Cone-beam computed tomography evaluation on the changes in condylar long axis according to asymmetric setback in sagittal split ramus osteotomy patients

Sun-Young Lim; Tingting Jia; Min-Hee Oh; Min-Suk Kook; Jin-Hyoung Cho; Hyeon-Shik Hwang

ABSTRACT

Objective: To determine whether the condylar rotation is affected by asymmetric setback in patients undergoing sagittal split ramus osteotomy.

Materials and Methods: Thirty patients who underwent bilateral sagittal split ramus osteotomy setback surgery were divided into the two groups, symmetric setback and asymmetric setback, according to the right/left difference of setback amount (<2.0, ≥2.0 mm). Condylar long axis changes were evaluated using the three-dimensional superimposition of before and immediately after surgery cone-beam computed tomography volume images. Evaluations were performed separately in lesser setback and greater setback side in patients undergoing asymmetric setback, whereas both side condyles were evaluated together in patients undergoing symmetric setback. Condylar axis changes on axial view were correlated with setback amount or right/left setback difference using Pearson correlation analysis.

Results: In general, the condylar axis change occurred in a pattern of inward rotation. The condyles in patients undergoing symmetric setback showed 3.4° rotation in average. In case of asymmetric setback, the lesser setback side showed larger value (4.3°) than the greater setback side (2.3°) with a statistical significance. In the correlation analysis, setback amount showed no significant correlation with the condylar axis changes in both groups. However, correlation with right/left setback difference showed a positive correlation in lesser setback side of patients undergoing asymmetric setback.

Conclusion: The findings of this study indicate that large amount of setback alone does not contribute to the change in condylar long axis, but asymmetric setback might cause a change in condylar long axis, particularly on the lesser setback side. (Angle Orthod. 2017;87:254–259)

KEY WORDS: Cone-beam computed tomography; Condyle; Asymmetric setback; Sagittal split ramus osteotomy

INTRODUCTION

The most common surgical procedure for the correction of skeletal Class III malocclusion is sagittal split ramus osteotomy (SSRO). Displacement of condyle is known to be a cause of early relapse during postsurgical orthodontic treatment.1–3 Condyle displacement with axial rotation after SSRO might have an increased risk of temporomandibular disorders.4,5 Harris et al.6 attempted to evaluate factors influencing condylar position after SSRO using three-dimensional (3D) computed tomography (CT). Although the changes in condyle position were obvious, influencing factors were not revealed in their study. Ueki et al.7,8 reported that condylar rotation after SSRO could be reduced considerably with the use of bent plates. They also demonstrated that the frequency of temporomandibular disorders after surgery in the bent-plate group...
was significantly less than that in the conventional straight-plate group. Lee and Park\(^9\) evaluated the positional change of the condyle after mandibular setback by SSRO and determined any correlations with the amount of setback. While significant condyle displacements were present 1 month after surgery, any directional displacement, including rotation, did not show significant correlation with setback amount. Ueki et al.\(^6\) reported that inward rotation mostly occurs after SSRO, whereas outward rotation is seen in case of intraoral vertical ramus osteotomy. Baek et al.\(^11\) reported that 3D positions of the condyle were not changed significantly after asymmetric mandibular setback in 12 skeletal Class III malocclusion patients with facial asymmetry.

Recently developed cone-beam computed tomography (CBCT) has enabled us to evaluate the changes in condylar long axis more accurately. Kim et al.\(^12,13\) assessed the changes in condylar position after SSRO using CBCT scan data. While condylar positions were evaluated on three planes, the condyle on the axial plane showed significant inward rotation in their study. Kim et al.\(^14\) evaluated condylar changes after one-jaw and two-jaw surgeries in patients with mandibular prognathism and compared them between the two surgery groups. They showed significant inward rotation of the condyle in two-jaw surgery group, whereas there was no significant difference in the one-jaw group. An et al.\(^15\) evaluated the effect of postoperative condylar rotation on the changes in mandibular condylar morphology using 3D surface models. They showed that the changes in condylar morphology occurred more with more rotational changes of the condyles regardless of one- or two-jaw surgery.

Literature review of recent CBCT studies\(^12–15\) regarding the positional changes in condyle after orthognathic surgery showed a significant change in condylar rotation by the surgery. However, few studies dealt with its contributing factors. Harris et al.\(^6\) and Lee and Park\(^9\) evaluated the positional changes of condyle using CT and correlated it with the amount of mandibular advancement\(^6\) and setback\(^9\), respectively. Although both studies showed obvious changes in condylar rotation by the surgery, they found no significant correlations with the amount of surgical movement.

The purposes of this study were to evaluate condylar long axis changes after mandibular setback by SSRO and to determine whether they are affected by the amount of setback or asymmetric setback using CBCT scan data before and immediately after surgery.

### MATERIALS AND METHODS

A retrospective study was performed on 30 adults diagnosed with skeletal Class III malocclusion who had undergone one-jaw setback surgery from 2011 through 2014 at Chonnam National University Hospital (Gwangju, Korea). Bilateral SSRO was performed, with semirigid fixation using four-hole straight plate (Synthes, West Chester, Pa), by a single surgeon. Patients with congenital anomaly, degenerative joint disease in temporomandibular joint, or masticatory muscle disorder were excluded. This study was reviewed and approved by the institutional review board at Chonnam National University Hospital (CNUDH-2016-001).

The subjects were divided into two groups, symmetric setback and asymmetric setback, according to the right/left difference of setback amount (\(<2.0, \geq 2.0\) mm). The setback difference was defined as the difference between the right and left setback. The setback amount was determined on the study cast when constructing surgical occlusion for the fabrication of surgical splint. Twelve (6 males, 6 females) and 18 (11 males, 7 females) patients were enrolled in symmetric and asymmetric setback group, respectively. The mean right/left setback difference was 0.8 mm in symmetric setback group and 3.3 mm in asymmetric setback group (Table 1).

### Image Acquisition

CT scans were obtained using a CBCT scanner (AlphardVega; Asahi Roentgen, Kyoto, Japan) before and immediately after surgery (\(3 \pm 1\) days). The scanner settings were as follows: 80 kVp, 5 mA, voxel size \(0.39 \times 0.39 \times 0.39\) mm, field of view 200 mm \(\times\) 179 mm, 17-second scan time. In order to reorient the volume image to a standard position, the CBCT scans were obtained with the use of reference ear plug (REP) and head posture aligner (HPA).\(^16,17\) The REP, which contains a 1.0-mm diameter titanium ball marker in its center, was inserted into each subject’s external

---

**Table 1. General Characteristics of Subjects**

<table>
<thead>
<tr>
<th></th>
<th>Mean ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (y)</strong></td>
<td>21.8 ± 3.8</td>
<td>17.9–29.7</td>
</tr>
<tr>
<td><strong>ANB (°)</strong></td>
<td>–2.6 ± 1.8</td>
<td>–6.0–1.0</td>
</tr>
<tr>
<td><em><em>Setback Difference</em> (mm)</em>*</td>
<td>0.6 ± 0.6</td>
<td>0.0–1.5</td>
</tr>
</tbody>
</table>

\(\ast\) Indicates the difference in right- and left-side setback amount.

---

*Angle Orthodontist, Vol 87, No 2, 2017*
auditory meatus. The HPA, which contains fluid-level equalizer and wire indicator, was placed on the patient’s left zygomatic area and adjusted the fluid level equalizer to register the degree of vertical head rotation at natural head position. The natural head position was obtained in an upright posture when the patient was focusing at a distant point at eye level.18,19

Image Processing

CBCT scan data were reconstructed as 3D images using In vivo software (version 5.3; Anatomage, San Jose, Calif). In order to evaluate condylar long axis change before and after surgery, 3D superimposition of pre- and postoperative volume images was performed. First, the preoperative volume images were reoriented into the standard position using two ball markers in REP and wire indicator in the HPA.16,17 Then, the postoperative volume image was reoriented into the same position as the preoperative volume image. The anterior cranial base was used as the registration area20 using the superimposition function of the In vivo program. A basal view of each reoriented volume image was captured to generate basal cephalograms. In order to visualize the condyles more clearly, the condyle segment was created separately in addition to generating an overall head image. After selecting axial views in 10-mm slab thickness using the clipping function of In vivo program, the image with the greatest mediolateral dimension of the condylar head was selected, and the overlapping area was removed using the sculpt function of the program. A photoshop program (CS4; Adobe, San Jose, Calif) was used to overlap the overall and segmental images to construct basal cephalograms with highlighted condyles (Figure 1).

Measurement of Condylar Long Axis Change

Condylar long-axis measurements were obtained on the generated cephalograms using an image analysis program (Image-Pro Plus, version 6.0; Media Cybernetics, Inc, Rockville, Md). All measurements were performed by a single operator. The measurements were made in degrees between the condylar long axis and the reference plane, which was drawn from right to left ball markers in the REP. Twenty images were randomly selected and repeated with a 4-week interval between the measurements to evaluate intraobserver reliability. Condylar long-axis change was defined as the difference between the pre- and postoperative condylar axis. Inward rotation was described as (+) whereas outward rotation was indicated as (−) (Figure 2).
Statistical Analysis

Reliability was assessed using the intraclass correlation coefficient (ICC). The condylar long axis before and after surgery and its changes were presented as means and standard deviations. The right and left sides were combined in the patients undergoing symmetric setback whereas lesser and greater setback side condyles were calculated separately in the patients undergoing asymmetric setback. In order to analyze the differences in condylar axis changes, a paired t-test was used. In the patients undergoing asymmetric setback, comparison of condylar axis changes between the lesser and greater setback sides was performed using a paired t-test. In order to identify the causes of condylar rotation, the condylar axis changes were correlated with setback amount or right/left setback difference using Pearson correlation analysis. All statistical analyses were carried out using SPSS software (version 21.0; SPSS Inc, Chicago, Ill).

RESULTS

Reliability analysis using ICC indicated good reliability as the Cronbach’s alpha showed 0.974. Before and after surgery, the condylar long-axis changes showed increases in degrees, indicating that the condylar rotation occurred generally in a pattern of inward rotation. All the changes were statistically significant ($P < .05$), indicating that the condylar rotation occurs regardless of symmetric and asymmetric setback. In patients undergoing symmetric setback, the condyles showed $3.4^\circ$ rotation in average. In case of asymmetric setback, the lesser setback side showed larger value ($4.3^\circ$) than the greater setback side ($2.3^\circ$) with a statistical significance (Table 2; Figure 3).

As a result of Pearson correlation analysis of condylar axis change with setback amount, the condylar axis changes had increasing tendency according to the amount of setback in patients undergoing symmetric setback. However, the correlations were not statistically significant. The correlation analysis of condylar axis change with right/left setback difference showed positive correlations, indicating a higher condylar rotation with greater right/left setback difference. In particular, the correlation was statistically significant in the lesser setback side of patients undergoing asymmetric setback (Table 3).

DISCUSSION

Although many methods to prevent condylar displacement have been reported, few studies are available regarding the factors influencing condylar displacement after SSRO. Harris et al. and Lee and Park evaluated condylar displacement by SSRO in three dimensions by means of helical CT and correlated with the amount of mandibular advancement or setback. However, they did not find any significant correlations with the amount of surgical movement. Moreover, patients undergoing asymmetric setback were not included in their studies. On the other hand, the present study evaluated the condylar axis changes not only in patients undergoing symmetric setback but also in patients undergoing asymmetric setback to investigate whether the changes are affected by the asymmetric setback. The evaluations were performed separately in lesser and greater setback side in patients undergoing asymmetric

Table 2. Changes in Condylar Long Axis (unit: $^\circ$) Before and After Surgery

<table>
<thead>
<tr>
<th></th>
<th>Before Mean ± SD</th>
<th>After Mean ± SD</th>
<th>Difference Mean ± SD (95% CI)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symmetric setback (n = 24)</td>
<td>14.8 ± 8.3</td>
<td>18.2 ± 7.7</td>
<td>+3.4 ± 4.0 (1.7, 5.1)</td>
<td>*</td>
</tr>
<tr>
<td>Lesser setback side (n = 18)</td>
<td>14.1 ± 5.9</td>
<td>18.4 ± 6.4</td>
<td>+4.3 ± 2.5 (3.1, 5.6)</td>
<td>*</td>
</tr>
<tr>
<td>Greater setback side (n = 18)</td>
<td>15.0 ± 7.5</td>
<td>17.2 ± 6.8</td>
<td>+2.3 ± 2.8 (0.9, 3.7)</td>
<td>*</td>
</tr>
</tbody>
</table>

* (+) indicates an inward rotation of condyle; CI, confidence interval. * $P < .05$. 

**Figure 3.** Comparison of condylar long axis changes between the lesser and greater setback side in asymmetric setback patients. *Results of paired t-test ($P < .05$).
Changes immediately after surgery. The present study however, few studies evaluated condylar rotation during setback surgery. Lee and Park9 and Ha et al.24 also reported significant, both in symmetric and asymmetric setback. However, the correlation analysis of condylar axis changes were affected by setback amount or right/left setback difference.

Measurement of condylar rotation showed 3.4° rotation in patients undergoing symmetric setback. Regarding the amount of rotation, previous studies reported a wide range of rotation, ranging from 1.5° to 5.8°. The rotation might be determined by many factors, including surgeon's experience, patient type, and time point of postoperative data. Some studies8,14 evaluated the changes at 3 months after surgery; other studies10–13 used the data 6 months after surgery. However, few studies evaluated condylar rotation changes immediately after surgery. The present study used data gathered immediately after surgery (3 ± 1 days), in other words, before the relapse or remodeling change. It was expected that such measurements can help in investigating the cause of condyle rotation changes.

Pearson correlation measures of condylar axis change with setback amount showed that the changes had increasing tendency according to the amount of setback in patients undergoing symmetric setback. However, the correlations were not statistically significant, both in symmetric and asymmetric setback surgery. Lee and Park8 and Ha et al.24 also reported that the positional change of the condyle after SSRO did not show significant correlation with the amount of setback. These results indicate that large amount of setback alone does not contribute the change in condylar long axis after surgery.

However, the correlation analysis of condylar axis change with right/left setback difference showed positive correlations indicating a higher condyle rotation with greater right/left setback difference. In particular, the correlation was statistically significant in lesser setback side of patients undergoing asymmetric setback. When the mandible is moved asymmetrically, the distal segment in the greater setback side is distally greater than in the opposite side. The intersegmental gap is bigger on the opposite side because the posterior aspect of distal segment interferes with the proximal segment. The fixation of proximal and distal segments with intersegmental discrepancy could cause the rotation of proximal segment, including condyle (Figure 2). The result of correlation analysis of condylar rotation with right/left setback difference indicates that asymmetric setback might cause the change in condylar long axis, particularly in the lesser setback side. This should be taken into consideration when formulating a postsurgical orthodontic treatment plan after SSRO, particularly in patients who need asymmetric setback to correct skeletal Class III malocclusion.

The present study did not use a specific fixation technique, such as bent plates,7,8 to reduce condylar rotation due to surgery. Instead, a four-hole straight plate was used in the manner of semirigid fixation to allow flexibility of postoperative functional adjustment of displaced condyle to the preoperative condylar position.25 Although the condyle exhibits significant rotation immediately after surgery, it could return to the original position without altering the position of distal segment. However, the orthognathic position of the distal segment can be influenced if a considerable amount of condyle displacement occurs and/or intermaxillary fixation is not sufficient. Such surgical instability could interfere with subsequent orthodontic treatment. Chen et al.36 reported that the changes in condylar position after SSRO were obvious 3 months after the surgery in mandibular reposition patients. Kim et al.37 also suggested that condyles tended to move, and this could influence postsurgical relapse up to 6 months after surgery, according to their study using patients with mandibular prognathism. Considering these, future studies regarding long-term changes of condylar rotation after SSRO are necessary to identify more clues about stable results after surgical treatment of patients with facial asymmetry. The studies about adaptive bone remodeling after surgery both in condyle and in glenoid fossa would also be needed as stability can be influenced by the changes in condylar morphology.

**CONCLUSIONS**

- A large amount of setback alone did not show significant correlation with the change in condylar long axis after SSRO.
- Right/left setback difference showed positive correlations with the condylar long axis change. In particular, the correlation was statistically significant in the lesser setback side.

**REFERENCES**


