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The effects of surgical expansion of the maxillary arch and its consequences for the incisor axis

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ABSTRACT

Purpose: Reduced transverse maxillary dental arch width may be treated either by surgically supported rapid maxillary expansion (SRME) with conservative orthodontic appliances or by means of Le Fort I osteotomy (LFIO). Both are means of transverse maxillary expansion.
Methods: Both surgical methods (SRME and LFIO) were evaluated with regard to the presurgical and postsurgical form of the maxillary dental arch and its consequences for the incisor axis by means of 32 dental casts and cephalometric analysis.
Results: In both groups, anterior and posterior dental arch width showed significant changes after surgery, but changes in anterior dental arch width were less significant after LFIO ($p = 0.004$) than after SRME ($p < 0.000$; t-test). Cephalometric analysis (OK1/N1) did not show any significant differences between the two surgical methods ($p = 0.1266$; t-test). Anterior arch length was not reduced after LFIO but significantly reduced after SRME. Thus, the ideal elliptical shape of the dental arch was lost in the SRME group, which may impede esthetic outcome of the maxillary dental arch.
Conclusion: Le Fort I osteotomy achieving direct transverse expansion should be favored over surgically supported rapid maxillary expansion if transverse expansion does not exceed 7 mm.

1. Introduction

Transverse maxillary hypoplasia is a frequent problem that may be caused by endogenous factors (often seen in dolichofacial types [Schopf, 2008]) as well as by exogenous factors, such as hypotonic muscles, adenoid vegetation, hyperplasia of the nasal concha, or mouth breathing (Schopf, 2008; Kahl-Nieke, 2010). Anatomically, the transverse increase in the apical base of the maxilla runs along the median palatine suture. Growth of the hard palate is permanently stimulated in a transverse direction through the support of the tongue behind the upper incisive when the mouth is closed. This way, dysgnathy and obstructive sleep apnea syndrome are avoided (Ashok et al., 2014).

Characteristics of transverse maxillary hypoplasia are narrow dental arches, a high arched palate, and acuminate primary anterior crowding (Knak, 2004). These conditions can either be treated conservatively with an orthodontic appliance or surgically, for instance, by bilateral splitting during Le Fort I osteotomy (LFIO) or by surgically supported rapid maxillary expansion (SRME) during which the maxilla is widened in skeletally matured patients (Lagravere et al., 2006). In the current study, SRME will be compared with two-piece LFIO. The choice of the treatment method depends on several criteria. In SRME, the bony structures are weakened, and the maxilla and the soft tissues are slowly and indirectly expanded by means of orthodontic appliances. In contrast, LFIO achieves direct transverse expansion. SRME involves cutting the bony structure of the zygomatic alveolar crest, the paranasal pillars, and the pterygoid process as well as splitting the median palatine suture. After application of an orthodontic appliance to the maxilla and activation of the screw, heavy orthodontic forces are used to separate the two halves of the maxilla (Isaacson and Ingram, 1964). Postoperatively, the screw must be activated daily to expand the maxilla. In contrast, LFIO involves the down-fracture-technique adapted from Obwegeser that allows direct three-dimensional correction of the maxilla (Hausamen, 2003).

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2. Materials and methods

2.1. Study concept

In this retrospective study, we used 32 maxillary casts of patients who had undergone maxillary expansion at the Department for Maxillofacial Surgery, University Medical Center Regensburg, between 1 January 2005 and 31 December 2009. The patients aged 15 years and above were divided into two groups. The first group consisted of 18 patients (16% men; 41% women) aged 22.2 years on average who had received LFIO therapy with transverse expansion. The second group consisted of 14 patients (31% men; 12% women) aged 27.1 years on average who had received SRME followed by orthodontic treatment and slow transverse expansion. 9 of the 14 patients in group 2 required a second orthognathic surgical intervention, whereby 6 of them underwent bimaxillary orthognathic surgery, two maxilla and one mandible. In general the preoperative casts were custom-built three weeks before the operation took place. The postoperative casts were manufactured after the completion of orthodontic treatment.

2.2. Measurement of anterior and posterior arch width

According to Pont, anterior arch width is the distance between tooth 14 and 24 of the maxilla, and the measuring point is the deepest point of the transverse fissure. Correspondingly, posterior arch width is the distance between tooth 16 and 26 of the maxilla, and the measuring point is the deepest point of the central fossa (Fig. 1) (Harzer, 1999). Measurements were done on the preoperatively and postoperatively manufactured plaster models of each patient with a manual sliding caliper.

The change in dental arch width can be determined by comparing the preoperative and the postoperative value. *diff = post-value − pre-value*.

2.3. Measurement of anterior arch length

According to Korkhaus, dental arch length is the largest distance between the dental arch and anterior arch width and is characterized with L0. A perpendicular could be dropped from L0 to the intersection of the cutting edge of the middle incisors to anterior arch width (Fig. 1) (Kahl-Nieke, 2010). The increase in length can be determined by comparing preoperative and postoperative L0 values. *L0 diff = L0 pre-value − L0 post-value*.

2.4. Cephalometric measurements

The lateral cephalogram of each patient was analyzed by means of the Onyx Ceph® program. For examining the axis arrangement of the front teeth in relation to the jaw, the following calculation was used: *OK1/NL*($70° \pm 5°$).

The angle between the upper middle front teeth (OK1) and the maxilla base (NL) allows the evaluation of the position of the front teeth in relation to the nasal line (Fig. 2).

The angle OK1/NL was measured preoperatively and postoperatively. The standard is $70° \pm 5°$. Deviation of $<70° \pm 5°$ characterizes protrusion and deviation of $>70° \pm 5°$ retrusion of the front teeth.

3. Results

3.1. Transverse modification of the dental arch

3.1.1. Time span between pre- and post-operative cast preparation

The time span between preoperative and postoperative cast preparation varied between both groups. For the SRME group the time range was between 13 and 92 months (average value 36.4 months). For the LFIO group the time range was between 5 and 28 months (average value 10.6 months) (Table 1). In the SRME group intraoperative mounting of the expansion device was performed. Five days after insertion, activation of the device followed. After reaching the desired width, no action was undertaken for three months followed by the shaping of the dental arch, closing the medial diastema. In the LFIO group the occlusal splint in the maxilla was left in situ for six weeks to stabilize the expanded maxilla. Afterwards orthodontic treatment was continued in terms of shaping the dental arch. Postoperative orthodontic treatment equals the time span between operation and cast preparation as the final casts were manufactured at the end of the orthodontic treatment.

3.1.2. Anterior arch width

After surgical intervention, the t-test showed a highly significant change in both groups. A p-value of 0.004 was measured in the LFIO group and a p-value of <0.000 in the SRME group. Considering the shifts in both groups, the ANCOVA test ($p < 0.000$) also showed highly significant changes (Table 2).

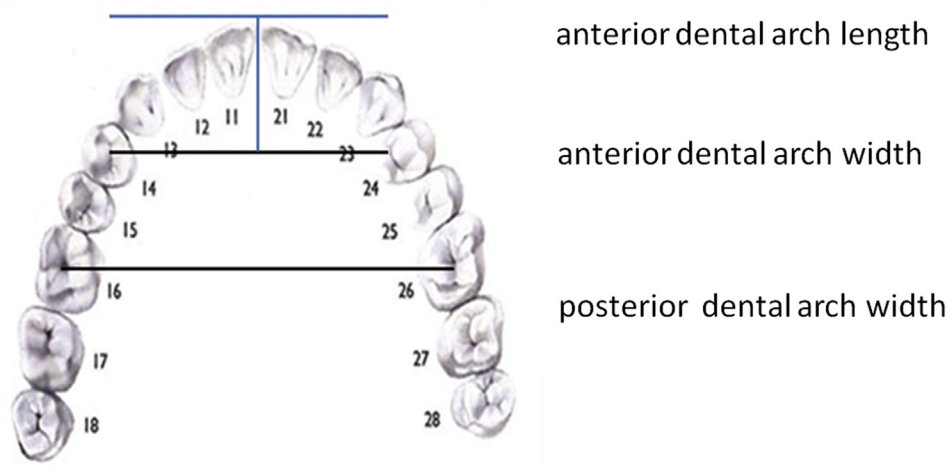

Fig. 1. Points measured to determine anterior and posterior arch width as well as anterior arch length.