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In vitro study of a modified sagittal split osteotomy fixation technique of the mandible: a mechanical test

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Abstract. This study was performed to evaluate the compressive mechanical strength of rigid internal fixation (RIF) using 1.5-mm L-shaped plates fixed with monocortical screws in sagittal split osteotomy (SSO). Thirty synthetic hemimandibles, which had all undergone a 5-mm advancement, were divided into three groups: three 12-mm bicortical titanium screws were placed in an inverted L pattern in group A; one straight 2.0-mm system spaced titanium plate fixed with four 5-mm monocortical screws was used in group B; two 1.5-mm system L-shaped titanium plates, each fixed with four 5-mm monocortical screws, were used in group C. The models were subjected to compressive and progressive mechanical tests with forces applied in the area between the second premolar and first molar to verify resistance in Newtons (N). A displacement speed of 1 mm/min was applied, with a maximum 10 mm displacement of the distal segment or until disruption of the fixation. The deformity and/or eventual rupture of the plates were evaluated, and consequently their technical stability was determined. The results showed that the modified fixation technique tested in this study on synthetic mandibles resulted in adequate stability and superior mechanical behaviour compared to simulated osteosynthesis with the use of a straight 2.0-mm titanium plate.

Key words: sagittal split osteotomy of the mandibular ramus; fracture fixation; material resistance.

Accepted for publication

Surgical procedures for dentofacial deformities are recommended in clinical situations in which the deformity cannot be corrected by orthodontic treatment alone. In such situations, surgical realignment of the maxilla or repositioning of the dentoalveolar segments is the only possibility for restoring function and aesthetics[1]. This surgical procedure has three main benefits: improved dental and facial aesthetics, better occlusal functioning, and psychosocial improvement, resulting in better quality of life[2]. The sagittal split osteotomy (SSO) of the mandible has been the preferred surgical technique for most

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oral and maxillofacial surgeons performing procedures aimed at correcting mandibular skeletal discrepancies[3].

Osteosynthesis methods in orthognathic surgery have been investigated and discussed in the literature, and studies have used either mechanical or virtual finite element models. Nevertheless, there is no consensus regarding the best bone fixation technique and the choice is based on the personal preference and experience of the surgeon[4–7].

Although it has been stated in the literature that biomechanical testing is best conducted on the human mandible, many authors have recommended the use of synthetic materials for ethical and legal reasons . These materials, used for in vitro laboratory tests, are mandible-shaped and usually made of polyurethane[6–8].

Taking these principles into consideration, the aim of this study was to evaluate the compressive mechanical strength of rigid internal fixation (RIF) using 1.5-mm system L-shaped plates fixed with monocortical screws in SSO.

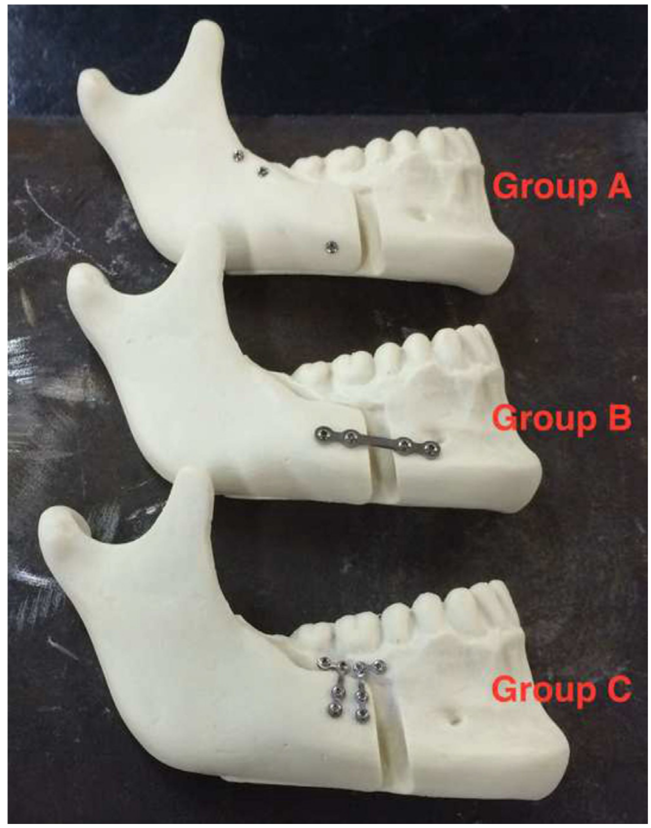

Fig. 1. Illustration of the simulated osteosynthesis methods used in the study.

Materials and methods

Sample selection

Thirty synthetic polyurethane hemimandible replicas, with an SSO included by the manufacturer (Nacional Ossos, Jau, SP, Brazil), were used for this study. The sample size calculation was based on the studies of Özden et al.[5] and Pereira Filho et al.[9].

The design of the SSO of the mandible was standardized and based on criteria proposed by Epker[10]. A horizontal osteotomy was performed above the mandibular lingula and an SSO was performed on the mandibular anterior ridge. The modified Epker technique used in this study aimed to extend the horizontal–lateral mandible osteotomy as far as the mesial area of the first molar. From that point, a third osteotomy was performed vertically in the mandibular body, extending at a perpendicular right angle towards the mandibular base. As a result, it was possible to perform the sagittal separation of the mandibular ascending ramus from the posterior part of the mandibular body, thus allowing a 5-mm advancement.

All samples belonged to the same lot so as to eliminate variables resulting from the manufacturing process of the replicas.

Sample preparation

All of the hemimandibles were subjected to Wolford's modified osteotomy[11] and a 5-mm advancement of the distal segment, measured with a millimetre rule. They were then divided into three groups with 10 hemimandibles in each ($n = 10$). All specimens were fixed by the same surgeon. Group A hemimandibles were allocated to simulated osteosynthesis with three bicortical 12-mm titanium screws (HealTech Ltda, Porto Alegre, RS, Brazil) in an inverted L shape (Fig. 1). Group B hemimandibles were allocated to simulated osteosynthesis with a straight 2.0-mm system spaced titanium plate (HealTech Ltda) fixed with four monocortical 5-mm screws in the osteotomy area, to bring the proximal and distal stumps closer together (Fig. 1). Group C hemimandibles were allocated to simulated osteosynthesis with two 1.5-mm system L-shaped titanium plates, with each plate fixed with four 5-mm monocortical screws (HealTech Ltda) for a total of eight screws in the anterior SSO, four located in the segment and four in the proximal stump (Fig. 1) .

Load tests

The hemimandibles were subjected to compressive mechanical testing to simulate masticatory force using an Instron DL3000 universal testing machine (Fig. 2). The forces were applied between the second premolar and first molar. The equipment was programmed to check resistance in Newtons (N) during progressive loading at a displacement speed of 1 mm/min for up to 10 mm maximum displacement from the distal segment, or until disruption of the system sample. The equipment was automatically set to halt the compressive strength process in the event of rupture of the model. All laboratory testing was done by a single operator. Using this methodology, it was possible to verify any deformities and/or rupture of the plate and consequently to determine the stability of the technique.

Statistical analysis

Data were entered into a Microsoft Excel 2007 worksheet table and then subjected to analysis of variance (ANOVA) with the Tukey–Kramer post-test using GraphPad InStat for Windows version 3.1 (2009) software (GraphPad Software, Inc., San Diego, CA, USA).

Results

Table 1 shows the values of the maximum load required for a 10-mm distal fragment