Three-Dimensional Surgical Changes of Mandibular Proximal Segments Affect Outcome of Jaw Motion Analysis

Ellen Wen-Ching Ko, DDS, MS, Abdelmounem Issam Alazizi, DDS, MS,† and Cheng-Hui Lin, DDS, MS‡*

Purpose: Displacement of the mandibular proximal segments is inevitable in surgical correction of the asymmetric mandible. The aim of the present study was to assess the outcomes of jaw motion analysis (JMA) in relation to the changes in the mandibular proximal segments after orthognathic surgery (OGS).

Patients and Methods: The present retrospective cohort study investigated the surgical changes using the cone-beam computed tomography records and the mandibular function with JMA and a temporomandibular joint (TMJ) examination. The predictor variables were the 3-dimensional (3D) changes in the proximal segments on the deviated and nondeviated sides. The outcome variables were the JMA data obtained 6 months after OGS. The Pearson correlation test was performed to assess the relationship between the surgical changes and the outcome of JMA.

Results: Twenty-one adult patients with skeletal Class III malocclusion and mandibular deviation greater than 4 mm were included in the present study. The change of the ramus axis to the coronal plane on the deviated side correlated negatively with the laterotrusive movement of the mandible toward the deviated side ($r = -0.452$, $P < .05$). The changes in the distance from the condyles to the midsagittal plane and the angulation of the ramus axis to midsagittal plane on the nondeviated side correlated negatively with the condyle range of retrusion on both sides. However, the increase in the angulation of the ramus axis to the midsagittal plane on the nondeviated side correlated positively with the angle of the horizontal condylar movement in laterotrusion on the deviated side ($r = 0.458$, $P < .05$).

Conclusions: 3D model visualization enabled us to clearly detect the changes in the proximal segments after OGS. A relationship between the condylar range of motion and skeletal changes in the proximal segments in patients with Class III malocclusion was observed, mainly on the deviated side of the mandible.

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Mandibular prognathism in patients with jaw deviation and asymmetry results from mandibular rotation or substantial structural differences between the right and left temporomandibular joints (TMJs).[1] Bilateral sagittal split osteotomy (BSSO) is a surgical technique commonly used to correct the sagittal, transversal, and vertical positions of the lower jaw. Patients with asymmetric Class III malocclusion are prone to a horizontal relapse of the mandible because of the difference between the right and left setback and because a

*Associate Professor, Graduate Institute of Craniofacial and Oral Science, Chang Gung University, Taoyuan, Taiwan; Director, Department of Craniofacial Orthodontics, Chang Gung Memorial Hospital, Taipei, Taiwan; and Principle Investigator, Craniofacial Research Center, Chang Gung Memorial Hospital, Linkou, Taiwan.

†Graduate Student, Graduate Institute of Craniofacial and Oral Science, Chang Gung University, Taoyuan, Taiwan.

‡Assistant Professor, Department of Plastic and Reconstructive Surgery, Chang Gung Memorial Hospital, Taoyuan, Taiwan; Principle Investigator, Craniofacial Research Center, Chang Gung Memorial Hospital, Linkou, Taiwan.

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Address correspondence and reprint requests to Dr Wen-Ching Ko: Graduate Institute of Craniofacial and Oral Science, Chang Gung University, 6F 199 Tung-Hwa North Road, Taipei 105 Taiwan; e-mail: ellenko.wc@msa.hinet.net

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mediolateral displacement occurs in the posterior margin of the distal bone segment while rotating the mandibular dentition to correct its deviation.[2] Changes in the proximal segments are sometimes necessary to adapt to the rotational and side-shifting changes in the distal segment and to increase the symmetry of the lower facial contour (Fig 1). Displacement of the proximal segment is expected to occur more frequently in patients with mandibular asymmetry than in those without asymmetry.[3]

Gross displacement of the proximal segment can create serious problems for patients undergoing orthognathic surgery (OGS), because the medial displacement of the proximal segment caused by moving the condyle away from the disc and posterior attachment and decompression of the TMJ apparatus can result in injury to the neurovascular bundles (lower lip hypoesthesia). Medial displacement of the proximal segment also causes flattening of the face. In addition, distal tipping of the proximal segment can cause bone necrosis in the affected area.[4]

Several studies have examined the changes in the proximal segment and the position of the condyle after OGS.[5-11] When patients with mandibular deviation undergo mandibular setback, more backward inward rotation of the condyle and the proximal segment occurs on the side with the greater setback (nondeviated side) than on the side with less setback (deviated side).[6,7,9,10] Rigid fixation of an osteotomized mandible can cause a positional change of the condyle, because fixation using screws tends to eliminate the gaps between the proximal and distal segments, potentially causing internal rotation of the condylar head. However, Kim et al[9,10] found that the condyle tends to return to its original position after the retention period. Most of the cited studies have yielded consistent results, indicating that changes in the proximal segment can vary according to the fixation type, material used, and surgeon skill.

Jaw motion analysis (JMA) is a favorable tool for evaluating 3-dimensional (3D) mandibular motions.[12] Kim et al[13] investigated the relationship between the changes in 3D facial morphology and mandibular movements after OGS. However, the information regarding mandibular function related to the surgical changes of the mandibular proximal segments remain lacking in the published data.

We hypothesized that the surgical changes of the mandibular proximal segment would correlate with the outcome of the JMA. The purpose of the present study was to assess the alteration of the mandibular proximal segments in patients with skeletal Class III mandibular deviation after OGS and to examine the 6-month postoperative outcomes of JMA in relation to the changes in the mandibular proximal segments.

Patients and Methods

STUDY DESIGN

To address the research purpose, we designed and implemented a retrospective cohort study. The study population included 21 consecutive patients who had undergone OGS at the Craniofacial Center at Chang Gung Memorial Hospital (Taipei, Taiwan) from 2011 to 2013.

The inclusion criteria used to select the patients were skeletal Class III malocclusion and mandibular deviation greater than 4 mm; 2-jaw OGS without genioplasty; complete medical records before and after OGS, including cone-beam computed tomography (CBCT) scans, cephalometric radiographs, facial and intraoral photographs, and JMA records; and OGS performed by the same group of surgeons. The exclusion criteria were craniofacial anomalies, including cleft lip and palate, hemifacial microsomia, and congenital muscular torticollis; a major craniofacial trauma history; painful temporomandibular disorder; and any obvious pathologic deformity of the TMJ.

The initial diagnosis of facial asymmetry was made from the frontal facial photographs and posteroanterior (PA) cephalograms. A horizontal line defined the connection between the bilateral latero-orbitale points on the PA cephalograms. The line that perpendicularly bisects the orbital line was defined as the vertical reference line (midsagittal line). The horizontal distance between the menton and midsagittal line was measured to determine the direction and extent of deviation (Fig 2). The amount of mandibular deviation was later measured again and verified by conducting 3D skeletal model analysis. The deviated side was defined as the part that contains the menton (the shorter side) and the nondeviated side as the contralateral half (the longer side).

The mandible was osteotomized using a modification of the Hunsuck intraoral BSSO of the ramus.[14] The internal pterygoid muscles were detached during osteotomy. Three 2-hole miniplates and 6 monocortical screws were used on each side of the mandible for fixation. No intermaxillary fixation was applied after surgery in any patient. Three main surgeons who used similar surgical techniques performed OGS.

PRIMARY PREDICTOR VARIABLES

3D Skeletal Measurements

CBCT was performed using an i-CAT scanner (Imaging Sciences International, Hatfield, PA) with 14-bit gray-scale resolution and a voxel size of 0.4 mm^3. The images were obtained 1 month before OGS (T1) (1.2 $\pm$ 0.44 months) and 3 weeks after OGS (T2) (0.66 $\pm$ 0.40 months). The CBCT data were constructed into 3D models. The head was placed in a natural position during scanning. The patients were