Three-dimensional assessment of transverse skeletal changes after surgically assisted rapid maxillary expansion and orthodontic treatment: A prospective computerized tomography study

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Introduction: The aim of this prospective longitudinal study was to evaluate transverse skeletal changes after surgically assisted rapid maxillary expansion. The changes were registered by using a 3-dimensional computerized tomography technique based on superimposition on the anterior base of the skull. **Methods:** The subjects comprised 35 patients (mean age, 19.7 years; range, 16.1-43.9 years). Low-dose, helical computerized tomography images were taken at treatment start and after orthodontic treatment. The 3-dimensional models were registered and superimposed at the anterior cranial base. **Results:** Surgically assisted rapid maxillary expansion had a significant transverse skeletal treatment effect, significantly greater posteriorly than anteriorly. The expansion was parallel anteriorly, but posteriorly there was significant transverse tipping. Although there was no statistically significant difference between the changes at the corresponding landmarks, the range of standard deviations was marked. **Conclusions:** The results showed that, for registering transverse skeletal changes after surgically assisted rapid maxillary expansion, 3-dimensional superimposition is a reliable method, circumventing projection and measurement errors. Surgically assisted rapid maxillary expansion had a significant but nonuniform skeletal treatment effect. Despite careful surgical separation, pronounced posterior tipping occurred. No correlation was found between the severity of tipping and the patient's age. (Am J Orthod Dentofacial Orthop 2012;142:825-33)

Surgically assisted rapid maxillary expansion is used primarily to correct maxillary transverse hypoplasia in skeletally mature patients and has been an accepted modality in orthodontic therapy for many years.[1-7] In principle, the indication is the same as for orthopedic rapid maxillary expansion: malocclusion associated with a narrow maxilla.[8-11] Although the advantages of surgically assisted rapid maxillary expansion are well documented, there is lack of consensus with respect to skeletal efficiency[12-14] and stability.[15-17]

The skeletal and dental effects of surgically assisted rapid maxillary expansion have been evaluated in a number of clinical and radiographic studies.[18-22] In an implant study of orthopedic rapid maxillary expansion in growing patients in 1958, Krebs[23] reported different effects in various zones of the maxilla: dental expansion was greater than skeletal expansion and more pronounced anteriorly than posteriorly. Furthermore, there was more expansion in the alveolar process than in the maxillary base. These findings were eventually accepted as state of the art.[8,24-28]

However, Krebs's results should be extrapolated with caution.[23] Many investigators have tried to verify his conclusions, but their findings have been inconclusive.[29,30]

Both orthodontic and surgical procedures used for surgically assisted rapid maxillary expansion can vary, and the different treatment approaches can affect the treatment outcome.[31] There is lack of consensus among clinicians with respect to achieving a balance between

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extensive surgery for mobilization and a more conservative procedure, with less risk of complications.[32]

In most studies, the results are based on evidence from conventional 2-dimensional cephalometrics, lateral or frontal. Such methods are limited and open to criticism: 2-dimensional cephalometric analysis of a 3-dimensional (3D) structure is subject to errors in projection, landmark identification, and measurements.[33]

In recent years, there have been major advances in computerized tomography and imaging techniques; it is now possible to achieve more precise and accurate data. Rapid, exact axial acquisition offers great potential for sophisticated image analysis. As early as 1982, Timms et al[34] used computerized tomography to analyze treatment outcomes after rapid maxillary expansion in growing patients but concluded that, in addition to the disadvantage of a high dose of radiation, it was difficult to produce valid superimpositions for evaluation. Podesser et al[35] investigated the reproducibility of maxillary structures using computerized tomography and concluded that the patient's position in the scanner was a crucial factor for projection and measurement errors.

To facilitate and standardize the orientation of the 3D images, various landmarks have been proposed.[36] However, the potential errors associated with such landmarks and coordinate systems are not acceptable for superimposition and treatment analysis.[37-39]

Thus, for reliable, quantitative 3D assessment of skeletal changes after surgically assisted rapid maxillary expansion, it is essential to use a superimposition technique that does not depend on landmarks or planes.

The purpose of this study was to evaluate the transverse treatment effects of surgically assisted rapid maxillary expansion, by using a 3D imaging technique and registration based on superimposition on the anterior cranial base.

MATERIAL AND METHODS

The subjects were skeletally mature patients scheduled to undergo surgically assisted rapid maxillary expansion for treatment of a skeletal maxillary transverse discrepancy exceeding 5 mm (Fig 1). According to a power calculation, a priori, the minimum sample size was set at 34 patients, with $\alpha = 0.05$ and power of 80%. Before treatment, all patients were informed of the voluntary basis of their participation in the study. To prevent a sample size not in accordance with the power calculation size, 40 consecutive patients were recruited from the Department of Orthodontics at the Institute for Postgraduate Dental Education, Jönköping, Sweden, and the Department of Dentofacial Orthopaedics, Maxillofacial Unit, University Hospital, Linköping, Sweden. Three patients declined to participate in the study but finished the treatment, and 2 patients had to be excluded because their computerized tomography records were incomplete. The sample thus comprised 35 patients (14 male, 21 female). The mean age at treatment start was 19.7 years (range, 16.1-43.9 years).

Registrations were made a week before surgery in connection with the presurgical examination and at the end of the orthodontic treatment, at a mean of 18 months postoperatively. The distribution of posttreatment registrations was not analyzed in detail but was less than 1 month.

The study was approved by the Research Ethics Committee, Faculty of Health Sciences, Linköping University, Linköping, Sweden (reference, M746-04).

The orthodontic phase of treatment was undertaken at local orthodontic clinics under the supervision of the orthodontic departments in Jönköping and Linköping. The maxillary expansion appliance comprised a toothborne device activated by means of a conventional hyrax expander (Hyrax II; Dentaurum, Ispringen, Germany) with a soldered framework and orthodontic bands (Fig 1, *A*). The appliance was scheduled for insertion as close as possible to the date of surgery. The amount of expansion was calculated for each patient, including a general bilateral overexpansion of half a cusp width. The patients were instructed to activate the jackscrew by 1 turn (0.25 mm) twice a day after a postoperative latency period of 5 days. Postoperative control was scheduled at 12 days postsurgery and included an occlusal radiograph to ensure a clinically symmetrical opening of the midpalatal suture and a medial diastema. At that time, the amount of additional expansion was measured.

After a mean active expansion period of 15 days (range, 11-17 days), with overexpansion of half a cusp, the appliance was used as a passive retainer for 90 days. At that time, the hyrax expander was replaced by a modified transpalatal arch (Fig 1, *B*), and fixed appliance treatment began.

On completion of the active treatment phase, the transpalatal arch was removed, and fixed appliance treatment continued with stiff rectangular archwires to adjust the transverse width and to control and correct the buccal root torque of the molars. All transverse discrepancies were corrected by the end of treatment, at a mean of 18 months postoperatively, and the orthodontic treatment period then concluded. At this point, 26 patients were referred for the second stage of orthognathic surgery (Fig 1, *C*). In the remaining 9 patients, the fixed appliance was debonded, and a Hawley plate was provided as a retainer.

Surgical treatment followed a technique similar to that described by Glassman et al[5] and was undertaken