalatal suture. The orthodontists may take these factors into account when RME therapy is required.

Additionally, because the middle palatal suture's ossification is so variable, it could be desirable to use CBCT to evaluate the midpalatal suture opening and then confirm the possibility of maxillary disjunction.

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