Segmental maxillary distraction with a novel device for closure of a wide alveolar cleft

Vasilios A. Bousdras, Chandra Liyanage, Michael Mars, Peter R. Ayliffe
Department of Maxillofacial, Great Ormond Street Hospital, London, UK

Address for correspondence:
Mr. Vasilios A. Bousdras, Al. Mihailidi 9, Thessaloniki, 54640 Greece
E-mail: vbousdras@yahoo.com

ABSTRACT

Treatment of a wide alveolar cleft with initial application of segmental distraction osteogenesis is reported, in order to minimise cleft size prior to secondary alveolar bone grafting. The lesser maxillary segment was mobilised with osteotomy at Le Fort I level and, a novel distractor, facilitated horizontal movement of the dental/alveolar segment along the curvature of the maxillary dental arch. Following a latency period of 4 days distraction was applied for 7 days at a rate of 0.5 mm twice daily. Radiographic, ultrasonographic and clinical assessment revealed new bone and soft tissue formation 8 weeks after completion of the distraction phase. Overall the maxillary segment did move minimising the width of the cleft, which allowed successful closure with a secondary alveolar bone graft.

Keywords: Alveolar bone graft, cleft lip and palate, distraction osteogenesis, maxillary cleft, novel distractor

INTRODUCTION

Cases involving reconstruction of hard and soft-tissue as a result of congenital deformities, as in patients with alveolar clefts can be among the most challenging seen in the clinical practice. In recent years, the technique of distraction osteogenesis (DO) has been applied to improve the facial esthetics and correct maxillary atrophy/hypoplasia in patients with alveolar clefts.

New surgical approaches for vertical[1] and horizontal[2] DO have been utilized more recently. Displaced teeth and various degrees of maxillary hypoplasia (horizontal, vertical and transverse dimensions) are seen in patients with cleft lip and palate. Combined orthodontic and surgical care is the standard treatment. Closure of the maxillary alveolar cleft is routinely done with a secondary bone grafting procedure with iliac crest cancellous bone graft around the age of ten, as described by Boyne and Sands.[3] This allows eruption of the non-erupted canine and formation of a one piece bony maxilla.

For cleft patients with severe maxillary deficiency, especially in the vertical dimension, DO has been used as an alternative procedure to augment new bone and mucosa, by creating a controlled fracture.[4] Sato et al.[5] applied distraction (bone borne) with a three-dimensional movement (laterally, inferiorly and medially) for the lateral maxillary segment, which was located particularly superiorly and a large bony defect (14 mm) was present.

Bone borne[6] and tooth-borne[7] distraction devices have been used, based on the anatomic characteristics of the distraction site and operator experience.

This report describes successful treatment of a wide alveolar cleft with initial application of segmental DO, in order to minimize the cleft size prior to secondary alveolar bone grafting. This was considered as the indicated approach in order to minimize risks for soft-tissue break down and graft failure.

THE TOOTH-BORNE DISTRACTOR DEVICE

A custom made distractor was fabricated following impressions of the maxillary arch, in order to mobilize the right (lesser) alveolar bony segment (right canine, 1st and 2nd premolars).
It uses a standard rapid maxillary expander's screw, which is rotated 90° to get antero-posterior (AP) expansion. The unique feature of this device is allowance of movement along a pre-determined rotational axis of distraction along the curvature of the maxillary dental arch.

The device is provisionally fitted to the maxillary teeth, to ensure proper fitting. Following completion of the osteotomy, the device was cemented on the teeth in order to test freedom and full extension of movement. Initially for practical issues during the distraction phase, activation took place at the clinic, while later this was done at home by patient’s mother.

**CASE REPORT**

This paper reports a case of a 16-year-old Caucasian boy with a unilateral cleft lip and palate seen in the Maxillofacial Department at Great Ormond Street Hospital (London) for closure of his wide alveolar cleft. He had undergone repair of his cleft lip and of his cleft palate at the age of 6 and 14 months respectively and his medical history was unremarkable and he was born following full term pregnancy and a normal delivery.

At the age of 8 year deciduous teeth were extracted under a short general anesthetic. Both right and left maxillary canines were present in the arch as he had extensive orthodontic treatment in the past to allow eruption. Radiographs showed absence of the maxillary right central and lateral incisors, which had been extracted due to increased mobility (grade III) following infection.

The maxilla was composed of a lesser (right) and a larger (left) segment with a wide maxillary cleft [Figure 1a and b]. As the right canine was not fully erupted, a total space of 15 mm was measured from mesial surface of the upper right first premolar to mesial of upper left central incisor. The former segment had undergone orthodontic expansion in 2005 in order to move to a more buccal position. An oro-nasal fistula was present.

A secondary alveolar bone grafting procedure was initially declined due to the cleft size and a decision was taken for pre-grafting orthodontics and a segmental distraction approach in order to mobilize the lesser maxillary segment anteriorly to minimize the gap. One year of orthodontic treatment did achieve alignment of the maxillary teeth [Figure 2a and b] and most importantly a 3 mm initial space between the 1st molar and the 2nd premolar in order to minimize risk of dental root injury during the surgery.

Under general anesthesia the right maxillary alveolar bony segment was exposed by a high maxillary sulcus incision, while the attached gingiva covering the crest of the ridge from the maxillary right 1st molar up to the right canine were not reflected. The palatal attached mucoperiosteum was minimally reflected in the area of the papilla between the 2nd premolar and 1st molar, enough to provide access for an osteotome. The aim of this study is to maintain the adequate blood supply to the osteotomized segment.

In order to mobilize the lesser segment a segmental osteotomy and a vertical extension were done with a saw under copious irrigation. The horizontal osteotomy was extending from the cleft site up to the 1st molar area aiming to avoid the roots of the teeth. This cut was done with an inclination of the saw of approximately 45° with the bevel facing the maxillary sinus in order to facilitate the sliding of the alveolar segment during the horizontal/rotational move at the distraction phase. The corticotomy through the buccal and palatal cortical plates was done with a fine fissure bur under copious irrigation between the 1st molar and 2nd premolar teeth aiming to avoid direct injury to the roots of the teeth and also any injury to the palatal mucosa. The segment was completely mobilised by using osteotomes in order to finish the cuts in the vertical segment both buccaly and palatally. Following completion of the osteotomies the distractor was cemented on the teeth and freedom of movement was tested. Patient went home on the next day on oral antibiotics and the overall healing phase was uneventful. No soft or hard tissue complications were noticed.
Following a latency period of 4 days the distraction process was initiated at a rate of 1 mm a day (0.5 mm twice a day) for 7 days, followed by a consolidation period of 12 weeks. The outcome of the distraction was monitored closely with follow-ups every 2 weeks and no complications were noted. Oral photographs taken at the 3rd and 7th day of the distraction stage clearly demonstrate the expansion of the alveolar segment between the 1st molar and 2nd premolar [Figure 3]. The distance from mesial surface of upper right canine to the left central incisor was now reduced to 4 mm.

Healing was uneventful during the immediate postoperative, distraction and consolidation stages. Clinical assessment revealed new bone and soft-tissue formation 8 weeks after completion of the distraction phase [Figure 4]. This was confirmed by ultrasonography [Figure 5]. After 2 months, the distractor was finally removed.

Overall there was new bone and attached gingival formation in the right maxillary segment of 7 mm (overall distance between mesial root first molar up to root of premolar is 10 mm, but 3 mm distance was created with pre-distraction orthodontics). The width of the cleft was now minimized (4 mm) and was closed with a secondary alveolar bone graft with iliac crest cancellous bone. Healing was uneventful with no fistula present.

Finally, orthodontic tooth movement (right canine) in the grafted cleft and restorative adjustment of the canine to make a lateral incisor, were scheduled for eliminating the dental space. Dental implants into the newly formed alveolar bone (right maxilla) can replace the posterior missing teeth in the future.

**DISCUSSION**

Cases involving reconstruction of hard and soft-tissue as a result of congenital deformities, as in patients with clefts, can be among the most challenging seen in clinical practice. Clefts of the lip and palate are often associated with midface deficiency and surgical closure might have inhibitory effects on craniofacial growth and development. In recent years, the technique of DO has been applied to improve facial esthetics and correct maxillary atrophy/hypoplasia in patients with alveolar clefts.

DO aims to augment new bone and mucosa by creating a controlled fracture for treatment of cleft patients. The advantage of increased bone turnover during the activation phase guarantees successful outcome because of the young age of these patients. In this young patient, this was achieved by vertical and horizontal osteotomies in order to mobilise and horizontally advance the maxillary segment anteriorly to minimize the alveolar cleft. So far, only a case of treating a patient who was missing the pre-maxillary segment had been reported in the literature with application of bone transport distraction to close a large oro-nasal fistula. A portion of the residual pre-maxillary/palatal segment had been transported anteriorly with a modified palatal expansion device.

The surgical approach followed in this case was different in that the maxillary alveolar segment was distracted/rotated mesially along the curvature of the dental arch, in order to decrease the size of the wide cleft. A minimally invasive surgical approach was followed through an intraoral sulcus incision. Via tunnelling techniques, minimal periostea...
stripping on the buccal cortex and non-stripping on the palatal cortex sufficient blood supply did ensure viability of the osteotomized segment. The distractor was then cemented on the maxillary teeth.

A novel custom made distractor was fabricated especially to allow movement of the alveolar segment along the curvature of the maxillary arch. Its novelty consists on having one rigid arm stabilised on the non-distracted maxillary segment, which makes it applicable to unilateral clefts. Others have also applied segmental distraction in terms of orthodontic forces supplied by nickel-titanium arch wires for bony transport.[7] Moreover, in other studies[4,6] missing teeth were replaced with transplantation, however National Health Services in the UK are unique, as they offer implant treatment free of charge in patients with congenitally missing teeth and associated disorders. The device was economic to fabricate (orthodontic lab) and easy to be used by the parent. The only limitation was the necessity for the orthodontist to be present in the operating theater for testing and finally cementing the device pre- and intraoperatively.

Direction, rate and quality of the osteogenetic process were precisely monitored as confirmed by ultrasound imaging [Figure 5]. The latter appeared to be a valid alternative in overcoming the main limitation of the X-ray, by detecting the active process of bone formation.[9] The ultrasound probe used had a range of wave emission from 7 to 13 MHz.

Certain parameters have to be ensured in order to safeguard success of this technically demanding approach:  
• Good quality/health and appropriate angulation of abutment teeth for distractor attachment  
• Occasionally space creation between teeth in order to facilitate the vertical bony cut may be difficult and unpredictable with unfavorable tipping of the root apices  
• Risk of damaging the roots and/or periodontium during the segmental osteotomies  
• Close monitoring to ensure proper device function and notice breakdowns or uncementing, which could lead to unfavourable early consolidation of the distraction regenerate.

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