Three-dimensional changes in maxiofacial and alveoler base during rapid maxillary expansion in mixed dentition

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Introduction

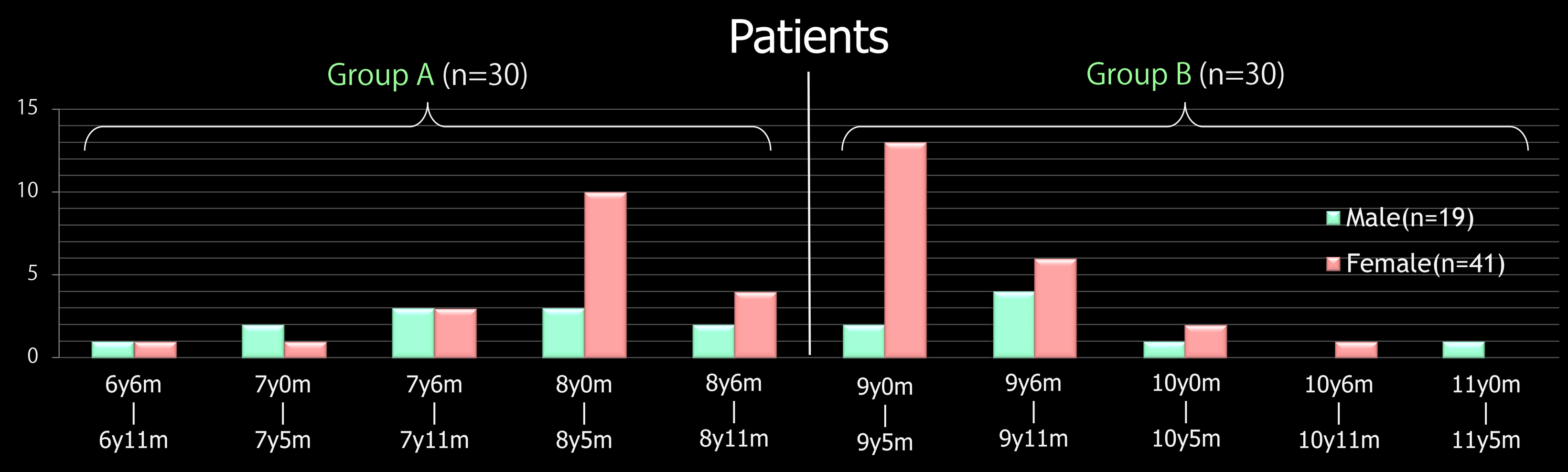
Rapid maxillary expansion (RME) is a major treatment option applied to maintain the eruption space of upper canines and improve anterior crowding in growing children. Numerous Rapid maxillary expanders such as Haas-, Hyrax-, and Minne-type banded appliances are widely used by clinicians. Most expanders not only alter the maxillary arch but also the maxillofacial skeletal complex.

Over the years, many types of maxillary expanders and their effects on facial structures have been studied. Historically, the effects of RME have been evaluated based on conventional lateral and posteroanterior cephalograms, occlusal films, and dental casts. Moreover, there are few three-dimensional studies that have examined the morphological changes in the maxillofacial skeletal complex after RME; therefore, three-dimensional changes after RME are still unclear.

To examine the morphological changes occurring during RME with three-dimensional cone beam computed tomography (3D-CBCT).

Materials & Methods

3D-CBCT were obtained before and after RME in 60 Japanese patients with mixed dentition (mean age: 8y 10m±11.1m), and manipulated using stereotaxic 3D-CT software. Patients were divided into 2 groups based on age.



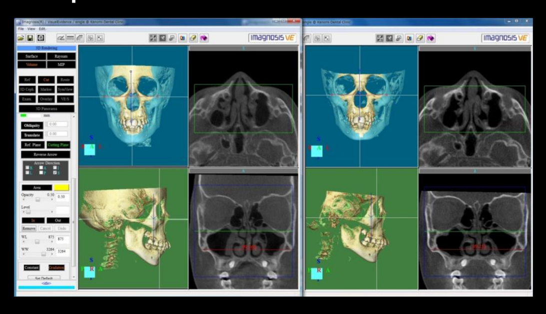
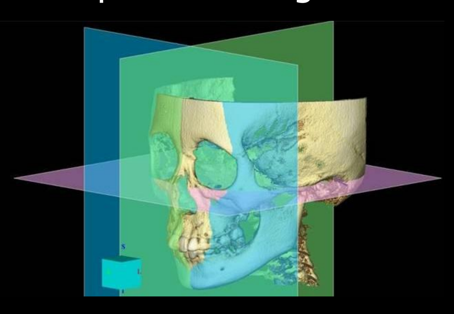
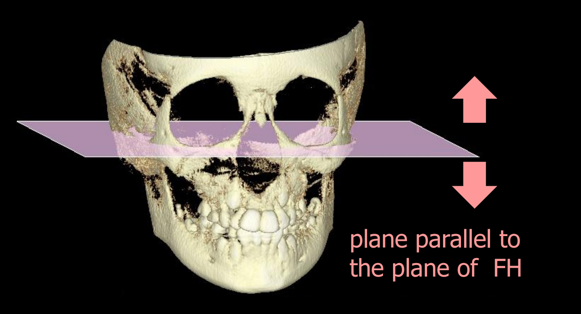
RME protocol

The McNamara type rapid expander was used for all patients. The expansion screw was turned twice a day (0.2 mm × 2/day), and the extent of expansion targeted was set as 5 mm for all patients. The expander was fixed for approximately 4 months after rapid expansion and then removed when bone formation was confirmed by occlusal x-ray. In addition, a lower Bi-Helix was used for all patients simultaneously in order to expand the lower dental arch and coordinate between upper and lower dental arches; upper molar cusps need to interlock with lower molar fossa to prevent the relapse of maxillary expansion.


McNamara Type

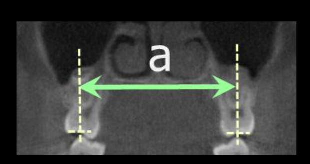
Measurement procedure

The volumetric CT data were analyzed using stereotaxic 3D-CT software. All 3D-CBCT data were repositioned and standardized, and the FH plane was used as the reference plane. The effects of RME were evaluated based on the changes in the 9 transverse distances given below. All parameters were measured and manipulated using stereotaxic 3D-CT software.

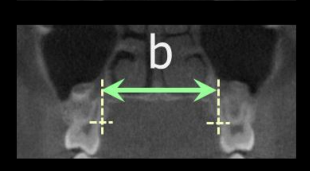




Parameters

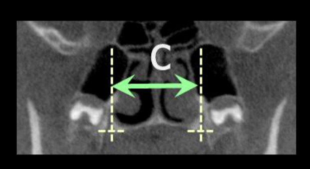
(a) Upper maxillary first molar
Horizontal maxillary dental arch width between central fossa of right and left upper first molars.



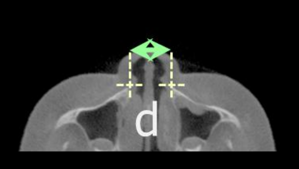
(b) Palatal alveolar crests of upper maxillary first molar
Horizontal maxillary width between palatal alveolar crests of right and left upper maxillary first molars on the coronal image.



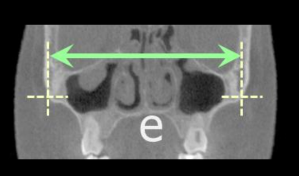
(c) Greater palatine foramen
Horizontal distance between right and left greater palatine foramen on the coronal image sliced at the mesiobuccal cusp of the upper first molars.



(d) Nasal width
Widest horizontal distance between right and left nasal notches on the coronal image.



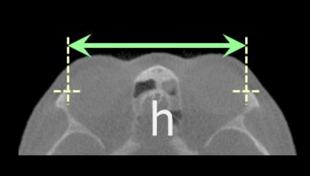
(e) Inferior margin of the zygomaticomaxillary suture
Horizontal distance between right and left zygomaticomaxillary sutures on the coronal image.



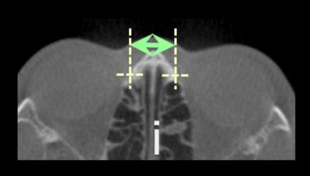
(f) Infraorbital foramen
Distance between the right and left infraorbital foramina on the axial images.

(g) Superior margin of the zygomaticomaxillary suture
Distance between the superior margins of the right and left zygomaticomaxillary sutures on the axial image.

(h) Anterior border of the frontozygomatic suture
Distance between the right and left anterior borders of the frontozygomatic suture on the axial image.



(i) Lateral border of the frontomaxillary suture
Widest horizontal distance between right and left frontomaxillary sutures on the axial image.



Results

N=60	Group A (n=30)				Group B (n=30)				Group A		Group B	
	Pre		Post		Pre		Post		Δ		Δ	
Parameter	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
(a) Upper maxillary first molar	46.3***	1.9	50.7***	1.8	47.0***	3.7	51.1***	4.0	4.4	0.9	4.0	1.3
(b) Palatal alveolar crests of upper maxillary first molar	32.4***	1.8	36.5***	1.9	33.9***	2.9	37.7***	3.1	4.1	0.9	3.8	0.8
(c) Greater palatine foramen	25.3***	1.8	26.6***	1.6	25.6***	2.1	26.7***	2.2	1.3	0.7	1.1	0.5
(d) Nasal width	22.3***	1.5	23.8***	1.5	22.3***	1.7	23.6***	1.7	1.5	0.7	1.3	0.5
(e) Inferior margin of the zygomaticomaxillary suture	81.5***	12.1	83.1***	12.1	86.3*	3.5	87.0*	3.3	1.7**	1.1	0.7**	1.0
(f) Infraorbital foramen	47.4***	3.5	48.5***	3.6	48.3***	3.3	49.2***	3.7	1.1	0.8	0.9	0.6
(g) Superior margin of the zygomaticomaxillary suture	46.8***	3.9	47.7***	3.7	45.8***	4.2	46.7***	4.1	0.9	0.8	0.9	0.7
(h) Anterior border of the frontozygomatic suture	86.1	4.4	86.1	4.1	87.9***	2.9	86.8***	2.9	0.1***	1.4	-1.1***	1.3
(i) Lateral border of the frontomaxillary suture	17.5	3.0	17.6	2.8	16.9	1.8	16.9	1.8	0.1	0.4	0.0	0.4

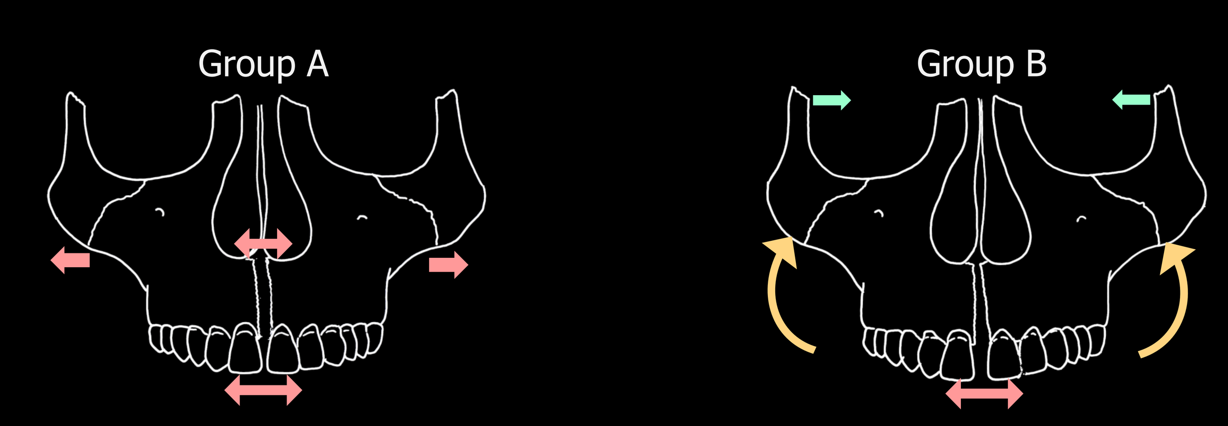
*P<0.05, **P<0.01, ***P<0.001

In both groups, RME resulted in significant expansion of the maxillary arch and maxillofacial skeleton, including the zygomaticomaxillary and zygomaticofrontal sutures.

Group A (n=30)
Significant changes were seen in all areas except at the anterior border of the frontozygomatic suture and the lateral border of the frontomaxillary suture.

Group B (n=30)
Significant changes were seen in all areas except at the lateral border of the frontomaxillary suture.

Comparison between Group A and Group B
Significant differences were seen in the inferior margin of the zygomaticomaxillary suture and the anterior border of the frontozygomatic suture.



Discussion

According to our results, significant reduction was seen in the anterior border of the frontozygomatic suture in Group B, whereas there were no significant differences in Group A. It could be assumed that the maxilla was expanded individually in Group A, but the maxilla and the zygoma were united in Group B. The maxilla would be expanded at the zygomaticomaxillary suture simultaneously in Group A, and the unified maxillo-zygomatic complex was distorted in Group B. Ossification of sutures matures with age, and the maxillofacial skeletal complex could be expanded without distortion in younger children. Expansion without distortion is preferred during clinical treatment; the stability and reliability after RME would thus be improved. Proffit stated that maxillary protraction was more effective under 8 years of age in Class III children. These findings support our results, and it is recommended that skeletal modification be applied in younger children. RME applied in younger children may have more positive effects on the growth of the maxillofacial skeletal complex.

Conclusion

Morphological changes in the maxillofacial skeletal complex after RME differed with age. Ossification of sutures, especially the zygomaticomaxillary suture, would be a key factor in RME. RME is an effective treatment option in younger children, resulting in significant expansion of the maxillary arch and the maxillofacial skeletal complex.

3D-CBCT is a very important diagnostic tool which enables 3D evaluation of the maxillofacial skeleton.

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