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Does fixation method affects temporomandibular joints after mandibular advancement?

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ABSTRACT

Purpose: Sagittal split ramus osteotomy (SSRO) is a standard procedure in which miniplates and screws are used to achieve stabilization. Although the titanium plate and screw fixation system is stable, resorbable fixation systems are also used. There is currently no consensus on the ideal fixation technique for SSRO procedures and its effect on the condyle. We aimed to evaluate the stress distribution on temporomandibular joints (TMJ).

Methods: A 3D finite element model of a hemimandible was designed and 5 mm advancement was simulated on a computer model. Four different fixation techniques were applied: inverted-L shaped bicortical screws, L-shaped bicortical screws, miniplate with monocortical screws, and miniplate with monocortical screws and bicortical screw. Computer models were prepared twice for resorbable and titanium material. Load of 600N and muscle forces were applied. In the finite element analysis, computer models simulated and analyzed stress distribution of bone, fixation materials and condyle.

Results: Bicortical screws increase the total stress on TMJ, and the stress is located more on the posterior part than the anterior. Miniplates decrease the stress, and the forces are located more on the anterior aspect of the TMJ.

Conclusion: According to our analysis, the use of bicortical screws increases the stress amount on the condyle. For the patients with a tendency toward temporomandibular disorders, using miniplate fixation techniques may decrease the forces around the condyle. These findings should be useful for oral surgeons when deciding on the most appropriate fixation technique in patients with a tendency toward temporomandibular joint disorders.

1. Introduction

Bilateral sagittal split osteotomy is one of the most common procedures among orthognathic surgery operations (Watzke et al., 1990). The introduction of modern devices for internal fixation substantially shortens the duration of intermaxillary fixation (IMF) or even obviates it (Sato et al., 2012b). Rigid internal fixation (RIF) of the SSRO has greatly increased the acceptance of mandibular surgery because patients no longer have to undergo a period of IMF (Ellis and Esmail, 2009). Miniplates and screws stabilize the proximal and distal segments after osteotomy to achieve fast bone healing, avoid postoperative IMF, and initiate early postoperative mandibular function and oral hygiene.

Changes in condylar position and TMJ loading during surgical maxillomandibular advancement have been associated with postsurgical condylar remodeling, resorption, and instability of the surgical correction (Nebbe et al., 1999; You et al., 2011; Yang et al. 2012).

The RIF has some disadvantages such as displacement of the condyle from the fossa and irreversible nerve damage due to the applied compression with miniplates and lag screws (Sato et al., 2012b). Recently, many surgeons have been using the hybrid technique, which was initially proposed by Schwartz and Relle (1996) to combine the advantages of fixation with bicortical screws and miniplates with monocortical screws.

The use of resorbable materials to stabilize the maxillofacial skeleton has been reported recently (Bos et al., 1987; Bessho et al., 1997; Edwards et al., 2001; Yang et al., 2013). Here, there is no need for a second operation to remove the implant. However, several problems remain including mechanical weakness (Takizawa et al.,

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1998), late foreign body reactions, osteolytic change, and the micro movement of bone due to a low initial stability (Donigian et al., 1993; Ahl et al., 1994).

Poly-L-lactic acid (PLLA) is one of the several absorbable materials that have been used for fixation after SSRO. PLLA miniplates promote osteosynthesis of the oral and maxillofacial skeleton, and PLLA screws have been used in patients undergoing orthognathic surgery (Harada and Enomoto, 1997; Ueki et al. 2005, 2006).

Relapse after osteotomy is common and has an incidence as high as 50% (Ardary et al., 1989). Movement at the osteotomy site is the main cause of relapse. According to some authors, the use of miniplates or screws can prevent or at least reduce the incidence of relapse. Different fixation methods including miniplate and lag screws have been compared in numerous studies—some with contradictory results (Van Sickels and Flanary, 1985; Thomas et al., 1986; Watzke et al., 1990).

RIF has been used for more than three decades in orthognathic surgery since the classic work of Spiessl, but there is no international consensus about the ideal rigid fixation technique of choice for SSRO. Many surgeons base their decisions about the fixation methods on their own clinical experience (Sato et al., 2012b).

Table 1
Elements and nodes amount.

5 mm advancement	Elements	Nodes
M	100877	29689
L	100134	23302
IL	100682	23384
H	106724	29922

Here, our aim is to determine the risk of TMJ disorders depending on fixation technique used for the stabilization of SSRO advancement surgeries, and to determine the most appropriate, secure and resistant fixation techniques and increase the success of these procedures.

2. Materials and methods

A three-dimensional virtual model of the mandible was constructed by VRMesh software using three-dimensional computed tomography DICOM data with 0.5-mm-thickness cut. The virtual model of the mandible consisted of the outer circumferential cortical layer and the inner cancellous layer (Table 1). For boundary conditions of this three-dimensional finite element analysis (FEA), the mandibular condyles of both sides were regarded to be rigidly fixed. After 5 mm advancement, the SSRO of the mandible with Obwegeser Dal-Pont modification was performed virtually. Fixation between the proximal and distal segments of the mandible was performed with 7 different techniques:

- 4 hole miniplate with four monocortical screws (M) (Fig. 1)
- 4 hole miniplate with four monocortical screws and a titanium bicortical screw (H) (Fig. 2)
- 4 hole miniplate with four monocortical screws and a resorbable bicortical screw (HR)
- 3 L-shaped titanium bicortical screws (L) (Fig. 3)
- 3 L-shaped resorbable bicortical screws (LR)
- 3 inverted L-shaped titanium bicortical screws (IL) (Fig. 4)
- 3 inverted L-shaped resorbable bicortical screws (ILR)

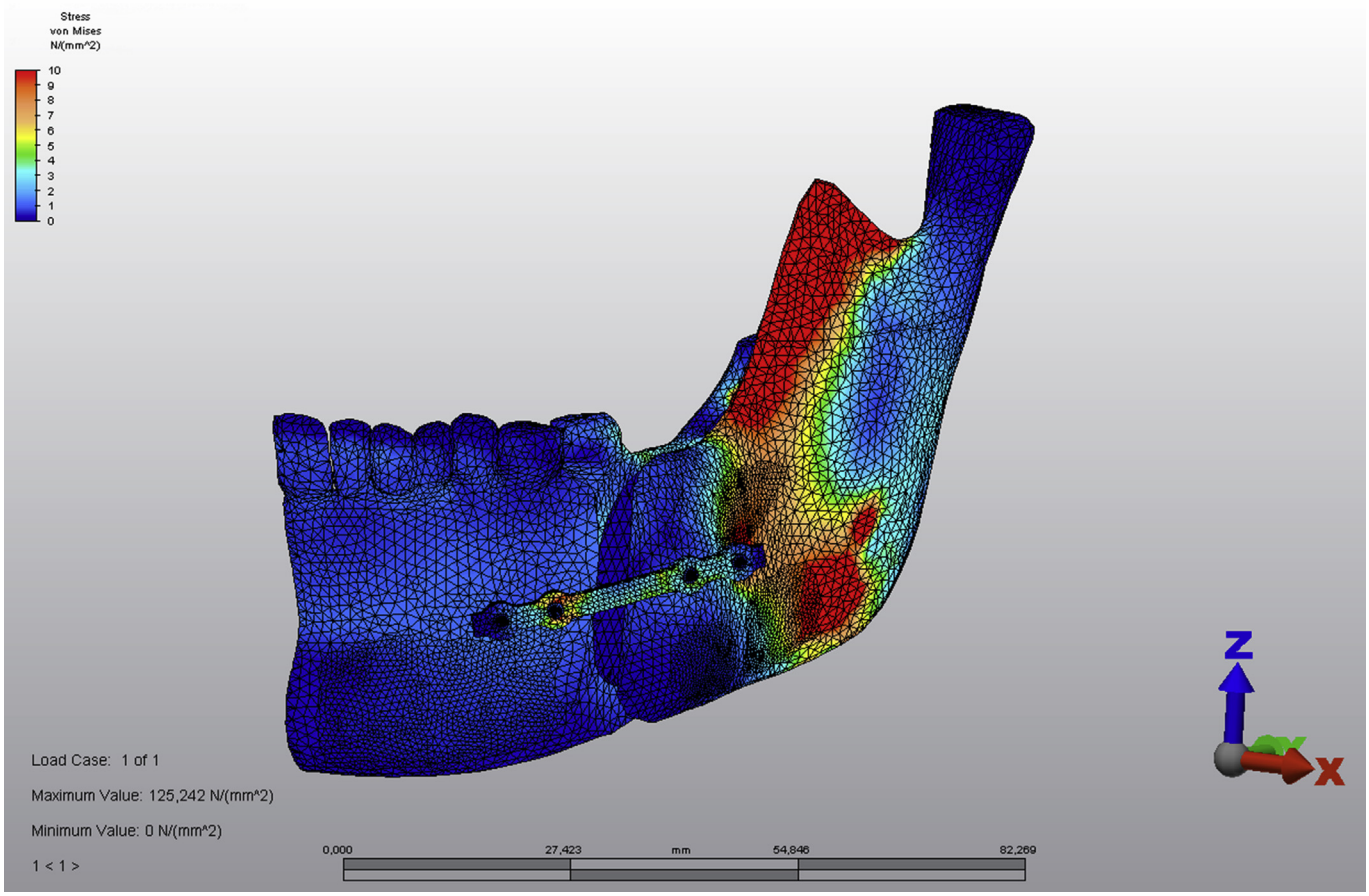

Fig. 1. 4 Hole miniplate with four monocortical screws (M).

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