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Abstract

Accurately estimating the maturation of a midpalatal suture can improve the success rate of a maxillary expansion procedures. The craniofacial sutural maturation is an essential consideration in the choice between non-surgical and surgical methods of maxillary expansion. The maturation of a midpalatal suture can be assessed in several ways. This article reviews the literatures on the assessment of midpalatal suture maturation and its importance for orthodontic diagnosis and treatment planning.

Keywords

midpalatal suture; sutural maturation; maxillary expansion

Review Article

Assessment of Midpalatal Suture Maturation for Orthodontic Diagnosis and Treatment Planning

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Accurately estimating the maturation of a midpalatal suture can improve the success rate of a maxillary expansion procedures. The craniofacial sutural maturation is an essential consideration in the choice between non-surgical and surgical methods of maxillary expansion. The maturation of a midpalatal suture can be assessed in several ways. This article reviews the literatures on the assessment of midpalatal suture maturation and its importance for orthodontic diagnosis and treatment planning. ***(Taiwanese Journal of Orthodontics. 30(1): 12-17, 2018)***

Keywords: midpalatal suture; sutural maturation; maxillary expansion.

BACKGROUND

Maxillary expansion is a treatment option in certain clinical conditions such as posterior crossbite (bilateral or unilateral), dental crowding (space deficiency), and a constricted maxillary basal bone causing a smaller buccal overjet. The origin of the transverse discrepancy in the maxilla may be skeletal, dental origin, or a combination of the two. An effective solution for this problem is rapid maxillary expansion (RME), which was first described by Angell in 1860 and later re-popularized by Haas.

Although RME is effective for treating the above conditions, its advantages and disadvantages must be carefully considered. The advantages include increased accuracy in correcting malocclusion, avoidance of tooth extraction, and increased dental arch perimeter (which relieves dental crowding). Furthermore, a growing number of clinicians use RME to increase volume and function in the nasal airway.[1,2] However, the disadvantages of RME include discomfort caused by the high force required to perform the procedure, the potential for traumatic separation of the midpalatal suture, the inability to correct rotated molars, the uncertainty of the compliance of the patient or parents for activating the screws on the appliance, bite opening, relapse, microtrauma of the temporomandibular joint and midpalatal suture, root resorption, and pain resulting from tissue impingement by RME appliances. Fabrication of an RME appliance is also labor intensive.[3] Potential side effects include severe pain,[2] gingival recession, dehiscence

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formation, palatal mucosa ulceration or necrosis, buccal dentoalveolar tipping in the posterior teeth, and poor long-term stability.[4]

Treatment options that later emerged for transverse expansion of the maxilla include tooth-borne expanders with or without an acrylic plate,[1] bone-borne maxillary expansion devices supported by temporary (skeletal) anchoring devices,[5] and surgically assisted rapid palatal expansion (SARPE).[2,4] Another method recently introduced in clinical practice is miniscrew-assisted rapid palatal expansion (MARPE), in which orthopedic pressure is applied directly on the bone.[6,7] The best treatment decision relies on many clinical indications, including the extent of correction required, whether skeletal or dentoalveolar correction is indicated, and the perceived efficacy of expansion at the time of treatment.[5]

METHODOLOGIES FOR ASSESSING MIDPALATAL SUTURE MATURATION

Successful application of RME requires an accurate assessment of midpalatal suture maturation. Table 1 shows that the various methodologies used to identify the structure and degree of palatal sutural fusion including animal and human histologic studies through evaluation of occlusal radiographs, and computerized tomography (CT) of both autopsy material and animal specimens.[8] In the previous studies, Korbmacher et al.[9] has performed an in-vitro study using micro-CT quantification of 3D palatal suture in the frontal and axial planes to quantify sutural morphology and its association with age. Franchi et al.[10] has conducted a prospective study using multi-slice low dose CT to capture axial slices of the maxilla to assess the palatal suture maturation quantitatively and calculating the radiodensity (Hounsfield units [HU]) of the ossification at the palatal suture from T0 (pre-expansion) and T2 (at 6 months retention). In a prospective study, Sumer et al.[11] used an ultrasonic device and evaluate the SARME and retention protocol at five-time points via assignment of semiquantitative bone fill scores (0–3). Angelieri et al.[4] performed a cross-sectional study and utilizing a standardized methodology to capture the cone-beam computed tomography (CBCT) in axial cross-sectional views of the palatal suture and provide individual staging of midpalatal suture maturation. On the other hand, in the cross-sectional study of Kwak et al,[12] CBCT and fractal analysis were used to quantitatively ascertain the extent of sutural maturation which following proposed maturation stages of Anglieri et al.[4] In a retrospective study of Jang et al,[14] CBCT images were applied to investigate their relationships with the conventional commonly used maturation indices, such as skeletal age HWM[15,16] and CVM.[17]

Various difficulties for assessing midpalatal suture maturation have been reported in the literatures. Due to widely varying study designs, only weak evidence from image assessment for midpalatal suture maturation could be obtained. With the developments in CBCT, the radiation dose is lower than those in conventional CT; the serial clinical images could be obtained within reasonable safety. The benefit of using CBCT is its ability to obtain a 3-dimensional (3D) reconstruction of the maxillofacial area without superimposition of nearby anatomical structures.[4] Angelieri et al.[4] developed a scheme for classifying maturation of the midpalatal suture into five stages (stages A–E) based on the analysis of CBCT images (Table 2). Kwak et al.[12] further proposed the use of fractal analysis for assessing the midpalatal suture maturation since this objective and quantitative method was already widely used in many domains of dental research. However, extensive training is required to achieve an adequate proficiency in fractal analysis.[12]

DISCUSSION

The appropriate time for performing maxillary expansion has been debated extensively. One study suggested that maxillary expansion should be limited to

Table 1. Methodologies in assessing midpalatal suture maturation.[23]

Methodology	Summary of Evidence
Micro-CT quantification of 3D palatal suture in the frontal and axial planes (Korbmacher et al.[9])	• Micro-CT analysis disproves the hypothesis of progressive closure of the suture directly related to patient age. • Skeletal age and/or calculation of an obliteration index are not useful in terms of diagnostic criteria to drive clinical decision making regarding the perceived efficacy of non-surgical RME. • Micro-CT quantification of the midpalatal suture yields very low obliteration and age-independent interdigitation in the coronal plane.
Multi-slice low dose CT and quantitative bone density measurements [HU] (Franchi et al.[10])	• Prepubertal subjects showed a lower bone density at the midpalatal suture. • The post-expansion low bone density supported findings that prepubertal RME effectively opens the suture. • After 6 months of retention phase, RME allows reorganization and ossification of the midpalatal suture with sutural bone density values similar to pre-RME values.
US and assignment of semi-quantitative bone fill scores (0–3) (Sumer et al.[11])	• US bone fill scores increased directly with the duration of time in post-expansion. • Non-invasive US can yield accurate information regarding bone formation at the midpalatal suture in patients undergoing SARME.
CBCT and proposed maturation stages (A–E) (Angelieri et al.[4])	• Utilizing CBCT to assess the midpalatal suture avoids any overlapping of soft and hard tissues. • The proposed methodology may be useful in making clinical decision for non-surgical (RME) or surgical expansion intervention (SARME).
CBCT and fractal analysis to quantitatively ascertain degree of sutural maturation per proposed maturation stages of Anglieri et al. (Kwak et al.[12])	• Adult patients possess a greater proportion of non-fused palatal sutures than what is assumed. Therefore, age of the patient should not drive SARME initiation. • Authors report a significant correlation between fractal dimension and degree of maturation of the midpalatal suture. • Determination of the fractal dimension cut-off value could be used as a reference to pursue RME vs. SARME. • Fractal analysis can be utilized to evaluate the degree of maturation at the palatal suture.
Using CBCT for the relationship between maturation indices and morphology of the midpalatal suture (Jang et al.[14])	• Skeletal age such as the HWM and CVM are the most commonly used maturation indices. • The HWM and CVM both showed significantly high values, but the HWM showed a slightly higher value. • Analysis between the HWM and CBCT stage showed higher values than the analysis between the CVM and CBCT stage in both genders.

CT: computed tomography; CVM: cervical vertebrae method; HU: Hounsfield unit; HWM: hand and wrist method; Micro-CT: Microcomputed tomography; RME: rapid maxillary expansion; SARME: surgically assisted rapid maxillary expansion; US: ultrasonography.

Table 2. *Midpalatal suture maturation stage*[4]

Stage	Shape / Observation	Interdigitation / Fusion	Distribution
A	straight / high-density sutural line	Little or no interdigitation	early childhood period from 5 to 11 years of age
B	scalloped, high-density midpalatal suture line		mostly up to 13 years of age
C	• 2 parallel, scalloped, high density line • the suture can be arranged in a straight or an irregular pattern	2 parallel line closed to each other, separated by small low-density spaces in the maxillary and palatine bones	mainly from 11 to 18 years of age
D	Not been visualized in the palatal bone	midpalatal suture was fused in the palatine bone, but not fused in the maxilla	mid-palatal suture in females was fused earlier than males
E	Actual suture is invisible in at least a portion of the maxilla	midpalatal suture was fused in the maxilla	

patients older than 14 years.[18] Another study proposed that surgery should only be considered in male patients older than 25 years and in female patients older than 20 years.[19] According to the Cohen hypothesis, termination of growth is unrelated to closure of the sutures. Even if 95% of the growth of the maxilla ends at 7 years of age, the suture may not already be closed.[20] A classification scheme for midpalatal suture maturation was proposed by Angelieri et al.[4] and has been applied and discussed in several subsequent studies. The various technologies that can be used to analyze the maxillary expansion include occlusal radiographs, multi-slice low dose CT, micro-CT, ultrasound, CBCT, hand and wrist method, cervical vertebrae method and fractal analysis. In some adults, the distribution of maturation stages revealed that the midpalatal suture may remain in a non-fused state. This suggested that the chronological age should not be the only factor used to determine whether SARPE or conventional RME can be performed in adult individuals.[10] An RME treatment performed in adults whose midpalatal suture is already ossified could induce a bending of the circum-maxillary structure, compression of the periodontal ligament, resorption of the buccal root in the posterior teeth, perforation of the buccal alveolar bone, severe pain, periodontal side effects, and gingival recession in the maxillary molar area.[21]

The SARPE has the similar advantages with the conventional RME. However, notable disadvantages of SARPE include potential for pressure-related non-infectious frank necrosis (occurred in approximately 1.8% of cases),[22] bleeding and infection during surgery, joint pain, periodontal problems, recurrence,[23] and the need for surgery and hospitalization. In adult individuals whose midpalatal suture is already closed, SARPE should be performed instead of RME. Therefore, the maturation phase of the midpalatal suture must be accurately determined, and the correct tools must be selected to perform the maxillary expansion that the patients require.

CONCLUSION

Selecting the best treatment option for patients who need maxillary expansion requires a clear understanding of the methods for assessing midpalatal sutures. Although many studies have discussed the factors relating the treatment of choice, including chronological age, skeletal age (e.g., hand and wrist method, cervical vertebrae method), and fractal analysis (which requires expertise in statistical analysis), a comprehensive survey is still demanded for further data collection and research. This information should be able to support the decision making procedures to choose between a non-surgical or surgical method of maxillary expansion.

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