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Comparative biomechanical study on three miniplates osteosynthesis systems for stabilisation of low condylar fractures of the mandible

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Abstract

Open reduction and fixation of low condylar fractures of the mandible can be achieved by many osteosynthesis systems that differ in size, shape, and site of placement according to the surgical approach. We investigated the maximum load and rigidity of 4 osteosynthesis systems: the standard double 4-hole straight miniplates, the inverted y-miniplate (with and without self-drilling screws), and the TriLock Delta condyle trauma plate. The standard double 4-hole straight miniplate osteosynthesis achieved the best fixation and resistance in view of a mean (SD) maximum load of 539.8 (100.2) N, followed by the inverted y-miniplate with the self-drilling screws (246.5 (23.8) N), the inverted y-miniplate with standard screws (242.4 (27.2) N), and finally the TriLock Delta plate (167.4 (39.2) N). Analysis of the slope of the force–displacement diagram from 80 N to 100 N in each group showed that the TriLock Delta miniplate had the highest values for rigidity (17.3 (5.1) N/μm), followed by the inverted y-miniplate groups with self-drilling screws (14.1 (6.4) N/μm), and with standard screws (12.6 (2.5) N/μm). The double 4-hole straight miniplate osteosynthesis had the lowest rigidity (8.7 1.4) N/μm). Despite the significant difference in the maximum load between the double 4-hole miniplates and other investigated osteosynthesis patterns, all groups had sufficient load for the fixation of low condylar fractures of the mandible when postoperative bite forces and the slowly increasing voluntary clenching during healing were considered.

Keywords: Condylar fracture; Maximum load; Miniplates; Osteosynthesis; Rigidity

Introduction

Open reduction and fixation for low condylar fractures of the mandible is a standard procedure in most hospitals, including ours, for treatment of fractures with a deviation of 10–45°, or a shortening of the ramus by more than 2 mm.[1] The aim is reconstruction of the vertical height of the mandibular ramus and restoration of habitual occlusion, as well as normal function of the temporomandibular joint.

To achieve sufficient osteosynthesis in this region, many systems have been introduced and reported to bear the expected load applied on the fracture site. For this purpose 4 main designs of miniplate are currently available: standard straight 4-hole plates as single or double osteosynthesis,[2–4] the TriLock Delta condyle trauma plate,[5] the trapezoid plate,[6] and the reinforced 3-dimensisonal rectangular plate.[7] Lag screws such as Eckelt's[8] are also used to stabilise such fractures.

A recently introduced inverted y-plate, mainly developed for open reduction and fixation by a transoral approach,

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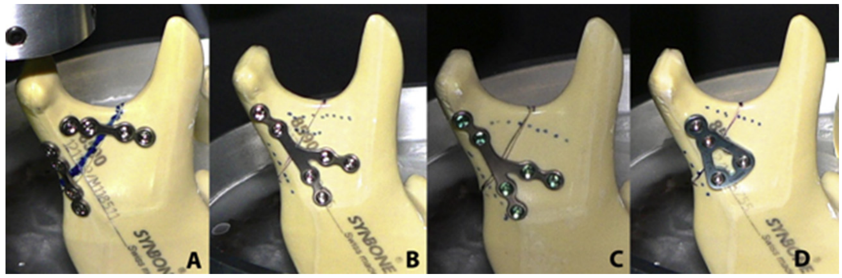

Fig. 1. Design of different osteosynthesis systems for the biomechanical evaluation: (A) standard double 4-hole straight miniplates; (B) inverted y-miniplate; (C) inverted y-miniplate with self-drilling screws; (D) the TriLock Delta miniplate.

combines the advantage of the standard 2-plates design in the caudal part, but works with one arm in the spongy condylar fragment.

To assess the biomechanical stability of this new plating system we compared the stability of fragments fixed with it with the results using 2 other systems also used in the transoral approach: the standard double straight 4-hole miniplates and the TriLock Delta condyle trauma plate.

Material and methods

Design of the study

Forty synthetic bony mandibles (Synbone® – 8590 Mandible, SYNBONE AG Malans, Switzerland) were divided into four groups ($n = 10$ in each). The fracture line was marked according to the classification of condylar fractures suggested by Krenkel[9] and Loukota et al.[10] and adapted by Meyer et al. in numerous biomechanical studies.[7] Briefly, an oblique line was drawn from the middle of the mandibular notch to the dorsal border of the ramus at a point measuring half the distance between the condyle and the angle.

Osteosynthesis was with standard double 4-hole straight miniplates, with the inverted y-miniplate (with and without self-drilling screws' length = 7 mm, Ø = 2 mm) all from Medicon®, Tuttlingen, Germany, or with the TriLock Delta condyle trauma plate (screws' length = 7 mm, Ø = 2 mm) (Medartis ®, Basel, Switzerland) (Fig. 1).

Afterwards the miniplates and screws were removed and a standard osteotomy done using a 100 μm diamond band saw (Exakt 310, Exakt, Norderstedt, Germany). The resulting gap between segments was 300 μm. To achieve precise repositioning a self-curing modelling compound with a corresponding impression of the fragment's surface of the mandible was used (Fimo Air, Staedler, Nürnberg, Germany). For biomechanical investigation miniplates and screws were

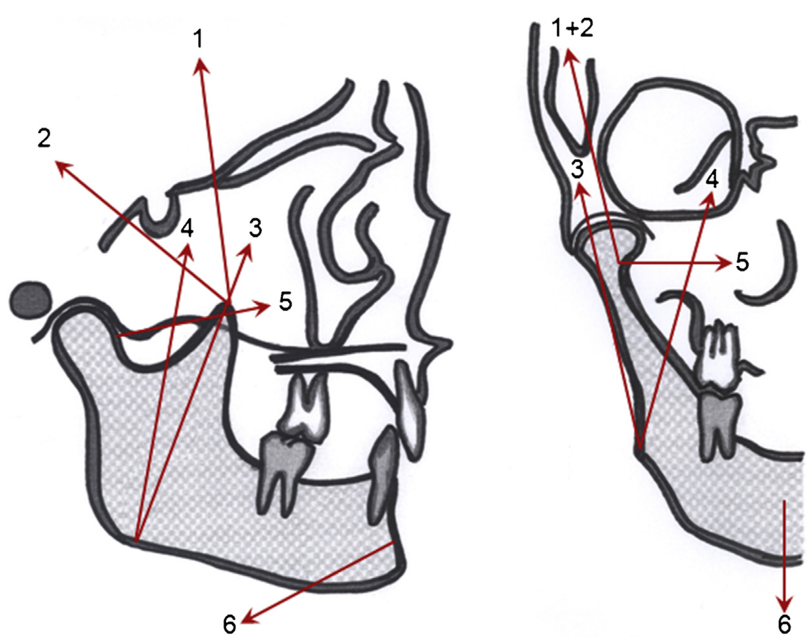

Fig. 2. Orientation of the muscle vectors according to Hart et al.[25] and Korioth and Hannam.[20] 1 = anterior bundles of the temporalis muscle; 2 = posterior bundles of the temporalis muscle; 3 = masseter muscle; 4 = medial pterygoid muscle; 5 = lateral pterygoid muscle; and 6 = suprahyoid muscles.[11]