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Original article

Evaluation of Midpalatal Suture Maturation Stages among Adolescents and Adults using Cone Beam Computed Tomography

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Abstract

Background: Transverse maxillary constriction is commonly found in skeletal discrepancies. Growth of the maxilla in the transverse plane is reflected by midpalatal suture maturation status. Previous studies attempted to assess the midpalatal suture maturation. However, literature of the evaluation of MPS maturation using cone beam computed tomography (CBCT) still was limited. **Objective:** The purpose of the study was to evaluate the different maturation stages of midpalatal suture among adolescents and adults using CBCT. **Materials and methods:** The sample comprised 200 CBCT reports of subjects. The images were exported to 3D imaging software, where axial sections were used for the suture maturation stages evaluation. The investigators interpreted the images to establish the staging of suture maturation according to the morphologic characteristics in five maturational stages (A to E). The statistical analysis was performed ($P < 0.05$). **Results:** The most frequently observed maturational stage in midpalatal suture was stage D (52 %), followed by stage C (22.50 %) and stage E (22.50 %) in mixed age samples. Males showed a higher occurrence of stage D (56.31 %) compared to females (43.69 %). **Conclusion:** Stage D was the most common maturation stage observed. The common occurrence of stage D in the study group indicates a greater likelihood of open midpalatal suture in adolescents and young adults.

Keywords: Cone beam computed tomography, Maturation stages, Midpalatal suture

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Introduction

Anatomically, a suture is a fibrous joint that connects the bone.[1] Midpalatal suture (MPS) starts at posterior site of the palatomaxillary suture and extends longitudinally to the nasopalatine foramen on the palatal bone.[2] Sicher emphasized the importance of sutures in craniofacial growth and adaptation in early 1940's.[1] Melsen's study identified three developmental stages of the median suture in histological sections, which included a broad and Y-shaped stage, a sinuous stage, and an interdigitating stage.[3] Angelieri et al. defined five stages of maturation for the midpalatal suture based on cone beam computed tomographic images, labeled as stage A, B, C, D, and E.[4]

Transverse maxillary deficiency is a common skeletal discrepancy. About 30 % of adult patients present with transverse maxillary constriction.[5] Previous study have shown that the growth of MPS is the most important factor for determining the transverse width of the maxilla.[2] Lack of growth in adults limit the option for functional orthopedic intervention. However, miniscrew assisted rapid palatal expansion (MARPE), surgically assisted rapid palatal expansion (SARPE), and orthognathic surgery are possible options for correcting the transverse skeletal deficiencies in adults.[4,6] MARPE was effective in 92.5 % of late adolescents and adults for correcting transverse malocclusion.[7] Many studies have shown variability in maturation of MPS which are essential to predict the effect of rapid maxillary expansion in adolescents and adults.[4,6,8,9]

The research question in the present study is whether the age difference is a reliable parameter to determine the developmental status of midpalatal suture. Thus, the aim of the study was to assess various maturation stages of midpalatal suture using CBCT.

Materials and methods

An observational cross-sectional study using the secondary data was conducted at the Department of Orthodontics, Kantipur Dental College and Hospital, Kathmandu during March-April 2022 after obtaining the ethical approval from institutional review committee (Ref No. 6/022). The sampling technique was random sampling. A total of 200 subjects meeting the inclusion criteria were selected for the study. The subjects were aged between 10-55 years with the good quality CBCT images showing the entire palate. Subjects with the record of craniofacial trauma, craniofacial neoplasm, craniofacial deformity, and a history of previous orthodontic/dentofacial orthopedic treatment and orthognathic surgeries were excluded. The data for sample size calculation was based on the study done by Angelieri et al.[4]

$$N = \frac{z^2 pq}{e^2} = 174$$

Where, N = minimum sample size, Z = 1.96 at 95 % confidence interval, p (prevalence) = 13 % prevalence of stage C of midpalatal suture maturation, q = 1-p, and e = maximum tolerable error of 0.05. The sample size was determined as 200 summing the 10 % permissible error. Data information sheet was used to collect the information from the samples. CBCT scans of the maxilla obtained from the Department of Oral Radiology, Kantipur Dental College and Hospital were used. Scans obtained using the standardized protocol at 85 kV, 6.3 mA, 11.30 second, voxel size of 300 and 17×13 cm field of view. Using Carestream 3D imaging software version 3.5.18, the scan was exported and read on orthogonal slicing view which were evaluated in a standardized way. The subject's head was adjusted such that the palatal bone was assessed at the central incisor region with the horizontal reference line in the median region of the palate in the sagittal section. In CBCT scans, the palate appeared as a single thin radio opaque line; hence, the horizontal reference line was placed as close to the center of the radio opaque palate. Axial section of the CBCT was used for the classification of maturation stages (Figure 1). The visualization and classification of the maturation stages of the MPS (Figure 2 and 3) was conducted according to the method of Angelieri et al.[4] Suture maturation

Figure 1 CBCT image in sagittal, coronal and axial section
(Image source: From the study samples)

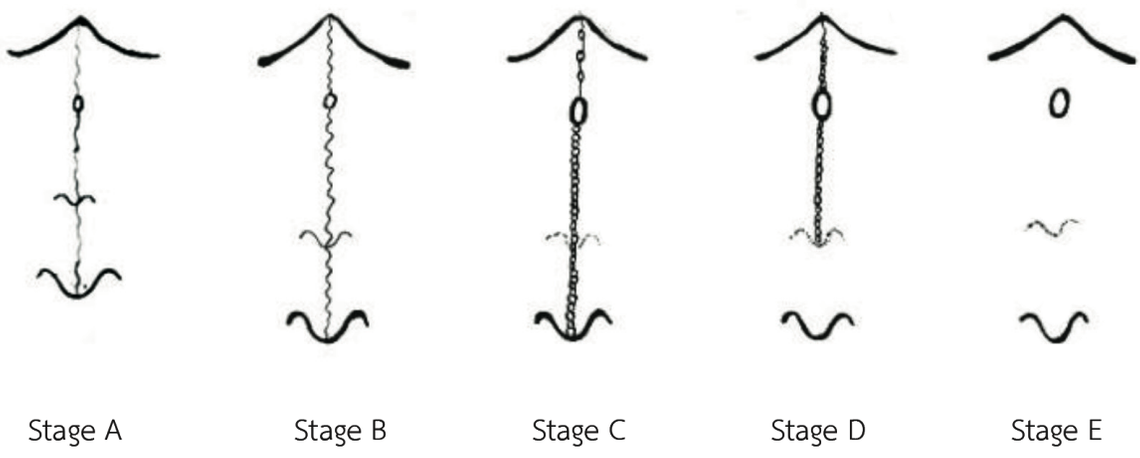

Figure 2 Schematic drawing of the maturation stages observed in the midpalatal suture
(Redrawn from Angelieri et al's study[4])

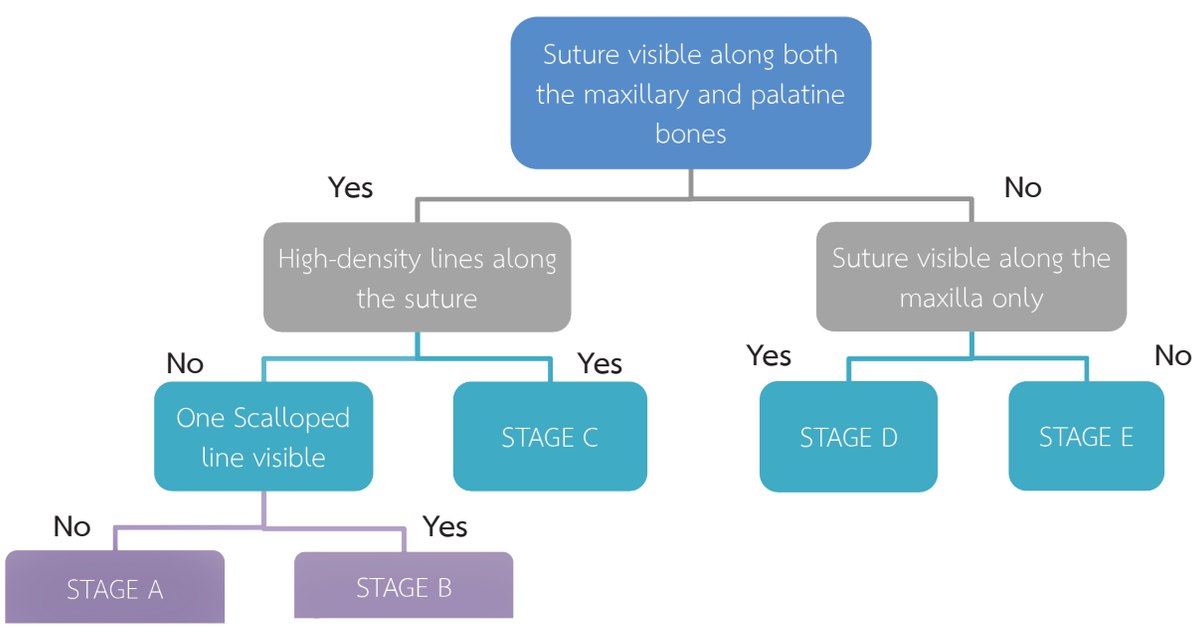

Figure 3 Decision tree for classification of the maturation stages of the midpalatal suture
(Modified from Angelieri et al's study[4])

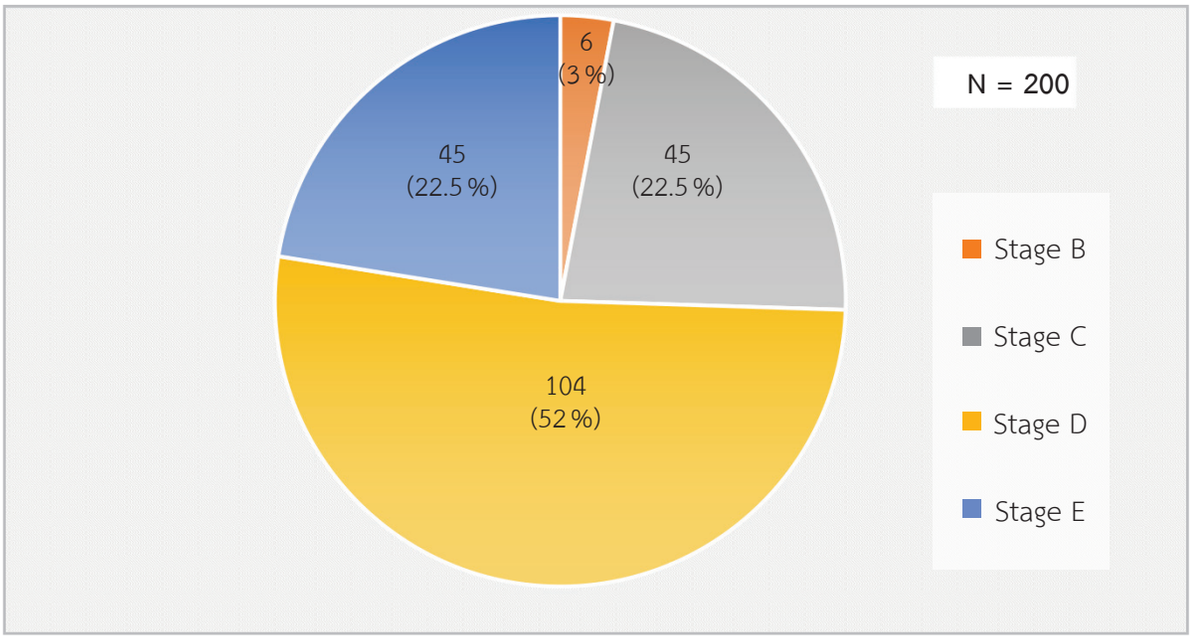

Figure 4 Distribution of midpalatal suture maturational stages

stages were determined according to age groups i.e. adolescents, young adults, and adults as per the classification of World Health Organization and Proffit et al.[9,10]

Data management and analysis was done using SPSS version 21 (Armonk, NY: IBM) Three investigators interpreted the images to establish the staging of suture maturation according to its morphologic characteristics in five maturational stages (stage: A, B, C, D and E) as proposed by Angelieri et al.[4] The kappa statistics was applied for inter-examiner measurement error with kappa value of 1 as the total agreement.

Results

The sample comprised of 200 CBCT reports of 114 male and 86 female subjects aged 10 to 55 years (mean age = 26.69 ± 10.03 years); which was further classified in three age groups: adolescents (10 to 19 years), young adults (> 19 to 35 years) and adults (> 35 years). The maturational stage most often observed in the study was stage D (N = 104). Stage A was not reported in the study. The frequency distribution of subjects with respect to MPS maturation stages is given in Figure 4. Stage D was the most prevalent (52 %), following by stage C and E (22.50 %), and the least was stage B (3 %).

Regarding the distribution of age groups in maturation stages (Table 1). No individuals were found in stage A across any age group. Among adolescents, stage C was most prevalent (56.75 %), followed by stage D (24.32 %), stage B (16.21 %), and stage E (2.70 %). In young adults, stage D became the most prevalent (64.44 %), followed by stages C and E (17.77 % each). Adults only displayed stages D and F, with stage F being the most prevalent (71.42 %) compared to stage D (28.57 %).

It was noteworthy that stage B was exclusive to adolescents, while stage C appeared in both adolescents and young adults. Stages D and E were presented in all age groups. Interestingly, the most prevalent stage shifted across age groups: stage C in adolescents, stage D in young adults, and stage F in adults.

Figure 5 displayed the frequency distribution of suture maturation stages by gender. Males exhibited a higher frequency than females across all maturation stages. Stage D was the most common stage for both genders compared to other stages.

Table 1 Distribution of age groups in maturation stages

Age group	Stage A	Stage B	Stage C	Stage D	Stage E
Adolescents (n = 37)	0	6 (16.21 %)	21 (56.75 %)	9 (24.32 %)	1 (2.70 %)
Young adults (n = 135)	0	0	24 (17.77 %)	87 (64.44 %)	24 (17.77 %)
Adults (n = 28)	0	0	0	8 (28.57 %)	20 (71.42 %)
Total	0	6	45	104	45

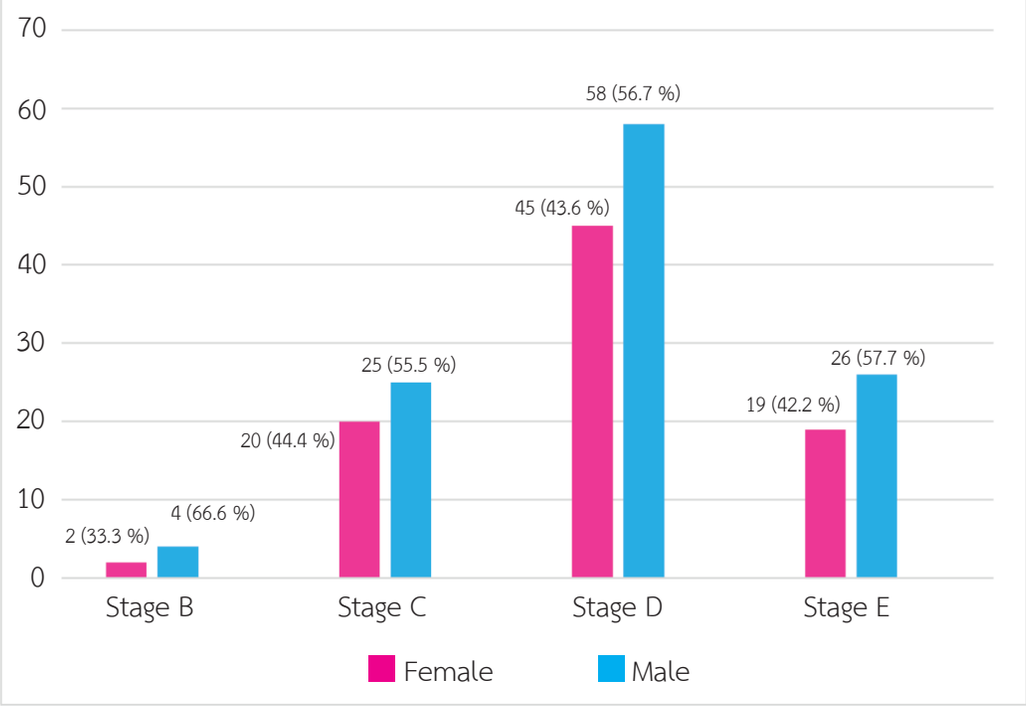

Figure 5 Distribution of midpalatal suture maturation stages between genders

Discussion

This study aimed to evaluate the maturation stages of the midpalatal suture, with a specific focus on its potential benefit in treatment cases involving transverse maxillary deficiencies. Transverse maxillary deficiencies themselves constitute a common skeletal discrepancy encountered in clinical practice.[5,6] Rapid maxillary expansion (RME), an orthopedic procedure, is a routine protocol to correct transverse maxillary constriction in patient with MPS opening. However, in patients with full MPS ossification, MARPE and SARPE has been recommended.[4,6,7,8]

The approximated age limit to shift from RME to MARPE or SARPE is not stated clearly in the literature. Several studies recommend the use of RME before puberty.[6,8,9] On contrary, study by Persson and Thilander have shown the patients with open sutures even at the ages of 27, 32, 54, and 71 years.[11] Thus, according to the authors; chronological age is not a reliable parameter to determine the developmental status of the MPS.[2,11] In 2013, Angelieri et al[4] proposed a method of classification of MPS maturation stages using CBCT. It is a simple and reliable parameter for clinical decision making and does not differ between various machines.

In the present study, No stage A was found in sample aged 10 to 55 years. This finding may be linked to a faster rate of skeletal maturation observed in the Asian population.[12] Stage D was the most commonly found, followed by stages C and E. Angelieri et al[4], demonstrated similar results, with the most frequent stage being stage D, followed by E, C and B in adults. However, the result obtained by Ladewig et al[13] in 2018 was different from the present study, where stage C was most frequently observed.

Previous literature[4] aligned with the present study in reporting observations of stage B up to 13 years of age. Notably, young adults exhibited the highest prevalence of stages C and D, while stage E was more prevalent in adults, as expected. This finding aligned with the understanding that these latter stages represent the partial or total ossification of the suture. According to Angelieri et al,[4] 84.4 % of the subjects above 18 years were in stage D or E. This value is higher compared to the present study, where 69.5 % of subjects above 18 years were presented with stage D or E of sutural maturation. This difference may be attributed to genetic or environmental factors and variations in the samples.[14]

A prior study suggested that, though there is a chance for RME treatment in young adults; age and gender factors deemed important but are not always the reliable parameters for determining MPS fusion in clinical decision-making.[11]

The assessment of midpalatal suture maturation using CBCT classification method[4] may provide reliable information for clinical decision between RME or SARPE. Based on the proposed staging method[4] suggested conventional RME approach in stages A and B, with more skeletal effects observed than in stage C. Whereas, MARPE and SARPE are better treated in stages D and E because of the total or partial fusion of the midpalatal suture.

In the present study, the CBCT data collected were limited to a single center. Thus, the results obtained could not be generalized to the larger population. It is recommended for a prospective study with a larger sample to assess the reliability of this classification method.

Conclusion

An evaluation of midpalatal suture maturation stages in a Nepali sample revealed that stage D was the most prevalent, followed by stages C and E. Furthermore, males exhibited a higher prevalence of stage D compared to females. These findings suggest an increased likelihood of an open midpalatal suture in adolescents and young adults, implying that age is not a reliable indicator for determining the developmental status of the midpalatal suture.

Author contributions

PP: Conceptualization, Methodology, Software, Writing-Original Draft, Writing-Review & Editing, Resources, Investigation, Data management and analysis and Funding acquisition; RMS: Conceptualization, Methodology, Software, Writing-Original Draft, Writing-Review & Editing, Resources, Investigation and Supervision; JD: Methodology, Software, Resources and Investigation; UP: Methodology and Software; KK: Methodology, Software, Data management and analysis

Ethical statement

The research protocol was approved by the Ethics Committee of Kantipur Dental College and Hospital, Kathmandu (No. of IRB-Ref No: 6/022).

Disclosure statement

No conflict of interest in the study

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