Short- and Long-Term Changes of Condylar Position After Bilateral Sagittal Split Ramus Osteotomy for Mandibular Advancement in Combination With Le Fort I Osteotomy Evaluated by Cone-Beam Computed Tomography

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Purpose: Bilateral sagittal split ramus osteotomy (BSSO) may change condylar position, which can be one of the factors contributing to skeletal relapse. This study evaluated short- and long-term changes in condylar position using cone-beam computed tomography (CBCT) and investigated changes in temporomandibular joint (TMJ) signs after BSSO for mandibular advancement in combination with Le Fort I osteotomy.

Materials and Methods: Thirty-one patients were included, and CBCT data of 62 TMJs were collected before surgery (T0), immediately after surgery (T1), 3 months after surgery (T2), and at the last follow-up at 12.1 ± 3.0 months after surgery (T3). The relation of the condyle to the fossa was evaluated by the method of Pullinger and Hollender (Oral Surg Oral Med Oral Pathol 62:719, 1986). Clinical examination, with a special focus on signs of temporomandibular disorder (TMD), was documented at T0, T2, and T3. Repeated-measures analysis of variance (P = .05) and χ^2 test (P = .05) were performed.

Results: Data of 27 patients were used for statistical analysis. Values from the formula of Pullinger and Hollender changed significantly with time, but there was no significant difference between the right and left condyles. Condyles moved inferoposteriorly immediately after surgery (T0 to T1) followed by anterosuperior movement 3 months after surgery (T1 to T2). The superimposed effect showed posterosuperior movement compared with the initial position before surgery (T0 to T2) and this position remained stable at 1-year follow-up (T2 to T3). A decrease of TMD signs over time, from 22.6% (T0) to 12.9% (T2) and 9.7% (T3), was observed, which showed no statistical significance.

Conclusions: There were obvious changes in condylar position after BSSO in combination with Le Fort I osteotomy. Condyles tended to be located in a concentric position in relation to the glenoid fossa 3 months after surgery and remained stable during the 1-year follow-up. These changes did not cause an increase of TMD signs.

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Postsurgical relapse is a major concern in the surgical correction of a skeletal Class II deformity. Orthognathic surgery may change condylar position and this is considered a contributing factor for early skeletal relapse[1-4] and the induction of temporomandibular disorders (TMDs).[5,6]

Various radiographic modalities have been used to evaluate condylar displacement, such as linear tomography, submentovertex radiography, lateral cephalometric radiography, and computed tomography (CT).[3,4,7-10] Traditional TMJ radiographs exhibit significant superimposition of adjacent anatomic structures, which makes it less suitable for an accurate evaluation of the condylar position. CT provides optimal imaging of the osseous components of the temporomandibular joint (TMJ). However, the high cost and relatively high radiation dose have limited the widespread use of CT for measuring condylar displacement. The recently developed cone-beam CT (CBCT) has been extensively applied in the oral and maxillofacial region, because of its lower radiation dose and lower cost.[11,12] CBCT provides accurate 3-dimensional imaging of the TMJ complex. Linear measurements are accurate and reliable[13,14]; therefore, CBCT could be the best choice for evaluating condylar displacement after orthognathic surgery.[15]

CBCT has been used for evaluating changes in condylar position after bilateral sagittal split ramus osteotomy (BSSO) for mandibular setback, without[16] or with[17,18] maxillary advancement. According to these studies, condyles changed from the anterior position to a concentric position after mandibular setback surgery and tended to return slightly toward the original position. CBCT evaluation of condylar position change after mandibular advancement has not been studied widely[19,20]; hence, the authors aimed to evaluate the short- and long-term changes of condylar position in the glenoid fossa after BSSO for mandibular advancement in combination with a Le Fort I osteotomy using CBCT. In addition, TMD signs were evaluated. The null hypothesis was that no significant changes in condylar position would be found after BSSO in combination with Le Fort I osteotomy.

Materials and Methods

SUBJECTS

The study was designed as a prospective study. All patients underwent BSSO in combination with Le Fort I osteotomy in the Peking University School and Hospital of Stomatology from January 1, 2010, to December 31, 2011. Clinical and CBCT examinations of the TMJ were conducted as part of the hospital's standard clinical protocol for patients having orthognathic surgery. Informed consent was obtained from each patient and the institutional review board approved this study. All patients were diagnosed with skeletal Class II and Angle Class II, Division 1 malocclusion without anterior open bite. The mean times of preoperative and postoperative orthodontic treatments were 17.0 $\pm$ 6.8 and 11.8 $\pm$ 3.6 months, respectively. Excluded were those who presented with degenerative TMJ disease according to research diagnostic criteria for TMD,[21] severe facial asymmetry, deformity secondary to trauma, cleft lip and palate, or systemic disease.

Standardized lateral cephalometric radiographs and CBCTs of the right and left TMJs were routinely obtained at the following 4 stages in all patients: *1)* within 1 week preoperatively (T0); *2)* 3 to 5 days postoperatively (T1), when the desired occlusion was obtained, to assess changes related to surgery; *3)* 3 months postoperatively (T2) to assess short-term adaptive changes; and *4)* at the last follow-up (T3; average time, 12.1 $\pm$ 3.0 months) to assess long-term adaptive changes.

SURGICAL TECHNIQUE

BSSO was carried out to advance the mandible in all patients using the technique of Obwegeser[22] with the modification of Epker[23] in combination with Le Fort I osteotomy for setback and impaction of the maxilla and genioplasty to advance the chin. The maxilla was operated on first, and rigid internal fixation was applied. After advancement of the distal segment, the desired occlusion was secured by a thin acrylic splint and intermaxillary fixation (IMF) with stainless steel wires. Then, rigid internal fixation was achieved with miniplates, as described by Rubens et al,[24] after manual manipulation of the proximal fragment into what was palpated as the posterior position in the glenoid fossa by the surgeon. IMF was released and occlusion was checked before closure.

POSTSURGICAL PROTOCOL

Tight elastics were applied on day 2 postoperatively to keep the mandible in proper occlusion and were maintained for 2 to 3 weeks. Then, light guiding elastics were used to help patients keep the proper occlusion and the patients were encouraged to exercise mouth opening. The occlusal acrylic splint was removed 3 to 4 weeks after surgery. Postoperative orthodontic treatment started usually 6 to 8 weeks after surgery.

CBCT DATA ACQUISITION

A CBCT machine (DCT Pro; Vatech, Seoul, Korea) was used to evaluate condylar movement at 4 stages. All patients sat in an upright position with the teeth in centric occlusion. The patients' Frankfort horizontal (FH) plane was parallel to the floor. The scanning settings of the CBCT machine were as follows: 16- $\times$ 10-cm field of view, 90-kVp tube voltage, 7.0-mA tube current, and 24-second scan time. The CBCT data were reconstructed with 3-dimensional image dental software (Ez3D2009 Simple Viewer 1.2.1.0; E-WOO Technology Co., Seoul, Korea).

Sagittal Scan Images

On the axial scan images, the slice with the largest condylar transverse diameter was acquired. The image of the sagittal plane was determined through the middle point of the condyle on the axial plane.

Evaluation of Condylar Position Changes

The FH plane was constructed by the right and left sides of the porion and the right side of the orbitale (Table 1; Figs 1, 2). Line A was drawn through the most superior surface of the glenoid fossa parallel to the FH plane. Anterior, superior, and posterior spaces were measured by the method of Kamelchuk et al[25] with 3 times enlargement for the multiplanar reconstruction image (Fig 3). The anterior space (AS) and posterior space (PS) were determined and ln(PS/AS) was calculated by the method of Pullinger and Hollender[26] to assess the anteroposterior relation of the condyle to the fossa. An ln(PS/AS) higher than 0.25 indicated the anterior position of condyle in the glenoid fossa. An ln(PS/AS) lower than −0.25 indicated the posterior position and all values in between indicated the concentric position. Measurements were repeated 3 times and the mean value was used for statistical analysis.

EVALUATION OF TMJ SIGNS

A TMD specialist in the authors' hospital who was blinded to the patients' operative history examined all patients clinically at T0, T2, and T3. Any signs of TMD, such as pain, clicking, crepitus, and limited mouth opening, were recorded. Maximum interincisal mouth opening (MIO) also was measured.

Table 1. REFERENCE POINTS

Landmark	Description
Porion	most superior point of external auditory meatus
Orbitale	lowest point on inferior orbital rim
B point	innermost point on the contour of the mandible between incisor tooth and bony chin
Condylion	most posterosuperior point on head of condyle
Gnathion	lowest, most anterior midline point on the symphysis of the mandible

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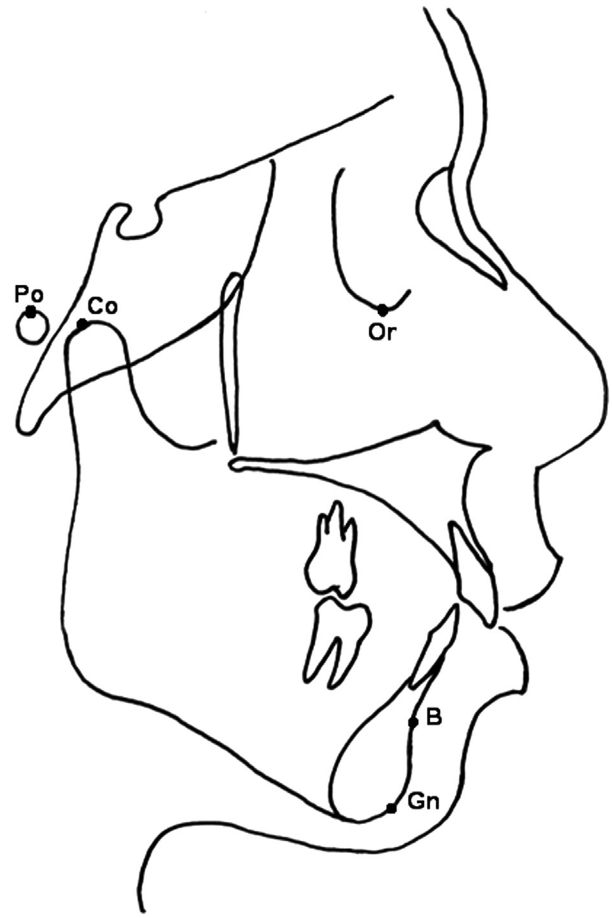

FIGURE 1. Hard tissue anatomic landmarks. B, B point; Co, condylion; Gn, gnathion; Or, orbitale; Po, porion.

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STATISTICAL ANALYSIS

Data were statistically analyzed using SPSS 13.0 for Windows (SPSS, Inc, Chicago, IL). Ten cases were randomly selected and the same investigator repeated the measurements at least 2 weeks apart to assess the reliability of the method. Paired *t* test was used to assess systematic error, and the formula of Dahlberg[27] was used to calculate the random error.

Comparisons of the condylar position in relation to the glenoid fossa at T0, T1, T2, and T3 were performed by repeated-measures analysis of variance (P = .05). Pairwise multiple comparisons were conducted using the Bonferroni correction (P = .05). The differences of TMD signs were assessed with χ^2 test, and probabilities less than .05 were considered significant.

Results

Thirty-one consecutive patients (9 male, 22 female; mean age, 27.0 ± 5.4 yr; range, 19.0 to 40.5 yr) were included in this prospective study. Paired *t* test showed

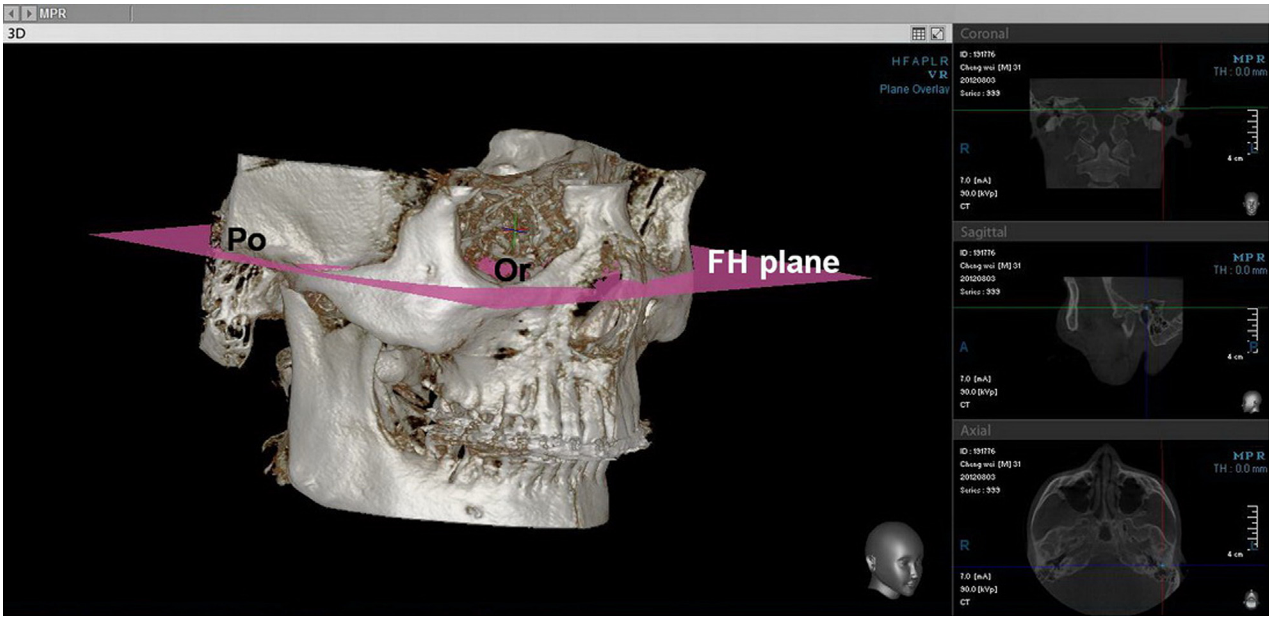

FIGURE 2. The FH plane was constructed by the Po on the right and left sides and the Or on the right side. FH, Frankfort horizontal; Or, orbitale; Po, porion.

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no significant differences at probabilities less than .05. The random error of the linear measurement varied from 0.12 to 0.14 mm.

GENERAL FINDINGS

Advancement of the mandibular at the B point (Table 1; Fig 1) ranged from 4.58 to 9.58 mm (mean, 7.02 mm; standard deviation, 1.46 mm). Pre- and postoperative clinical examinations regarding TMJ signs are presented in Table 2. The most frequent preoperative TMJ sign was joint sound, ie, clicking on mouth opening. None of the patients was found to have crepitus, popping, or pain before or after surgery. A decrease of TMD signs over time, from 22.6% (T0) to 12.9% (T2) and 9.7% (T3), was observed, although there was no significant difference (P = .112). MIO at the last follow-up (41.3 ± 5.6 mm) recovered approximately to the preoperative level (45.1 ± 5.1 mm).

Condylar resorption was observed in 2 of 31 patients (6.5%) at the last follow-up. Because morphologic condylar changes can affect accurate measurements of the

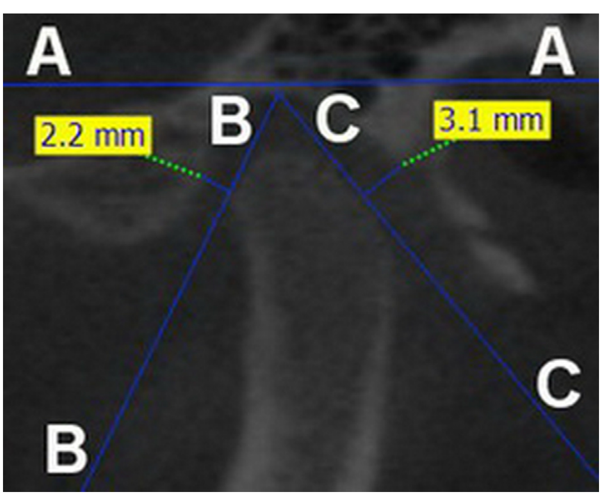

FIGURE 3. Evaluation of condylar position in the glenoid fossa. *Line A* was drawn through the most superior surface of the glenoid fossa parallel to the Frankfort horizontal plane. The lines tangent to the most prominent anterior (*line B*) and posterior (*line C*) aspects of the condyle were drawn from the most superior surface of the glenoid fossa. Anterior and posterior spaces were measured from the most prominent anterior and posterior points of the condyle to the glenoid fossa. Superior space was the vertical distance from the most superior surface of the glenoid fossa to the condyle.

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Table 2. PRE- AND POSTOPERATIVE CLINICAL FINDINGS IN RELATION TO THE TEMPOROMANDIBULAR JOINT

	T0 (n = 62)	T2 (n = 62)	T3 (n = 62)
Clicking*	14^a	8^a	6^a
Preauricular pain	0	0	0
MIO (mm)†	45.1 ± 5.1^a	32.6 ± 4.7^b	41.3 ± 5.6^c

Note: The same superscript letters indicate no significant statistical differences among the indicated groups (P > .05).

Abbreviations: MIO, maximum interincisal mouth opening; T0, before surgery; T2, 3 months after surgery; T3, last follow-up at 12.1 ± 3.0 months after surgery.

* Differences were not significant by χ^2 test.

† Differences were analyzed by repeated-measures analysis of variance (P < .05).

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TMJ space, these 2 patients were excluded from this study (Fig 4). Another 2 cases showed anteroinferior displacement of the condyles after surgery (Fig 5), which was contrary to most cases in the study. Therefore, 27 patients were evaluated for condylar position change after BSSO for mandibular advancement in combination with Le Fort I osteotomy in this study.

CONDYLAR POSITION CHANGES AFTER SURGERY

The descriptive statistics for measuring the TMJ spaces of the 27 patients are listed in Table 3, and condylar position changes for calculating ln(PS/AS) are listed in Table 4. The value of ln(PS/AS) between the right and left condyles was not significantly different ($P = .585$). Ln(PS/AS) changed significantly with time ($P < .001$), and the details follow.

Condylar Position Before Surgery

The distribution of condylar position on the right and left sides at different stages is presented in Table 5. Most condyles were in the concentric or anterior position before surgery (Table 5); 46% of condyles were in the concentric position and 43% were in the anterior position before surgery.

Short-Term Change

When measuring the TMJ space, the anterior and superior spaces increased from T0 to T1, indicating that the condyles tended to move posteroinferiorly with surgery. However, at 3 months after surgery, the condyles moved anterosuperiorly (T1 to T2), showing a recovery toward the original position after splint removal. An overall trend of posterosuperior movement of condyles was observed compared with the preoperative position (T0 to T2; Figs 6, 7).

Long-Term Change

The ln(PS/AS) and superior space showed no significant difference from T2 to T3, suggesting the condylar position at 3 months after surgery was stable throughout the average 1-year follow-up (Figs 6, 7). There were more condyles situated in the center of the glenoid fossa at 3 months after surgery (67%) and at the last follow-up (65%) compared with before surgery (46%).

Discussion

A major concern in orthognathic surgical correction of skeletal Class II malocclusion is potential postsurgical relapse. Although skeletal relapse involves multiple contributing factors, postoperative movement at the B point results only from changes of 2 anatomic locations: movement at the osteotomy sites (intersegmental movement) after IMF is released and condylar positional and morphologic changes. With the introduction of rigid internal fixation to promote bone healing and prevent intersegmental movements, some of these problems have been overcome.[28,29] Condylar position change is another important factor contributing to postsurgical relapse.[1-4] Control of the proximal segment is always important in skeletal stability and the prevention of relapse.[30] In this study, the authors investigated changes in condylar position immediately after, 3 months after, and 1 year after surgery using linear measurements on CBCT images, which has not been reported previously to the best of the authors' knowledge. The present results indicate that the condyles moved posteroinferiorly with surgery and moved back anterosuperiorly at

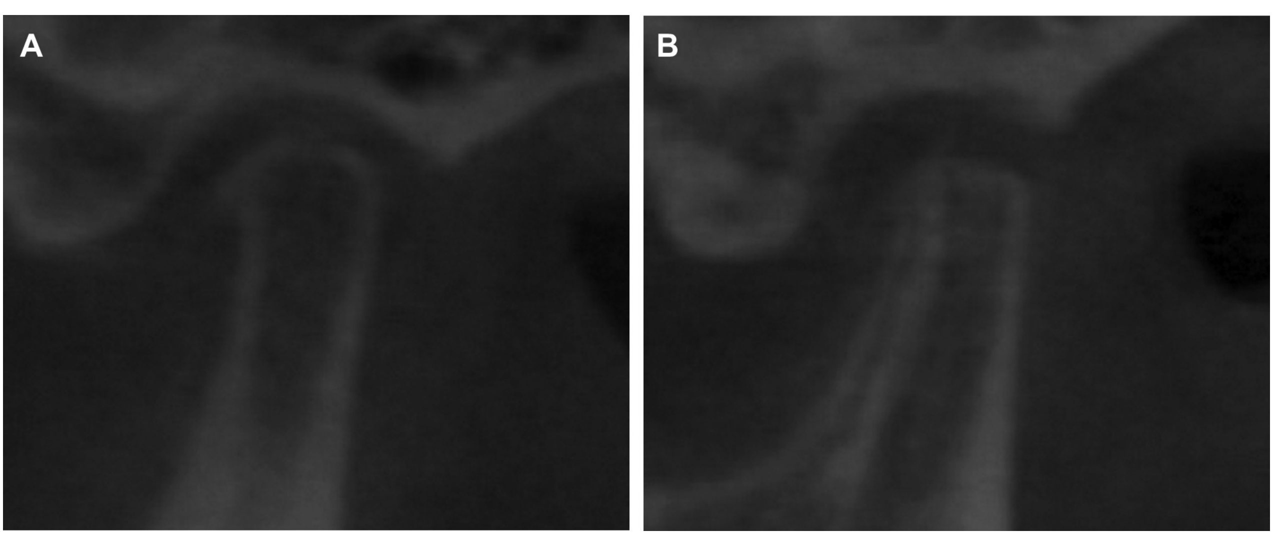

FIGURE 4. Left condyle of a 22-year-old female patient. *A*, Normal condylar morphology before surgery. *B*, Condylar resorption was observed at 1 year postoperatively.

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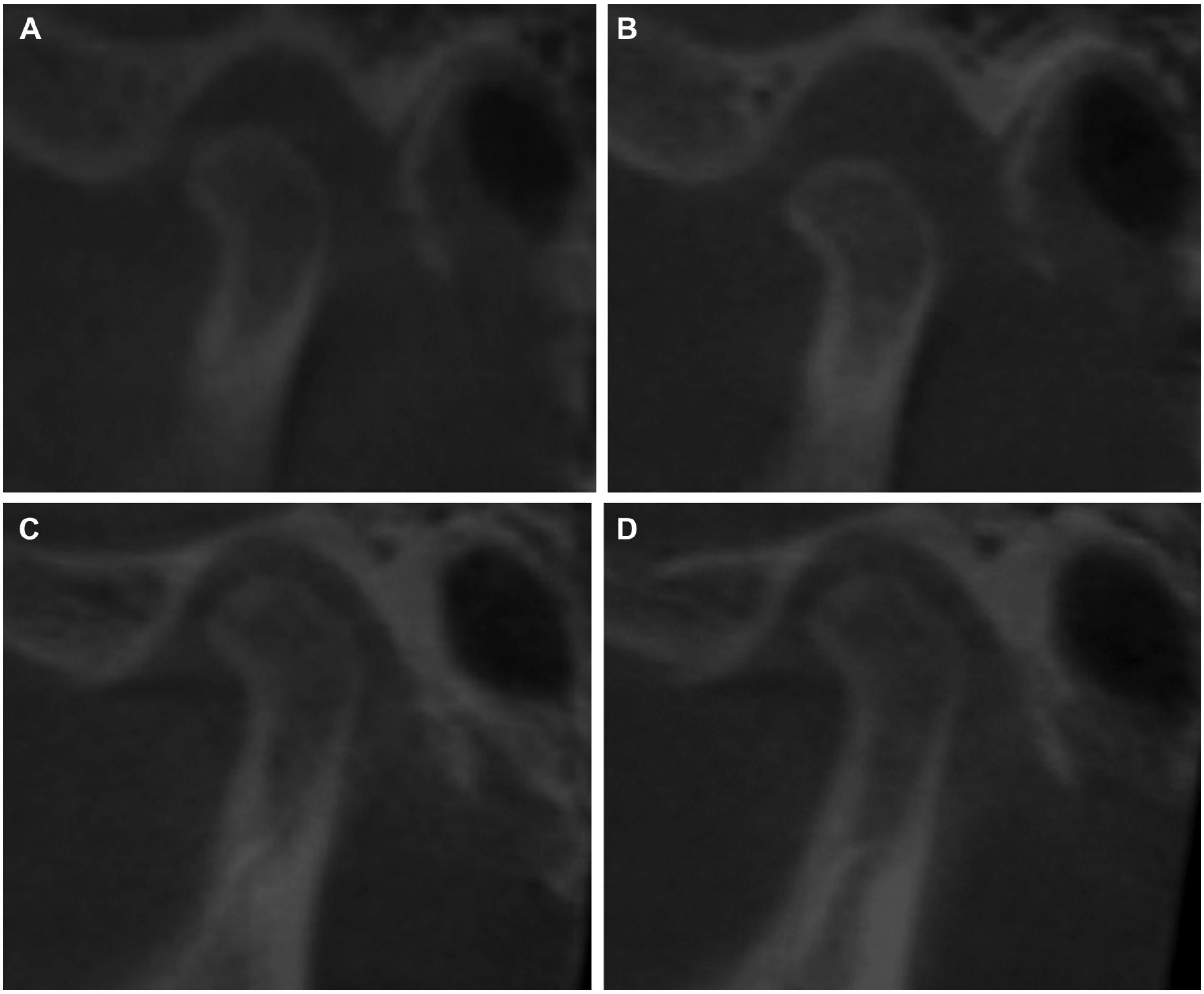

FIGURE 5. Condylar position changes in a 23-year-old male patient. *A*, The condyle was located at an anterior position in the glenoid fossa before surgery. *B*, The condyle moved inferiorly and anteriorly immediately after surgery. *C*, The condyle moved posteriorly and superiorly and was located at a concentric position in the glenoid fossa 3 months after surgery. *D*, The condylar position was stable at 1 year postoperatively compared with 3 months postoperatively.

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3 months after surgery. This position remained stable during the 1-year follow-up.

Several studies have been conducted to investigate condylar position in the fossa and the relation between condylar position and craniofacial morphology.[30-33] Condyles in Class I were located in the center of the fossa,[31] whereas those in Class II, Division 1 were located more anteriorly than those in Class I or III.[32-34] In the present study, 43% of condyles were positioned anteriorly in the fossa according to the formula of Pullinger and Hollender[26]; furthermore, the condyles showed symmetric positions on the right and left sides.

The condyles play an important role in mandibular growth. The cartilage surface of the condyle is a major growth site in the mandible and growth of the condylar cartilage contributes to the increase in height of the mandibular ramus and to the overall increased length of the mandible.[35(p124)] The increase in mandibular length (condylion to gnathion) at pubertal peak and the overall mandibular length at the postpubertal stage have been shown to be significantly smaller in patients with untreated Class II, Division 1 malocclusion than in those with normal occlusion.[36] Other studies have reported a visible change of condylar growth toward the posterior and superior direction in patients with Class II malocclusion treated with the Herbst appliance during puberty. This growth characteristic was combined with relocation of the condyle.[37,38] Hence, patients with Class II, Division 1 malocclusion may exhibit undeveloped condyles situated anteriorly in the glenoid fossa.

According to previous studies, condylar displacement immediately after mandibular advancement surgery is variable. Anteroinferior,[4] posteroinferior,[4,19,39] and

Table 3. TEMPOROMANDIBULAR JOINT SPACES ACQUIRED BY CONE-BEAM COMPUTED TOMOGRAPHY AT DIFFERENT STAGES (n = 27)

	T0	T1	T2	T3
Anterior space (left)	2.20 ± 0.52[a]	3.33 ± 0.72[b]	2.24 ± 0.56[a]	2.23 ± 0.56[a]
Posterior space (left)	2.71 ± 0.87[a]	2.74 ± 0.91[a]	2.16 ± 0.43[b]	2.10 ± 0.44[b]
Superior space (left)	2.84 ± 0.60[a]	3.71 ± 0.84[b]	2.41 ± 0.61[c]	2.34 ± 0.60[c]
Anterior space (right)	2.39 ± 0.56[a]	3.31 ± 0.76[b]	2.35 ± 0.68[a]	2.39 ± 0.74[a]
Posterior space (right)	2.79 ± 0.78[a]	2.66 ± 0.71[a]	2.18 ± 0.58[b]	2.17 ± 0.54[b]
Superior space (right)	2.97 ± 0.68[a]	3.90 ± 0.94[b]	2.51 ± 0.65[c]	2.46 ± 0.66[c]

Note: Distances are presented as millimeters. The same superscript letters indicate no significant statistical differences among the indicated groups ($P > .05$). Adjustment for pairwise multiple comparisons was applied by the Bonferroni test.

Abbreviations: T0, before surgery; T1, immediately after surgery; T2, 3 months after surgery; T3, last follow-up at 12.1 ± 3.0 months after surgery.

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equal distributions in the vertical direction have been reported.[19] In the present study, the condyles were displaced posteroinferiorly immediately after surgery (Figs 6, 7). The posterior displacement may be related to the manual manipulation of the proximal segment during surgery. Intra-articular edema has been verified using magnetic resonance imaging during the early postoperative period in patients treated by mandibular subcondylar osteotomy.[40] Manipulation of the proximal segment during sagittal split osteotomy may cause intra-articular edema and result in inferior displacement of the condyle at an early stage. Other factors, such as using an acrylic splint and a muscle relaxant under general anesthesia, also may contribute to condylar sag.

After splint removal, the condyles tended to move back anterosuperiorly from T1 to T2, representing a recovery toward the preoperative position. The reason for this is probably multifactorial. Posteroinferior displacement of condyles may stretch the masticatory muscle and the temporomandibular ligament.[35(p146,180)] Adaptive properties of soft tissue functional pattern may elicit changes of condylar position toward the anterior and superior position. Hence, this recovery movement may well be the combined result of masticatory muscle and ligament stretching, resolution of edema, and removal of the splint. The posteroinferior displacement with surgery and the tendency of returning toward the original position were considered advantageous, which caused an additional forward movement of the mandible postoperatively.[41] Compared with the preoperative position (T0 to T2), condyles showed posterosuperior displacement. This finding was consistent with previous studies.[4,9,10,19] Therefore, more condyles relocated to the center of the glenoid fossa at 3 months after surgery (67%), whereas only 46% of condyles were in the concentric position before surgery.

Unexpectedly, condyles in 2 cases were found to move anteroinferiorly immediately after surgery; this positional change was not intentional. With mandibular advancement, gaps between the proximal and distal segments frequently occur in the anterior aspect of the osteotomy,[7,42] which is related to the mandibular anatomy. Bony interferences were removed using a bur or rasp to eliminate or minimize the gaps. Any incompletely removed potential bony interference can affect the surgical manipulation for condylar position. However, the condyles tended to return to a centralized position in relation to the glenoid fossa 3 months after surgery (Fig 5). This movement of the condyles may result from stretch of the posterior

Table 4. CONDYLAR POSITIONS CALCULATED BY THE FORMULA OF PULLINGER AND HOLLENDER[26] AT DIFFERENT STAGES (n = 27)

	T0	T1	T2	T3
ln(PS/AS) (left)	0.19 ± 0.23[a]	−0.22 ± 0.25[b]	−0.03 ± 0.23[c]	−0.05 ± 0.21[c]
ln(PS/AS) (right)	0.14 ± 0.25[a]	−0.23 ± 0.25[b]	−0.07 ± 0.24[c]	−0.08 ± 0.24[c]

Note: The same superscript letters indicate no significant statistical differences among the indicated groups ($P > .05$). Adjustment for pairwise multiple comparisons was applied by the Bonferroni test.

Abbreviations: AS, anterior space; PS, posterior space; T0, before surgery; T1, immediately after surgery; T2, 3 months after surgery; T3, last follow-up at 12.1 ± 3.0 months after surgery.

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Table 5. DISTRIBUTION OF CONDYLAR POSITIONS AT DIFFERENT STAGES

	Right Condylar Position (n = 27)				Left Condylar Position (n = 27)			
	T0	T1	T2	T3	T0	T1	T2	T3
Anterior	11^a	2^b	2^b	2^b	12^a	1^b	2^b	2^b
Concentric	12^a	10^a	18^a	17^a	13^a	10^a	18^a	18^a
Posterior	4^a	15^b	7^a	8^a	2^a	16^b	7^a	7^a

Note: The same superscript letters indicate no significant statistical differences among the indicated groups ($P > .05$ by logistic regression compared with T0).

Abbreviations: AS, anterior space; PS, posterior space; T0, before surgery; T1, immediately after surgery; T2, 3 months after surgery; T3, last follow-up at 12.1 ± 3.0 months after surgery.

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portion of the temporalis muscle and the deep portion of the masseter muscle[35(p148)] combined with the resolution of edema and splint removal. DuBrul[35(p187)] pointed out that, in all synovial joints in the human body, the articulating surfaces of the opposing bones are kept in firm contact by the associated ligaments and musculature, and this mechanism becomes especially critical in highly moveable joints to ensure their integrity and stability. Orthognathic surgery changes patients' occlusion and neuromuscular environment, which need some time to adapt.[43] Condylar position displacement after splint removal suggests an adaptive response from the ligaments and musculature. It was speculated that the concentric position was more stable for condyles in the glenoid fossa after surgery and this stability was maintained at 1-year follow-up.

Condylar resorption after orthognathic surgery is not uncommon. The incidence of condylar resorption according to the literature ranges from 4% to 8% after

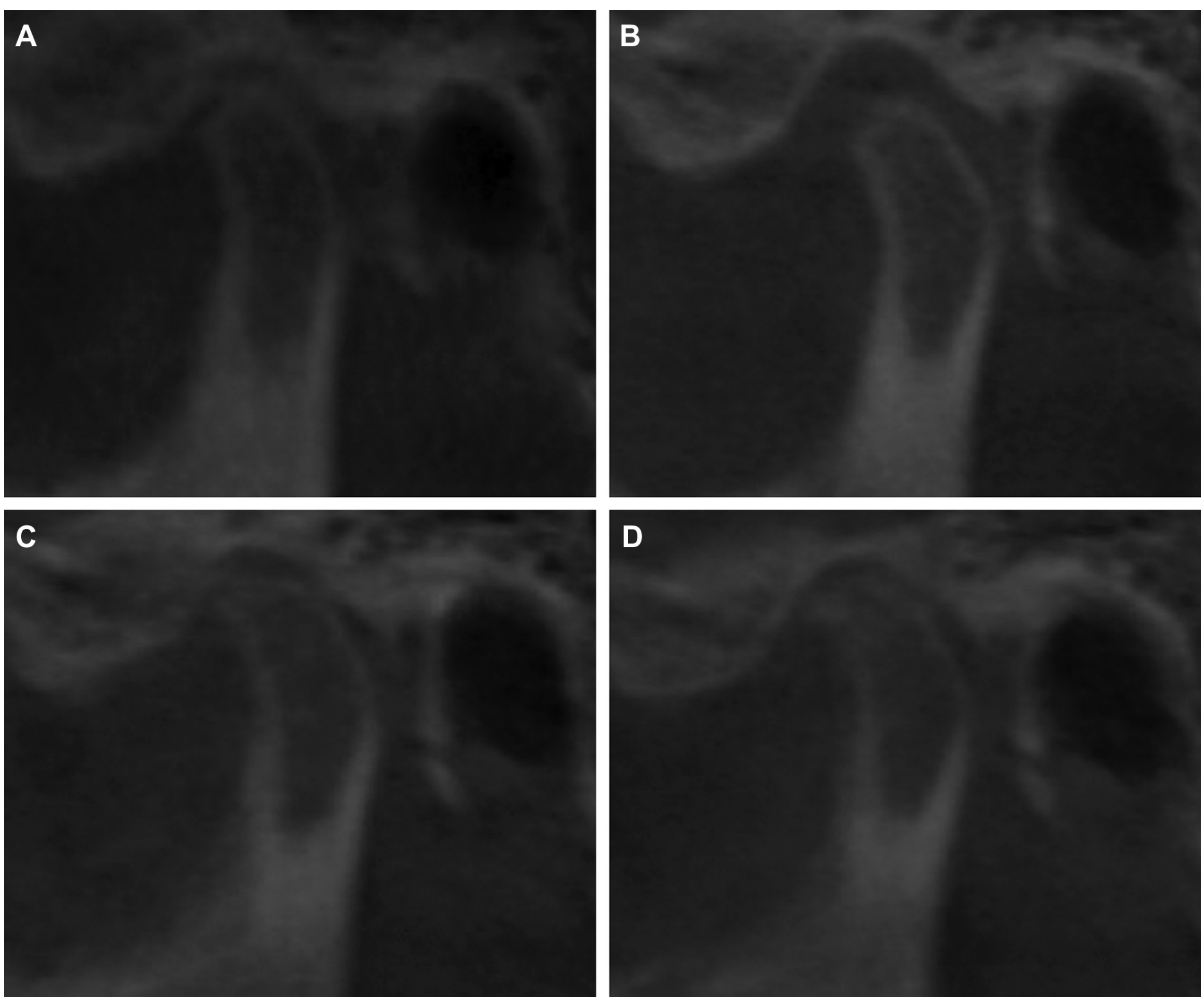

FIGURE 6. Condylar position changes in a 23-year-old female patient. *A,* The condyle was located at a concentric position in the glenoid fossa before surgery. *B,* The condyle moved posteriorly and inferiorly immediately after surgery. *C,* The condyle moved anteriorly and superiorly 3 months after surgery. *D,* The condylar position was stable at 1 year postoperatively compared with 3 months postoperatively.

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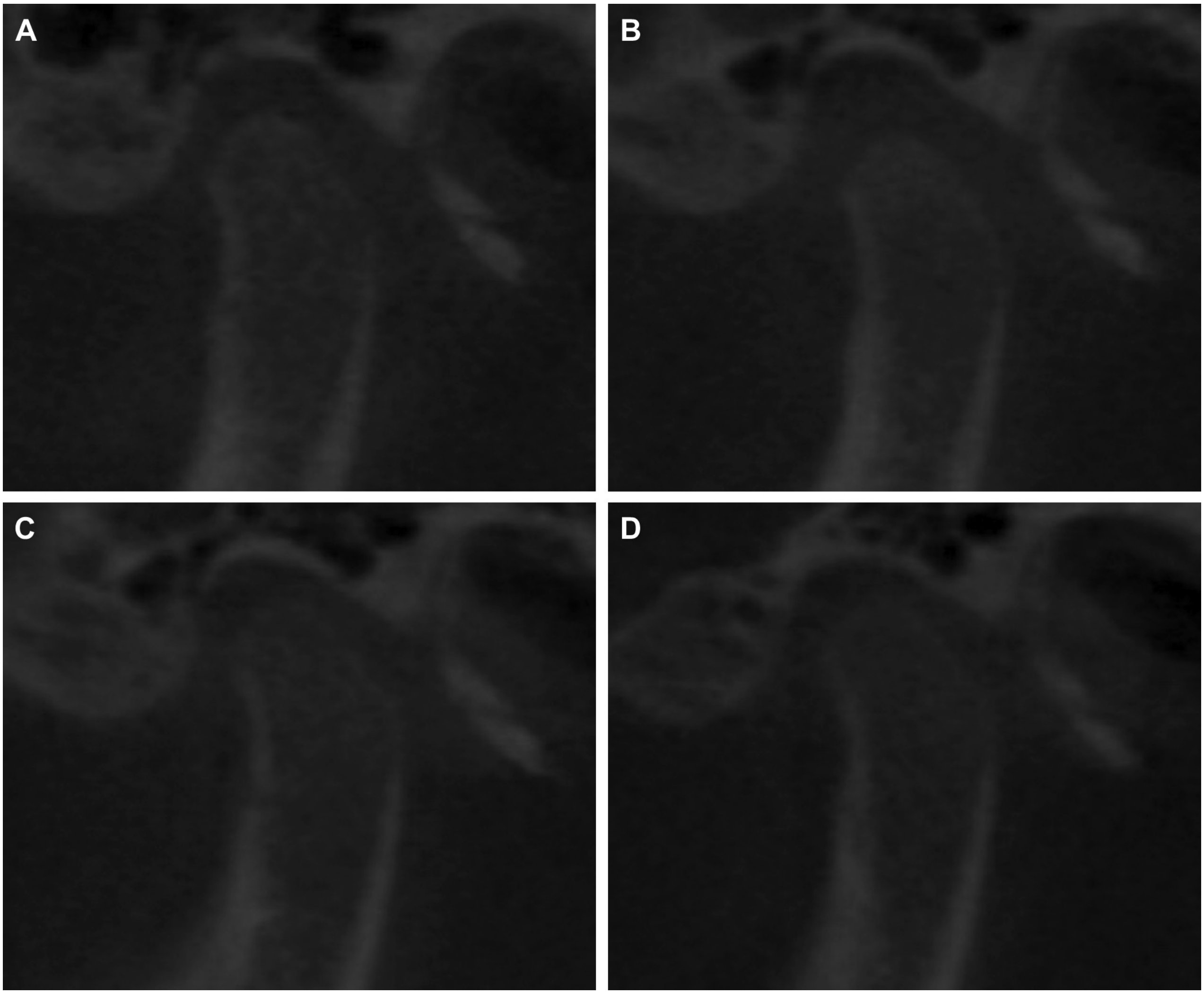

FIGURE 7. Condylar position changes in a 20-year-old male patient. *A*, The condyle was located at an anterior position in the glenoid fossa before surgery. *B*, The condyle moved posteriorly and inferiorly immediately after surgery. *C*, The condyle moved anteriorly and superiorly and was located at a concentric position in the glenoid fossa 3 months after surgery. *D*, The condylar position was stable at 1 year postoperatively compared with 3 months postoperatively.

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BSSO fixed with miniplates.[44,45] The etiology of condylar resorption is still not clear. The TMJ is thought to be in a constant stage of remodeling. Functional remodeling is characterized by an adaptation of the articular structures of the TMJ in response to mechanical stress. When the balance between the host adaptive capacity and the mechanical loading on the condyle is lost, dysfunctional remodeling, such as condylar resorption, can occur.[46,47] Counterclockwise rotation of the distal and proximal mandibular segments and surgically induced posterior condylar displacement were considered surgical risk factors for postoperative condylar resorption,[48] whereas a posteriorly inclined condylar neck was considered a nonsurgical risk factor.[49] When the condyle was rotated posteriorly with counterclockwise rotation of the proximal mandibular segment, the anterosuperior condylar surface was located more superiorly.[50-52] When the condylar neck was inclined posteriorly, the previously less-loaded anterosuperior condylar surface[53] was more exposed to loading. The posteriorly and superiorly displaced condyle may push the articular disc anteriorly[54] and induce internal derangement or osteoarthrosis.[5,55] A causal relation between advanced internal derangement and condylar resorption has been supported by a previous clinical study.[56] A decrease in blood supply to the condyles after BSSO[57] may be another factor, because decreased perfusion may result in avascular necrosis involving the mandibular condyle.[58] In addition, a continuous, homogeneous, and compact cortical bony layer around the periphery of the condyle is formed only when a condyle is fully developed,[59] and the incomplete cortical bony layer may be more susceptible to compressive stress changes. Further studies are necessary to clarify the contributing factors of postoperative condylar resorption.

Patients with Class II deformity are prone to internal derangements[60] or osteoarthritis.[61] The relation of TMD to orthognathic surgery has been much debated and remains a controversial topic. Most studies have reported that patients with dentofacial deformity and TMD signs who have orthognathic surgery are more likely to show improved rather than deteriorated signs and symptoms.[62] In the present study, a decrease of clicking over time, from 22.6% (T0) to 12.9% (T2) and 9.7% (T3), was noted. MIO returned to almost preoperative values. There was no new complaint of TMD symptoms postoperatively. The decrease of TMD signs might have resulted from the improvement of occlusion and disc position.[63]

There were obvious changes in condylar position after BSSO in combination with Le Fort I osteotomy. Condyles tended to be located in a concentric position in relation to the glenoid fossa 3 months after surgery. It was speculated that the concentric position was more stable for condyles in the glenoid fossa and this stability remained at 1-year follow-up. The condylar position changes did not lead to an increase of TMD signs and symptoms. Whether BSSO is an independent risk procedure leading to condylar displacement should be further investigated in patients having only the BSSO procedure.

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