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# Evaluation of bone formation after sagittal split ramus osteotomy using different fixation materials

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ABSTRACT

*Purpose:* The purpose of this study was to evaluate bony change between the proximal and distal segments after sagittal split ramus osteotomy (SSRO) using different fixation materials.

*Subjects and methods:* The subjects consisted of 74 patients (21 male and 53 female; 148 sides) who underwent SSRO with and without Le Fort I osteotomy.

They were divided into five groups: (1) an MT group, mono-cortical titanium plate fixation (26 sides); (2) an MA group, mono-cortical absorbable plate fixation (48 sides); (3) a BA group, bi-cortical absorbable plate fixation (22 sides); (4) an MA$\alpha$ group, mono-cortical plate absorbable fixation with $\alpha$-tricalcium phosphate (36 sides); and (5) a BA$\alpha$ group, bi-cortical plate absorbable fixation with $\alpha$-tricalcium phosphate (16 sides).

Ramus square (RmS), ramus width (RmM-RmL) and ramus length (RmA-RmP) at the horizontal plane under the mandibular foramen were assessed pre-operatively, immediately after surgery, and at 1 year after surgery by computed tomography (CT).

*Results:* There were significant differences among the groups regarding change over time in RmS ($p = 0.0126$) and RmM-RmL ($p = 0.0001$). However, there was no significant difference among the groups regarding change over time in RmA-RmP.

*Conclusion:* These results suggest that the use of different fixation materials leads to significant differences in the bone healing process after SSRO.



## 1. Introduction

Sagittal split ramus osteotomy (SSRO) is the most common surgical method used for correcting jaw deformities (Trauner and Obwegeser, 1957).

We previously used bent plates to secure fragments without a positioning device and found that the bent plate increased the incidence of postoperative temporomandibular dysfunction (TMD) and did not change skeletal or occlusal stability (Ueki et al., 2001, 2008). In this method, the gap between the proximal and distal segments is created by a bent plate, preventing the formation of a large area of bony contact. In setback surgery, especially with asymmetry, fixation between segments can be performed without bony contact to prevent large changes in condylar position and angle. The following study showed that the gap between the proximal and distal segments can fill with new bone after SSRO, even when there is little bony contact between segments (Ueki et al., 2009).

Recently, an absorbable plate system has been used in orthognathic surgery as well as the titanium plate system, and there have been many studies that proved the usefulness and skeletal stability of the absorbable plate (Ueki et al., 2005, 2006, 2011). However, the absorbable plate system was used in cases where there was a wide space between the bony segments, and also considered whether proper rigidity and stability can be achieved; the combined use of segmental fixation with the absorbable plate system and filling in of the space between the segments were assumed to be clinically necessary. Our previous study using animals proved that the use of an absorbable plate in combination with Biopex (Pentax Co. Tokyo, Japan) was useful in providing adequate bone regeneration (Okabe et al., 2010). The clinical study suggested that inserting Biopex in the gap between the proximal and distal segments was useful for

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new bone formation after SSRO with bent plate fixation (Ueki et al., 2012).

However, there is no report that compared the bone healing process using different fixation materials. The purpose of this study was to evaluate bony morphological change between the proximal and distal segments after SSRO using various fixation materials.

## 2. Patients and methods

### 2.1. Patients

The 74 Japanese adults (men: 21, women: 53) enrolled in this study presented with jaw deformities diagnosed as mandibular prognathism with and without maxillary deformity. At the time of orthognathic surgery, the patients ranged in age from 16 to 58 years, with a mean age of 29.7 (standard deviation, 11.1). Although this study was retrospective, informed consent was obtained from the patients and the study was approved by Kanazawa University Hospital and Yamanashi University Hospital.

### 2.2. Surgery

The study sample of 74 patients (148 sides) with mandibular prognathism was divided into five groups: (1) MT group, mono-cortical titanium plate fixation (26 sides); (2) MA group, mono-cortical absorbable plate fixation (48 sides); (3) BA group, bi-cortical absorbable plate fixation (22 sides); (4) MAα group, mono-cortical absorbable plate fixation with α-tricalcium phosphate (36 sides); and (5) BAα group, bi-cortical absorbable plate fixation with α-tricalcium phosphate (16 sides). Although the subjects were divided into five groups according to the fixation methods and materials used in this study, they have changed from 2000 to 2014. In short, the fixation methods and materials used varied over time; this dictated the allocation of patients to a particular group, so the sample numbers for the groups vary.

Before surgery, lateral, frontal, and submental–vertex (S–V) cephalograms were obtained as described previously (Ueki et al., 2001). All patients underwent bilateral sagittal split osteotomy (BSSO) setback by the Obwegeser method. Of the 74 patients, 26 underwent Le Fort osteotomy.

In the MT group, mono-cortical titanium plate fixation, a long miniplate (4 holes, burr 8 mm, thickness 1.0 mm) and 4 screws (2 × 14 mm and 2 × 5 mm) (Universal Mandible fixation module, Stryker Leibinger Co, Freiburg, Germany) were placed in the mandibular angle region. In the MA group, mono-cortical uHA/PLLA plate fixation, a miniplate (28 × 4.5 × 1.5 mm) and 4 screws (2 × 8 mm) (Fixorb-MX, Takiron Co, Osaka, Japan) were placed in the same region and manner. In the BA group, bi-cortical uHA/PLLA plate fixation, a miniplate (28 × 4.5 × 1.5 mm) and 4 screws (2 × 8 mm) (Fixorb-MX, Takiron Co, Osaka, Japan) were placed in the same region and manner, and 1 screw (2 × 16 mm) (Fixorb-MX, Takiron Co, Osaka, Japan) was also placed. In the MAα group, mono-cortical uHA/PLLA plate fixation with α-tricalcium phosphate, a miniplate (28 × 4.5 × 1.5 mm) and 4 screws (2 × 8 mm) (Fixorb-MX, Takiron Co, Osaka, Japan) were placed in the same region and manner; and α-tricalcium phosphate (Biopex, Pentax Co. Tokyo, Japan) was inserted at the anterior part of the gap between the segments after plate fixation. In the BAα group, bi-cortical uHA/PLLA plate fixation with α-tricalcium phosphate, miniplate (28 × 4.5 × 1.5 mm) and 4 screws (2 × 8 mm) (Fixorb-MX, Takiron Co, Osaka, Japan) were placed in the same region and manner, and 1 screw (2 × 16 mm) (Fixorb-MX, Takiron Co, Osaka, Japan) was also placed; and á-tricalcium phosphate (Biopex) was inserted at the anterior part of the gap between the segments after plate fixation.

Before surgery, an S–V cephalogram was obtained for all patients followed by simulation. First, a distal segment including the lower dental arch was set back according to the position of the upper dental arch on the S–V cephalometric trace.

When the proximal and distal segments are fixed with straight plates after BSSO, proximal segments containing the condylar head cause internal rotation. To prevent internal rotation of the proximal segments, overlapped cortical bone at the anterior edge of the proximal segment was not removed to keep the contact area between the proximal and distal segments and was fixed with a bent plate and screws in each side of the mandible. At the posterior part, a 3–7 mm gap was maintained between the proximal and distal segments (Ueki et al., 2001, 2008) (Fig. 1).

After surgery, elastic traction was placed to maintain ideal occlusion. All patients received orthodontic treatment before and after surgery. CT was taken for all patients pre-operatively, immediately after surgery, and 1 year after surgery.

The patients were placed in the gantry with the tragal–canthal line perpendicular to the ground for CT scanning. They were instructed to breathe normally and to avoid swallowing during the scanning process. CT scans were obtained in the radiology department by skilled radiology technicians using a high-speed, advantage-type CT generator (Light Speed Plus; GE Healthcare, Milwaukee, WI, USA) with each sequence taken 1.25 mm apart for 3D reconstruction (120 kV, average 150 mA, 0.7 s/rotation, helical pitch 0.75). The resulting images were stored in the attached workstation computer (Advantage workstation version 4.2; GE Healthcare) and the 3D reconstruction was performed using the volume rendering method. Simplant (Materialise, Leuven, Belgium) was used for morphologic measurements.

#### 2.2.1. Measurements of ramus using CT

The RL line was determined as the line between the most anterior points of the auricles bilaterally. The horizontal plane under the mandibular foramen parallel to the FH plane was identified, and ramus area was measured pre- and postoperatively and bilaterally (Ueki et al., 2009) (Figs. 2 and 3).

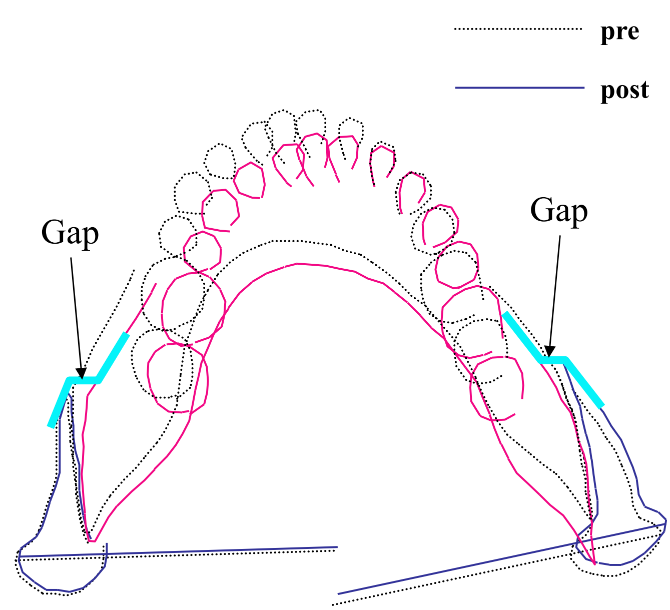


**Fig. 1.** Simulation of plate bending. The plates were bent to prevent the proximal segments from rotating internally. Note the gap between the osteotomy surfaces on both sides.