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Comparative study of skeletal stability between bicortical resorbable and titanium screw fixation after sagittal split ramus osteotomy for mandibular prognathism

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ABSTRACT

Introduction: Resorbable screw fixation for orthognathic surgery is widely used in oral and maxillofacial surgery and has several advantages. However, surgeons are concerned about using resorbable screws in orthognathic surgery because of possible postoperative complications such as relapse, screw fracture, and infection. The purpose of this study was to evaluate the skeletal stability of bicortical resorbable screw fixation after sagittal split ramus osteotomies for mandibular prognathism.

Materials and methods: This study included 25 patients who underwent mandibular setback surgery fixed with resorbable screws after sagittal split osteotomy at the Department of Oral and Maxillofacial Surgery at Seoul National University Dental Hospital. Five resorbable screws (Inion CPS®, Inion Ltd., Finland) were applied bicortically at each osteotomy site via a transbuccal approach. No rigid intermaxillary fixation was applied on the first postoperative day. Passive mouth opening exercises were allowed, using two light, rubber elastics for guidance. The control group was 25 patients fixed with four titanium screws. The follow-up period was 12–22 months (mean 17.8 months). Postoperative skeletal changes on lateral cephalometric radiographs were analyzed and compared between the two groups preoperatively, immediately postoperatively, and 6 months postoperatively.

Results: The average setback was 6.9 mm and no major intraoperative complications occurred. One patient experienced infection immediately after surgery that was controlled uneventfully. The data did not demonstrate any significant difference in postoperative skeletal stability between the two groups. Differences between the immediate postoperative state and 6 months after surgery were not significant. In earlier cases, especially for patients with severe mandibular prognathism, immediate postoperative elastic traction was needed for stable occlusal guidance.

Conclusions: The results of this study indicate that bicortical resorbable screws offer a clinically stable outcome for the fixation of mandibular sagittal split osteotomies in mandibular prognathism. However the resorbable screws showed less stable results vertically than the titanium screws.

1. Introduction

The use of resorbable plates and screws remains unpopular for internal fixation among oral and maxillofacial surgeons, despite its long history (Suuronen et al., 1992a, b, c) and well-documented safety. The first reports of its application in orthognathic surgery were published more than 10 years ago (Suuronen et al., 1994); however many surgeons hesitate to use the resorbable system for orthognathic patients because of its cost, longer operation time, uncertain stability, and increased risk of infection. A main concern of maxillofacial surgeons and orthodontists after orthognathic surgery is attaining skeletal stability to maintain surgical results. Methods of fixation for orthognathic surgery have developed from wire osteosynthesis to titanium plates and screws for maintaining fixation and stability after surgery. Although semi-rigid plates are widely used for fixation of mandibular osteotomy, the stability of the fixation is still an important consideration in orthognathic surgery. Titanium plates and screws show significant evidence of reliable stabilization and low complication rates.

Several clinical reports describe the use of biodegradable plates or screws for fixation after sagittal split ramus osteotomy (Haers and Sailer, 1998; Haers et al., 1998). However, they mainly focus on mandibular advancement, with few studies comparing titanium screws and mandibular setback. Orthognathic surgery is currently

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popular in East Asian countries. The majority of surgical candidates in East Asia, especially in Korea, have class III malocclusions, a problem that is not common in Western countries. The results of mandibular setback surgery are known to be less stable than mandibular advancement. This study compared the skeletal stability of fixation with bicortical resorbable screws and bicortical titanium screws for sagittal split ramus osteotomy of skeletal class III malocclusions.

2. Patients and methods

We selected 50 consecutive patients with skeletal class III malocclusion. Patients with craniofacial deformities such as cleft lip and palate or severe facial asymmetry were excluded. Consecutive cases using titanium screws were selected before those with resorbable screws. The control group (Ti) included 25 patients in whom titanium screws were used for fixation. The experimental group included 25 patients who underwent orthognathic surgery from January 2005 using biodegradable screws. With the exception of the fixation material, all other surgical procedures were identical in both groups. Mandibular osteotomy was performed with sagittal split ramus osteotomy using the Obwegesser-Dal Pont technique. However, intentional osteotomy of the posterior border of the distal segment of the mandibular ramus was performed as described previously (Kim et al., 2002). This procedure reduces tension from the protruding posterior border of the distal segment. Maxillae were fixed with titanium plates and screws by the same methods in both groups.

In group Ti, four titanium screws (diameter 2.4 mm, length 12–16 mm, Le Forte system®, Jaeil, Korea) were placed bicortically via the transbuccal approach, with three screws on the superior border and one screw on the inferior border.

Five resorbable bicortical screws (diameter, 2.5 mm; length, 14–18 mm; Inion CPS®, Inion Ltd., Finland) were placed transcutaneously, with three screws on the superior border of the mandible and two screws below the inferior alveolar canal. After determining the condylar position, a 2.4-mm titanium screw was fixed on the external oblique ridge in an area just distal to the mandibular second molar. After four other resorbable screws were fixed, the titanium screw was removed, and after tapping, the last resorbable screw was inserted (Fig. 1). No rigid intermaxillary fixation was used. Two rubber elastics were applied to restrict excessive mouth opening. A surgical wafer was applied on the second postoperative day.

2.1. Cephalometric analysis

Lateral cephalometric radiographs were taken on postoperative day 2 or 3, with the addition of a surgical splint. Radiographs were also taken at 2-, 6-, and 12-month follow-ups. Cephalometric analysis of lateral cephalometric radiographs was performed with computer software (V-Ceph® 4.0, CyberMed, Seoul, Korea), and the standard landmarks sella (S), nasion (N), A-point, B-point, upper and lower incisor tip (U1, L1), pogonion (Pog) and menton (M) were traced (Fig. 2).

A line oriented 7° from the sella-nasion (SN) line was used as a horizontal reference. The vertical reference line (SN7perpen) was defined as the line perpendicular to the horizontal reference line (SN7) (Fig. 3). The distances of landmarks (A-point, B-point) from the vertical reference line were measured in millimeters. The point at the right side of the vertical reference plane was defined as a positive value. To determine dental relapse, the distance of the upper and lower incisor tip from the vertical reference line and interincisal angle were measured. Other measurements (ANB, SNA, SNB) were also taken. Comparisons were made for B-SN7perpen, Me-SN7, SNB, and ANB between resorbable screws in one and in two jaws, resorbable screws in one jaw and titanium in one jaw, resorbable screws in two jaws and titanium in two jaws, and between the total resorbable and titanium groups. Points that were more difficult to reproduce such as porion, orbitale, and gnathion were excluded. In addition, pogonion was not used because genioplasty was simultaneously performed in some cases.

2.2. Measurement errors

The reproducibility of measurements was determined by choosing 20 cephalometric radiographs at random and having a single investigator retrace all points. Systemic error was assessed by a paired *t*-test.

3. Results

The average patient age was 22.6 ± 2.9 years (range 18–30) in the resorbable group, and 25.3 ± 4.1 years (range 18–33) in the titanium group. Follow-up periods ranged from 12 to 22 months, averaging 17.8 months. The average amount of mandibular setback was

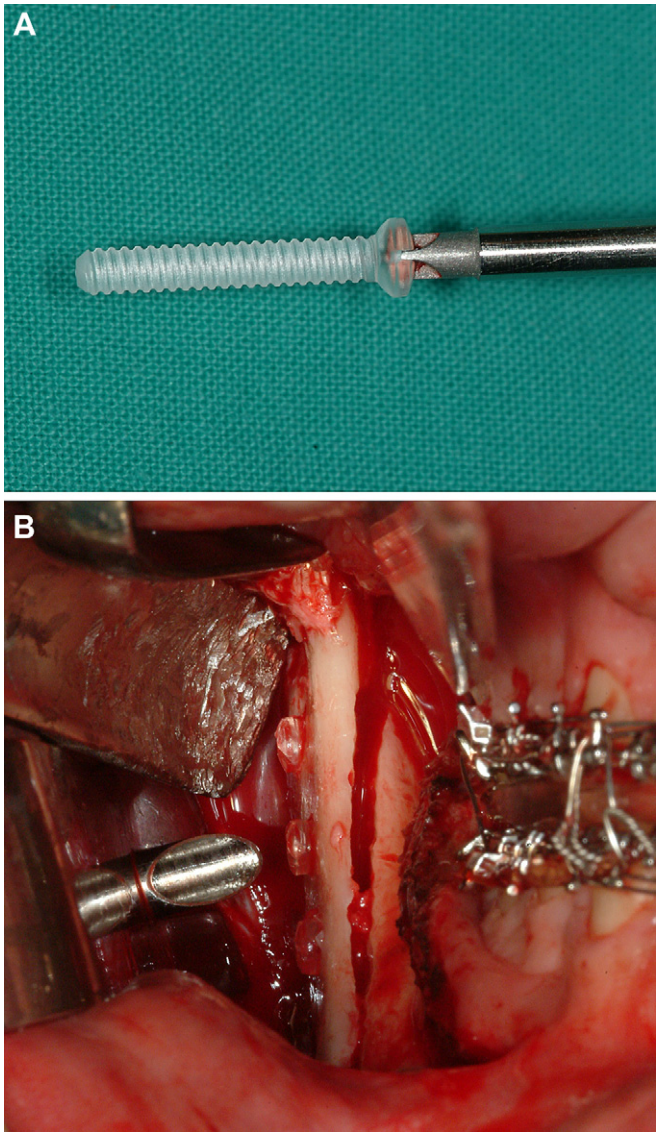

Fig. 1. Resorbable screw (left, 2.5-mm diameter) and bicortical fixation via transbuccal approach (right).

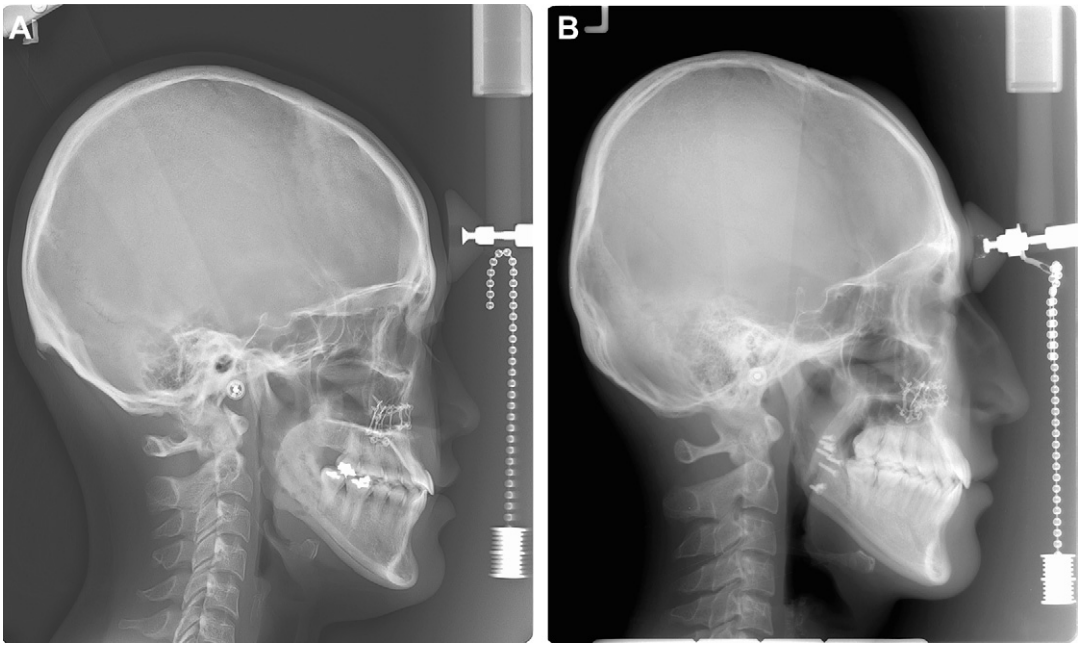

Fig. 2. Lateral cephalometric radiographs of the resorbable screw group (left) and titanium screw group (right). The maxilla was fixed with titanium plates in both groups.

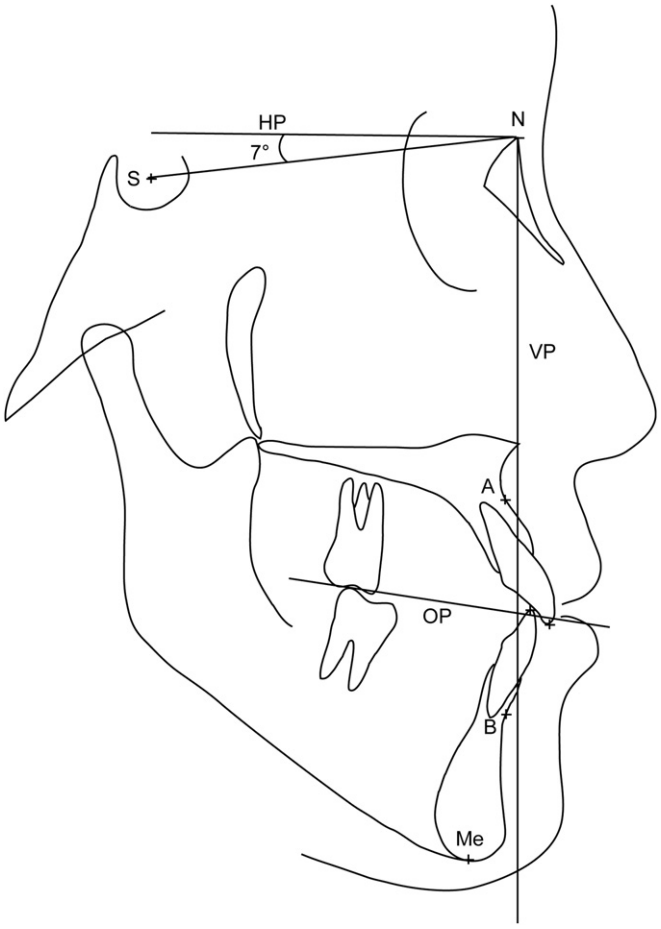

Fig. 3. Measurement for lateral cephalometric analysis. A line angled 7° from the SN line was used as a horizontal reference. The vertical reference line SN7perpen was defined as the line perpendicular to the horizontal reference line SN7. The distance of landmarks (A-point, B-point) from the vertical reference line was in millimeters. The point at the right side of vertical reference plane was defined as a positive value.

6.7 ± 2.2 mm in group R and 6.7 ± 3.2 mm in group T. No statistical difference was seen between the two groups ($p < 0.05$) (Table 1).

3.1. Clinical findings

No serious complications were experienced after fixation with resorbable screws. During fixation, four screw heads were broken, but other screws were inserted after re-drilling and tapping. This occurred during early cases with resorbable screws. One patient demonstrated wound infection at 7 postoperative days and underwent incision and drainage. This patient healed without incident. Condylar sagging was found intraoperatively in another patient after fixation. The resorbable screws were removed and the proximal segment was repositioned (Table 2).

3.2. Cephalometric analysis

Cephalometric changes were analyzed from immediately after the operation to 6 postoperative months with no significant differences in horizontal factors such as A-SN7perpen, B-SN7perpen, SNA, and SNB. Dental factors showed differences in overjet and overbite; however, these factors could easily be influenced by preoperative and postoperative orthodontic treatment. The M point showed a vertically lower position with resorbable screws (increased distance from the horizontal reference line). This indicated that the mandible in the R group had rotated clockwise after 6 months.

Table 1
Patient characteristics.

	Resorbable screw group (R)	Titanium screw group (Ti)
Age	22.6 ± 2.9	25.3 ± 4.1
Gender (Male/Female)	11/14	13/12
Patients number		
One jaw (Genio)	10 (8)	10 (4)
Two jaw (Genio)	15 (7)	15 (9)
Amount of setback (mm)*	6.7 ± 2.2	7.0 ± 3.2

* No statistically significant difference, p-value > 0.05.

Table 2
Interval changes in cephalometric analysis from immediately postoperative to 6 months postoperative.

	R1 ($n=10$)	R2 ($n=15$)	R12 ($n=25$)	T1 ($n=10$)	T2 ($n=15$)	T12 ($n=25$)
Linear measurement (mm)						
U1-SN7perpen	0.26 ± 1.63	0.80 ± 1.17	0.56 ± 1.33	−0.09 ± 0.89	0.79 ± 1.72	0.45 ± 1.50
L1-SN7perpen	0.50 ± 1.53	0.57 ± 1.09	0.54 ± 1.26	0.60 ± 1.56	0.55 ± 1.61	0.57 ± 1.56
A-SN7perpen	−0.79 ± 1.64	−0.88 ± 1.38	−0.84 ± 1.45	0.33 ± 0.66	−0.79 ± 1.85	−0.36 ± 1.59
B-SN7perpen	0.74 ± 1.14	0.34 ± 1.32	0.51 ± 1.23	0.73 ± 1.81	0.76 ± 1.94	0.75 ± 1.85
Me to SN7	0.65 ± 1.29	0.75 ± 1.44	0.71 ± 1.35*	−1.51 ± 1.21*	−1.50 ± 1.53*	−1.50 ± 1.39*
U1 to SN7	0.32 ± 0.92	0.50 ± 1.13	0.42 ± 1.03	0.06 ± 0.89	−0.65 ± 1.33	−0.38 ± 1.21
L1 to SN7	1.51 ± 6.35	−0.48 ± 1.20	0.34 ± 4.14	−1.80 ± 1.33*	−1.40 ± 1.89*	−1.55 ± 1.68*
Incisor overjet	0.34 ± 0.69	0.40 ± 0.57*	0.37 ± 0.61*	−0.44 ± 0.99	0.42 ± 1.49	0.09 ± 1.37
Incisor overbite	0.79 ± 0.93*	0.97 ± 1.03*	0.90 ± 0.97*	1.92 ± 1.16*	0.70 ± 1.59	1.17 ± 1.54*
Angular measurement (degree)						
SNA	−0.58 ± 1.33	−0.75 ± 1.08	−0.68 ± 1.16	0.26 ± 0.56	−0.57 ± 1.46	−0.25 ± 1.25
SNB	0.40 ± 0.60	0.18 ± 0.67	0.27 ± 0.64	0.34 ± 0.97	0.34 ± 1.01	0.34 ± 0.98
ANB difference	−0.99 ± 1.10	−0.91 ± 0.80	−0.94 ± 0.91	−0.08 ± 1.30	−0.92 ± 1.67	−0.60 ± 1.57
Occ. plane to SN	0.20 ± 2.10	−0.91 ± 1.64	−0.45 ± 1.88	−0.52 ± 2.05	−0.72 ± 2.18	−0.64 ± 2.10
Interincisal angle	−0.78 ± 3.19	−2.50 ± 6.14	−1.79 ± 5.12	−2.18 ± 4.81	−3.54 ± 5.24	−3.02 ± 5.03

Each value is the average ± standard deviation. R1: resorbable one jaw, R2: resorbable two jaw, R12: all resorbable patients. T1: titanium one jaw, T2: titanium two jaw, T12: all titanium patients.
* Statistically significant, p-value < 0.05.

Table 3
Comparison of postoperative cephalometric changes between group R and group Ti (p-value).

	R1-R2	R1-T1	R2-T2	R12-T12
B-SN7perpen	0.47	0.97	0.51	0.60
SNB	0.43	0.87	0.62	0.77
ANB	0.23	0.58	0.98	0.77
Me-SN7	0.86	Stat. diff.	Stat. diff	Stat. diff

Statistically significant difference: p-value < 0.05.

Differences between the R group and the T group could not be found in horizontal mandibular landmarks (Table 3). Only M showed a difference between the R group and the T group.

4. Discussion

Oral and maxillofacial surgeons prefer titanium plates and screws for fixation in orthognathic surgery for numerous reasons and are concerned about foreign body reaction and instability with resorbable screws. In addition, the price of resorbable screws is higher, and the operation time is longer than with titanium screws. This report focused on the stability of resorbable screws, mainly because price and operation time are not academic considerations for orthognathic surgery results. The infection rate with resorbable plates is reported to be higher than with titanium plates. The bicortical resorbable screws were used in this study instead of resorbable plates. The bicortical resorbable screw may be considered to be less susceptible to infection than resorbable plates because of its position far from the wound and the reduced exposure from the bone.

The rate of complications with titanium screws and plates is clinically low, and a majority of surgeons feel no reason to remove them in the absence of complications. Panular reported titanium plate removal in 48 of 655 orthognathic patients (8%) secondary to symptomatic problems (Panula et al., 2001). However many patients desire removal during their outpatient follow-up, particularly for reasons relating to East Asian traditional culture to avoid the foreign material in their body.

Edwards et al. (2001) reported relatively long-term outcomes after using resorbable screws for fixation in mandibular orthognathic surgery. The PLLA-PGA fixation devices demonstrated complete resorption at 18–24 months after surgery. This report demonstrated the long-term safety of resorbable screws; however, it did not describe the stability of fixation. It reported the results of 37 patients, including 12 with mandibular setbacks, but described only clinical findings. Mazzonetto et al. (2004) reported on 30 patients who underwent orthognathic surgery using self-reinforced (70L:30DL) polylactide plates and screws, evaluated stability by manual palpation, and described subjective clinical findings. Cheung et al. (2004) performed a randomized controlled study comparing the clinical results of resorbable versus titanium fixation for orthognathic surgery. These authors showed that bioresorbable fixation devices function similarly to titanium in fixation for orthognathic surgery.

Few studies have evaluated resorbable plates and screws for mandibular setback (Table 4). Only five comparative studies (Ferretti and Reyneke, 2002; Harada and Enomoto, 1997; Landes and Ballon, 2006; Turvey et al., 2006/1; Ueki et al., 2005) have discussed skeletal stability after fixation with biodegradable screws after mandibular bilateral split ramus osteotomy. Two reports described mandibular advancement cases, and two reports focused on mandibular setback. Harada and Enomoto (1997) first suggested that fixation of the bony segments with PLLA screws after SSRO may be used effectively. However, the lower incisor tip was used as a landmark for measuring relapse rather than the B-point, so postoperative skeletal relapse could not be distinguished from dental relapse factor. To avoid this issue, we analyzed horizontal relapse with B-point and vertical relapse with Me. Ueki et al. (2005) also studied the use of resorbable plates and found no clinical differences between resorbable and titanium plate groups, using rigid intermaxillary fixation at 2 postoperative weeks. Landes and Ballon (2006) detected no difference in mandibular setback cases when comparing resorbable and titanium fixation groups. However, they used plates for mandibular fixation and the maxillary stability results differed from other reports. Among the various orthognathic surgeries, mandibular setback showed the most unstable results.

Two types of fixation methods with resorbable systems are used for mandibular osteotomy. One involves positioning screw fixation and the second entails plate and monocortical screw fixation. Experimental results showed that the two systems can endure occlusal loading after orthognathic surgery. Dolanmaz et al. (2004) demonstrated with *in vitro* experiments using a gradual force up to 140 N, that absorbable plates experienced significant displacement, but no residual deformation. They hypothesized that when absorbable miniplates are used, intermaxillary fixation may be necessary to stabilize bony fragments in the early postoperative period. In addition, their experiments were performed at room temperature. Under physiologic conditions with heat and moisture, the absorbable plate system can show a greater reduction in resistance.

In our clinical experience, two-jaw maxillo-mandibular surgeries seemed more stable than mandibular one-jaw surgery

Table 4
Studies for resorbable plates and screws after mandibular setback sagittal split ramus osteotomies.

Authors	Year	Patient number	Fixation material	IMF	Follow-up period	Study method	Result
Harada	1997	10 (10/10)	Bicortical screw	2 weeks	1 year	Comparative study	No difference
Shand	2000	8 (22/0)	LactoSorb bicortical screw	No	8 weeks	Clinical description	Clinically successful
Ueki	2005	20 (20/20)	Fixorb plate	2 weeks	1 year	Comparative study	Same skeletal stability
Landes	2006	20 (30/12)	PolyMax plate	Elastics	1 year	Comparative study	Slight clinical mobility

Patient number; Mandible resorbable (total resorbable/Ti control).

during the immediate postoperative period. Additionally, immediate postoperative occlusion in patients undergoing two-jaw surgery was more passively seated into the surgical splint. However, the results of this study did not provide statistical evidence for this. Our results did show that there were no significant horizontal changes at B-point after 6 postoperative months in both groups, and no differences between the two groups. However, ANB showed significant differences in the absorbable group, leading us to propose that the resorbable screws are weaker than the titanium. The M point moved to a lower position in the absorbable group and an upper position in the titanium group, indicating that the resorbable screw was still weak for open bite tendency. Our clinical findings showed that, even with the bicortical resorbable screws, the amount of bony contact between the proximal and distal segment is important for immediate postoperative stability. If the proximal and distal segments have point contact, the stability between them might be decreased with resorbable screws.

In this study, only titanium plates and screws were used for the maxillary fixation after Le Fort I osteotomy in both groups. Postoperative maxillary relapse or occlusal instabilities are more difficult to control than their mandibular counterparts. Costa et al. (2006) reported significant correlations between maxillary advancement and relapse after fixation with resorbable plates. Other reports showed early postoperative instability (Araujo et al., 2001; Norholt et al., 2004). This report used titanium plates and screws for fixation of the Le Fort I osteotomy in both groups. No significant differences were seen between the groups in maxillary position after fixation with titanium plates. In addition, the maxillary plate can be easily removed under local anesthesia if complications arise.

Usually, three titanium screws are considered to be sufficient for rigid fixation after mandibular setback surgery with BSSRO. Four titanium screws have been used in our clinic for more rigid fixation; however, there is no scientific evidence supporting the use of four titanium screws. Five resorbable screws were used in this study because we were not sure if four resorbable screws were sufficient for rigid fixation after mandibular setback surgery. Further evaluation may be needed to determine if the use of four or less number of resorbable screws provides enough stability for rigid fixation after mandibular setback surgery.

5. Conclusion

The results presented here indicate that resorbable bicortical screws showed clinically acceptable stability. Additionally, no statistical differences were seen when compared to titanium screws in the anteroposterior aspect for mandibular setback surgery. However, resorbable screws were less stable than titanium screws from a vertical aspect.

Conflict of interest

There are no financial or personal relationships with other people or organizations that can inappropriately influence the work of the authors.

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