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Midfacial changes in the coronal plane induced by microimplant-supported skeletal expander, studied with cone-beam computed tomography images

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Introduction: Our objectives were to evaluate midfacial skeletal changes in the coronal plane and the implications of circummaxillary sutures and to localize the center of rotation for the zygomaticomaxillary complex after therapy with a bone-anchored maxillary expander, using high-resolution cone-beam computed tomography. **Methods:** Fifteen subjects with a mean age of 17.2 ± 4.2 years were treated with a bone-anchored maxillary expander. Pretreatment and posttreatment cone-beam computed tomography images were superimposed and examined for comparison. **Results:** Upper interzygomatic distance increased by 0.5 mm, lower interzygomatic distance increased by 4.6 mm, frontozygomatic angles increased by 2.5° and 2.9° (right and left sides), maxillary inclinations increased by 2.0° and 2.5° (right and left sides), and intermolar distance increased by 8.3 mm ($P < 0.05$). Changes in frontoethmoidal, zygomaticomaxillary, and molar basal bone angles were negligible ($P > 0.05$). **Conclusions:** A significant lateral displacement of the zygomaticomaxillary complex occurred in late adolescent patients treated with a bone-anchored maxillary expander. The zygomatic bone tended to rotate outward along with the maxilla with a common center of rotation located near the superior aspect of the frontozygomatic suture. Dental tipping of the molars was negligible during treatment. (Am J Orthod Dentofacial Orthop 2018;154:337-45)

It is believed that during rapid palatal expansion (RPE), the main resistance to the opening of the midpalatal suture is probably not in the suture itself but, rather, in the surrounding structures with which the maxilla articulates, particularly the sphenoid and zygomatic bones.[1] Therefore, the expansion force might affect all circummaxillary sutures: internasal, nasomaxillary, frontomaxillary, frontonasal, frontozygomatic, zygomaticomaxillary, zygomaticotemporal, and pterygopalatine. This involvement has been hypothesized based on investigations that used histologic methods,[2] radiologic imaging,[3-5] photoelastic models,[6] bone scintigraphy,[7] and finite element methods.[8-12]

Cranial sutures respond differently to external orthopedic forces depending on their anatomic location and degree of interdigitation, and different studies have indicated diverse regions of the midfacial skeleton as the most affected by RPE. Some authors cited the frontozygomatic, zygomaticomaxillary, and zygomaticotemporal sutures as the primary anatomic sites of resistance to RPE.[13,14] Other clinical investigations have described greater changes in the sutures directly articulating with the maxilla than those indirectly articulatig.[4,15] Finite element method analyses found high stress levels in the zygomatic process of the maxilla, external walls of the orbit, frontozygomatic suture, and frontal process of the maxilla.[8-10]

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Fig 1. Method used to diagnose transverse maxillary skeletal deficiency. Measurement of **A,** maxillary and **B,** mandibular widths with a digital caliper; **C,** frontal view of the relationship between maxillary (*blue*) and mandibular (*red*) widths. In this patient, maxillary width is 55 mm, and mandibular width is 59.6 mm, for a maxillary transverse deficiency of 4.6 mm. Reprinted with permission from Cantarella D et al. Changes in the midpalatal and pterygopalatine sutures induced by micro-implant-supported skeletal expander, analyzed with a novel 3D method based on CBCT imaging. Prog Orthod 2017;18:34, Elsevier.

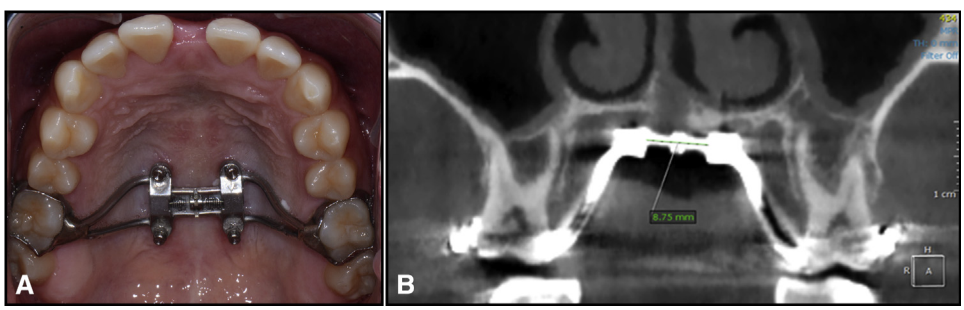

Fig 2. Maxillary skeletal expander: **A,** intraoral occlusal view; **B,** CBCT section showing the distance between the 2 halves of the expansion jackscrew after expansion on a patient. The opening of the midpalatal suture can also be appreciated. Reprinted with permission from Cantarella D et al. Changes in the midpalatal and pterygopalatine sutures induced by micro-implant-supported skeletal expander, analyzed with a novel 3D method based on CBCT imaging. Prog Orthod 2017;18:34, Elsevier.

For the rotational fulcrum of the maxillary bone during RPE, it is still being debated where it is located. Studies have established this center of rotation in different areas, frequently at the frontomaxillary suture.[9,10,16-20] Other authors have identified the center of rotation close to the superior orbital fissure.[2,11] In relation to the zygomatic bone, although high stress levels have been reported at the zygomatic sutures, no study has described its motion path during RPE and the location of its rotational fulcrum.[6,8,11,21]

Analysis of the circummaxillary suture modifications during rapid maxillary expansion have been previously conducted using study models,[22] 2-dimensional imaging,[16,19] and, more recently, 3-dimensional (3D) imaging based on computed tomographic data.[3-5,15,23] The introduction of cone-beam computed tomography (CBCT) and the development of new computer software allow obtaining multiplanar, 3D reconstructions, extending the possibilities for analysis of the craniofacial complex in living subjects.[24,25]

Miniscrews have been added to RPE devices, as proposed by Wilmes et al[26] in the hybrid hyrax appliance, to prevent buccal tipping of the lateral teeth and the negative consequences on their periodontal support. Furthermore, various miniscrew-assisted RPE appliances with different designs have been developed in recent years,[3,8,27-30] with the goal to enhance the orthopedic effects of maxillary expansion. A maxillary skeletal expander (MSE) is a specific type of bone-borne expander that uses 4 miniscrews in the posterior part of the palate with bicortical engagement.[3,31] The advantages of miniscrew-assisted RPE appliances over conventional expanders in achieving orthopedic changes are controversial in the literature. Comparisons between tooth-borne and bone-borne expanders have been published using CBCT technology, and different conclusions were drawn regarding the possibility for generating a greater orthopedic response with miniscrew-supported devices.[29,30] The aim of this investigation was to further evaluate the skeletal changes in the midface