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British Journal of Oral and Maxillofacial Surgery 54 (2016) 757–761

BRITISH Journal of Oral and Maxillofacial Surgery

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Biomechanical evaluation of different fixation systems after Le Fort I osteotomy in polyurethane models of unilateral clefts

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Accepted 19 April 2016
Available online 12 May 2016

Abstract

We compared the stability of three different titanium plate-and-screw fixation systems after Le Fort I osteotomy in polyurethane models of unilateral clefts. Thirty-six models were divided into 3 groups. In the first group, we adapted standard Plates 1 mm thick with 2.0 mm screws and placed them bilaterally on the zygomatic buttress and the piriform rim. In the second group, we did the same and added Plates 0.6 mm thick with 1.6 mm screws between the standard 2 mm miniplates on both sides. In the last group, we placed Plates 1.4 mm thick with 2.0 mm screws bilaterally on the maxillary zygomatic buttress and piriform rim. Each group was tested in the inferosuperior (IS) and anteroposterior (AP) directions with a servo-hydraulic testing unit. In the IS direction, displacement values were not significantly different up to 80 N, but between 80 and 210 N, those in the 2 × 1.4 mm group were better. In the AP direction, displacement values were not significantly different up to 40 N, but between 40 and 180 N, they were better in the standard with 1.6 × 0.6 mm group and the 2 × 1.4 mm group. When normal biting forces (90 - 260 N) in the postoperative period are considered, the greatest resistance to occlusal loads was seen in the 2 × 1.4 mm group. In the others, the biomechanical properties were better in the AP direction.

Keywords: Cleft palate; Le fort osteotomy; Orthognathic surgery; Skeletal stability

Introduction

The craniofacial morphology of patients with cleft lip and palate (CLP) is different from that of those without clefts. The profile of adults who have had repair of an isolated cleft palate is characterised by general retrusion relative to the cranial base that involves the nasal bone, maxilla, and mandible.[1]

Maxillary deficiencies in patients with and without clefts are usually corrected by Le Fort I osteotomy. However, in those with clefts, previous scar tissue or pharyngoplasty, the severity of the deformity, and the presence of pharyngeal flaps or grafts, can lead to skeletal instability and relapse after operation.[2,3] As instability and relapse can also depend on mobilisation, orthodontics, and the operating surgeon, the technique used for fixation is vital.[4] Different miniplates have been used, but to our knowledge, their effectiveness alone has not been reported, and we know of few biomechanical studies on fixation after Le Fort I osteotomy in patients with clefts.[5]

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http://dx.doi.org/10.1016/j.bjoms.2016.04.019

Fig. 1. Standard titanium L-shaped miniplates 1 mm thick and 2.0 mm diameter screws adapted and placed bilaterally (2 × 1 mm group).

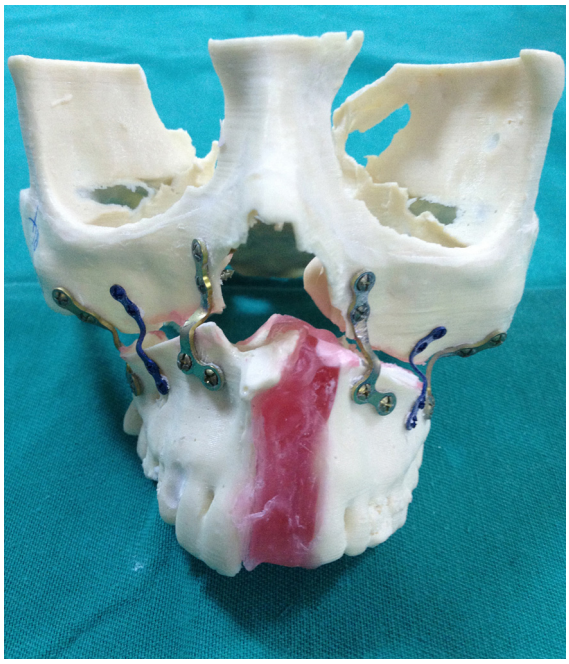

Fig. 2. Microplates 0.6 mm thick with screws 1.6 mm in diameter added between the standard L-shaped miniplates on both sides (1.6 × 0.6 mm group).

We therefore compared the stability of three different titanium plate-and-screw fixation systems after Le Fort I osteotomy in polyurethane models of unilateral clefts.

Material and methods

We used slices from a 3-dimensional computed tomogram of a patient with a unilateral cleft to make 36 polyurethane skulls. Before conventional Le Fort I osteotomy, we filled the clefts with wax to advance the maxillary segments in a single piece and to simulate alveolar bone grafts. We made a palatal splint to cover the maxillary teeth.

All the cuts were standardised with reference to certain anatomical landmarks such as the medial and distal orbital wall, the zygomatic buttress, and the teeth. After positioning the excised maxilla uniformly using reference lines along the lateral wall of the maxilla, we advanced it 7 mm and fixed it to the skull with a utility wax strip. We also used the wax strip to leave a 3 mm gap between the maxillary segment and the base of the skull to prevent bony contact and to allow us to measure the strength of the plates.

We divided the 36 models into 3 groups. In the first group (A), we adapted standard 4-hole, L-shaped titanium miniplates 1 mm thick from a standard 2 mm miniplating system and placed them bilaterally on the zygomatic buttress and piriform rim (Fig. 1). In the second group (B), in addition to the standard titanium plates, we placed a 1.6 mm microplating system with 4-hole titanium microplates 0.6 mm thick between the L-shaped miniplates on both sides (Fig. 2). In the last group (C), we used a 2 mm miniplating system with L-shaped titanium Plates 1.4 mm thick and placed them bilaterally on the zygomatic buttress and piriform rim (Fig. 3) (all systems Trimed Titanium Implant System, Trimed Ucmed Medical Ltd, Ankara, Turkey). We applied load forces in the inferosuperior (IS) and anteroposterior (AP) directions.

Fig. 3. L-shaped titanium Plates 1.4 mm thick with 2.0 mm diameter screws placed bilaterally on the zygomatic buttress and the piriform rim (2 × 1.4 mm group).