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# Stability of the chin after advancement genioplasty using absorbable plate and screws with template devices

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ABSTRACT

*Purpose:* The purpose of this study was to compare the stability of the chin between absorbable plate and screws with a template device and titanium plate after advancement genioplasty in class II patients.
*Patients and methods:* The subjects consisted of 22 Japanese class II patients who underwent genioplasty advancement in combination with bi-maxillary surgery. After genioplasty horizontal osteotomy, the template plate and screws were fixed at the central region of the chin temporarily. Then, two absorbable bi-cortical screws (uncalcined and unsintered hydroxyapatite and poly-L-lactic acid: uHA/PLLA) were used and fixed bilaterally. After removal of the template plate and screws, one absorbable plate and screws were added to fix the segment in the advancement genioplasty (n = 14). The remaining 8 patients underwent genioplasty advancement surgery with the conventional titanium plate.

For all patients, lateral cephalograms were obtained pre- and immediately after surgery and at 1 year after surgery. Change in the Pogonion (Pog) and Menton (Me) points and the corresponding soft tissue points (PogS and MeS) were evaluated.
*Results:* Although there were no significant differences in the change from before to immediately after surgery between the absorbable and titanium groups, there were significant differences in the Pog (Y) (P = 0.0379) and PogS (Y) (P = 0.0379) from immediately after surgery to after 1 year between both groups.
*Conclusion:* This study shows that predicted advancement of the chin in the absorbable group could be achieved by using a template and screws, and likewise in the titanium group. However, this study suggested that vertical relapse to the inferior site or resorption at the antero-superior edge of the segment could occur in the absorbable group.


## 1. Introduction

Genioplasty is used to improve chin morphology and aspiratory function for obstructive sleep apnea syndrome. Usually, genioplasty is performed in combination with other orthognathic procedures such as Le Fort I osteotomy and sagittal split ramus osteotomy (Talebzadeh and Pogrel, 2001).

Although wire fixation was the procedure used to stabilize the segments in genioplasty in those days, previous studies demonstrated significant post-operative changes ranging from 10% to 80% (Poulton and Ware, 1971; McNeill et al., 1973). Next, rigid fixation using titanium plate and screws was introduced to prevent post-surgical relapse. Kirkpatrick and Woods (1987) demonstrated a mean horizontal relapse of 8% after mandibular advancement with rigid fixation. Reyneke et al. (1997) showed that there was no significant difference between wire fixation and screw fixation after advancement genioplasty.

However, the recently developed bioresorbable plates are being used in place of the titanium plates in orthognathic surgery (Norholt et al., 2004; Landes and Ballon 2006a, 2006b; Dhol et al., 2008; Cheung et al., 2008; Ueki et al., 2012) and SSRO (Ueki et al., 2017a,b; Ueki et al., 2018a,b). Lee et al. (2014) reported that there were no clinical differences between 2 self-reinforced

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biodegradable poly-70L/30DL-lactide screws and conventional metal plates used for fixation.

It was suggested that use of the absorbable plates (Super Fixsorb-MX®; Teijin, Osaka, Japan) made from composites of uncalcined and unsintered hydroxyapatite (u-HA) particles and Poly-L-Lactic Acid (PLLA) was reliable for stability in Le Fort I osteotomy (Norholt et al., 2004; Landes and Ballon 2006a, 2006b; Dhol et al., 2008; Cheung et al., 2008; Ueki et al., 2012) and sagittal split ramus osteotomy (SSRO) (Ueki et al., 2017a,b; Ueki et al., 2018a,b).

However, absorbable plates are much weaker in strength than titanium plates. When an absorbable plate is used in advancement genioplasty, it is difficult to keep the segmental position from resisting the attached suprahyoid muscles (anterior digastric and geniohyoid muscles) (Ueki et al., 2017b). Therefore, bi-cortical absorbable screws are used to fix it rigidly (Ueki et al., 2017a). It is necessary to keep the segmental position manually, until the plate and screws are fixed completely. If bending metal plates are used to fix the advanced segment, the metal plate can tolerate the resisting force (Ramos et al., 2017). To solve this problem, we have developed the template plate and temporary screws to keep the segmental position of the chin in advancement genioplasty (Fig. 1).

The purpose of this study was to compare the stability of the chin between absorbable plate and screws with a template device and titanium plate after advancement genioplasty in class II patients.

## 2. Patients and Methods

The subjects were 22 Japanese class II patients (18 females and 4 males, mean age 26.4 years, standard deviation 7.0 years, ranging from 18 to 42 years). This was a retrospective factorial cohort study and informed consent was obtained from the patients. This study was performed according to the Declaration of Helsinki, and was approved by the ethics committee of the University of Yamanashi (No 1152).

All 22 patients underwent advancement genioplasty in combination with sagittal split ramus osteotomy (SSRO) (advancement) and Le Fort I osteotomy. After genioplasty horizontal osteotomy, the template plate and screws were fixed at the center region of the chin temporarily (Fig. 2A). After osteotomy was completed, the inferior segment of the chin was moved forward. The anterior edge of the chin segment was fitted to the bent step of the template plate. Then, template screws were implanted to fix the template plate, keeping the segment. These template devices were so rigid that the inferior chin segment attached to the suprahyoid muscles could be kept at the predicted advancement position. Then, two absorbable bi-cortical screws (uHA/PLLA) were used and fixed bilaterally. After removing the template plate and screws, one absorbable plate was bent manually and fixed to the segment in the advancement genioplasty (n = 14) (Fig. 2B). The remaining 8 patients underwent genioplasty advancement surgery with the conventional titanium plate (Orthognathic fixation module, chin plate 6 holes, Stryker, Michigan, USA).

Lateral cephalometric measurements were analyzed, according to modification of the previous reports (Park et al., 1989; Kim et al., 2005; Lee et al., 2014) (Fig. 3). The landmarks described below were determined (Fig. 4).

- Occlusal plane: the line between the most superior point of the incisor and the most superior point of the distal cusp of the second molar.
- Me (menton): the most inferior point of the symphysis of the mandible parallel to the occlusal plane.
- MeS (soft tissue menton): the point on the outline of the skin across Me on the perpendicular line to the occlusal plane.
- Pog (pogonion): the most protrusive point from the line between the most superior point of the incisor and Me.
- PogS (soft tissue menton): the point on the outline of the skin across Pog on the parallel line to the occlusal plane.
- P (posterior reference point): the cross point between the lingual cortex outline of the symphysis and parallel line 25 mm below the occlusal plane.
- The coordinates (X, Y) of Me, Pog, MeS and PogS at the region of the chin were measured. Coordinate X was determined as the distance between P and each point perpendicular to the occlusal plane. Coordinate Y was determined as the distance between the occlusal plane and each point.
- Statistic comparisons in each point of the coordinates were performed pre-operation, immediately after surgery, and 1 year after surgery. The following time interval changes were subsequently calculated in each coordinate point.
- T1: Immediately after surgery−pre-operation.
- T2: 1 year after surgery −Immediately after surgery.

### 2.1. Statistical analysis

Data were compared among each period in each group, and time interval data were compared between the absorbable group and the titanium group by t-test using the SPSS software program (SPSS Japan Inc., Tokyo, Japan). Differences were considered significant at $p < 0.05$.

## 3. Results

During the operation, desorption and breakage of the plate and screws were not found in both groups. After surgery, plate and screw breakage, post-operative infection, incomplete bony union or other uncomfortable complications were not seen in any case.

Mean and standard deviation amount of mandibular advancement was 4.3 ± 1.9 mm at the right molar region and 4.4 ± 1.7 mm at the left molar region in the absorbable group, and 4.3 ± 2.4 mm at the right molar region and 4.5 ± 1.8 mm at the left molar region in the titanium group. There was no significant difference in mandibular advancement amount between the two groups.

In the absorbable group, changes in Pog (X) immediately after surgery and at 1 year after surgery were significantly larger than that before surgery ($P < 0.0001$ and $P < 0.0001$). The change in PogS (X) immediately after surgery was significantly larger than that before surgery ($P < 0.0001$), however, the change at 1 year after surgery was significantly smaller than that immediately after surgery ($P = 0.0004$). However, the change at 1 year after surgery was still larger than that before surgery ($P = 0.0153$). On the other hand, the changes in Pog (Y) and PogS (Y) at 1 year after surgery were significantly larger than those before surgery ($P = 0.0255$) and immediately after surgery (0.0236). Changes in Me (X) and MeS (X) immediately after surgery and at 1 year after surgery were significantly larger than those before surgery ($P < 0.0001$ and $P < 0.0001$), however there was no significant difference between the changes after surgery and those at 1 year after surgery. On the other hand, changes in Me (Y) and MeS (Y) showed no significant difference between those before surgery and those immediately after surgery and at 1 year after surgery (Table 1).

In the titanium group, changes immediately after surgery and at 1 year after surgery were significantly larger than those before surgery in the Pog (X) ($P < 0.0001$ and $P = 0.0002$), however there was no significant difference between immediately after surgery and at 1 year after surgery. In the PogS (X), changes immediately after and at 1 year after surgery were significantly larger than those

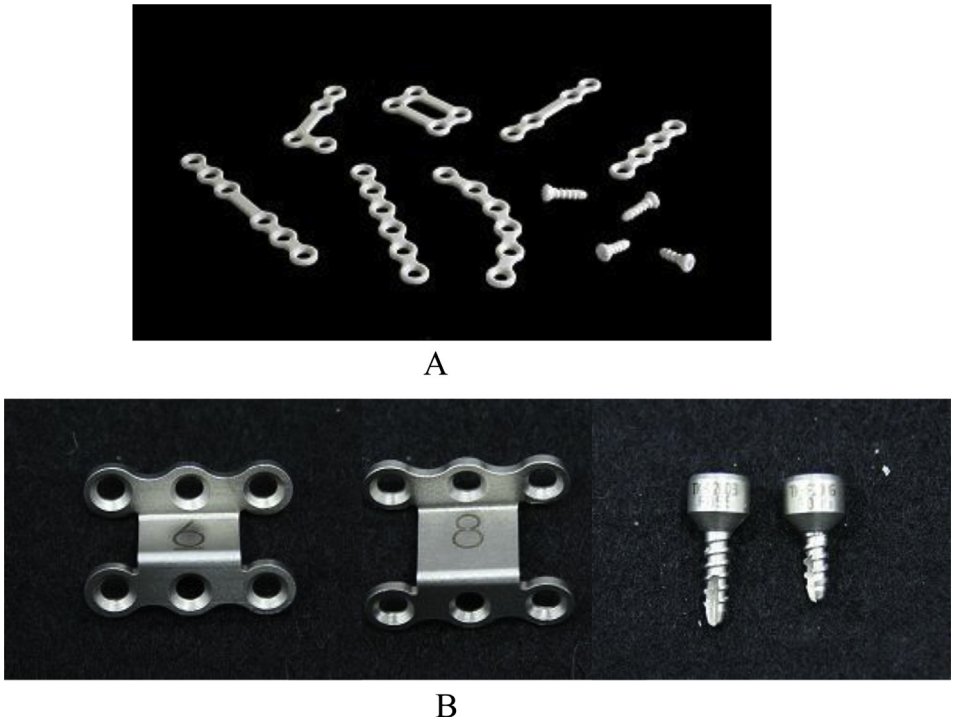

**Fig. 1.** A) uHA/PLLA plates and screws, B) Templates and temporary screws.

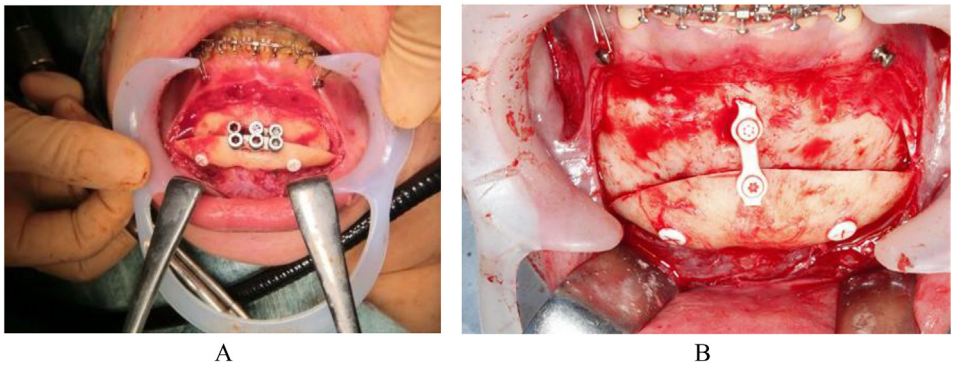

**Fig. 2.** Intraoperative photograph using the template and screws. A) After a template plate and temporary screws were fixed, bi-cortical absorbable screws were fixed. B) After removal of the template and temporary screws, an absorbable plate was fixed at the center of the chin.

before surgery ($P = 0.0005$ and $P = 0.0012$), however there was no significant difference between immediately after surgery and 1 year after surgery. On the other hand, there were no significant differences between the changes before surgery, immediately after surgery and at 1 year after surgery, in the Pog (Y) and PogS (Y). In the Me (X) and MeS (X), the changes immediately after surgery and at 1 year after surgery were significantly larger than those before surgery ($P = 0.0004$ and $P = 0.0017$), however there was no significant difference between those after surgery and at 1 year after surgery. On the other hand, there were no significant differences between the changes before surgery, immediately after surgery and at 1 year after surgery in the Me (Y) and MeS (Y) (Table 2).

Although there were no significant differences in the change from before surgery to immediately after surgery between the absorbable and titanium groups, there were significant differences in the Pog (Y) ($P = 0.0379$) and PogS (Y) ($P = 0.0379$) from immediately after surgery to after 1 year (T2) between the absorbable and titanium groups (Table 3).

## 4. Discussion

Absorbable plates and screws have been used in orthognathic surgery, and reliable achievement has been reported. However, few studies have reported on the stability of genioplasty using absorbable plates (Lee et al., 2014). Landes et al. (2014) reported the usefulness of the uHA/PLLA plate and screw for the mandibular advancement and setback surgery with Le fort I osteotomy, however, the stability of genioplasty was not mentioned in the study. Only one study by Lee et al. (2014) has shown stability of advancement genioplasty. However, in the study by Lee et al. (2014), most subjects (25/27) were class III setback cases and only 2 were class II advancement cases. They concluded that there were no clinical differences between biogradable screws and conventional metal plates used for fixation.

The present study dealt with solely class II cases (in both the absorbable and titanium groups) who underwent advancement genioplasty (without vertical change) in combination Le Fort I and

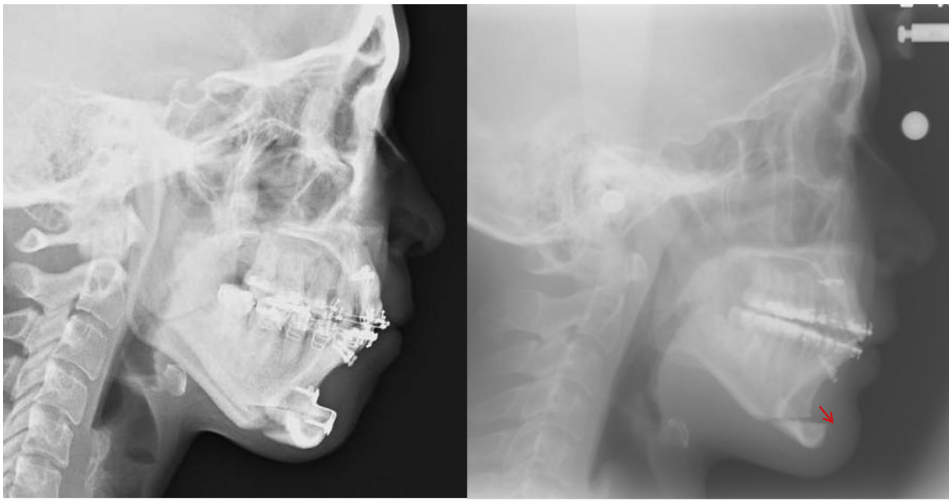


**Fig. 3.** Lateral cephalogram immediately after surgery. A) Titanium plate was used in the titanium group, B) Absorbable plate and screws were used in the absorbable plate group. The materials were not invisible. It was assumed that the red arrow shows the stretch direction of the bending absorbable plate after surgery. Advancement of the chin was recognized in both groups.

SSRO advancement surgery. Two absorbable (uHA/PLLA) bi-cortical screws and one absorbable (uHA/PLLA) plate were used similarly in all patients in the absorbable group. On the other hand, the titanium chin plate was used in all patients in the titanium group. As the subject sample background (including occlusion, skeletal pattern and surgical procedure) was similar, the study design was considered to be comparatively reliable and valid, even though the sample size was quite small. There was no significant difference regarding the amount of mandibular advancement between the absorbable and titanium groups. It was assumed that this could not reflect any difference in stability after advancement genioplasty.

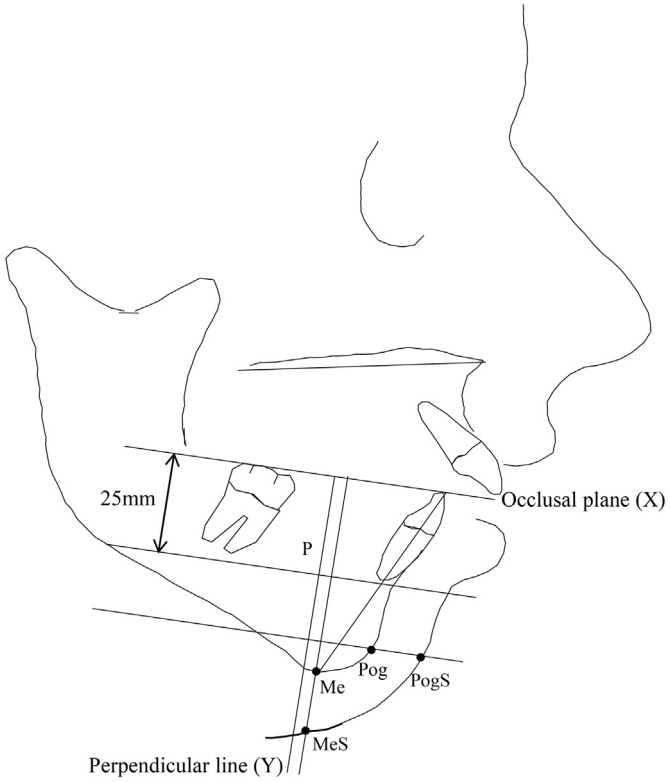


**Fig. 4.** Cephalometric measurements. The coordinates (X, Y) of the points Me, Pog, MeS and PogS at the region of the chin were measured. The coordinate (X) was determined as the distance between P and each point perpendicular to the occlusal plane. The coordinate (Y) was determined as the distance between the occlusal plane and each point.

The measurement methods used were based on the study by Lee et al. (2014). However, the values for Pog, PogS, Me, and MeS were altered in a manner that could not be controlled. That was because in the class II retrognathia patients, Pog and Me tended to be positioned more posteriorly than the incisor edge, perpendicular to the occlusal plane. Similarly, PogS and MeS tended to be positioned more posteriorly than the labial contour.

In this study, Pog (X) and PogS (X) were moved to the exact predicted positions of advancement in both the absorbable and titanium groups immediately after surgery. The template plate and temporary screws were very useful to support the strength of the absorbable materials, until all the screws and the plate were fixed keeping the advanced chin position, intra-operatively. Similarly, Me (X) and MeS (X) were also moved anteriorly. This meant that the chin segment was protruded with mandibular advancement by SSRO. However, movement direction of the chin segment was advancement only (vertical change was so small) in all cases. Therefore, Pog (Y), PogS (Y), Me (Y) and MeS (Y) were considered not to have changed after surgery in both groups. Immediately after surgery, the amount of skeletal advancement in the Pog (X) could be reflected in soft tissue PogS (X) at a rate of over 100%. This could have been due to the remnant swelling at 1 month post-surgery. However, the amount of skeletal advancement was close to that of soft tissue advancement at 1 year post-surgery.

On the other hand, Pog (X) and PogS (Y) in the absorbable group showed a decreased tendency while Pog (Y) and PogS (Y) showed an increase tendency, although Pog (X)(Y) and PogS (X)(Y) in the titanium group did not change from immediately after to 1 year after surgery. In short, the Pog point tended to move inferiorly 1 year after surgery in the absorbable group, although that was stable in the titanium group. These findings suggested some reasons. First, the bent plate at the center of the chin gradually stretched, causing the inferior chin segment to be pushed down inferiorly (Fig). In some cases, a slight gap between the segments was recognized at the anterior site in the lateral cephalogram after surgery. Second, the resorption of the anterio-superior edge of the

**Table 1**
The result of cephalometric analysis in the absorbable group.

| Absorbable group (mm) | | Pre-operation | | Immediately after surgery | | 1 year after sugary | |
|---|---|---|---|---|---|---|---|
| Pog (X) | Ave | 9.5 | a, b | 14.4 | a | 13.9 | b |
| | SD | 2.2 | | 2.3 | | 2.2 | |
| Pog (Y) | Ave | 38.6 | a, | 38.9 | b | 40.0 | a, b |
| | SD | 3.2 | | 2.9 | | 3.7 | |
| PogS (X) | Ave | 19.5 | a, b | 24.8 | a, c | 23.3 | b,c |
| | SD | 3.2 | | 3.3 | | 3.7 | |
| PogS (Y) | Ave | 38.6 | a | 38.9 | b | 40.0 | a, b |
| | SD | 3.2 | | 2.9 | | 3.7 | |
| Me (X) | Ave | 5.2 | a, b | 10.0 | a | 8.8 | b |
| | SD | 2.0 | | 2.7 | | 2.7 | |
| Me (Y) | Ave | 45.4 | | 46.0 | | 47.6 | |
| | SD | 3.1 | | 3.7 | | 5.0 | |
| MeS (X) | Ave | 7.8 | a, b | 10.0 | a | 8.8 | b |
| | SD | 9.4 | | 2.7 | | 2.7 | |
| MeS (Y) | Ave | 54.2 | | 54.2 | | 55.0 | |
| | SD | 4.6 | | 4.1 | | 5.8 | |

Ave indicates average. SD indicates standard deviation. Same letters show significant differences between each period at $P < 0.05$.

**Table 2**
The result of cephalometric analysis in the titanium group.

| Titanium group (mm) | | Pre-operation | | Immediately after surgery | | 1 year after surgery | |
|---|---|---|---|---|---|---|---|
| Pog (X) | Ave | 8.7 | a, b | 14.8 | a | 14.2 | b |
| | SD | 2.5 | | 2.8 | | 2.6 | |
| Pog (Y) | Ave | 40.1 | | 40.9 | | 40.5 | |
| | SD | 2.5 | | 3.3 | | 3.2 | |
| PogS (X) | Ave | 17.5 | a, b | 25.3 | a | 23.9 | b |
| | SD | 3.5 | | 4.6 | | 3.8 | |
| PogS (Y) | Ave | 40.1 | | 40.9 | | 40.5 | |
| | SD | 2.5 | | 3.3 | | 3.2 | |
| Me (X) | Ave | 4.2 | a, b | 9.4 | 3 | 8.6 | b |
| | SD | 2.6 | | 3.5 | | 2.7 | |
| Me (Y) | Ave | 47.2 | | 47.7 | | 47.5 | |
| | SD | 3.7 | | 3.7 | | 3.7 | |
| MeS (X) | Ave | 4.2 | a, b | 9.4 | 3 | 8.6 | b |
| | SD | 2.6 | | 3.5 | | 2.7 | |
| MeS (Y) | Ave | 55.9 | | 55.5 | | 55.2 | |
| | SD | 4.7 | | 5.3 | | 6.0 | |

Ave indicates average. SD indicates standard deviation. Same letters show significant differences between each period at $P < 0.05$.

**Table 3**
The results of T1 (Immediately after surgery − Pre-operation) and T2 (Immediately after surgery − 1 year after surgery).

| T1: Immediately after surgery - Pre-operation | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Pog | | PogS | | Me | | MeS | |
| | X | Y | X | Y | X | Y | X | Y |
| absorbable group | | | | | | | | |
| Ave | 5.0 | 0.3 | 5.3 | 0.3 | 4.8 | 0.6 | 4.8 | 0.0 |
| SD | 1.0 | 1.6 | 2.0 | 1.6 | 1.4 | 2.7 | 1.4 | 2.6 |
| Titanium group | | | | | | | | |
| Ave | 6.1 | 0.7 | 7.8 | 0.7 | 5.2 | 0.5 | 5.2 | −2.0 |
| SD | 1.8 | 2.2 | 3.6 | 2.2 | 2.3 | 1.7 | 2.3 | 2.9 |
| T2: Immediately after surgery -1 year after surgery | | | | | | | | |
| | Pog | | PogS | | Me | | MeS | |
| | X | Y | X | Y | X | Y | X | Y |
| absorbable group | | | | | | | | |
| Ave | −0.5 | 1.1* | −1.5 | 1.1* | −1.2 | 1.6 | −1.2 | 0.8 |
| SD | 0.9 | 1.6 | 2.0 | 1.6 | l.9 | 4.0 | l.9 | 4.7 |
| Titanium group | | | | | | | | |
| Ave | −0.6 | −0.4* | −1.3 | −0.4* | −0.8 | −0.2 | −0.8 | 1.3 |
| SD | 1.3 | 1.2 | 1.8 | 1.2 | 1.5 | 0.9 | 1.5 | 5 3 |

Ave indicates average. SD indicates standard deviation. *Significant difference between groups at $P < 0.05$.

chin likely caused the position of the most anterior point of the chin to move inferiorly. Therefore, the more inferior point after surgery was determined as the Pog point after 1 year. On the other hand, the titanium chin plate was adequately strong and covered the anterio-superior edge of the chin area widely such that resorption could not occur at the Pog region. Third, the difference in degree of the anterior open bite was considered. Even if movement by the advancement genioplasty was forward only, the change in the occlusal plane angle might be different (clockwise rotation or counter-clockwise rotation). In this study, change in the occlusal plane angle was not examined. It might be difficult to keep the segmental position resisting the attached suprahyoid muscles (anterior digastric and geniohyoid muscles) using the absorbable plate and screws. However, use of an additional plate and screws or other fixation method may solve the problem. In Me(Y) and MeS(Y), post-operative change was not found in the Both group. This might be because the thickness of the submandibular soft tissue including fat was large and variable. Therefore, the post-operative changes of Pog(Y) and PogS(Y) might not be affected in the absorbable group.

In this study, gradual stretch (relapse) of the bending part of the plate could be found at the center of the chin after surgery. To prevent this material change, a new pre-bending absorbable plate (uHA/PLLA) for advancement genioplasty has been developed in Japan. Therefore, we are expecting good usefulness and stability.

## 5. Conclusion

This study shows that predicted advancement of the chin in the absorbable group could be achieved by using a template and screws; the same was true for the titanium group. However, this study suggested that vertical relapse to the inferior site or resorption at the antero-superior edge of the segment could occur in the absorbable group.

## Offprint request

Not required.

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None.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcms.2019.07.027.

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