OPEN

Analysis of Sagittal Position Changes of the Condyle After Mandibular Setback Surgery Across the Four Different Types of Plating Systems

Jeong-Kui Ku, DDS, PhD,[*] Sun-Kyu Choi, PhD,[†‡] Jung-Gon Lee, DDS,[§] Han-Chang Yu, DDS,[§] Sang-Yun Kim, DDS,[§] Young-Kyun Kim, DDS, PhD,[§||] Yonsoo Shin, DDS,[¶] and Nam-Ki Lee, DDS, PhD[¶]

Abstract: The authors analyzed the three-dimensional postoperative condylar position change across the plating systems. This retrospective study was conducted with the patients who underwent bilateral sagittal split ramus osteotomy with setback surgery. The condylar change was analyzed from preoperative cone-beam computed tomography to postoperative 1 month (T1) and postoperative 6 months (T2) using superimposition software, automatically merging based on the anterior cranial base. The condylar changes during T1 and T2 were analyzed across the four types of plates (4-hole sliding, heart-shaped, 3-hole sliding, and 4-hole conventional) Mean intraclass correlation coefficient values were consistently high for each measurement (>0.850). During T1, the conventional plate had a decreased condylar anterior distance when compared with the 3-hole sliding plate ($P = 0.032$). During T2, the conventional plate had an increased condylar posterior distance when compared with the 3-hole sliding plate ($P = 0.031$). Superimposition software based on the anterior cranial base could be available for measurement of condylar position with highly reproducible results. After bilateral sagittal split ramus osteotomy, the 3-hole sliding plate could effectively compensate for the anterior displacement of the condyle compared to other plates.

Key Words: Cone-beam computed tomography, mandibular condyle, orthognathic surgery, sagittal split ramus osteotomy, temporomandibular joint

(*J Craniofac Surg* 2021;32: 2441–2445)

Bilateral sagittal split ramus osteotomy (BSSRO) requires complex movement of the mandibular segments, which usually induces postoperative condylar displacement. Condylar displacement is one of the contributing factors to postoperative instability, temporomandibular joint disorders (TMDs), and condylar resorption.[1] Recently, many studies have been conducted regarding postoperative condylar position using three-dimensional images.[2–14] Because of the nature of orthognathic surgery, dental parts such as the teeth and jaw are changed; the unchanged cranial base is commonly used as a baseline to superimposition.[15,16] As a result, images can be accurately superimposed, but the effects of orthognathic surgery on postoperative condylar position remain controversial due to the three-dimensional axis setting and remodeling of the temporomandibular joint complex.[2,3]

One of the major problems related to condylar position during orthognathic surgery is the difficulty in checking the intraoperative condylar position. To overcome this problem, rigid fixation has been largely replaced with semi-rigid fixation using a miniplate.[17–19] Furthermore, the condylar repositionable plate, which is designed to allow repositioning of the condyle during the early postoperative period, was introduced according to the same principle of semi-rigid fixation.[8] In this plating system, the proximal segment can complete a pivot movement with 3-hole plates, a sliding movement with oval-shaped sliding plates, and a dynamic movement with heart-shaped plates. This system had been reported to be relatively stable and convenient for the operators.[8] Because both condyles should be evaluated independently even for one patient,[20] making analysis difficult due to the difference in the setback and yawing of the segment, limited research has been conducted on postoperative condylar position with the condylar repositionable plate.

The purpose of this study has 2 parts. The first was to evaluate the reproducibility of superimposition based on the anterior cranial base using an automatic three-dimensional analysis program. The second was to analyze the postoperative condylar position change at one and twelve months after surgery across the four different types of plating systems.

From the *Department of Oral and Maxillofacial Surgery, Section of Dentistry, Armed Forces Capital Dental Hospital, Armed Forces Medical Command, Seongnam; †Department of Biostatistics, Korea University College of Medicine, Seoul; ‡Medical Research Collaborating Center; §Department of Oral and Maxillofacial Surgery, Section of Dentistry, Seoul National University Bundang Hospital, Seongnam; ||Department of Dentistry and Dental Research Institute, School of Dentistry, Seoul National University, Seoul; and ¶Department of Orthodontics, Section of Dentistry, Seoul National University Bundang Hospital, Seongnam, South Korea.

Received August 6, 2020.

Accepted for publication January 10, 2021.

Address correspondence and reprint requests to Young-Kyun Kim, DDS, PhD, Department of Oral and Maxillofacial Surgery, Section of Dentistry, Seoul National University Bundang Hospital, 82 Gumi-ro 173, beon-gil, Bundang-gu, Seongnam, 13620, South Korea; E-mail: kyk0505@snubh.org

The authors report no conflicts of interest.

Supplemental digital contents are available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.jcraniofacialsurgery.com).

ISSN: 1049-2275

DOI: 10.1097/SCS.0000000000007578

MATERIAL AND METHODS

Study Design and Sample

Due to the retrospective nature of this study, it was granted an exemption in writing by the Institutional Review Board at Seoul National University Bundang Hospital (No. B-2003-598-106) and the authors have read the Helsinki Declaration and have followed the guidelines in this investigation.

This study was conducted on patients whose bilateral sagittal split ramus osteotomy (BSSRO) was performed for mandibular prognathism between March 2015 and January 2019 by one expert surgeon. The inclusion criteria were:

1) cone-beam computed tomography (CBCT) at the 0.2-mm voxel size level (Kodak 9500, Carestream Health, Inc., Trophy, France),
2) CBCT with fixed the bilateral external auditory canals and soft tissue nasion, and
3) CBCT both preoperatively and postoperatively at 1 and 6 months after surgery.

The exclusion criteria were a history of maxillofacial trauma, uncontrolled systemic diseases, and the presence of a dentofacial-related deformity or syndrome.

Surgery Protocol

All patients received orthognathic surgery by one expert surgeon (YKK). All patients underwent BSSRO using the modification known as the Obwegeser-Dal Pont sagittal split of the ramus. There were no cases of maxillary operation included in this study. In all cases, the proximal segment of the mandible was stripped of its pterygomasseteric sling at the inferior and posterior borders. The condylar position was set manually in order to confirm free movement of the proximal segment before internal fixation. Intended manual condylar positioning consists of placement of the condyle according to the following procedure[21]:

(1) Force the condyle to the highest position
(2) release the force to find the stable position of the condyle
(3) repeat the above steps until a stable, reproducible position is found, and
(4) position the proximal segment within 2 mm slightly forward.

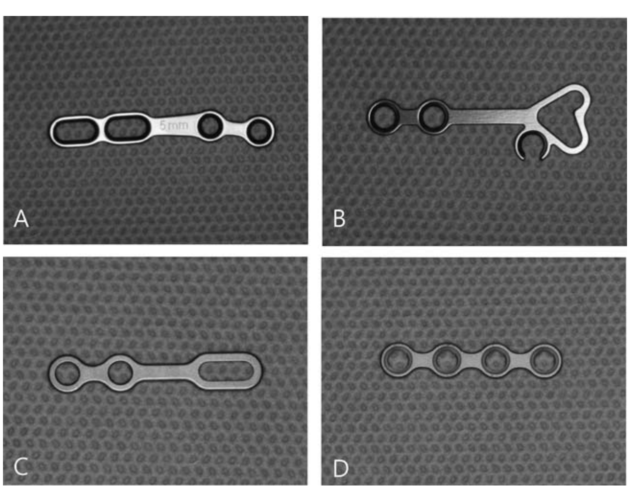

FIGURE 1. Four types of internal fixation plates. (A) APIS plate (4-hole sliding plate). (B) SJ plate (heart-shaped sliding plate). (C) Leforte-III plate (3-hole sliding plate). (D) Leforte-IV plate (4-hole conventional plate).

Both proximal segments were fixed with one of four different types of plates for bilateral non-rigid internal fixation: 4-hole sliding (APIS plate, Tradimedics, Gwangju, Korea; Fig. 1A), heart-shaped sliding (SJ plate, Jeil Medical, Seoul, Korea; Fig. 1B), 3-hole sliding (Leforte-III plate, Jeil Medical, Seoul, Korea; Fig. 1C), and conventional 4-hole (Leforte-IV plate, Jeil Medical, Seoul, Korea; Fig. 1D) plates. The intermaxillary fixation (IMF) was performed with four 0.7 mm wires using eight skeletal anchorage screws (6 mm length, Dual Top Anchor System, Jeil Medical, Seoul, Korea) on each of anterior and posterior of mandible and maxilla, respectively, for 2 or 3 weeks, with a surgical stent fixed on both maxillary canines. The surgical stent maintained for one to two weeks after surgery, even after removing the intermaxillary fixation.

Orthodontic Consideration

All patients received orthodontic treatment before and after their operation by one expert orthodontist (NKL) with minimal orthodontic preparation.[22] Preoperative orthodontic was treated during 7.5 ± 3.3 months (ranged 2–14). The intermaxillary fixation period was 2 to 3 weeks after the orthognathic surgery, and postoperative orthodontic treatment was performed immediately after the removal of the intermaxillary fixation to resolve a premature contact on the posterior teeth and to stabilize the occlusion.

With regarding mandibular position, lateral cephalometric analysis was done based on radiographs taken 1 and 6 months after surgery. The lateral cephalometric measurements were performed three times each by 2 orthodontist (YS and NKL), who did not involve the surgery to avoid the observer bias, using V-ceph program (Cybermed, Seoul, Korea). The means of the two rater's data were used. During postoperatively one to six months, the

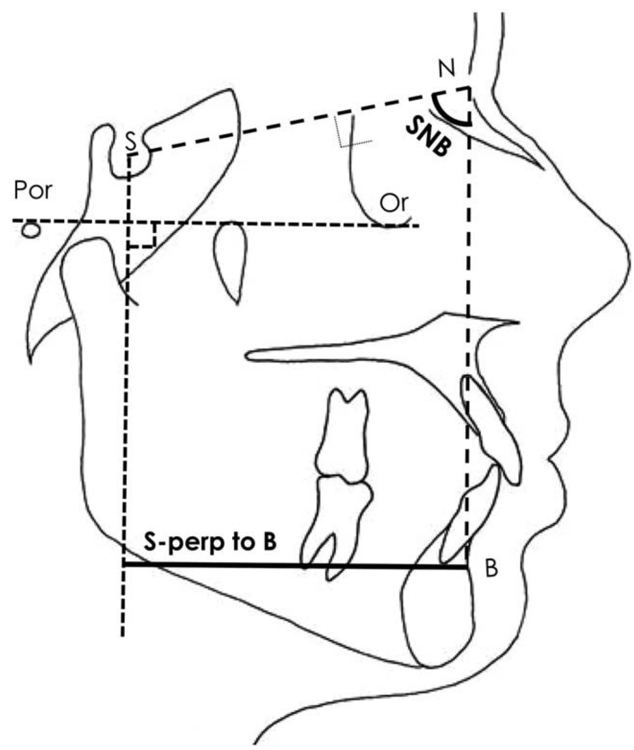

FIGURE 2. Cephalometric analysis and definition for measurements of mandibular position. (B, Point B (most concave point of mandibular symphysis); N, nasion; Or, orbitale; Por, porion; S, sella; S-perp to B, perpendicular line to Frankfort horizontal plane from the sella; SNB, angle between S-N line to N-B line).

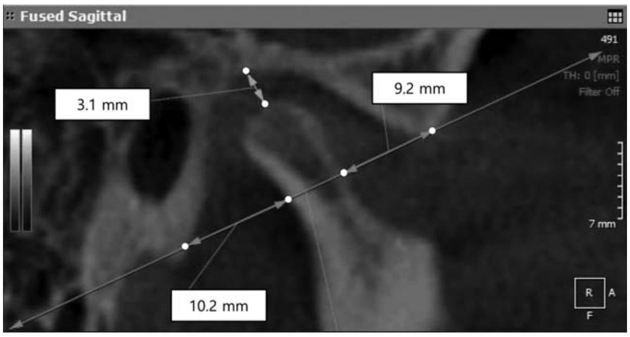

FIGURE 3. Measurement of condylar sagittal position on cone-beam computed tomography. Measuring the anterior and posterior distance between the eminence and condyle on the baseline between the orifice of the petrotympanic fissure and the lowest point of the articular eminence. The superior distance was measured from the perpendicular extent line to the baseline, across the highest point of the condyle.

mandibular position change was evaluated through S-perp to B and SNB (Fig. 2).

Measurements of Condylar Sagittal Position With Standardization and Superimposition of Cone-Beam Computed Tomography

For standardized volume images, the CBCT scans were obtained in the natural head, which was obtained in an upright posture when the patient was focusing at a distant point at eye level.[9] The CBCT images were exported as Digital Imaging and Communications in Medicine (DICOM) files and imported to the three-dimensional analysis program (On-Demand 3D, CyberMed Co., Seoul, Korea) to measure the right and left condylar positions separately.

The maxillary occlusal plane was defined between the middle of the maxillary incisor tip and the maxillary first molar as the x-axis plane. The mid-sagittal plane was defined as the plane that was perpendicular to the x-axis plane and passed through a nasion, which is defined as the middle point of the frontonasal suture.[23]

The sagittal section was analyzed on the view with the most superior point of the glenoid fossa. The anterior and posterior sagittal positions were measured as the anterior and posterior distances, respectively, between the eminence and condyle, based on the line between the orifice of the petrotympanic fissure and the lowest point of the articular eminence. The superior sagittal position was measured as the largest superior distance between the eminence and condyle, based on a perpendicular line to the aforementioned baseline (Fig. 3).

The automated registration tool for the On-Demand3D software was used to perform the superimposition, based on the intensity of the voxels' gray levels within the anterior cranial bases of the two volumes. The superimposition of CBCT was made from preoperative image to postoperatively at 1 month (T1), and to postoperatively 6 months (T2), respectively. The anatomical structures of the anterior cranial base were selected on axial, sagittal, and coronal slices of the early input DICOM files. After automated superimposition, the axial, coronal, and sagittal views were formed as slice directions of the early input image (Fig. 4).

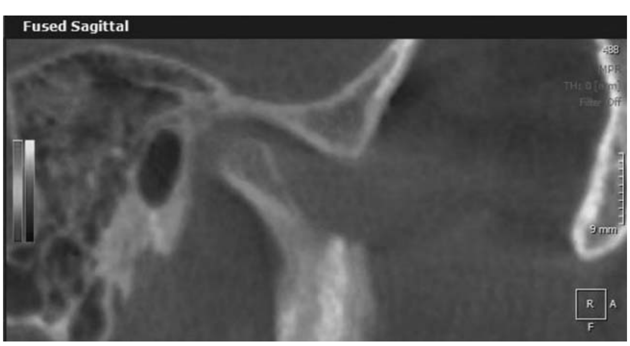

FIGURE 4. Cone beam computed tomography image after superimposition of condyle (red and yellow) based on the anterior cranial base using On-Demand 3D.

Statistical Analysis

Two examiners measured both condyles of the same patients twice, 3 months apart, at the 0.01 mm level. A total of 4 analyzed results, two measurements each by the 2 examiners, were considered as independent tests. The reliability of the measurements was evaluated through the intraclass correlation coefficient (ICC) with 95% confidence intervals. All continuous variables are shown as the median value [interquartile range]. Kruskal-Wallis analysis was applied to the age, amount of setback, IMF period, and changes of the mandibular body and the condyle across the types of plates. Post-hoc analysis was performed using the Mann-Whitney *U* test with a correction of type 1 error according to Bonferroni's method. Statistical significance was assessed based on a *P* value less than 0.05. All statistical analysis was performed by SPSS 22.0 for Windows (SPSS Inc., Chicago, IL, USA).

RESULTS

A total of 52 condyles on 26 patients (14 males and 12 females, median age of 21.50 [5.00] years) were enrolled. The average amount of setback was 8.00 [4.00] and 7.50 [6.00] mm on the right and left side, respectively. Intermaxillary fixation was performed for two weeks on 18 patients and 3 weeks on 8 patients. Six patients were fixed with the APIS plate, 6 with the SJ plate, nine with the Leforte-III plate, and five with the Leforte-IV plate. No significant difference was seen in the mean age, amount of setback on either side, and the fixation period (Supplementary Digital Content, Table 1, http://links.lww.com/SCS/C518).

Changes in Mandibular Body Position Among the Types of Plates

Overall, the distal segment of mandible moved forward direction as a relapse after the setback orthognathic surgery. However, there was no difference in the relapse tendency of mandible among the types of plates from postoperative one month to 6 months (S perp to B, $P < 0.190$; SNB, 0.821; Supplementary Digital Content, Table 2, http://links.lww.com/SCS/C518)

Reliability Analysis of the Condylar Position

The ICC values of the 4 data points on condyle position, as measured by the 2 examiners twice each, were calculated for the right and left sagittal distances on anterior (0.961, CI: 0.973–0.987 and 0.970, CI: 0.957–0.979, respectively), posterior (0.957, CI: 0.939–0.971 and 0.950, CI: 0.929–0.966, respectively), and superior (0.923, CI: 0.890–0.947 and 0.862, CI: 0.805–0.906, respectively). Overall, this method showed consistently high mean ICC values across all four measurements (Supplementary Digital Content, Table 3, http://links.lww.com/SCS/C518).

Changes in Condyle Position Among the Types of Plates

During T1, changes in the condylar anterior distance showed a statistically significant difference among the different types of plates ($P = 0.017$). Among the plates, the anterior distance was decreased in the Leforte-IV plate compared with no change in the Leforte-III plates (−0.80 [3.96] versus 0.00 [0.52], $P = 0.032$)

(Supplementary Digital Content, Table 3, http://links.lww.com/SCS/C518). However, changes in the condylar posterior and superior distances showed no statistically significant difference across the types of plates.

The condylar anterior distance change showed no statistically significant difference among the types of plates during T2 (Supplementary Digital Content, Table 4, http://links.lww.com/SCS/C518). However, the posterior distance changes showed a statistically significant difference among the types of plates ($P = 0.010$). Among the plates, the posterior change was increased in Leforte-IV plate compared with the Leforte-III plate (0.00 [0.72] and 1.16 [2.88] mm, 0.031) (Supplementary Digital Content, Table 4, http://links.lww.com/SCS/C518). During T2, the superior distance changes with the APIS and Leforte-III plates (0.03 [0.89] and 0.00 [0.22] mm, respectively) were less than those of the SJ and Leforte-IV plates (0.30 [0.54] and 0.51 [2.13] mm, respectively), and the overall changes were significantly different among the groups ($P = 0.031$). However, the statistically corrected values of type 1 error did not show any significant difference in each group.

DISCUSSION

Two assumptions were verified in the present study with 52 condyles on 26 patients (14 males and 12 females, average aged 21.50 years). First, the automatic superimposition software based on the anterior cranial base showed high reproducibility. Second, the condylar position changes after setback surgery with BSSRO showed different aspects associated with the types of plates (one conventional plate and three condylar repositionable plates—4-hole sliding, heart-shaped, and 3-hole sliding plates).

CBCT is a three-dimensional imaging technique with low radiation exposure and is widely used for planning maxillofacial surgery. The technical development of the software program allows for precise measurements of distances and angles by superimposition of a stable structure.[2,3] Considering the shape and axis direction of the mandibular condyle, however, the condylar evaluation is difficult to determine on a selected single CT cut image.[24] We selected the cut image, included the most protruding part of the condyle, based on a three-dimensional axis with maxillary occlusal planes. Our criterion was found to be highly reliable among the four results of measurements between the 2 examiners (all ICC values > 0.850). As a base axis, the maxillary occlusal plane could be an available reference for dentists that enables accurate analysis.

Since 1962, joint space measurements have been used to assess the mandibular condyle position radiographically.[25] The distance measurement between the joint space, composed of the condyle and eminence, could be related to TMDs.[26] In addition, the condyle undergoes compensatory adaptation during the postoperative period.[27] Such remodeling could change the distance or rotation and has been suggested as a possible factor in TMDs.[28] However, some studies reported no significant change in condylar shape, disc position, and relevant symptoms after mandibular setback orthognathic surgery.[6,7] The authors measured the change from preoperative to postoperative 1 month (T1) and to postoperative 6 months (T2).

The average age, setback distance of the right and left sides, intermaxillary fixation period, and distal segment (mandibular body) position change were not significantly different among the types of plates (Supplementary Digital Content, Table 1, http://links.lww.com/SCS/C518 and Supplementary Digital Content, Table 2, http://links.lww.com/SCS/C518). The mandibular body was relapsed forwardly regardless of the types of plates, and the condylar position was anteriorly and inferiorly displaced after the orthognathic surgery. These results corroborated those of previous studies.[4,10–13]

During T1, the overall anterior sagittal distance decreased. In particular, the anterior distance decreased more with the conventional plate (0.80 [3.96] mm) compared to the 3-hole sliding plate (0.00 [0.52] mm) ($P = 0.032$). Kim et al[13] reported that this anterior movement at 2 weeks after surgery was due to the occurrence of edema and hemarthrosis. However, this early displacement of the proximal segment could be more successfully compensated with the 3-hole sliding plate than with the conventional plate. This tendency became more pronounced during T2 in the posterior condylar distance, which was overall increased, but was more increased with the conventional plate (1.16 [2.88] mm) compared to the 3-hole sliding plate (0.00 [0.50]) ($P = 0.031$). With regard to the antero-posterior sagittal position, the 3-hole sliding type of condylar repositionable plate could effectively compensate for condylar anterior displacement during the 6 months after surgery.

Furthermore, during T2, the 4-hole sliding and 3-hole sliding plates showed little change in the median value of the superior distance (0.03 [0.89] and 0.00 [0.22] mm, respectively), while the heart-shaped and 4-hole conventional plates showed increased inferior displacement (0.30 [0.54] and 0.51 [2.13] mm, respectively). Among the groups, the superior distance changes showed a significant difference in the Kruskal-Wallis test ($P = 0.031$). Although there was no significant difference between each group by Bonferroni correction, the 3-hole sliding plates showed less of a change than the heart-shaped and 4-hole conventional plates when considering the interquartile range. Considering the limitations of this study, the 3-hole sliding plate, among the 3 types of condylar repositionable plates, might most effectively compensate for the well-known inferior displacement of the condyle, as seen in previous studies.[4,10–12]

The relationship between changes in condylar position and TMDs has been very controversial within the scientific community. Some studies have reported that minor changes do not play a significant role, as corroborated by the present study.[6,7] However, some degree of condylar displacement may jeopardize not only stability in orthognathic surgery but also the orthodontic treatment.[14] Therefore, the importance of including the determination of condyle position during orthodontic diagnostic procedures becomes very clear. Although this study did not analyze condylar shape change, condylar remodeling affects long-term outcomes of orthognathic surgery in association with condylar position. We could not evaluate the lateral and medial angulation of the condylar process because there was lack of reproducibility to measure a long axis of condyle on coronal and axial plane. In addition, the distal segment (mandibular body) position was evaluated antero-posteriorly on cephalometric radiographs. To overcome several limitations of this retrospective study, further research on condylar position and shape should include an improved prospective design and a larger number of patients with considering the three-dimensional positional change of the distal segment.

CONCLUSION

Using the maxillary occlusal plane as a reference axis plane, a three-dimensional measurement was performed with highly reproducible results and enabled accurate analysis. Considering the limitations of this study, the condylar repositionable plate could compensate for the anterior displacement of the condyle, and, in particular, the 3-hole sliding plate could prevent anterior displacement in the early period and might be effective in compensating for inferior displacement of the condyle during the 6 months after setback surgery.

REFERENCES

1. Borstlap WA, Stoelinga PJ, Hoppenreijs TJ, et al. Stabilisation of sagittal split advancement osteotomies with miniplates: a prospective,

multicentre study with two-year follow-up. Part II. Radiographic parameters. *Int J Oral Maxillofac Surg* 2004;33:535–542
2. Cevidanes LH, Styner MA, Proffit WR. Image analysis and superimposition of 3-dimensional cone-beam computed tomography models. *Am J Orthod Dentofacial Orthop* 2006;129:611–618
3. Lee JH, Kim SM, Lee BK, et al. 3D vector analysis of mandibular condyle stability in mandibular setback surgery with bicortical bioabsorbable screw fixation. *J Craniomaxillofac Surg* 2014;42:e105–e110
4. Wang T, Han JJ, Oh HK, et al. Comparison of orthodontics-first and surgery-first approach in positional changes of the condyle after mandibular setback surgery using three-dimensional analysis. *J Oral Maxillofac Surg* 2016;74:2487–2496
5. Baek SH, Kim TK, Kim MJ. Is there any difference in the condylar position and angulation after asymmetric mandibular setback? *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2006;101:155–163
6. Kim YK, Yun PY, Ahn JY, et al. Changes in the temporomandibular joint disc position after orthognathic surgery. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2009;108:15–21
7. Fang B, Shen GF, Yang C, et al. Changes in condylar and joint disc positions after bilateral sagittal split ramus osteotomy for correction of mandibular prognathism. *Int J Oral Maxillofac Surg* 2009;38:726–730
8. Roh YC, Shin SH, Kim SS, et al. Skeletal stability and condylar position related to fixation method following mandibular setback with bilateral sagittal split ramus osteotomy. *J Craniomaxillofac Surg* 2014;42:1958–1963
9. Oh MH, Hwang HS, Lee KM, et al. 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. *Angle Orthod V 87* 2017:733–738
10. Lee W, Park JU. Three-dimensional evaluation of positional change of the condyle after mandibular setback by means of bilateral sagittal split ramus osteotomy. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2002;94:305–309
11. Sheikh Z, Sima C, Glogauer M. Bone replacement materials and techniques used for achieving vertical alveolar bone Augmentation. *Materials (Basel)* 2015;8:2953–2993
12. Choi BJ, Choi YH, Lee BS, et al. A CBCT study on positional change in mandibular condyle according to metallic anchorage methods in skeletal class III patients after orthognatic surgery. *J Craniomaxillofac Surg V 42* 2014:1617–1622
13. Kim YJ, Lee Y, Chun YS, et al. Condylar positional changes up to 12 months after bimaxillary surgery for skeletal class III malocclusions. *J Oral Maxillofac Surg* 2014;72:145–156
14. Hidaka O, Adachi S, Takada K. The difference in condylar position between centric relation and centric occlusion in pretreatment Japanese orthodontic patients. *Angle Orthod* 2002;72:295–301
15. Cevidanes LH, Oliveira AE, Grauer D, et al. Clinical application of 3D imaging for assessment of treatment outcomes. *Semin Orthod* 2011;17:72–80
16. Cevidanes LH, Bailey LJ, Tucker GR Jr et al. Superimposition of 3D cone-beam CT models of orthognathic surgery patients. *Dentomaxillofac Radiol* 2005;34:369–375
17. Ueki K, Nakagawa K, Takatsuka S, et al. Plate fixation after mandibular osteotomy. *Int J Oral Maxillofac Surg* 2001;30:490–496
18. Chung IH, Yoo CK, Lee EK, et al. Postoperative stability after sagittal split ramus osteotomies for a mandibular setback with monocortical plate fixation or bicortical screw fixation. *J Oral Maxillofac Surg* 2008;66:446–452
19. Choi BH, Min YS, Yi CK, et al. A comparison of the stability of miniplate with bicortical screw fixation after sagittal split setback. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2000;90:416–419
20. Martins E, Silva J-C, Pires CA, et al. Coronal joint spaces of the Temporomandibular joint: systematic review and meta-analysis. *J Clin Exp Dent* 2015;7:e435–e440
21. Hwang D-S, Kim Y-I, Lee K-M. Effect of intended manual condylar positioning on skeletal and dental changes in Skeletal Class III deformities: CBCT-generated Half-Cephalograms. *J Craniomaxillofac Surg* 2013;42:
22. Lee JY, Kim YK, Yun PY, et al. Evaluation of stability after orthognathic surgery with minimal orthodontic preparation: comparison according to 3 types of fixation. *J Craniofac Surg* 2014;25:911–915
23. Li J, Ryu SY, Park HJ, et al. Changes in condylar position after BSSRO with and without Le Fort I osteotomy via surgery-first approach in mandibular prognathism with facial asymmetry. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2017;123:661–669
24. Yang HJ, Hwang SJ. Change in condylar position in posterior bending osteotomy minimizing condylar torque in BSSRO for facial asymmetry. *J Craniomaxillofac Surg* 2014;42:325–332
25. Rickets RM. Present status of laminagraphy as related to dentistry. *J Am Dent Assoc V 65* 19391962:56–64
26. Crawford SD. Condylar axis position, as determined by the occlusion and measured by the CPI instrument, and signs and symptoms of temporomandibular dysfunction. *Angle Orthod* 1999;69:103–115, discussion 115-106
27. Ueki K, Marukawa K, Nakagawa K, et al. Condylar and temporomandibular joint disc positions after mandibular osteotomy for prognathism. *J Oral Maxillofac Surg* 2002;60:1424–1432, discussion 1432-1424
28. Lin H, Zhu P, Lin Y, et al. Mandibular asymmetry: a three-dimensional quantification of bilateral condyles. *Head Face Med* 2013;9:42

