Transverse Displacement of the Proximal Segment After Bilateral Sagittal Osteotomy: A Comparison of Lag Screw Fixation Versus Miniplates With Monocortical Screw Technique

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Purpose: The purpose of the present study was to compare lag screw fixation versus miniplates with monocortical screw technique with respect to the amount of transverse displacement of the proximal segment after bilateral sagittal osteotomy (BSO) for mandibular advancement surgery.

Patients and Methods: We conducted a multicenter, retrospective investigation of 82 patients who underwent a mandibular advancement with BSO and rigid internal fixation. Forty-five patients from Denmark and Sweden, the miniplate fixation group, received a rigid fixation consisting of miniplates with monocortical screws. Thirty-seven patients from the Mayo Clinic, the lag screw fixation group, received a rigid fixation with lag screw fixation of the mandible. The transverse displacement and angulation of the proximal segments were measured on posterior-anterior cephalometric radiographs, using the best-fit method.

Results: After BSO, 44 of 45 patients in the miniplate fixation group showed an increased transverse intergonion distance with a mean of 5.0 mm and an increase transverse interramus width with a mean of 2.4 mm. Thirty-six of 37 patients in the lag screw fixation group had an increased intergonial width with a mean of 5.6 mm, and 35 of 37 patients showed an increased transverse interramus width with a mean of 3.3 mm. *t* tests showed that there were no significant differences between the 2 groups with respect to these 2 variables.

Conclusions: Our results indicate that transverse displacements of the proximal segments occur after BSO surgery with both miniplate or lag screw fixation technique. Attention and future studies should focus on possible complications that transverse displacement of the proximal segment may cause.

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Combined orthodontic and surgical procedures are commonly used to correct dentofacial malformations. Bilateral sagittal osteotomy (BSO) is the first choice for many surgeons when operating on adolescent and adult patients with mandibular retrognathia. Despite its popularity, postsurgical instability due to displacement of the condyle from its seated position in the glenoid fossa in the 3 planes of space (ie, sagittal, vertical, and transverse) remains an area of concern.

The sagittal and vertical position of the condyle in the glenoid fossa after a BSO has been analyzed in several studies and a superior and posterior movement of the condyle postsurgically has been described.[1-3] Studies have also reported a correlation between an increasing amount of mandibular surgical advancement and an increasing postsurgical superior movement of the condyle.[1,2,4] Relapse has often been described to be associated with condylar distraction.[4,5] Schendel and Epker[6] concluded that control of the proximal segment was the single most important aspect in determining prevention of relapse and stability of planned postsurgical position and that the amount of relapse increased with the amount of initial advancement. There is, however, no general consensus as to what constitutes an ideal functional and stable relationship between the condyle, the meniscus, and the glenoid fossa. Intraoperative diagnosis of an unfavorable condylar position is desirable but difficult to accomplish.

Different surgical fixation techniques and their influence on the condylar position have been discussed. Becktor et al[7] reported on the transverse displacement of the proximal segment after BSO with rigid internal fixation (RIF) using lag screw technique for mandibular advancement, and they found increased intergonial width for 36 of 37 patients immediately after surgery. However, no study to date has yet shown if any 1 type of fixation is superior with regard to minimizing proximal segment displacement. Investigating the type of fixation could lead to more answers on why proximal segment displacement occurs during surgery.

The purpose of the present study was to compare lag screw fixation versus miniplates with monocortical screw technique with respect to the amount of transverse displacement of the proximal segment after BSO for mandibular advancement surgery.

Materials and Methods

SUBJECTS

This study was conducted as a multicenter, retrospective investigation of consecutively treated patients selected from *1*) the Department of Oral and Maxillofacial Surgery, Rigshospitalet, Copenhagen University Hospital, Denmark, *2*) Division of Oral and Maxillofacial Surgery, Maxillofacial Unit, Halmstad, Sweden, and *3*) the Department of Orthodontics, Mayo Clinic, Rochester, MN.

Forty-five patients from Denmark and Sweden underwent mandibular advancement with BSO performed by 4 surgeons between the years 1995 to 2002. All patients received a rigid fixation consisting of miniplates with monocortical screws. Thirty-seven patients from the Mayo Clinic also underwent mandibular advancement with BSO, performed by 2 surgeons between the years 1990 and 1999. All patients from the Mayo Clinic received lag screw fixation of the mandible, placed intraorally, with no skin incisions made. The Mayo Clinic material has been investigated and discussed in a previous publication by Becktor et al.[7]

The choice of treatment was determined by the orthodontist and the oral surgeon at the clinical and radiographic presurgical examinations. Patients included in the study met the following criteria: *1*) the malocclusion was caused by mandibular retrognathia; *2*) presurgical and postsurgical orthodontic treatment was performed; and *3*) BSO with either miniplates and monocortical screws, or lag screw fixation, was used as the surgical procedure to advance the mandible with or without genioplasty. No other adjunctive surgical procedures were performed. Of a total of 64 patients from the centers in Denmark and Sweden, 19 subjects (29.7%) were excluded, all as a result of inconsistent radiographic pre- and postoperative examinations. The radiographic records of the remaining 45 (14 men, 31 women), with a mean age of 31 years, were examined retrospectively. Of a total of 42 patients from the center in the Mayo Clinic, 5 subjects (11.9%) were excluded for the same reasons previously mentioned, leaving 37 (14 males, 23 females), with a mean age of 28 years (Table 1).

SURGERY

Patients from all centers received conventional pre- and postoperative orthodontic treatment and underwent a mandibular bilateral sagittal ramus osteotomy advancement as described by Obwegeser[8] and modi-

Table 1. DISTRIBUTION OF PATIENTS WITH REGARD TO GENDER AND AGE

Fixation Type	n	Male/ Female	Mean Age, yr (SD)	Age Range, yr
Miniplates	45	14/31	31.0 (10.83)	17 to 56
Lag screws	37	14/23	27.8 (11.63)	14 to 55

Abbreviation: SD, standard deviation.

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fied by Dal Pont.[9] The planned occlusion was established with a prefabricated splint. The proximal segment was manually repositioned and stabilized with a self-retaining clamp.

At the Danish and Swedish centers, RIF of the osteotomy was accomplished by using a 4-hole straight miniplate or a 5-hole L-formed miniplate with monocortical screws (2 mm) bilaterally in the body of the mandible. The miniplate was placed on the lateral aspect of the body of the mandible to engage both proximal and distal segments. The occlusion was checked after placement of RIF. The patients from the Danish center wore the splint in place for 4 weeks postoperatively, whereas the patients from the Swedish center did not. All the patients from the Danish and Swedish centers were not intermaxillary wire fixated or had only very light guiding elastics for 1 to 4 weeks postoperatively. Seven patients had advancement genioplasty in addition to mandibular advancement.

At the Mayo Clinic, RIF was accomplished by using 2 lag screws bilaterally in the ramus. The screws were placed with the lag screw technique, through both proximal and distal segments in the region distal to the second molar tooth and above the mandibular canal. The occlusion was checked after the placement of the RIF. The patients had intermaxillary wire fixation with the splint in place for 1 to 2 weeks after surgery. Seven patients underwent advancement genioplasty in addition to the mandibular advancement.

RADIOGRAPHIC EXAMINATION

The radiographic material for this study consisted of 2 posterior-anterior (P-A) cephalometric radiographs and 2 lateral cephalometric radiographs for each patient. The P-A and lateral cephalometric radiographs were obtained at the following time periods: presurgically (T1) and postsurgically (T2). Table 2 shows the distribution of the time periods of when the radiographs were taken relative to the time of surgery.

A standardized natural head position was used while obtaining the lateral and P-A cephalometric radiographs. At each center, the radiographs were taken with the same equipment, and the same film/focus distance was used. All radiographs were taken at optimal exposure, and anatomical landmarks were clearly visualized.

All radiographs were hand-traced on acetate paper. Superimposition of P-A radiographs was performed according to the method as described in a previous article by Becktor et al.[7] Superimposition of lateral cephalometric radiographs was performed as recommended by Björk and Skieller.[10,11] Two examiners shared the duty of tracing the radiographs of the lag screw fixation patients, and 3 examiners were involved in tracing the radiographs on the miniplate fixation patients. At the Mayo Clinic, 2 examiners independently traced P-A and lateral cephalometric radiographs of 25 patients. The level of agreement between the 2 investigators (interexaminer reliability) on these 25 patients was estimated by calculating the intraclass correlation coefficient (ICC). The measurement error (intraexaminer reliability) was determined by the Dahlberg formula and was based on 10 randomly selected patients that were retraced and remeasured by the same 2 investigators.

The P-A radiographs were used to measure the angulation of the proximal segment, and the mandibular width. The following reference points and lines were used (Fig 1): Ramus point (RP) was defined as the most superior visible point on the lateral border of the ramus. Gonion point (GO) was defined as the most inferior point on the lateral border of the mandible determined by a tangent to the outline from RP. Upper orbital margin (UOM) was defined as the most superior visible margin of the orbit.

Reference lines were drawn through GO and RP, and a tangent line to the UOMs was used as a horizontal reference plane. Points GO and RP were then transferred forward from the T1 to the T2 radiograph by a best-fit superimposition of the proximal segment cortical outline.

The following variables were recorded:

The medial ramus angles between UOMs and GO-RP lines, the distances between left GO and right GO, and the distance between the left and right RP.

Table 2. DISTRIBUTION OF TIME PERIODS OF WHEN RADIOGRAPHS WERE TAKEN RELATIVE TO SURGERY

	Range (Miniplate/Lag Screw)	Mean (Miniplate/Lag Screw)	SD (Miniplate/Lag Screw)
T1 radiographs (preop)			
Weeks before surgery	1-56/1-8	8.9/1.5	12.96/1.61
T2 radiographs (postop)			
Weeks after surgery	1-26/1-4	3.5/1.2	3.96/0.55

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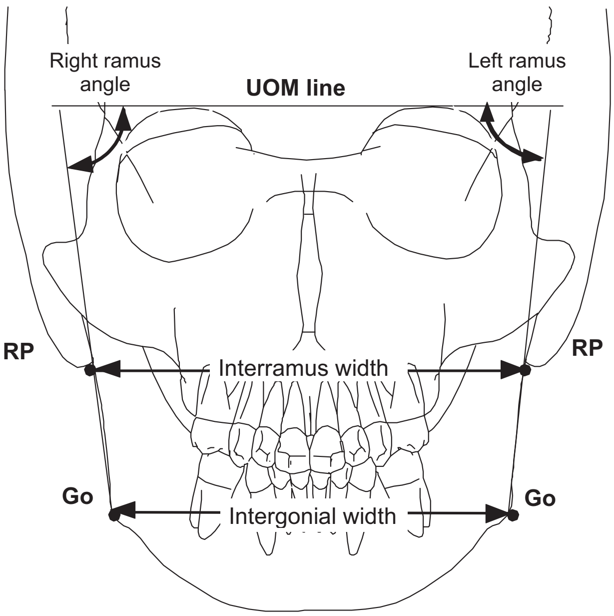

FIGURE 1. The distances from RP to RP and from GO to GO were measured. Reference lines through RP and GO and a tangent line to UOMs were used to measure the angulation of the proximal segment. UOM, upper orbital margin; RP, ramus point; GO, gonion.

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The lateral cephalometric radiographs were used to measure the advancement of the distal segment in the mandible, obtained by the BSO. The sagittal and vertical movements were recorded by changes in the position of B point from T1 to T2.

The reference points used were marked directly on the radiographs with a sharp soft pencil. B point, defined as the most posterior point on the anterior surface of the symphysis, was transferred from the T1 tracing to the T2 tracing by a best-fit superimposition of the distal segments on each other.[12] Lateral cephalometric radiographs were superimposed on anatomically stable structures in the anterior cranial base, according to the method described by Bjork.[10,11] A reference line, perpendicular to the occlusal plane, was constructed.

It is to be noted that B point movements in the superior and anterior direction relative to the reference line were recorded as positive values, and inferior and posterior movements were recorded as negative values.

ERROR OF MEASUREMENT TECHNIQUE

Table 3 shows the measurement error using the Dahlberg formula:

$$ME = \sqrt{\left(\sum D^2/2N\right)}$$

where D = difference between the 2 measurements on the same patient, and N = number of patients remeasured. Method error scores were found to be low for all variables retested. The agreement or reliability between the 2 investigators was estimated by calculating the intraclass correlation coefficient (ICC).[13] The ICC assesses the correlation between repeated measurements on the same patient. The ICC was calculated from the variance components estimated by fitting a 2-way random effects analysis of variance model, with subjects and investigators being handled as 2 random effects. The interpretation of an ICC is similar to that of a correlation coefficient and

Table 3. MEASUREMENT ERROR AND AGREEMENT RELIABILITY

	Measurement Error Using Dahlberg's Formula Based on n = 10 Patients		Agreement (Reliability) Based on n = 25 Patients	
Measurement	Investigator 1	Investigator 2	ICC	95% CI
Intergonial width (Go-Go)				
T1	0.38 mm	0.46 mm	0.98	0.95-0.99
T2	0.70 mm	0.34 mm	0.98	0.96-0.99
Left UOM/RP/Go angle				
T1	1.01°	0.51°	0.96	0.92-0.98
T2	0.58°	0.76°	0.97	0.93-0.99
Right UOM/RP/Go angle				
T1	0.79°	0.56°	0.93	0.83-0.97
T2	0.74°	0.63°	0.93	0.84-0.97
B point—horizontal				
T1	1.71 mm	0.72 mm	0.93	0.84-0.97
T2	0.94 mm	0.70 mm	0.92	0.83-0.96
B point—vertical				
T1	1.54 mm	0.81 mm	0.93	0.76-0.97
T2	1.41 mm	0.82 mm	0.94	0.86-0.98

Abbreviations: ICC, intraclass correlation coefficient; 95% CI, 95% confidence interval for the ICC estimates.

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Table 4. CHANGES IN LATERAL CEPHALOMETRIC RADIOGRAPHIC MEASUREMENTS BETWEEN T1 AND T2

	Range (T1-T2)	Mean	SD
Horizontal movement at B point (mm)*			
Halmstad Clinic (16)	2-7	4.7	1.66
Copenhagen Clinic (29)	2-12	5.8	1.98
Miniplate fixation patients (all 45)	2-12	5.4	1.92
Mayo Clinic—lag screw fixation (37)	0.9-12	4.9	2.44
Vertical movement at B-point (mm)*			
Halmstad Clinic (16)	−7-3	−2.2	3.19
Copenhagen Clinic (29)	−8-3	−2.2	2.66
Miniplate fixation patients (All 45)	−8-3	−2.2	2.8
Mayo Clinic — lag screw fixation (37)	−7.2-6.8	−1.9	2.85

*B-point movements in the superior and anterior direction were recorded as positive values, whereas inferior and posterior movements were recorded as negative values.

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the kappa statistic. The values range from −1 to 1. Values in the range of 0 to 0.2 indicate slight agreement, 0.2 to 0.4 fair, 0.4 to 0.6 moderate, 0.6 to 0.8 substantial, and 0.8 to 1.0 almost perfect agreement. The 95% confidence intervals for the ICC estimates were also calculated. All variables measured by the 2 examiners showed almost perfect agreement. This shows a high level of interexaminer reliability, and that the measurement methods are easily learned with low variability between examiners. Therefore, although 3 examiners from the centers were involved in tracing the radiographs and measuring the variables, the ICC scores support the fact that there may not have been any greater reliability of the data by having 1 examiner perform all the tracings and measurements.

Results

A review of the clinical records of all the patients studied showed that no significant adverse events occurred prior to or during the time of operation, and up to the time of the postoperative radiographs, which might have resulted in any unexpected displacements of the segments. Table 4 shows that mandibular advancement measured at B point for all patients ranged from 0.9 to 12 mm, with a mean of 5.4 mm for the miniplate fixation group (Halmstad Clinic had a mean of 4.5 mm; Copenhagen Clinic had a mean of 5.6 mm) and 4.9 mm for the lag screw fixation group. *t* test comparison showed no statistically significant difference between the 2 groups with respect to the amount of mandibular advancement.

The distributions of measurements from T1 (presurgery) and from T2 (postsurgery) P-A radiographs are shown in Table 5. By subtracting the value at T1 (presurgery) from T2 (postsurgery), the change in position of each landmark caused by surgery was calculated. A positive value for change in the ramus angles represents a flaring out of the proximal segment, also known as an increase in proximal segment torque.

Table 6 shows the results of the changes in the P-A measurements from T1 to T2. Almost all (44 of 45) patients in the miniplate fixation group had an increased width between the GO points with a mean of 5.0 mm, and 1 patient had no change (range, 0-10 mm). Between the RP points, 44 of 45 patients had an increased width, with a mean of 2.4 mm and a range of −4 to 8 mm. Thirty-six of 37 patients in the lag screw fixation group had an increased intergonial width of 5.6 mm (range, −2.6 mm to 12.2 mm), and 35 of 37 patients showed an increased width between

Table 5. DISTRIBUTION OF T1 AND T2 P-A CEPHALOMETRIC RADIOGRAPHIC MEASUREMENTS FOR ALL 82 PATIENTS

	Range (Miniplate/Lag Screw)	Mean (Miniplate/Lag Screw)	SD (Miniplate/Lag Screw)
T1 radiographs (preop)			
Intergonion (GO) width (mm)	91-124/91-122	103.7/103.2	7.20/7.42
Interramus (RP) width (mm)	101-132/100-124	113.2/111.1	5.99/5.99
Right UOM/RP/GO angle (°)	72-96/77-95	83.5/84.7	4.88/4.55
Left UOM/RP/GO angle (°)	77-95/76-94	83.8/84.6	4.03/4.19
T2 radiographs (postop)			
Intergonion (GO) width (mm)	96-126/95-127	108.7/108.8	7.62/7.40
Interramus (RP) width (mm)	104-133/105-130	115.6/114.3	6.11/6.68
Right UOM/RP/GO angle (°)	74-96/78-95	85.3/86.4	5.16/4.23
Left UOM/RP/GO angle (°)	75-98/74-97	85.4/85.9	4.15/4.70

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Table 6. CHANGES IN P-A CEPHALOMETRIC RADIOGRAPHIC MEASUREMENTS BETWEEN T1 AND T2

	Range (T1-T2)	Mean	SD
Intergonion (GO) width change (mm)			
Halmstad Clinic (16)	0-6	3.8	1.52
Copenhagen Clinic (29)	2-10	5.7	2.45
Miniplate fixation patients (all 45)	0-10	5.0	2.33
Mayo Clinic—lag screw fixation (37)*	−2.6-12.2	5.6	3.05
Interramus (RP) width change (mm)			
Halmstad Clinic (16)	0-4	1.9	1.18
Copenhagen Clinic (29)	−4-8	2.7	2.37
Miniplate fixation patients (all 45)	−4-8	2.4	2.05
Mayo Clinic—lag screw fixation (37)*	−2.8-7.2	3.3	2.23
Right UOM/RP/GO angle change (mm)			
Halmstad Clinic (16)	−2-4	1.2	1.48
Copenhagen Clinic (29)	−1-6	2.2	1.81
Miniplate fixation patients (all 45)	−2-6	1.8	1.74
Mayo Clinic—lag screw fixation (37)*	−3.5-7.0	1.2	2.38
Left UOM/RP/GO angle change (mm)			
Halmstad Clinic (16)	−2-4	1.3	1.67
Copenhagen Clinic (29)	−3-5	1.8	2.18
Miniplate fixation patients (all 45)	−3-5	1.6	2.00
Mayo Clinic—lag screw fixation (37)*	−3.5-5.5	1.7	1.98

*Data previously published in Becktor et al.[7]

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RP points (range, −2.8-7.2 mm). *t* tests showed that there were no significant differences between the 2 groups with respect to these 2 variables.

In both the miniplate and lag screw fixation groups, the right and left ramus angles demonstrated an increased angle on average, although many patients also showed a decreased angle (Table 6). *t* tests showed that there were no significant differences between the 2 fixation groups with respect to ramus angle changes.

Discussion

The results of this study show that statistically significant increases in intergonion and interramus distances occur after routine mandibular sagittal ramus osteotomy advancement surgery (BSO). This mandibular widening seems to occur whether lag screw fixation or miniplate with monocortical screws fixation is used. Studies with tantalum markers have demonstrated positional stability between proximal and distal segments after a BSO of the mandible with RIF.[14,15] Therefore, the postsurgical mandible can be assumed to be a single rigid body. The displacements observed in this study are therefore likely to occur during the surgical procedure and not in the postoperative period.

Transverse condylar displacement has been studied before, but different methods have been used, and different results have been presented.[3,16-20] Several studies showed that the use of RIF following BSO resulted in a greater transverse condylar displacement than wire fixation.[18,21,22] The most common displacement of the condyle is laterally with an increased angle, and the condyle is displaced more posteriorly and superiorly in relation to the glenoid fossa.[1-4] Nonetheless, the benefits of rigid fixation have led to the current widespread use of rigid fixation for BSO.

It has been suggested that the role of fixation technique in condylar and proximal segment displacement could be of importance.[18,21,22] Astrand and Ericson used P-A radiographs to report an outward angulation of the condylar fragment following oblique ramus ostetomy surgery.[23] Becktor et al[7] reported a transverse displacement of the proximal segment after BSO. It was suggested that the type of RIF could have an effect on the amount of transverse displacement. Our results showed that there were no statistically significant differences in the amount of transverse displacement of the proximal segment when using titanium miniplates and monocortical screws compared with the lag screw technique.

When looking at the data for all 82 patients included in this study, an increased outward angulation of the ramus was observed on average, and an increase in intergonial width was recorded in 80 of 82 patients. Due to the radiographs used, however, no statements can be made concerning the actual changes in condylar position. Because the P-A radiograph is a routine radiograph that can be used in the planning and follow-up of patients treated with a BSO, the advantage of using this radiograph is obvious.

An important source of error may be the variability in the radiographic enlargement of transverse skeletal dimensions projected onto P-A films. The subjects were positioned facing the film, and the head was placed in the cephalometer with the Frankfort plane horizontal. The film-object distance was standardized. Although the radiographs for this study were taken by experienced technicians, some degree of up-and-down and side-to-side tilting of the head was probably inevitable. Therefore, some differences in enlargement between 2 P-A radiographs could be expected. A change of up to 10° of up-and-down movement or right or left rotation of the head, however, has been shown to be less than the method error and is, therefore, a negligible factor in breadth measurements.[23,24] A change in 10° rotation of the head would easily have been detected by the technicians.

It was also shown that the increase in intergonial and inter-ramus width was positively correlated to the amount of horizontal advancement. These findings were similar to the report from Becktor et al.[7]

It is conceivable that the adaptation capacity of the temporomandibular joint (TMJ) could be exceeded with a significant transverse change in the proximal segment positioning due to surgery, especially in a susceptible individual. Van Sickels et al[25] suggest that surgeons and orthodontists should carefully observe patients who complain of pain in the TMJ after a BSO. The patient who complains of a physical barrier to opening should be assessed for excessive condylar torque.[25]

Factors contributing to relapse include slippage at the osteotomy site, condylar malpositioning, or remodeling/resorption of the condyle and/or fossa at the TMJ.[26] Skeletal and dental relapse could also be influenced by unfavorable postsurgical growth or preexisting TMJ derangement. Progressive condylar resorption giving rise to considerable relapse at pogonion and B point in relation to BSO was first described in 1985 by Sesenna and Raffaini.[27] Saka et al[28] suggest that there is an enhanced risk for anterior disc derangement after bilateral sagittal split osteotomy advancement, and stated that if they actively positioned the condyle in the glenoid fossa before and during the RIF, they reduced the risk of anterior disc derangement from 50% to 11%. If a surgical technique or fixation method can be developed that eliminates, or at least minimizes, the amount of proximal segment displacement, there should be less risk for postoperative structural changes in the TMJ.

In conclusion, the results of this study would indicate that there is no difference between miniplates with monocortical screws versus lag screw fixation in minimizing proximal segment displacement.

The results should be interpreted with caution because the study design was not prospective and randomized. Further investigations into what different surgical methods and/or different types of RIF can be of importance for the transverse displacement would be beneficial. Furthermore, attention and future studies should focus on possible complications that transverse displacement of the proximal segment may cause.

References

1. Rebellato J, Lindauer SJ, Sheats RD, et al: Condylar positional changes after mandibular advancement surgery with rigid internal fixation. Am J Orthod Dentofacial Orthop 116:93, 1999
2. Van Sickels JE, Larsen AJ, Thrash WJ: Relapse after rigid fixation of mandibular advancement. J Oral Maxillofac Surg 44:698, 1986
3. Alder ME, Deahl ST, Matteson SR, et al: Short-term changes of condylar position after sagittal split osteotomy for mandibular advancement. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 87:159, 1999
4. Gassmann CJ, Van Sickels JE, Thrash WJ: Causes, location, and timing of relapse following rigid fixation after mandibular advancement. J Oral Maxillofac Surg 48:450, 1990
5. Van Sickels JE, Larsen AJ, Thrash WJ: A retrospective study of relapse in rigidly fixated sagittal split osteotomies: Contributing factors. Am J Orthod Dentofacial Orthop 93:413, 1988
6. Schendel SA, Epker BN: Results after mandibular advancement surgery: An analysis of 87 cases. J Oral Surg 38:265, 1980
7. Becktor JP, Rebellato J, Becktor KB, et al: Transverse displacement of the proximal segment after bilateral sagittal osteotomy. J Oral Maxillofac Surg 60:395, 2002
8. Obwegeser H, Trauner R: Zur Operationstechnik bei Progenie und anderen Unterkieferanomalien. Dtsch Zahn Mund Kieferheilkd 23:11, 1955
9. Dal Pont G: Retromolar osteotomy for the correction of prognathism. J Oral Surg Anesth Hosp Dent Serv 19:42, 1961
10. Bjork A: The use of metallic implants in the study of facial growth in children: Method and application. Am J Phys Anthropol 29:243, 1968
11. Bjork A, Skieller V: Normal and abnormal growth of the mandible. A synthesis of longitudinal cephalometric implant studies over a period of 25 years. Eur J Orthod 5:1, 1983
12. Nielsen IL: Maxillary superimposition: A comparison of three methods for cephalometric evaluation of growth and treatment change. Am J Orthod Dentofacial Orthop 95:422, 1989
13. Shrout PE, Fleiss JL: Intraclass correlations: Uses in assessing rater reliability. Psychol Bull 86:420, 1979
14. Rubenstein LK, Strauss RA, Lindauer SJ, et al: Tantalum implants as markers for evaluating postoperative orthognathic surgical changes. Int J Adult Orthodon Orthognath Surg 8:203, 1993
15. Strauss RA, Rubenstein LK: A technique for accurate long-term follow-up of segment positional changes following sagittal split osteotomies [see comments]. J Oral Maxillofac Surg 51:815, 1993
16. Harris MD, Van Sickels JE, Alder M: Factors influencing condylar position after the bilateral sagittal split osteotomy fixed with bicortical screws. J Oral Maxillofac Surg 57:650, 1999
17. Schultes G, Gaggl A, Karcher H: Changes in the dimensions of milled mandibular models after mandibular sagittal split osteotomies. Br J Oral Maxillofac Surg 36:196, 1998
18. Stroster TG, Pangrazio-Kulbersh V: Assessment of condylar position following bilateral sagittal split ramus osteotomy with wire fixation or rigid fixation. Int J Adult Orthodon Orthognath Surg 9:55, 1994
19. Hackney FL, Van Sickels JE, Nummikoski PV: Condylar displacement and temporomandibular joint dysfunction following bilateral sagittal split osteotomy and rigid fixation. J Oral Maxillofac Surg 47:223, 1989
20. Will LA, Joondeph DR, Hohl TH, et al: Condylar position following mandibular advancement: Its relationship to relapse. J Oral Maxillofac Surg 42:578, 1984
21. Freihofer HP Jr: [Model test on the change of position of the mandibular condyle after sagittal splitting of the mandible]. SSO Schweiz Monatsschr Zahnheilkd 87:12, 1977
22. Kundert M, Hadjianghelou O: Condylar displacement after sagittal splitting of the mandibular rami. A short-term radiographic study. J Maxillofac Surg 8:278, 1980
23. Astrand P, Ericson S: Relation between fragments after oblique sliding osteotomy of the mandibular rami and its influence on postoperative conditions. Int J Oral Surg 3:49, 1974
24. Ishiguro K, Krogman WM, Mazaheri M, et al: A longitudinal study of morphological craniofacial patterns via P-A x-ray headfilms in cleft patients from birth to six years of age. Cleft Palate J 13:104, 1976

25. Van Sickels JE, Tiner BD, Alder ME: Condylar torque as a possible cause of hypomobility after sagittal split osteotomy: Report of three cases. J Oral Maxillofac Surg 55:398, 1997
26. 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 III—Condylar remodelling and resorption. Int J Oral Maxillofac Surg 33:649, 2004
27. Sesenna E, Raffaini M: Bilateral condylar atrophy after combined osteotomy for correction of mandibular retrusion. A case report. J Maxillofac Surg 13:263, 1985
28. Saka B, Petsch I, Hingst V, et al: The influence of pre- and intraoperative positioning of the condyle in the centre of the articular fossa on the position of the disc in orthognathic surgery. A magnetic resonance study. Br J Oral Maxillofac Surg 42:120, 2004