# **Original Article**

# Cone-beam computed tomography evaluation on the condylar displacement following sagittal split ramus osteotomy in asymmetric setback patients:

# Comparison between conventional approach and surgery-first approach

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## ABSTRACT

Objective: To compare the condylar displacement following sagittal split ramus osteotomy (SSRO) in asymmetric setback patients between the conventional approach and surgery-first approach and to determine whether the condular displacement is affected by asymmetric setback in SSRO patients. Materials and Methods: This was a retrospective study. The subjects consisted of patients with facial asymmetry who underwent SSRO and had cone-beam computed tomography taken before and 1 month after surgery. They were allocated into the conventional (n = 18) and surgery-first (SF) groups (n = 20). Descriptive, independent *t*-tests and Pearson correlation analysis were computed. Results: The amount of condylar displacement in x-, y-, and z-directions and Euclidean distance showed no statistically significant differences between the conventional and SF groups. Comparing the postoperative condylar position with the preoperative position, the condylar displacement occurred in posterior (P < .05) and downward (P < .05) directions in both groups except on the deviated side in the conventional group. The condylar displacement occurred in a posterior (P <.05) direction on the deviated side of the conventional group. However, the condylar displacement in three dimensions showed no statistically significant differences between the two groups. In the correlation analysis, the condular displacement in both the deviated and contralateral sides showed no significant correlation with asymmetric setback in either group.

**Conclusion:** The condylar displacement in three dimensions and the distance of condylar displacement in SSRO patients with facial asymmetry showed no significant difference between conventional and SF groups. Condylar displacement was not associated with asymmetric setback. (*Angle Orthod.* 2017;87:733–738.)

**KEY WORDS:** Cone-beam computed tomography; Mandibular condyle; Asymmetric setback; Sagittal split ramus osteotomy; Surgery-first approach

## INTRODUCTION

The conventional three-stage surgical-orthodontic approach, which consists of presurgical orthodontics, surgery, and postsurgical orthodontics, has been well established as the most common procedure for the correction of skeletal deformities.<sup>1</sup> Dental decompensation is achieved via presurgical orthodontic treatment, so that the maximum skeletal correction is obtained at the time of surgery.<sup>1-4</sup> However, this approach has definite disadvantages including worsening facial esthetics and occlusal functions during presurgical orthodontic treatment.<sup>5-7</sup>

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	Age		ANB, °		Menton Deviation, $^{\circ}$		Setback Difference, <sup>a</sup> mm	
	Mean $\pm$ SD	Range	$\text{Mean} \pm \text{SD}$	Range	$\text{Mean} \pm \text{SD}$	Range	$\text{Mean}\pm\text{SD}$	Range
Conventional (n = 18) Surgery-first (n = 20)	$\begin{array}{c} 23.7\pm2.2\\ 21.8\pm3.7\end{array}$	20–28 18–32	$-2.1 \pm 2.5 \\ -3.0 \pm 2.2$	-8 <b>-</b> 2 -6 <b>-</b> 1	$\begin{array}{l} 4.1  \pm  2.2 \\ 3.6  \pm  1.1 \end{array}$	2–10.5 2–6.0	$\begin{array}{c} 4.4  \pm  2.2 \\ 3.8  \pm  1.6 \end{array}$	2–11 2–7.5

Table 1. Demographic Characteristics

<sup>a</sup> This indicates the difference in right- and left-side setback amount.

The surgery-first approach (SFA) includes orthognathic surgery first, followed by postsurgical orthodontic treatment.<sup>8–10</sup> The SFA can accelerate orthodontic tooth movement by the regional acceleratory phenomenon after surgery<sup>8,11–13</sup> and improve facial appearance immediately, which may contribute to improving satisfaction in orthognathic surgery patients.<sup>7,12,14–16</sup> However, it also has disadvantages, such as difficulty in precisely predicting the orthodontic outcome and management of unstable occlusion after surgery.<sup>17</sup>

A review of the recent literature regarding the positional changes of the condyles after orthognathic surgery showed a significant change after surgery.<sup>18–22</sup> Displacement of the condyle is known to influence surgical stability and cause early surgical relapse during postsurgical orthodontic treatment.<sup>23–25</sup> An asymmetric setback can cause displacement and rotation of the condyle in the treatment of prognathism with facial asymmetry.<sup>26,27</sup>

Numerous previous studies assessed the condylar displacement after surgery in the conventional threestage surgical-orthodontic approach, whereas few studies have evaluated condylar displacement in SFA patients. Wang et al.<sup>28</sup> evaluated the three-dimensional postoperative changes of the condylar position after mandibular setback surgery using the conventional approach and SFA. No significant difference was found between the two groups in the time-course changes of the condylar position. However, they evaluated condylar displacement after surgery in mandibular prognathism without facial asymmetry.

There is no evidence regarding the differences of condylar displacement in facial asymmetry between the conventional surgical approach and SFA. The purposes of this study were to compare condylar displacement following sagittal split ramus osteotomy (SSRO) in facial asymmetry between the conventional approach and SFA and to determine whether condylar displacement is affected by asymmetric setback.

### MATERIALS AND METHODS

### **Study Design and Subjects**

The institutional review board at Chonnam National University Dental Hospital approved this retrospective study. All patients who consecutively underwent mandibular setback surgery using SSRO from January 2011 to December 2015 at Chonnam National University Hospital were considered. The inclusion criteria were as follows: (1) menton deviation over 2° on posteroanterior radiographs, (2) mandibular setback surgery performed, (3) difference greater than 2 mm between the right and left setback amount, and (4) surgery performed by one oral and maxillofacial surgical team in which the surgeon had more than 10 years of experience in orthognathic surgery. Patients were excluded if they had any syndromes, facial trauma, degenerative joint disease, or masticatory muscle disorder.

This study included 38 patients divided into two groups, conventional and SF, according to the treatment procedure of presurgical orthodontics. Eighteen (12 men, 6 women) and 20 (12 men, 8 women) patients were enrolled in the conventional and SF groups, respectively. There was no significant difference between the two groups in demographic characteristics, such as age, ANB, menton deviation, or right/left setback difference (Table 1).

### **Image Acquisition and Processing**

Computed tomography (CT) scans were obtained using a cone-beam CT (CBCT) scanner (AlphardVega; Asahi Röentgen, Kyoto, Japan) under the following conditions: 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. The subjects were scanned in a seated position before and 3 to 4 weeks after surgery. In the conventional group, data were taken 1 month before surgery, whereas initial CBCT data were selected as the before-surgery data in the SF group. In the conventional group, after surgery data were selected as the intermaxillary fixation (IMF) was removed. On the other hand, data were taken after surgery as the orthodontic brackets were attached, 1 week after IMF removal in SF group. For standardized volume images, the CBCT scans were obtained in the natural head position with the use of a reference ear plug (REP) and head posture aligner (HPA).<sup>29,30</sup> The REP, which contains a 1.0-mm diameter titanium ball marker in its center, was inserted into the subject's ears. The HPA, which contains a fluid level equalizer and wire indicator, was placed on the patient's left zygomatic area, and the fluid level equalizer was adjusted to register the degree of vertical head rotation at natural



**Figure 1.** Evaluation of condylar displacement using three-dimensional superimposition of cone-beam computed tomography volume images. Although frontal and lateral cephalograms were generated in this study, frontal cephalograms are presented here as an example.

head position. The natural head position was obtained in an upright posture when the patient was focusing at a distant point at eye level.<sup>31,32</sup>

The CBCT scan data were reconstructed as threedimensional (3D) images using InVivo software (version 5.3; Anatomage, San Jose, CA). For reorientation of the preoperation volume images into the standard position, two ball markers in REPs and the wire indicator in the HPA were used.<sup>29,30</sup> To evaluate condylar displacement before and after surgery, 3D superimposition of pre- and postoperation volume images was performed. The anterior cranial base was used as the registration area using the function of superimposition of the InVivo program.33 Using the import orientation function of the program, the postoperation volume images were reoriented into the same position as the preoperation volume images. Three cephalograms (frontal, right lateral, and left lateral) were generated from each reoriented volume image. To visualize condyles more clearly, segmented images of the condyle were created separately from the volume image by removing overlapping areas using the clipping and sculpt functions in addition to generating an overall head image. Overall and segmental images were overlapped in Photoshop (CS4; Adobe, San Jose, CA),



**Figure 2.** Measurements of condylar displacement were obtained from cone-beam CT-generated cephalograms using scan data obtained before and after surgery. X-directional displacement was measured on frontal cephalograms (A), whereas y- and z-directional displacements were obtained from lateral cephalograms (B). L, Lateral condylar surface; P, posterior condylar surface; S, superior condylar surface.



Figure 3. Measurements of the distance of condylar displacement to evaluate amount of condylar displacement.

constructing cephalograms with more clearly visualized condyles (Figure 1).<sup>17</sup>

#### Measurement of Condylar Displacement

The origin coordinates (0, 0, 0) were set at the center point of the line drawn from right to left ball markers in the REPs. Cephalograms before and after surgery were precisely placed in the same coordinate system. To analyze the direction of condylar displacement, the condylar displacement was evaluated in the x- (mediolateral), y- (antero-posterior), and z- (upward-downward) directions (Figure 2). Condylar displacement was defined as the difference between pre- and postoperative condylar position in each direction. The values of lateral movement on frontal cephalograms and anterior and upward movement of the condyle on lateral cephalograms were described as positive, and the movements in the opposite directions were described as negative.

To compare the amount of condylar displacement between conventional and SF groups, the distance of condylar displacement was defined as the absolute difference between the pre- and postoperative condylar position in each direction (Figure 3). Euclidean distance was calculated.

All measurements were performed by a single operator. Twenty images were randomly selected and repeated with a 4-week interval between the measurements to evaluate intraobserver reliability.

#### **Statistical Analysis**

The normality of the measurement distribution was first checked using the Shapiro-Wilk test. The reliability was assessed using the intraclass correlation coefficient (ICC). The deviated and contralateral side condyles were evaluated separately in both conventional and SF groups. Independent *t*-tests were used to compare the condylar displacement and Euclidean distance between the conventional and SF groups. To identify the cause of condylar displacement, condylar displacement was correlated with right/left setback

	Conventional (n = 18)	Surgery-first $(n = 20)$	Significance
	$\text{Mean}\pm\text{SD}$	$\text{Mean}\pm\text{SD}$	(P Value)
Deviated side			
x-distance	$0.53\pm0.48$	$0.50\pm0.40$	.847
y-distance	$0.52\pm0.39$	$0.70\pm0.37$	.161
z-distance	$0.51\pm0.37$	$0.45\pm0.39$	.623
Euclidean distance	$1.03\pm0.51$	$1.07\pm0.48$	.792
Contralateral side			
x-distance	$0.55\pm0.59$	$0.33\pm0.49$	.214
y-distance	$0.41\pm0.30$	$0.58\pm0.46$	.191
z-distance	$0.43\pm0.41$	$0.53\pm0.38$	.451
Euclidean distance	$0.93\pm0.61$	$1.01\pm0.52$	.689

 Table 2.
 Comparison of the Distance of Condylar Displacement

 Between the Conventional and Surgery-First Approach

difference using Pearson correlation analysis. All statistical analyses were carried out using SPSS software (version 23.0; IBM SPSS, Armonk, NY).

## RESULTS

The Shapiro-Wilk test showed the data to be normally distributed. The ICC ranged from .993 to .999 for all variables, indicating excellent intraobserver reliability.

After surgery, most of the condyles showed significant displacement (P < .05), with minimal changes (<1 mm) observed in both the conventional and SF groups. Comparing the amount of condylar displacement between conventional and SF groups, the distance of condylar displacement in each direction and Euclidean distance exhibited no statistically significant differences between the 2 groups (Table 2).

Comparing the postoperative condylar position with the preoperative position: in the conventional group, condylar displacement occurred in a downward direction (P < .05) on the deviated side and in posterior (P< .05) and downward (P < .05) directions on the contralateral side. On the other hand, in the SF group, the condylar displacement occurred in posterior (P <.05) and downward (P < .05) directions on both the deviated and contralateral sides. However, the condylar displacement in 3D showed no statistically significant differences between the conventional and SF groups (Table 3).

In the Pearson correlation analysis of condylar displacement with right/left setback difference in the conventional and SF groups, the condylar displacement in both the deviated and contralateral sides showed no significant correlation with asymmetric setback in the x-, y-, and z-directions (Table 4).

### DISCUSSION

After introduction of SFA to overcome disadvantages including worsening facial esthetics<sup>7</sup> during presurgical

 Table 3.
 Comparison of Condylar Displacement in 3D Between the Conventional and Surgery-First Approach

	Conventional (n = 18)	Surgery-first (n = 20)	Significance	
	$\text{Mean}\pm\text{SD}$	$\text{Mean}\pm\text{SD}$	(P Value)	
Deviated side				
x-direction <sup>a</sup>	$-0.07 \pm 0.72$	$0.26 \pm 0.59$	.128	
y-direction <sup>ь</sup>	$-0.38 \pm 0.54$	$-0.61 \pm 0.51$	.183	
z-direction°	$-0.24 \pm 0.59$	$-0.44 \pm 0.40$	.236	
Contralateral sid	de			
x-direction <sup>a</sup>	$-0.04 \pm 0.82$	$0.23\pm0.55$	.239	
y-direction <sup>₅</sup>	$-0.25 \pm 0.45$	$-0.32 \pm 0.67$	.725	
z-direction <sup>c</sup>	$-0.35\pm0.48$	$-0.51  \pm  0.41$	.288	
a (⊥) denot	as lataral displa	acomont (_) don	intes medial	

 (+) denotes lateral displacement, (-) denotes medial displacement.

<sup>b</sup> (+) denotes anterior displacement, (-) denotes posterior displacement.

 $^{\rm c}$  (+) denotes upward displacement, (-) denotes downward displacement.

orthodontic treatment and a long presurgical orthodontic period<sup>34</sup> in the conventional approach, the interest in SFA is increasing among practitioners. However, few studies have compared the condylar displacement between conventional and SF approaches. Although Wang et al.<sup>28</sup> reported that condylar displacement was not significantly different between orthodontics-first approach and SFA, they did not include facial asymmetric subjects. The present study evaluated patients with facial asymmetry to assess the effect of asymmetric setback on condylar displacement.

Wang et al.<sup>28</sup> assessed the postoperative changes in condylar position using CT data taken in the supine position. Smith et al.<sup>35</sup> reported that slight positional changes of the head might alter the radiographic joint space. The present study evaluated condylar displacement using CBCT data obtained in an upright posture, which is most similar to natural head position. Based

	Conve (n =	entional = 18)	Surgery-first (n = 20)		
	Correlation Coefficient	Significance (P Value)	Correlation Coefficient	Significance (P Value)	
Deviated side					
x-direction <sup>a</sup>	385	.115	.120	.614	
y-direction <sup>b</sup>	114	.652	134	.575	
z-direction <sup>°</sup>	.220	.379	179	.449	
Contralateral s	ide				
x-direction <sup>a</sup>	409	.092	092	.701	
y-direction <sup>₅</sup>	.388	.112	.201	.397	
z-direction <sup>c</sup>	175	.487	092	.699	

 $\ensuremath{\,^{\ensuremath{a}}}$  (+) denotes lateral displacement, (-) denotes medial displacement.

 $^{\scriptscriptstyle \rm b}$  (+) denotes anterior displacement, (-) denotes posterior displacement.

 $^{\circ}\left( +\right)$  denotes upward displacement, (-) denotes downward displacement.

on the previous literature,<sup>35</sup> evaluation using CBCT data taken in the upright posture is believed to be appropriate for evaluating condylar displacement after surgery.

Measurement of condylar displacement showed no statistically significant differences between the two groups. This result is consistent with the results from a previous study.28 However, directions of condular displacement were different from previous studies.28,36 Condylar displacement might be affected by many factors, including patient type and surgical techniques. The present study showed posterior and downward displacement in both groups except on the deviated side in the conventional group, whereas Wang et al.28 showed lateral and inferior displacement in both groups. Wang et al.<sup>28</sup> evaluated condylar displacement in prognathism without asymmetry after surgery. However, the present study assessed condylar displacement in asymmetric setback patients. Han et al.<sup>36</sup> reported that linear condylar displacement occurred in the anterior, medial, and inferior directions, but their patients underwent intraoral vertical sagittal ramus osteotomy (IVSRO) with rigid fixation. The present study evaluated condylar displacement in SSRO setback patients with semirigid fixation. Moreover, the present study evaluated only linear condylar displacement. The changes of condylar position occurred not only in linear but also angular displacement. Future studies comparing angular displacement in facial asymmetry between conventional and SF groups are necessary.

The correlation between condylar displacement and right/left setback difference was not statistically significant regardless of deviated and contralateral side in both groups. Kim et al.<sup>37</sup> also reported that condylar displacement after SSRO in facial asymmetry did not show significant correlation with the extent of distal segment movement. These results indicate that asymmetric setback does not contribute to changes in the condyle after surgery in either conventional or SF groups.

The present retrospective study had several limitations, including the small sample size and the different time points of postsurgical CBCT data collected between conventional and SF groups. After surgery, IMF was applied for 3 weeks in both the conventional and SF groups. In the conventional group, CBCT scans were obtained after removal of IMF. However, we converted the surgical splint into a removable type by adding acrylic resin on the lateral sides of the splint in the SF group and had the patients wear it during functional jaw exercises so that the orthognathic position of the mandible was maintained by the indentations in the splint. One week later, CBCT scans and impressions were taken for orthodontic bracket attachment in the SF group. Thus, the time of postsurgical data collection was 3 weeks after surgery in the conventional group and 4 weeks after surgery in the SF group. Previous studies<sup>18,19</sup> reported that the condylar position had moved to the concentric position. Considering these previous results, although the condylar displacement showed no significant difference between the two groups, the changes in the SF group might be larger than those in the conventional group. Additional studies regarding the immediate condylar changes occurring after SFA in facial asymmetry are necessary.

In addition, the present study has a lack of long-term CBCT data. Thus, the long-term evaluation of condylar displacement needs to be addressed in future studies to identify more clues about surgical stability in asymmetric setback patients after surgery by means of SFA. Although a previous study<sup>36</sup> showed that displacement was not associated with postoperative temporomandibular joint (TMJ) pain and sounds after surgery, this was evaluated in IVSRO patients. Thus, studies regarding TMJ signs and symptoms following SSRO using a conventional approach vs SFA are also needed.

#### CONCLUSIONS

Condylar displacement in all 3D and the amount of condylar displacement in SSRO patients with facial asymmetry showed no significant differences between the conventional and SF groups. Condylar displacement was not associated with asymmetric setback.

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