Mid-maxillary distraction osteogenesis of cleft patients using a special custom-made tooth-borne device

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Abstract

A relatively new approach to maxillary advancement by maxillary distraction using a combined surgical and modified orthodontic technique is described. This protocol and the technique have been used for the past 3 years (2006 to 2009) on more than 60 patients, aged between 14-29 years. Distraction of between 7 and 18 mm has been achieved, creating class 1 or mild class 2 arch relationships in cleft lip and cleft palate patients who had class 3 arch relationship compounded by significant maxillary retrusion. The technique is simple, inexpensive and less time consuming.

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Introduction

Primary cleft lip and palate repair in infancy has a significant negative impact on mid-facial growth and frequently results in maxillary hypoplasia and a resulting skeletal discrepancy and malocclusion [1]. Nearly 60% of children born with cleft lip and palate will require correction of maxillary hypoplasia while as much as 25% of patients with treated unilateral cleft lip and palate develop maxillary hypoplasia extending beyond the boundaries of conventional orthodontic treatment [2]. The standard treatment is to advance the hypoplastic maxilla through a maxillary osteotomy coupled with pre and post operative orthodontics to align the dental arches [2]. Le Fort I osteotomy is the most commonly reported choice and the osteotomy is potentially capable of correcting maxillary hypoplasia in all three dimensions [3].

The challenges in cleft patients frequently outrun the versatility of the osteotomy technique. Extensive scarring from previous cleft repairs makes it difficult to mobilise the maxilla adequately and the deficient soft tissue matrix, the large advancements and downward repositioning needed increase the risk of post operative relapse [4,5]. Further, the advancement at Le Fort I level has shown to be detrimental to the velopharyngeal closure in cleft patients [6,7].

Distraction osteogenesis (DO), described in 1905 for limb fractures exploits the regenerative capacity of bone to create and maintain an active area of new bone formation in the surgically created gap [8].

Animal studies have confirmed the feasibility of utilising distraction osteogenesis for treating facial skeletal deformities [9]. Distraction osteogenesis has been used to lengthen the human mandible too [10]. Several surgical techniques and distraction devices have been designed for use in the facial skeleton with each method claiming merit over the others. We describe a method of mid-maxillary distraction osteogenesis using a tooth borne custom made device, performed on cleft patients in our unit over the past three years.

Methods

Patients included in this study (n = 60; M:F = 23:37; age range = 14-29 years) had mid facial hypoplasia secondary to repair of cleft lip and cleft palate. All patients had pre-operative cephalometric analysis and a study model assessment in occlusion to quantify the degree of antero-posterior and vertical skeletal and arch discrepancies. A pre-operative speech assessment established a baseline to monitor the effects on the velopharyngeal competence. All patients had pre-operative orthodontics to create surgical space in the arch for osteotomy cuts to be made with ease. Nickel titanium open coil springs were used to achieve the desired root separation preferably between the maxillary second premolar and the maxillary first molar teeth. Where this was not achievable, a space created between the first and second maxillary molar teeth became the alternative choice. Once the separation was deemed adequate, orthodontist designed and constructed a special custom made tooth-borne distraction device, incorporating a Hyrax screw that is routinely used for rapid maxillary expansion (Figure 1). The screw was aligned in the sagittal plane to achieve an antero-posterior vector and was tilted anteriorly to incorporate a downward vector in patients where an increase in vertical height of the maxilla too, was deemed beneficial. The appliance included a molar band and a premolar band on each side for cementing onto the maxillary dentition.

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Figure 1. **Distraction device on the plaster cast model.**

Osteotomy was then performed under general anaesthesia. Bone cuts were made in the orthodontically created gaps. A minimally tunnelled elevation of the palatal mucoperiosteum facilitated the extension of bone cuts through palatal shelves, taking care to preserve the integrity of the palatal mucosa. The vertical cuts on the buccal cortex were directed superiorly and posteriorly to achieve maximum amount of maxillary bone anterior to the bone cuts. In patients with a severely retruded nose, the vertical cuts were directed to reach the infra-orbital margin at the infero-medial corner of the orbital rim and to extend through the nasal bones. The average surgical time excluding induction and recovery from anaesthesia was 45 minutes.

The mid-palatal distraction device was fixed to a pair of maxillary molar teeth (posterior to the bone cuts) and to a pair of premolars (anterior to the bone cuts) on the second post-operative day. Distraction commenced on the 4th or the 5th post-operative day and continued at a rate of 1 mm per day until the desired anterior movement was achieved. In the majority of cases the distraction was continued further to achieve a degree of over correction to compensate for a potential future relapse. The device was left in place for an average of 3 months to serve as a fixator during the consolidation phase (Figure 2). Thereafter orthodontic treatment was continued (Figures 3 and 4). Post-operative lateral cephalometry was performed at 6 months and speech re-assessed at 3 months, 6 months and at one year post-distraction.

Results

All but two patients achieved a positive incisal over-jet and a change from a concave facial profile to a convex profile. Two patients failed to achieve the required distraction and had to undergo a repeat procedure to meet the desired anterior movement. There was no excessive incisal tipping resulting from the distraction. Most patients achieved a more aesthetically pleasing naso-labial angle and in some the nasal tip projection was enhanced (Figures 5 and 6). There was a positive improvement in speech quality in 30% and none had any worsening of their existing velopharyngeal incompetence.

Figure 2. **Distractor fitted on maxillary teeth.**

Figure 3. **Pre-operative occlusion.**

Figure 4. **Post-operative occlusion.**

Figure 5. **Pre-operative profile.**

Figure 6. **Post-operative profile.**

Complications encountered were few. In two patients the molar bands broke during distraction. Four patients developed anterior open bite which was later corrected with inter-arch orthodontic elastics. One patient developed overlapping between buccal and premaxillary segments on the cleft side.

Discussion

The patient convenience and acceptance, flexibility in vector control, reliable long term stability and the preservation of velopharyngeal competence appear to be the key factors in the search for more and more cost-effective methods for maxillary distraction osteogenesis. Rigid external devices (RED) provide greater flexibility in vector control and are capable of achieving greater distraction lengths in all dimensions [11]. They could be easily removed following completion of treatment without resorting to a second surgery. However, they are cumbersome to wear and are aesthetically conspicuous. Bone anchored internal distractors are more aesthetic and less cumbersome to the patient but carries the disadvantage of the need for a second surgery for removal at the end of treatment. Further they lack the versatility of the RED in vector control and the distraction achievable is limited by the length of the screw incorporated in the device. Both, external and internal devices are expensive and need adequate bone above the root apices for safe placement to ensure good anchorage.

Using tooth borne appliances for distraction of the mid maxillary suture is a time-tested technique practiced by orthodontists both in isolation and as a surgically assisted distraction osteogenesis. They are simple to fabricate, easy to anchor onto the dentition and allow flexible vector control during use. Tooth borne devices were claimed to produce tipping movements in anterior teeth and less skeletal movements [12]. A divided opinion exists on the long term stability of results obtained from tooth-born distracters with some being cautious while others optimistic of its value [13,14].

In our study, we were able to achieve significant improvements in facial aesthetics and function for a group of cleft patients with mid facial hypoplasia. The appliance was well tolerated by patients and fitting a second appliance with a longer screw was easily accomplished during the distraction period, should the first appliance prove inadequate to achieve the extent of planned forward movement. We believe that the positioning of the osteotomy cuts in the mid maxillary region instead of the premaxilla, the postero-superiorly directed vertical cuts which maximise the bone in the anterior segment and the innovative designing of the appliance which transmitted the distraction forces through molar and premolar teeth

instead of maxillary anteriors, were the key factors behind achieving effective and stable results with minimal dental tipping. Further the mid maxillary osteotomy and distraction forces employed perhaps had an inadvertent but beneficial reciprocal posterior vector, which could be the reason for improved speech quality witnessed in some of our patients. We feel that our technique is relatively simple, versatile and is cost-effective in addressing maxillary hypoplasia to achieve the desired treatment goals.

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