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Mechanical evaluation of six techniques for stable fixation of the sagittal split osteotomy after counterclockwise mandibular advancement

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Abstract

We have evaluated the resistance to displacement of six stable methods of fixation of a sagittal split ramus osteotomy (SSRO) in the mandibular advancement with counterclockwise rotation. We tested 60 synthetic hemimandibles in six groups of 10 each: Group I – fixation with a straight four-hole 2.0 mm miniplate; Group II – a straight six-hole 2.0 mm miniplate; Group III – two straight 2.0 mm four-hole miniplates; Group IV – an eight-hole 2.0 mm (grid plate); Group V – a 2.0 mm four-hole straight miniplate and 2.0 × 12 mm bicortical screw; and Group VI – a straight four-hole 2.0 mm locking miniplate. We applied a linear force in the region between the canine and the first premolar using a universal testing machine (EMIC- DL2000) with a loading cell of 10 KN. The loads at 1, 3, and 5 mm displacement were recorded (N) and the data transmitted from the load cell to a computer. Results were analysed using analysis of variance (ANOVA) ($p < 0.001$) and the Tukey post-test for comparison of the significance of the differences between the groups. For the three degrees of displacement, fixation with two straight 2.0 mm plates and with the grid plate gave higher load values.

Keywords: Rigid internal fixation; Sagittal split ramus osteotomy; Bone plate

Introduction

The mandibular sagittal split osteotomy is one of the most common operations for the correction of dentofacial deformities that directly or indirectly affect the mandible.[1] It is versatile because it results in wide contact between the cut segments, which favours healing and stability and allows precise and adequate stable internal fixation. This eliminates the need for intermaxillary fixation, reduces the risk of postoperative aspiration, and facilitates recovery of chewing. It leads to improved oral hygiene and better quality of life for patients during the immediate postoperative period.[2]

Stable fixation of a bilateral sagittal split osteotomy (BSSO) usually involves bicortical screws or miniplates with monocortical screws. Previous studies have shown that fixation with bicortical screws tends to be more rigid and less susceptible to deformation than with a monocortical plate.[4,5] However, other studies have suggested that there is no

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significant difference between the strength of bicortical fixation and a miniplate with monocortical screws.[6,7] To maintain the advantages of the miniplates and monocortical screws, and increase the rigidity of fixation, some authors have proposed insertion of a supplementary bicortical screw in the retromolar region. This is known as "the hybrid technique".[8]

Currently, the use of the locking miniplate/screw systems is thought to minimise displacement of the segments of bone and improve primary and secondary stability. It also avoids excessive compression of the plate and screw against the cortical bone that could result in localised osteolysis.[9]

BSSO of the mandible with counterclockwise rotation was traditionally considered the least stable treatment and, if the fixation material was not strong enough, early relapse was possible.[9] To better understand the biomechanics of fixation of a SSO and to improve fixation, experiments are often used to quantify and evaluate it. However, the ideal method has not yet been established. Specifically, we know of few studies on the mechanical evaluation of stable fixation of BSSO for counterclockwise advancement because most studies have focused on mandibular advancement or setback without rotation.[3,11]

The aim of this study therefore was to compare the biomechanical stability of six methods of osteosynthesis after BSSO of the mandible for counterclockwise advancement.

Material and Methods

We used 60 polyurethane replicas of a hemimandible. To obtain standardisation of the BSSO the operation was done on one replica hemimandible using the modification described by Epker.[10] Sixty, two-segment, polyurethane samples were then produced from that sectioned hemimandible (Nacional Ossos, Jaú, Brazil) for mechanical tests. The experimental specimens were divided into six groups with 10 hemimandibles in each, according to the fixation method used (Fig. 1). The groups are described in Table 1.

The repositioning simulated a mandibular advancement with counterclockwise rotation of the mandible. Acrylic guides were used to standardise repositioning, which measured 8 mm of advancement at the upper border and 11 mm

Table 1
Details of groups studied (n = 10 in each).

Group No.	Method of fixation
I	One four-hole (two proximal and two distal) standard miniplate fixed with standard screws measuring 2.0 × 6.0 mm
II	One six-hole (three proximal and three distal) standard miniplate fixed with standard screws measuring 2.0 × 6.0 mm
III	Two four-hole (two proximal and two distal) miniplates fixed with standard screws measuring 2.0 × 6.0 mm
IV	One eight-hole (four proximal and four distal) grid miniplate fixed with standard screws measuring 2.0 × 6.0 mm
V	Hybrid technique, using one four-hole (two proximal and two distal) standard miniplate fixed by standard screws and a single 12 mm bicortical screw on the proximal segment 5 mm distal to the second molar and below the upper mandibular border
VI	One four-hole (two proximal and two distal) locking miniplate fixed with locking screws measuring 2.0 × 6.0 mm

Fig. 1. Experimental design showing different fixation systems in groups I-VI.