치의과학석사 학위논문

Analysis of postoperative isolated movement of proximal segment and distal segment after orthognathic surgery for mandibular prognathism

하악 전돌증 환자에서 악교정 수술 후 근심 골편 및 원심 골편의 독립적 이동에 대한 분석

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치의과학과 구강악안면외과학 전공

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이 논문을 치의과학과 석사학위논문으로 제출함

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-Abstract-

Analysis of postoperative isolated movement of proximal segment and distal segment after orthognathic surgery for mandibular prognathism

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1. Objective

In orthognathic surgery for mandibular setback surgery in patients with mandibular prognathism, masticatory muscles can be stretched because of perioperative clockwise rotation (CWR) of proximal segment (PS). Postoperatively, stretched muscles will be returned to the original length, which leads to counterclockwise rotation (CCWR) of PS. Because there is a discrepancy between the amount of postoperative CCWR and the

total relapse, it can be postulated that an isolated movement (IM) of the PS and distal segment (DS) may occur. The skeletal changes in postoperative 2D/3D cephalometric analysis in point B, Pog, and Me reflect total relapse which is composed of the positional changes in PS and DS during postoperative healing period. However, there is still no detailed report related with the IM of PS and DS. The purpose of this present study was to evaluate the IM of the PS and DS during postoperative period after orthognathic surgery for mandibular prognathism. In addition, the IM was analyzed depending on the different fixation type of the mandible.

2. Materials and methods

The study included data from 40 patients who underwent Le Fort I osteotomy and setback surgery of the mandible via sagittal split ramus osteotomy (SSRO) with or without genioplasty. Lateral cephalograms were taken before surgery (T0), immediately after surgery (T1), 1 year after surgery (T2). To evaluate the IM of PS and DS, the acetate paper traced with the whole mandible at T1 was overlaid on T2. The overlaid acetate paper of mandible at T1 was rotated until mandibular central incisor at T1 reached cingulum of maxillary central incisor at T2. Landmarks at this position of mandible were marked in T2, and they were defined as T3. To measure the IM of PS, the traced mandible at T1 was overlaid on T2, and Mandible at T1 was rotated until the posterior border of PS at T1 was aligned with the posterior border of PS at T2 (T3). The differences of cephalometric parameters and the SN−ArGo angle between T2 and T3 were measured.

The linear and angular changes of landmarks and parameters between T0 and T1, T1 and T2, T3 and T2 was evaluated. In group I, a four-hole miniplate was used on both sides of mandible for fixation of PS and DS. In group II, at least one positional screw was additionally used to fix PS and DS because of lack of bone contact in retromolar area. Mann-Whitney test and independent student t test were used to determine statistically significance between two groups. Pearson's correlation coefficient was used to assess the relation of surgical changes, postoperative relapses, and IM.

3. Results

The postoperative IM of PS (CCWR) and DS (CWR) were observed in all patients. However, the use of additional positional screws didn't significantly affect the amount of IM of PS and DS. The amount of perioperative mandibular setback was proportional to the amount of the perioperative clockwise rotation of PS. The amount of postoperative CCWR of PS (Group I : −2.53 ± 1.84° / Group II : −2.72 ± 2.05°) was less than that of perioperative CWR of PS (Group I : +4.27 ± 1.89° / Group II : 4.22 ± 1.84°). When the posterior border of PS at T1 aligned with that at T2, the difference of horizontal point B was 1.55 ± 1.71 mm. The total amount of horizontal relapse (T2−T1) at point B was 2.01 ± 1.69 mm.

4. Conclusion

All patients showed IM of PS and DS, and postoperative IM of PS and DS were significantly correlated with postoperative relapse of mandible.

In order to prevent postoperative relapse, PS should not be rotated clockwise perioperatively. Different from CCWR of PS postoperatively, CWR happens in DS postoperatively. Therefore, adequate care is necessary to prevent open bite during postoperative period.

Keywords : mandibular prognathism, SSRO, proximal segment, distal segment, isolated movement, relapse of mandible

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CONTENTS

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I. Introduction

Since sagittal split ramus osteotomy (SSRO) for the correction of mandibular deformity was introduced by Trauner and Obwegeser, SSRO has been widely used for orthognathic surgery.[1] It became clear that the amount and direction of surgical movement impact largely on the result of orthognathic surgery.[2]

The amount of force applied by the pterygomasseteric sling is relevant to the postoperative relapse of mandible.[3] Stretched masticatory muscles due to perioperative clockwise rotation (CWR) of proximal segment (PS) lead to counterclockwise rotation (CCWR) of the mandible as they contract after surgery.[4-9] Franco et al. stated that the further the distal segment (DS) moves backwards, the greater is the inclination of the PS to rotate clockwise perioperatively, as the muscle attachment on the medial side of PS is not detached and measurements are not taken to prevent rotation. These changes elongate and stretch lateral attachments.[5]

The skeletal changes in postoperative 2D/3D cephalometric analysis in point B, Pog, and Me reflect total relapse which is composed of the positional changes in PS and DS during postoperative healing period. In other aspects, an isolated movement (IM) of the PS and DS may occur during postoperative healing period. Park et al. reported larger postoperative CCWR of the PS and smaller relapse at point B were observed, which implies isolated CCWR movement (IM) of the PS in addition to CCWR of whole mandible. The total relapse can be increased or decreased depending on this IM. However, there is still no detailed report related with the IM of PS and DS. The purpose of this present study was to evaluate the IM of the PS and DS during postoperative period after orthognathic surgery for mandibular prognathism. In addition, the IM was analyzed depending on the different fixation type of the mandible.

II. Materials and methods

1. Patients

The study included data from 40 patients (22 males, 18 females, average age : 26.6yr) who underwent Le Fort I osteotomy and setback surgery of the mandible via SSRO [10] with or without genioplasty from 2009 to 2014 at Seoul National University Dental Hospital. The exclusion criteria were as followed; (1) patients who showed less than 2° of perioperative CWR or CCWR of the PS, (2) patients with re-operation, (3) patients who simultaneously underwent mandibular angle reduction, (4) patients with cleft lip or palate, craniofacial syndrome and history of trauma on maxillofacial area, (5) patients with open bite greater than 4mm (overbite : < -4mm), (6) patients with postoperative horizontal and vertical relapse greater than 2mm because of possible postoperative positional changes of maxillary anterior teeth by mandibular relapse).

One surgeon performed operation in all patients. Masseter muscles were partially detached from the mandible in all patients, even when transbuccal fixation with positional screw was needed. But both sides of medial pterygoid muscles were totally detached from mandible. Patients were divided into the two groups depending on the fixation type between PS and DS. In group I, a four-hole miniplate was used on both sides of mandible for fixation of PS and DS. In group II, at least one additional positional screw was used to fix PS and DS after the fixation of mandible on both sides with four-hole miniplates, because of lack of bone contact in retromolar area. The same type of four-hole miniplate was used in all patients. All patients received pre- and postoperative orthodontic treatment. No intermaxillary fixation was performed after the operation. Instead, light elastic boxing was used for 4 to 5 weeks after surgery.

2. Cephalometric analysis

Lateral cephalograms were taken before surgery (T0), immediately after surgery (T1) and 1 year after surgery (T2). All cephalograms were traced on acetate paper for cephalometric analysis. Landmarks, such as Sella (S), Nasion (N), Articulare (Ar), Gonion (Go), point A, point B, Anterior nasal spine (ANS), Posterior nasal spine (PNS), Pogonion (Pog), Menton (Me), Incision superioris (Is), Incision inferious (Ii), and Mesiobuccal cusp tip of mandibular 1^{st} molar (6MBC) were marked on the lateral cephalograms at T0 phase. The same landmarks were transferred to the lateral cephalograms at stage T1 and T2 using the superimposition technique.

To evaluate the IM of PS and DS, the acetate paper traced with the whole mandible at T1 was overlaid on T2. The overlaid acetate paper of mandible at T1 was rotated until mandibular central incisor at T1 reached cingulum of maxillary central incisor at T2 (Figure 1). The center of condyle was used as the mandibular rotation centers, and the determination of rotation center was presented in detail in Figure 2. The seven landmarks (Ar, Go, point B, Pog, Me, Ii, mesiobuccal cusp tip of mandibular 1^{st} molar) at this position of mandible were marked in T2, and they were defined as T3. To measure the IM of PS, the traced mandible at T1 was overlaid on T2, and Mandible at T1 was rotated until the posterior border of PS at T1 was aligned with the posterior border of PS at T2 (T3). The differences of cephalometric parameters and the SN-ArGo angle between T2 and T3 were measured (Figure 3).

For the cephalometric analysis, an x-y coordinate system was constructed on traced acetate paper. The x–axis was designated by the straight line passing through N and rotated by 7° clockwise from the sella–nasion line. The y–axis was defined as the line perpendicular to the x–axis and passing through S. The landmarks and reference lines are illustrated in Figure 4.

The horizontal and vertical changes at point A, point B, Pog, and Me were measured by the distances from y–axis and distances from x–axis respectively from T0 to T1, and from T1 to T2. And the same vertical and horizontal changes at point B, Pog, and Me were determined from T3 to T2. Also the overbite and overjet were measured at T0 phase in reference to Is, and Ii. The angular changes of SNA, SNB, ANB, SN–ArGo, Palatal plane (Y–axis - ANS:PNS), SN–Mandibular occlusal plane, SN–Mandibular plane from T0 to T1, and from T1 to T2 were obtained. Also the changes of SN–ArGo, SN–Mandibular plane from T3 to T2 were obtained.

3. Statistical analysis

In order to assess the error of each landmark positions used in this study, the tracing was re–performed in 20 randomly selected cephalograms and the Dahlberg's formula was used to evaluate each measurement value (Table 1).[11]

Statistical analyses were performed using SPSS 25 (SPSS Inc., Chicago, IL, USA). The Kolmogorow–Smirnov test was applied to evaluate normal distribution. As the result, vertical relapse of point B and

Me, surgical change of SNA, relapse of SNA and SNB did not show normal distribution. Mann−Whitney test was applied for these five measurements, and independents student t test was used for the other measurements to determine statistically significance. Pearson's correlation coefficient was used to assess the relation of surgical changes, postoperative relapses, and IM.

III. Results

1. Overbite and overjet

The overbite at T0 was −0.30 ± 1.96mm in group I and −0.37 ± 1.49mm in group II. The maximum values of open bite in each group were −3.93mm and −3.83mm, respectively (Table 2). There were no significant differences between two groups. The overjet at T0 was −4.89 ± 3.81mm in group I and −4.24 ± 3.24mm in group II.

2. Surgical changes

Surgical changes in group I and II are presented in Table 3. In both groups, point A was slightly moved anteriorly and inferiorly. Point B, Pog, and Me were moved posteriorly and superiorly. SNA was decreased, and SNB, ANB were increased after surgery. According to the CWR of PS perioperatively, the SN−ArGo angle was increased. The angle between SN−mandibular occlusal plane was rotated clockwise, while mandibular plane angle (SN−GoMe) was rotated counterclockwise. There were no significant differences of surgical changes in palatal plane between the two groups. There were no statistically significant differences of surgical movements between two groups.

In group I, point A was surgically moved by 1.02 ± 2.31mm anteriorly and by 0.41 ± 2.42mm superiorly. Point B was moved by 9.47 ± 4.65mm posteriorly and by 1.09 ± 2.69mm superiorly. Pog was moved by 8.54 ± 5.25mm posteriorly and by 2.87 ± 4.70mm superiorly. Me was moved by 8.40 ± 6.07mm posteriorly and by 3.47 ± 3.79mm superiorly. SN-ArGo was increased by 4.27 ± 1.89° perioperatively. Palatal plane was increased by 4.54 ± 4.09. SN-Mandibular occlusal plane was increased by 1.38 ± 6.25°, while mandibular plane angle was decreased by 1.04 ± 3.14°.

In group II, point A was moved by 1.14 ± 1.86mm anteriorly and by 0.14 ± 2.47mm superiorly after operation. Point B was moved by 10.10 ± 3.41mm posteriorly and by 1.34 ± 2.38mm superiorly. Pog was moved by 9.13 ± 4.28mm posteriorly and by 2.90 ± 4.29mm superiorly. Me was moved by 9.25 ± 4.33mm posteriorly and by 3.32 ± 4.34mm superiorly. SN-ArGo was increased by 4.22 ± 1.84° perioperatively. Palatal plane was increased by 5.73 ± 3.27°. SN-Mandibular occlusal plane was increased by 2.32 ± 3.55°, while mandibular plane angle was decreased by 0.49 ± 2.65°.

3. Relapse

Postoperative relapse one year after surgery is presented in Table 4. There were minimal changes in point A in both groups. Point B, Pog, and Me were changed anteriorly and superiorly, and the SN-ArGo angle was decreased according to the CCWR of PS, which showed postoperative relapse. SN-Mandibular occlusal plane was also minimally rotated counterclockwise. There were no significant differences of the relapse parameters between two groups ($p>0.05$).

In group I, point A was changed by 0.01 ± 0.92mm anteriorly and by 0.43 ± 0.82mm superiorly one year after operation. Point B was moved by 2.16 ± 1.94mm anteriorly and by 1.30 ± 1.46mm superiorly. Pog was moved by 2.23 ± 2.27mm anteriorly and by 1.16 ± 1.65mm superiorly. Me was moved by 2.27 ± 2.35mm anteriorly and by 0.98 ± 1.55mm superiorly. The SN-ArGo angle was decreased by 2.53 ± 1.84°. Palatal plane was decreased by 1.33 ± 1.80°. SN-Mandibular occlusal plane was decreased by 0.57 ± 2.16°, while mandibular plane angle was decreased by 0.30 ± 1.66°.

In group II, A point was moved by 0.27 ± 0.73mm posteriorly and by 0.29 ± 0.92mm superiorly one year after operation. Point B was moved by 1.86 ± 1.43mm anteriorly and by 0.96 ± 1.19mm superiorly. Pog was moved by 1.93 ± 1.72mm anteriorly and by 0.97 ± 1.16mm superiorly. Me was moved by 1.81 ± 1.82mm anteriorly and by 0.97 ± 1.16mm superiorly. The SN-ArGo angle was decreased by 2.72 ± 2.05°. Palatal plane was decreased by 1.41 ± 1.41°. SN-Mandibular occlusal plane was decreased by 0.42 ± 2.53°, while mandibular plane angle was increased by 0.15 ± 1.45°.

4. Isolated movement of proximal segment and distal segment

IM of PS and DS is presented in Table 5. The difference of cephalometric parameters between T2 and T3 showed that point B, Pog, and Me were moved inferiorly, and mandibular plane angle was increased in both groups. According to these changes, the superimposed traced T2 and T3 demonstrated that DS was independently rotated clockwise during postoperative period.

The SN−ArGo angle was decreased in both groups. The difference of the SN−ArGo angle between T2 and T3 showed that PS was rotated counterclockwise by IM. There were no significant differences between two groups.

In group I, point B was moved by 0.11 ± 1.15mm posteriorly and by 0.93 ± 1.28mm inferiorly. Pog was changed by 0.44 ± 1.26mm posteriorly and by 1.13 ± 1.37mm inferiorly. Me was moved by 0.51 ± 1.39mm posteriorly and by 0.99 ± 1.24mm inferiorly. SN−ArGo was decreased by 1.06 ± 1.71° and mandibular plane angle was increased by 1.08 ± 1.20°.

In group II, Point B was moved by 0.13 ± 1.08mm posteriorly and by 1.10 ± 1.19mm inferiorly. Pog was moved by 0.48 ± 1.03mm posteriorly and by 1.13 ± 1.11mm inferiorly. Me was changed by 0.71 ± 1.05mm posteriorly and by 0.92 ± 1.13mm inferiorly. SN−ArGo was decreased by 1.42 ± 1.82° and mandibular plane angle was increased by 1.69 ± 1.35°.

When align the posterior border of PS at T1 and T2 (Figure 3), the differences of horizontal point B was 1.55 ± 1.71 mm.

5. The correlation of surgical changes, postoperative relapses, and isolated movements

Table 6 represents the correlations among perioperative changes, postoperative relapses, and IM. There was a significant difference between the amount of perioperative mandibular setback (amount of point B, Pog, and Me setback) and that of perioperative CWR of PS (Post op SN−ArGo). There was a significant difference between the amount of perioperative setback of Pog and that of postoperative CCWR of PS (Relapse of SN−ArGo) (r= 0.312, P=0.050). Also, there was a significant difference between the amount of perioperative CWR of PS (Post op SN−ArGo) and that of postoperative CCWR of PS (Relapse of SN−ArGo) (r=−0.395, P=0.012). The greater the amount of setback of the mandible perioperatively was, the greater was the amount of relapse of the mandible during the first year after surgery.

The change of mandibular plane angle from T2 to T3 phase showed postoperative IM of DS, and the change of the SN−ArGo angle from T2 to T3 phase represented postoperative IM of PS. There was a significant difference between the amount of postoperative CCWR of PS and that of postoperative IM of PS (r=0.753, p=0.000). Also, there was a significant difference between the amount of postoperative CCWR of PS and that of postoperative IM of DS (r=−0.319, p=0.045). There was a significant difference between the postoperative change of mandibular plane angle and that of postoperative IM of DS (r=0.734, p=0.000).

IV. Discussion

Normally, in other research, the change of mandibular setback was measured by the horizontal setback of point B and Pog. In this study, horizontal relapse rate at point B was 23% in group I and 18.4% in group II. And horizontal relapse at Pog was 26.5% in group I and 21.1% in group II. Other research reported various results (19~25% at point B, 26~50% at Pog).[6, 7, 12, 13]

The amount of perioperative mandibular setback was proportional to the amount of the perioperative clockwise rotation of PS. Choi et al. said that in 3D analysis, as mandibular setback movement increased, the pitch movement of PS (rotation of PS) showed a significant increasing relapse tendency at postoperative phase.[14]

The postoperative IM of PS and DS were observed in all patients. It means that although PS and DS were fixed with miniplate and screws, IM was happened between two segments. The statistical analysis above indicates that the two groups showed only a slight difference in the IM of PS and DS. It demonstrates that the usage of additional positional screws didn't significantly affect the amount of IM of PS and DS.

However, the contracture force of stretched masticatory muscles due to CWR of PS and that of scar tissues on periosteum may outweigh the fixation force of screws. The positional screws are used for fixing PS and DS to stabilize the lack of bone contact area. Lack of bone contact may allow IM of PS and DS more easily.

The amount of rotation of PS was measured by SN−ArGo and the horizontal distance between B point at T1 and B point at T2 when alignment the posterior border of PS were done (Figure 3). The amount of postoperative CCWR of PS (Group I : $-2.53 \pm 1.84^\circ$ / Group II : $-2.72 \pm 2.05^\circ$) was less than that of perioperative CWR of PS (Group I : $+4.27 \pm 1.89^\circ$ / Group II : $4.22 \pm 1.84^\circ$). This indicates that perioperative clockwise rotation of PS cannot fully return to its preoperative position at postoperative time. But Choi et al. found that PS showed a clockwise rotation immediately after surgery, but a compensatory counterclockwise rotation was observed. And rotated PS returned in its original position.[14]

Interestingly, the amount of postoperative IM of PS occupied quite a large part of the amount of postoperative CCWR of the entire mandible. When align the posterior border of PS at T1 and T2, the difference of horizontal point B was 1.55±1.71 mm. And the total amount of horizontal relapse (T2−T1) at point B was 2.01±1.69 mm.

The amount of rotation of DS was measured by SN−Mandibular plane. Unlike PS, DS showed a significant increase in the amount of postoperative isolated CWR (Group I : +1.08 ± 1.20° / Group II : +1.69 ± 1.35°) compared to that of postoperative relapse of whole mandible (SN−Mandibular plane from T1 to T2, Group I : −0.30 ± 1.66° / Group II : +0.15±1.45°). It was assumed that as the patient starts to eat and do rehabilitation exercise, occlusal force and the function of suprahyoid muscles may accelerate the postoperative isolated CWR of DS. Will et al. also reported that posterior and inferior recurrence was found in the anterior portion of DS after BSSRO with intraosseous wire fixation. [2] They also concluded that the anterior portion of DS was rotated clockwise by suprahyoid muscle forces.

Despite the noteworthy findings above, the present study has two limitations: 1) removal of the surgical wafer after surgery can affect the amount of mandibular relapse between T1 and T2. 2) Changes in tooth position due to postoperative orthodontic treatment can affect the results of the data. Nevertheless, the amount of IM of PS and DS from T3 to T2 phase is not affected by the inaccuracy incurred by surgical wafer. Yet the dental changes caused by orthodontic treatment can still have an impact on the results.

In summary, the amount of IM of PS and DS is directly proportional to that of the amount relapse of mandible, and the amount of the IM of DS is directly proportional to the amount of the relapse of DS.

As mentioned above, masticatory muscle force is the main contributing factor for postoperative relapse of mandible, and that postoperative IM of PS and DS are significantly correlated with postoperative relapse of mandible. Therefore, the findings of this study suggest that the IM of PS and DS are strongly influenced by muscle forces.

Proffit el al. noted that modulating the inclination of the ramus during mandibular setback surgery seems promising to eliminate relapse after mandibular setback.[1] In more concrete terms, in order to prevent postoperative relapse, PS should not be rotated clockwise but should be positioned in preoperative location.

The study of Yang et al. demonstrates the group with greater perioperative CWR of the PS exhibited notably greater CCRW of mandible compared to the other group [7] Furthermore, they also stated that the PS, instead of the whole mandible, can be rotated counterclockwise into a somewhat more stable position by postoperative soft tissue force. This occurrence can decrease the CCWR of the whole mandible and conduce less postoperative relapse.[7]

On the other hand, although PS showed CCWR postoperatively, CWR happens in DS postoperatively. So adequate care is necessary to prevent open bite during postoperative period.

As an alternative to minimizing the relapse of mandible, an internal fixation system should allow a certain degree of IM of PS and DS. Ghang et al. suggested the semi−rigid sliding plate system for fixation of mandibular setback surgery to minimize the early relapse.[8] The screw into the sliding hole was tightened and then slightly loosened to allow the IM of PS at the postoperative stage. In the study, a semi−rigid sliding plate showed a stable amount of relapse after SSRO until the end of orthodontic treatment (Perioperative horizontal setback at B point : 8.86 ± 5.17mm / Horizontal relapse at B point between 6 months and 1 year: 2.13 ± 1.89mm). Roh et al. compared the horizontal relapse of three groups separated by the fixation type (sliding plate, miniplate, bicortical screws).[15] Sliding plate group showed less horizontal relapse rate (1.8%) than other two group (4.8% in miniplate, 15.4% in bicortical screws).

V. Conclusion

The IM of PS and DS are strongly influenced by muscle forces. Although PS and DS are fixed with miniplate and screws, this movement happens. In order to prevent postoperative mandibular relapse, PS should not be rotated clockwise but should be positioned in preoperative location perioperatively. Also semi−rigid type miniplate is recommended so as to allow the IM of PS and DS.

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VII. Tables

Table 1. Measurement errors of references in lateral cephalograms

Reference point	X	Y
S	0.051	0.237
N	0.272	0.000
ANS	0.390	0.317
PNS	0.296	0.331
A	0.443	0.420
L1	0.259	0.281
6MBC	0.323	0.517
B	0.158	0.301
Pog	0.202	0.252
Me	0.309	0.301
Ar	0.275	0.400
Go	0.292	0.357

S, sella; N, nasion; ANS, anterior nasal spine; PNS, posterior nasal spine; A, point A; L1, lower incisor tip; 6MBC, mesiobuccal cusp tip of mandibular first molar; B, point B; Pog, pogonion; Me, menton; Ar, articulare; Go, gonion.

Numerical errors of reference points were calculated using the Dahlberg formula $\boldsymbol{S^2 = \sum d^2 / 2n}$.
'd' is the differences between double-checked distance values and 'n' is the number of double measurements.

Table 2. Overbite and Overjet

	Fixation type	Overbite (mm)			Overjet (mm)		
		Mean	SD	Max.	Mean	SD	Max.
Group I (n=20)	Both 4-hole miniplate	−0.30	1.96	−3.93	−4.89	3.81	−11.35
Group II (n=20)	Both 4-hole miniplate + any additional positional screw	−0.37	1.49	−3.83	−4.24	3.24	−10.98

Table 3. Mean surgical changes (T1−T0)

	Group I (n=20)		Group II (n=20)		P−value
	Mean	SD	Mean	SD	
Horizontal(mm)					
A	1.02	2.31	1.14	1.86	NS
B	−9.47	4.65	−10.10	3.41	NS
Pog	−8.54	5.25	−9.13	4.28	NS
Me	−8.4	6.07	−9.25	4.33	NS
Vertical(mm)					
A	−0.41	2.42	−0.14	2.47	NS
B	1.09	2.69	1.34	2.38	NS
Pog	2.87	4.70	2.90	4.29	NS
Me	3.47	3.79	3.32	4.34	NS
Angular(°)					
SNA	−0.99	2.68	−0.90	2.37	*NS
SNB	4.47	2.31	5.38	2.49	NS
ANB	5.46	3.29	6.29	2.28	NS
SN−ArGo	4.27	1.89	4.22	1.84	NS
Palatal plane (Y−axis − ANS:PNS)	4.54	4.09	5.73	3.27	NS
SN−Mandibular occlusal plane	1.38	6.25	2.32	3.55	NS
SN−Mandibular plane	−1.04	3.14	−0.49	2.65	NS

Horizontal change – (+): advancement, (−): setback

Vertical change – (+): upward, (−): downward

Angular change – (+): clockwise rotation, (−): counterclockwise rotation

NS : no statistically significant, by Independent sample t−test
*NS : no statistically significant, by Mann−Whitney test

Table 4. 1 year postoperative relapse (T2−T1)

	Group I (n=20)		Group II (n=20)		P-value
	Mean	SD	Mean	SD	
Horizontal(mm)					
A	0.01	0.92	−0.27	0.73	NS
B	2.16	1.94	1.86	1.43	NS
Pog	2.23	2.27	1.93	1.72	NS
Me	2.27	2.35	1.81	1.82	NS
Vertical(mm)					
A	0.43	0.82	0.29	0.92	NS
B	1.30	1.46	0.96	1.19	*NS
Pog	1.16	1.65	0.97	1.16	NS
Me	0.98	1.55	0.97	1.16	*NS
Angular(°)					
SNA	0.36	1.66	0.41	0.60	*NS
SNB	−0.62	1.75	−0.91	0.71	*NS
ANB	−0.98	0.68	−1.32	0.87	NS
SN−ArGo	−2.53	1.84	−2.72	2.05	NS
Palatal plane (Y−axis − ANS:PNS)	−1.33	1.80	−1.41	1.41	NS
SN−Mandibular occlusal plane	−0.57	2.16	−0.42	2.53	NS
SN−Mandibular plane	−0.30	1.66	0.15	1.45	NS

Horizontal change – (+): advancement, (−): setback

Vertical change – (+): upward, (−): downward

Angular change – (+): clockwise rotation, (−): counterclockwise rotation

NS : no statistically significant, by Independent sample t−test

*NS : no statistically significant, by Mann−Whitney test

Table 5. Isolated sliding movement of proximal and distal segment (T2 − T3)

	Group I (n=20)		Group II (n=20)		P−value
	Mean	SD	Mean	SD	
Horizontal(mm)					
B	−0.11	1.15	−0.13	1.08	NS
Pog	−0.44	1.26	−0.48	1.03	NS
Me	−0.51	1.39	−0.71	1.05	NS
Vertical(mm)					
B	−0.93	1.28	−1.10	1.19	NS
Pog	−1.13	1.37	−1.13	1.11	NS
Me	−0.99	1.24	−0.92	1.13	NS
Angular(°)					
SN−Mandibular plane	1.08	1.20	1.69	1.35	NS
SN−ArGo	−1.06	1.71	−1.42	1.82	NS

Horizontal change – (+): advancement, (−): setback

Vertical change – (+): upward, (−): downward

Angular change – (+): clockwise rotation, (−): counterclockwise rotation

NS : no statistically significant, by Independent sample t−test

Table 6. Correlation between surgical change, postoperative relapse and isolated proximal and distal segment sliding

		Relapse of horizonal Pog (T2−T1)	Relapse of horizonal Me (T2−T1)	Post op SN−ArGo (T1−T0)	Relapse of SN−ArGo (T2−T1)	Post op SN−Mandibular occlusal plane (T2−T1)	Relapse of SN−Mandibular occlusal plane (T2−T1)	ISM of vertical Me (T2−T3)	ISM of SN−Mandibular plane (T2−T3)	ISM of SN−ArGo (T2−T3)
Amount of B setback (T1−T0)	Pearson Correlation	−.348*	−0.307	−.593**	0.298	−.637**	.350*	0.168	−0.085	0.225
	Sig.(2−tailed)	0.028	0.054	0.000	0.062	0.000	0.027	0.300	0.600	0.164
Amount of Pog setback (T1−T0)	Pearson Correlation	−.458**	−.426**	−.429**	.312*	−.596**	.460**	0.004	−0.035	0.158
	Sig.(2−tailed)	0.003	0.006	0.006	0.050	0.000	0.003	0.982	0.830	0.330
Amount of Me setback (T1−T0)	Pearson Correlation	−.462**	−.425**	−.399*	0.307	−.634**	.433**	0.039	−0.085	0.148
	Sig.(2−tailed)	0.003	0.006	0.011	0.054	0.000	0.005	0.812	0.603	0.363
Post op SN−ArGo (T1−T0)	Pearson Correlation	0.249	0.221	1	−.395*	0.230	−0.217	−0.310	0.226	−0.140
	Sig.(2−tailed)	0.121	0.171		0.012	0.154	0.179	0.051	0.161	0.388
Relapse of SN−ArGo (T2−T1)	Pearson Correlation	−.458**	−.411**	−.395*	1	−0.287	0.247	−0.095	−.319*	.753**
	Sig.(2−tailed)	0.003	0.009	0.012		0.073	0.125	0.558	0.045	0.000
Post op SN−Mandibular Occlusal Plane (T1−T0)	Pearson Correlation	0.241	0.194	0.230	−0.287	1	−.372*	−0.242	0.124	−0.259
	Sig.(2−tailed)	0.135	0.230	0.154	0.073		0.018	0.133	0.446	0.107
Relapse of SN−Mandibular Plane (T2−T1)	Pearson Correlation	−.689**	−.709**	0.060	−0.066	0.005	.423**	−.317*	.734**	−.429**
	Sig.(2−tailed)	0.000	0.000	0.712	0.686	0.977	0.006	0.046	0.000	0.006

**. Correlation is significant at the 0.01 level (2−tailed)

*. Correlation is significant at the 0.05 level (2−tailed)

VIII. Figures

Figure 1. The red line represents 1 year after operation (T2). The blue line represents traced mandible of T1. The blue one is rotated until its' tip of the incisor is occluded with upper incisor of T2.

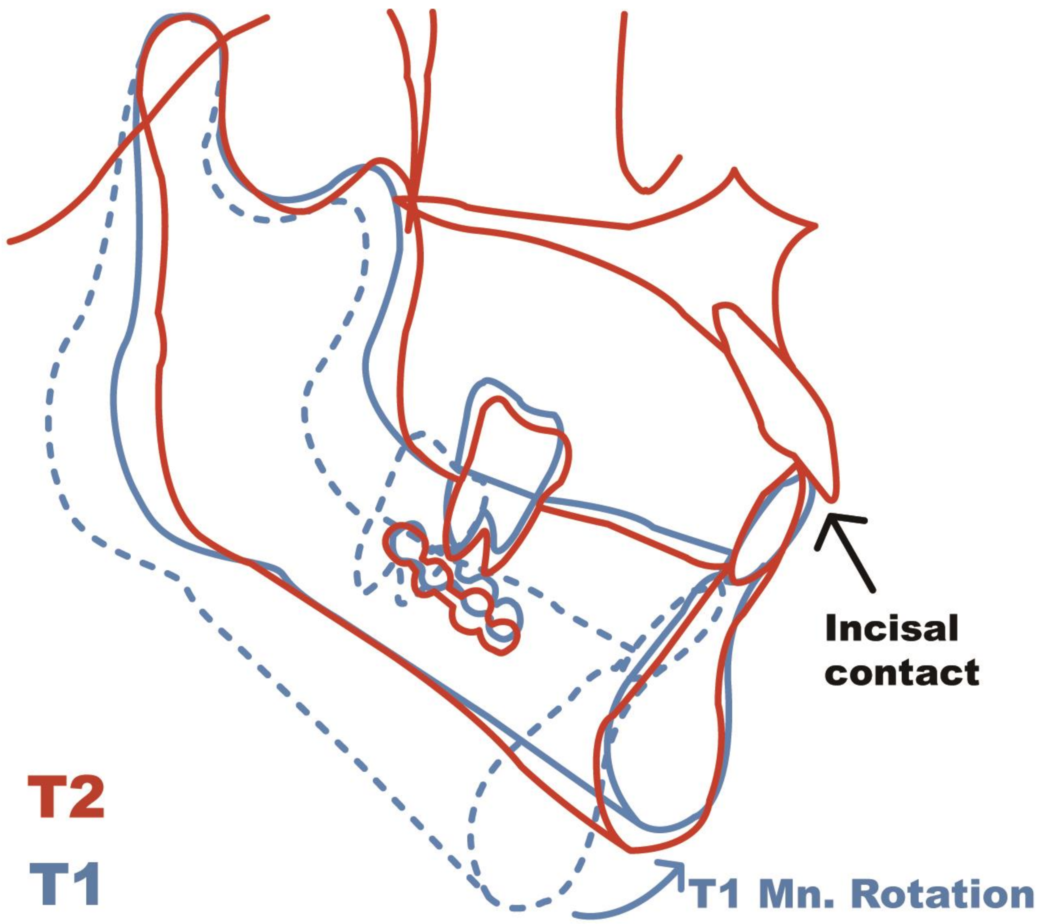


Figure 2. When the distance of CoAr is a radius, and the circle centering on Co is drawn, the point of contact with condyle on the opposite side of Ar is called Ar′. Draw a perpendicular bisector from Co to ArAr′ in the isosceles triangle of CoArAr′. At this perpendicular bisector, the position corresponding to 1/2 of the ArAr′ distance from Co is defined as Hinges axis.

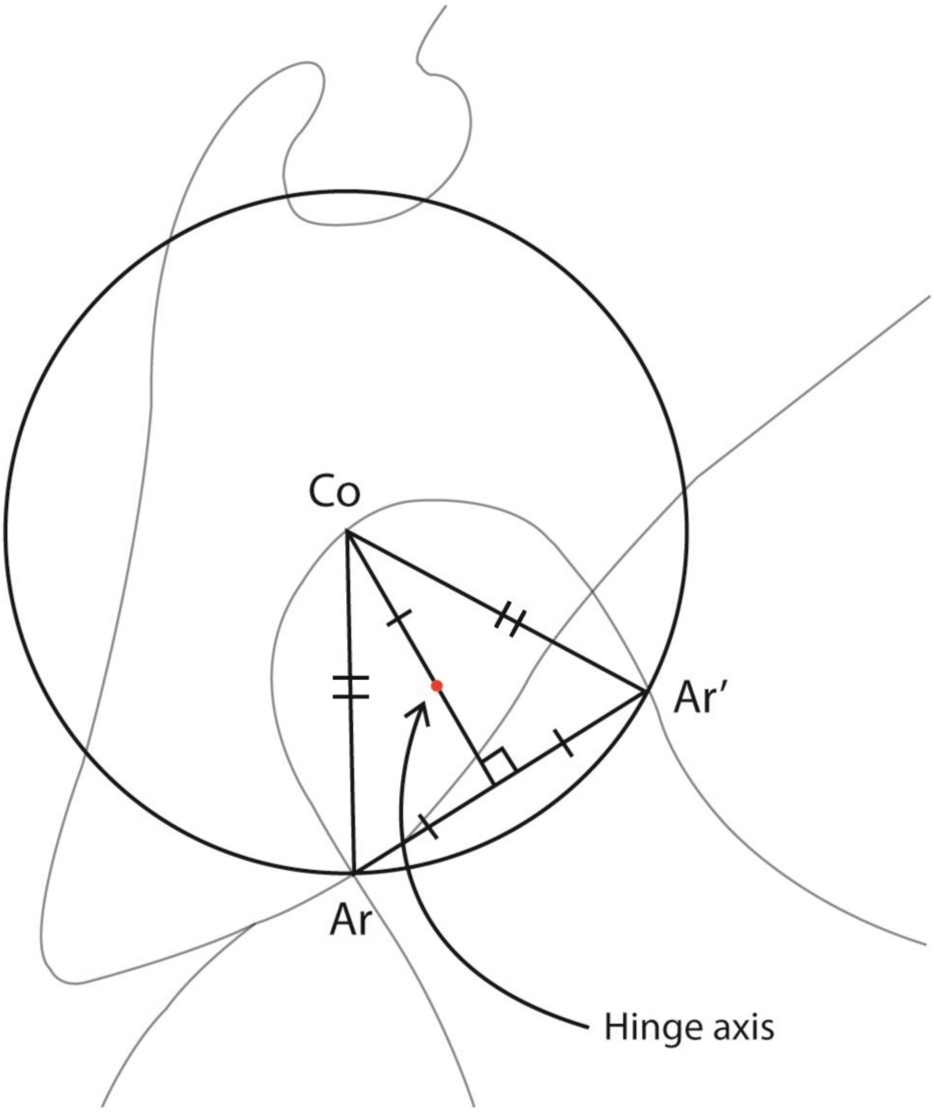


Figure 3. To measure the ISM of PS, traced mandible at T1 was overlaid on T2. Rotating the mandible of T1 until posterior border of PS at T1 is aligned with the posterior border of PS at T2 based on the center of mandibular rotation, horizontal differences were measured between T1 and T2 at point B

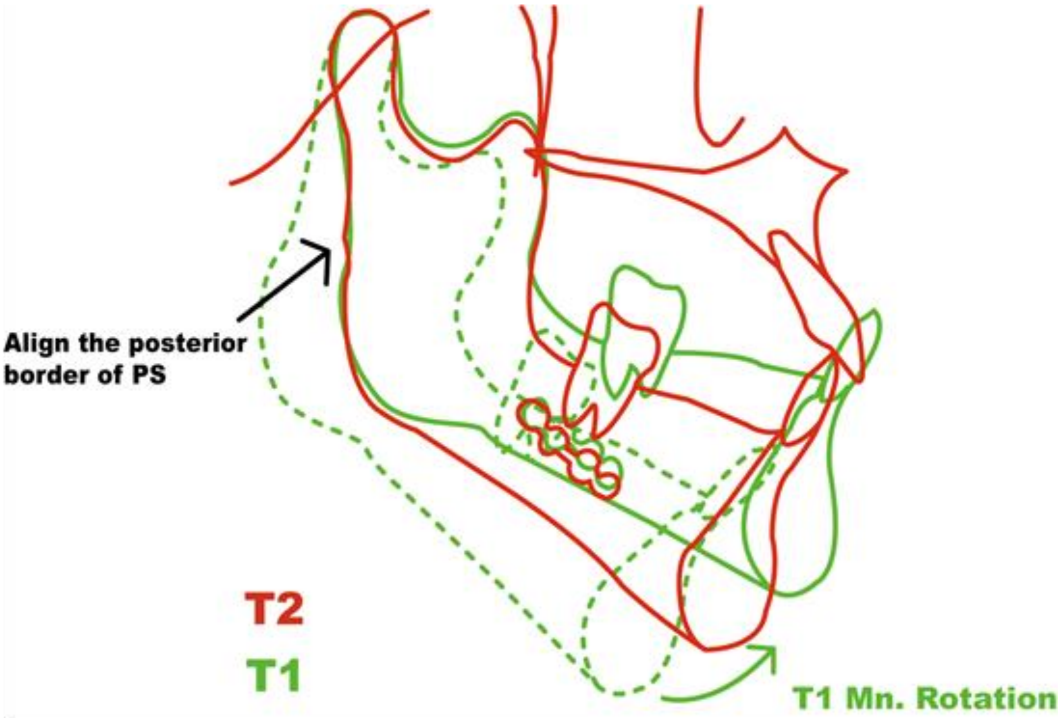
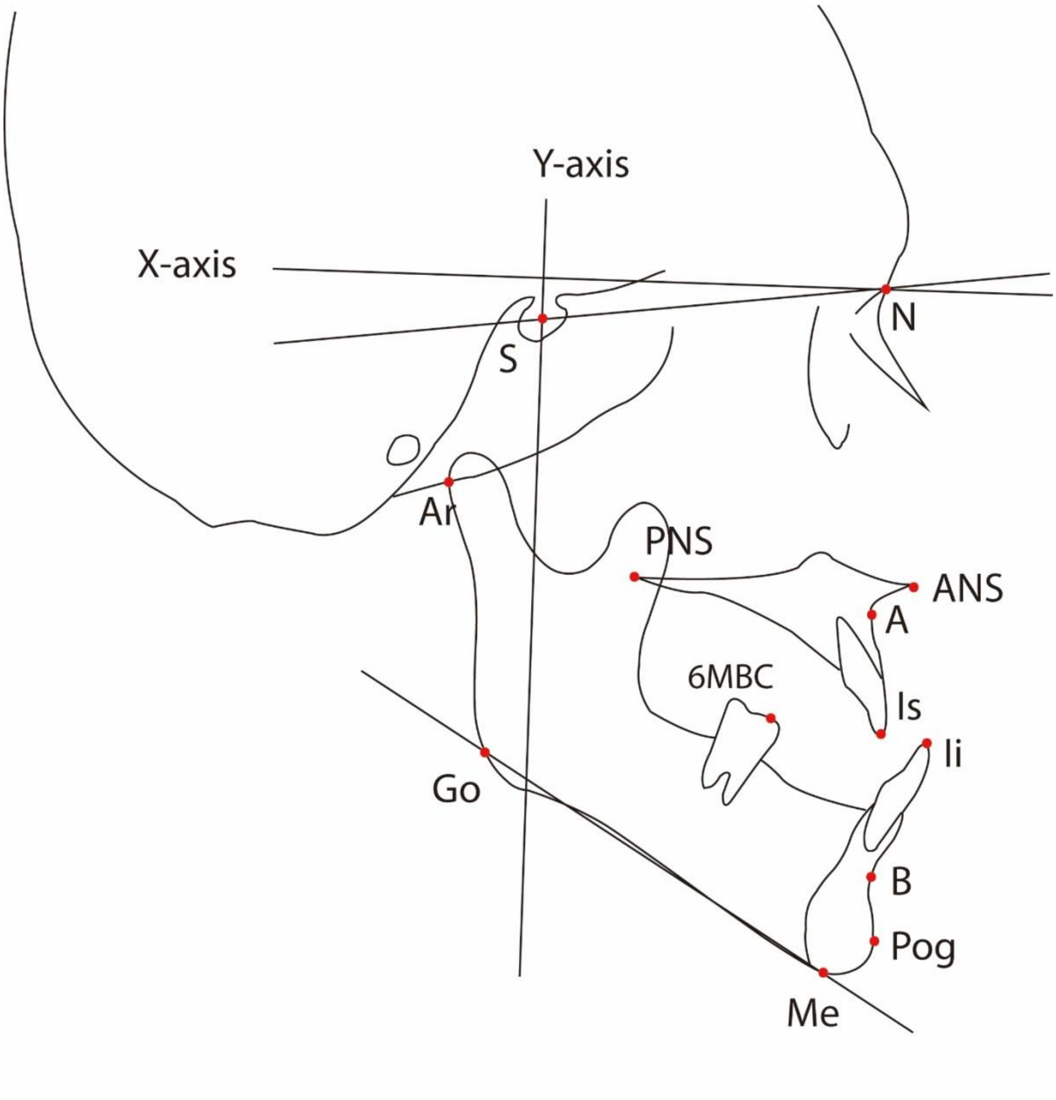


Figure 4. The landmarks and reference lines.



- 국문초록 -

하악 전돌증 환자에서 악교정 수술 후 근심 골편 및 원심 골편의 독립적 이동에 대한 분석

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1. 목 적

하악 전돌증 환자에서 악교정 수술 직후 근심 골편이 시계 방향으로 회전하면, 저작근들이 늘어나게 된다. 수술 후 늘어난 저작근들이 수축하면서 근심 골편을 반시계방향으로 회전시킨다. 악교정 수술 후 하악골의 회귀에 대한 기존의 연구들은 point B, Pog, Me 등의 계측점의 변화만으로 전체 하악골의 회귀 경향을 분석하였다. 하지만 악교정 수술 후 회복 과정에서 근심 골편과 원심 골편은 각각 독립적으로 움직일 수 있지만 아직까지 이 이동에 대한 자세한 연구는 보고된 바가 없다. 본 연구를 통해 하악 전돌증으로 하악골 상행지 시상분할 절단술을 이용하여 악교정 수술을 받은

환자의 두부측모 방사선 사진을 이용하여 근심 골편과 원심 골편의 독립적인 움직임을 분석하고자 한다. 또한 하악골에서 금속판 및 금속 나사의 고정 방식에 따른 회귀량의 차이를 알아보고자 한다.

2. 방 법

하악 전돌증으로 진단을 받고, 상악에 르포트 1형 골 절단술 (Le Fort I osteotomy) 및 하악골 상행지 시상분할 절단술을 시행 받은 환자 40명의 수술 전(T0), 수술 직후(T1), 수술 1년 후(T2)의 두부측모 방사선사진을 분석하였다. 근심 골편과 원심 골편의 독립적인 이동량을 평가하기 위해, T1의 하악골을 트레이싱한 아세테이트지를 T2를 트레이싱한 아세테이트지에 중첩시키고, 하악과두의 회전 중심을 기준으로 T1의 하악 중절치가 T2의 상악 중절치 설면에 닿을 때까지 회전시켜, 이 때의 T1와 T2에서의 근심 및 원심골편의 차이를 측정했다.

또한 하악골 상행지 시상분할 절단술 후 금속판 만을 이용하여 근심 골편과 원심 골편을 고정한 군(group I)과 금속판 및 하악 상행지에 추가 금속 나사를 이용하여 고정한 군(group II)로 나누어 두 군 간에 유의한 차이 유무를 확인했다.

하악 근심골편과 원심골편의 고정 방식에 따른 각 변화량의 평가를 위해 Kolmogorove-Smirnov test로 계측치가 정규분포를 따르는 지를 평가했다. Kolmogorov-Smirnov test를 이용해 각 측정값의 정규성 검정 결과 B점과 Me의 수직적 회귀량, SNA의 수술 전후 변화량 및 수술 1년 후 회귀량, SNB의 수술 1년 후 회귀량은 정규분포를 만족하지 않았다($p<0.05$). 위 다섯

가지 측정값들은 Mann-Whitney test를 통해, 정규분포를 만족하는 나머지 측정값들은 독립표본 T 검정을 실시하여 두 군 간에 유의한 차이가 있는지를 평가했다. 또한 40명 전체 환자에서의 각 변화량 간의 상관관계는 Pearson's correlation analysis를 이용하여 평가했다.

3. 결 과

모든 환자에서 수술 후 근심 골편과 원심 골편의 독립적 이동이 관찰됐다. 하악골 고정 방식에 따라 구분한 두 그룹에서 통계적으로 유의한 차이는 관찰되지 않았다. 즉 추가 금속 나사의 유무가 두 골편의 독립적인 이동에 큰 영향을 주지 못했다.

수술 전후 하악골의 후퇴량과 수술 직후 근심 골편의 시계방향 회전량은 양적인 상관관계를 보였다(수술 중 B점의 변화과 수술 직후 SN-ArGo의 변화량 : r= 0.593, P=0.000 / 수술 중 Pog의 변화량과 수술 직후 SN-ArGo의 변화량 : r= 0.429, P=0.006 / 수술 중 Me의 변화량과 수술 직후 SN-ArGo의 변화량 : r= 0.399, P=0.011). 또한 수술 직후 시계방향으로 회전한 골편은 수술 후 1년간 반시계방향으로의 회귀 양상을 보였지만, 수술 전 위치까지 돌아오지 않았다. 수술 1년 후(T2) 하악골 B점에서의 반시계방향 전체 회귀량은 2.01±1.69 mm였으며, T2에서의 근심골편의 반시계 방향으로의 회전량은 2.63±1.95° 였다. T1에서 트레이싱한 하악 전체 이미지를 T2에서의 하악 근심골편에 맞게 중첩을 한 결과, 하악 B 점에서의 회귀량은 1.55±1.71 mm였고, 원심골편의 독립적인 시계방향 회전이 관찰되었다.

4. 고 찰

저작근의 운동은 수술 후 하악골 회귀 현상의 주된 원인이고, 근심 골편 및 원심 골편의 독립적 이동은 수술 후 하악골의 회귀와 관련이 있으므로, 두 골편의 독립적 이동은 저작근의 힘에 영향을 받는다고 할 수 있다. 본 연구의 결과에 근거하면 근심골편과 원심골편은 수술 후 각각 독립적인 움직임이 있었으며, 이는 금속판 및 금속나사의 고정에도 불구하고 근심골편과 원심골편 사이에 미끄럼 이동이 발생하였음을 제시한다.

따라서 수술 후 회귀량을 줄이기 위해 근심 골편이 수술 중에 시계방향으로 회전하지 않도록 조절해야 한다. 또한 수술 후 근심골편의 반시계 방향의 회전에도 불구하고 원심골편에서는 일부 시계방향의 회전이 발행하므로 개방교합이 발생하지 않도록 유의해야 한다. 근심골편과 원심골편 사이에 미끄럼 이동이 발생함을 고려하여 골편의 독립적인 움직임을 허용할 수 있는 반고정(semi-rigid) 방식의 금속판을 사용해 전체 하악골의 회귀량을 줄이는 것이 바람직하다.

주요어 : 하악 전돌증, 악교정 수술, 근심 골편, 원심 골편, 독립적인 운동, 하악골의 회귀

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