Journal of Cranio-Maxillo-Facial Surgery 43 (2015) 1918–1925

Contents lists available at ScienceDirect

Journal of Cranio-Maxillo-Facial Surgery

journal homepage: www.jcmfs.com

Three-dimensional analysis of postoperative returning movement of perioperative condylar displacement after bilateral sagittal split ramus osteotomy for mandibular setback with different fixation methods

Jeong Joon Han [a, b], Soon Jung Hwang [b, *]

[a] Department of Oral and Maxillofacial Surgery (Head: Prof. H.J. Park, PhD), Chonnam National University Hospital, Gwangju, Republic of Korea

[b] Department of Oral and Maxillofacial Surgery (Head: Prof. B.M. Seo, PhD), School of Dentistry, Dental Research Institute, BK 21 Plus, Seoul National University, Seoul, Republic of Korea

ARTICLE INFO

Article history:
Paper received 10 March 2015
Accepted 10 August 2015
Available online 18 August 2015

Keywords:
BSSRO
Condylar displacement
Condylar torque
Fixation method

ABSTRACT

This study aimed to evaluate postoperative returning movement of perioperative condylar displacement after bilateral sagittal split ramus osteotomy (BSSRO) depending on a fixation method using three-dimensional (3D) analysis of computed tomography (CT). Twenty-five mandibular prognathic patients (50 condyles) who underwent orthognathic surgery with BSSRO were divided into three groups depending on the fixation method, which consisted of miniplate only (Group A), combined with single bicortical screw (Group B), or with more than one bicortical screw (Group C). CT data taken before, immediately after, and 3 to 6 months after surgery were analyzed. The condyle exhibited mainly lateral bodily displacement and inward and inferior rotation immediately after surgery. The amount of perioperative lateral displacement of the condyle increased according to the increasing number of fixation screws, but the mean displacements were not significantly different among the three groups. During the postoperative follow-up period, the amount of medial returning of the condyle was 102.2% of the intraoperative lateral displacement in Group A. In contrast, Group B and C exhibited partial returning movement by 71.3% and 38.9% of cases, respectively. In conclusion, stronger rigid internal fixation in orthognathic surgery using BSSRO is associated with reduced flexibility of postoperative functional adjustment of displaced condyle to the preoperative condylar position.

1. Introduction

Positional change of the condyle after bilateral sagittal split ramus osteotomy (BSSRO), which is the most frequently used surgical technique to correct mandibular deformities, has been reported by many authors. It can lead to malocclusion, postoperative relapse, temporomandibular joint (TMJ) disorder, and condylar resorption (Will et al., 1984; Epker and Wylie, 1986; Van Sickels et al., 1986; Hwang et al., 2000; Borstlap et al., 2004). Epker and Wylie (1986) asserted that maintenance of the normal or presurgical position of the mandibular condyles and contiguous proximal mandibular ramus segments after BSSRO was important to enhance the stability of the surgical result, to reduce adverse and/or potentially adverse effects upon the TMJ, and to optimize masticatory efficiency. The contributing factors for condylar displacement include the relationship with surrounding muscle tissue, joint edema and hemarthrosis, the method of condyle repositioning, patient position, misalignment of the bony fragment, and fixation technique (Bamber et al., 1999; Ueki et al., 2005, 2012; Toro et al., 2007; Yang and Hwang, 2014).

In BSSRO, rigid internal fixation (RIF) is commonly used to immobilize the distal segment with the proximal segment. RIF without intermaxillary fixation or to a very minor degree if necessary provides sufficient early stabilization between bony segments, early recovery of the mouth opening, and mastication function (Paulus and Steinhauser, 1982; Reitzik and Schoorl, 1983; Van Sickels and Flanary, 1985; Chung et al., 2008). RIF includes miniplates with monocortical screws, two to three bicortical

* Corresponding author. Department of Oral and Maxillofacial Surgery, School of Dentistry and Dental Research Institute, Seoul National University, 101 Daehakro, Jongro-Gu, Seoul 110-749, Republic of Korea. Tel.: +82 2 2072 3061; fax: +82 2 766 4948.

E-mail address: sjhwang@snu.ac.kr (S.J. Hwang).

http://dx.doi.org/10.1016/j.jcms.2015.08.004

positional screws at the ascending ramus, or their combination (hybrid method) (Schwartz and Relle, 1996; Sato et al., 2014; Ueki et al., 2014). Indeed, the hybrid method has been used for further bicortical stabilization of semi-rigid miniplate fixation (Schwartz and Relle, 1996). In vitro analysis has shown that an additional bicortical screw in the retromolar region for miniplate fixation in BSSRO can be used to achieve similar stabilization as observed with bicortical fixation of three positional screws in a triangular position at the ascending ramus (Brasileiro et al., 2012; Sato et al., 2014).

It is well known that RIF can induce perioperative condylar displacement more frequently than non-rigid wire fixation during BSSRO, especially inward condylar torque with lateral shifting, which can be clearly observed on axial plane images from immediate postoperative CT (Buckley et al., 1989; Stroster and Pangrazio-Kulbersh, 1994; Lee and Park, 2002; Jang et al., 2009; Kim et al., 2011; Choi et al., 2014). On the contrary, other reports have indicated that there are no major differences between preoperative and postoperative condylar position in long-term follow-up with two-dimensional CT images (Baek et al., 2006). In spite of this discrepancy in condylar position after surgery, few reports have evaluated three-dimensional (3D) postoperative condylar changes of perioperative condylar displacement in CT.

After positioning the distal segment according to the final splint, it is fixed with a proximal segment by RIF under condylar guidance. Occlusal stability is well maintained by RIF in the correct perioperative condylar reposition. However, in the case of condylar sagging or incorrect positioning, postoperative occlusal disturbance and mandibular deviation is inevitable due to the postoperative movement of the displaced condyle into the physiological position within the glenoid fossa by muscle actions (Reyneke and Ferretti, 2002; Politi et al., 2007). In such cases, slight to mild postoperative intersegmental movement in terms of slippage between the proximal and distal segment as a result of the loosening of rigid fixation resulting from muscle activity might be helpful for postoperative functional adjustment of the displaced condyle into the glenoid fossa, while also maintaining the occlusion in a stable position without severe disturbance.

It is reasonable to postulate that the stronger RIF is associated with reduced flexibility of the postoperative functional adjustment of displaced condyle to the preoperative condylar position with maintenance of stable occlusion. However, there are currently no reports regarding the degree of postoperative returning movement of the displaced condyle according to different fixation methods. Thus the aims of this study were to evaluate the positional change of the condyle in three dimensions after BSSRO and the effect of fixation methods on postoperative 3D changes in condyle position.

2. Material and methods

2.1. Patients

This retrospective study included 50 condyles from 25 patients (14 male and 11 female; mean age, 23.3 years; range 18–40 years) who exhibited condylar torque movement with medial or lateral displacement in CT immediately after BSSRO combined with Le Fort I osteotomy. All patients underwent BSSRO for the correction of mandibular prognathism. Exclusion criteria were cases with preoperative condylar displacement, cleft lip or palate, craniofacial syndromes, previous TMJ surgery or history of trauma. All patients received pre- and postoperative orthodontic treatment. The condyles were divided into three subgroups according to method of rigid fixation used for BSSRO: Group A ($n = 19$) had one 2.0-mm titanium miniplate and four monocortical screws, Group B ($n = 22$) had one 2.0-mm titanium miniplate and four monocortocal screws combined with one bicortical positional screw in the retromolar area, and Group C ($n = 9$) had one 2.0-mm titanium miniplate and four monocortical screws with more than one bicortical positional screw. The application and number of bicortical positional screws was determined intraoperatively to increase intersegmental stability in cases of a small bone contact surface between the proximal and distal segment, and preoperative anterior open bite. Clinical symptoms of TMJ disorders before surgery and 1 month and 3 months after surgery were retrospectively analyzed in terms of joint noise (clicking, crepitation), pain, and mouth opening limitation (less than 35 mm).

2.2. Surgical procedures

Each patient underwent a Le Fort I osteotomy and modified BSSRO with a short lingual osteotomy (Wolford et al., 1987). For removal of bony interferences between the distal and proximal segment, selective grinding, posterior bending osteotomy (Yang and Hwang, 2014), or both were performed. As mentioned above, three different osteosynthesis methods were applied for fixation of the mandibular proximal and distal segments. Immediately after surgery, rigid maxillomandibular fixation was not performed, and only light guiding elastics were placed for 3 to 4 weeks after surgery. Mouth opening exercises were initiated 3 weeks after surgery with the goal of allowing patients to regain adequate mouth opening ability 6 weeks postoperatively.

2.3. Evaluation of surgical change and condylar displacement

Three-dimensional CT (SOMATOM Sensation 10, Siemens, Germany) was performed at 120 kVp and 80 mAs before surgery (T0), 3 days after surgery (T1), and 3 to 6 months after surgery (T2). Using a simulation program (OnDemand3D, Cybermed, Seoul, Korea), superimposition of CT images at different time points were performed on the best fit of the cranial base structures. For evaluation of the condylar position, a 3D coordinate system (X, Y, Z) was established (X, medial–lateral; Y, anterior–posterior; Z, superior–inferior). The Frankfort horizontal plane (FH plane) was used as horizontal reference plane, which passed through the right and left orbitale and right porion. According to manufacturer's recommended protocol, we set the X-axis as the vector from the right orbitale to the left orbitale, and used the midsagittal plane as the plane that was perpendicular to the X-axis and passed through a nasion. The coronal plane served as the plane that passed through the line passing both the orbitale and perpendicular FH plane (Ghang et al., 2013) (Fig. 1). To measure the direction and amount of segmental movement, anteroposterior and superoinferior changes of point B and both lower first molar points, which were defined as the mesial contact point of lower first molar on each side, were calculated (Kim et al., 2012). To measure surgically induced perioperative changes and postoperative returning movement of the condylar position three dimensionally, 3D coordinates of the lateral pole of the condyle head (LP) and medial pole of the condyle head (MP) were obtained. The center of the condyle head (CC) was defined as the midpoint between LP and MP, and its coordinate was calculated. The condylar position in T1 was regarded as the perioperative condylar position, while in T2 it was documented as the postoperative condylar position. The change of the condylar position in three dimensions was divided into bodily shift and rotational movement (Yang and Hwang, 2014). To evaluate the degree of the bodily shift, the amount of the positional change of the CC was calculated. Condylar rotation was assessed according to the change in the major axis of the condyle on the horizontal ($\Delta\theta$ (T1−T0), $\Delta\theta$ (T2−T1), $\Delta\theta$ (T2−T0)) and coronal ($\Delta\omega$ (T1−T0), $\Delta\omega$ (T2−T1), $\Delta\omega$ (T2−T0)) planes. The equations used to determine $\Delta\theta$ are shown below: