Original Article

Surgical Accuracy of Maxillary Repositioning According to Type of Surgical Movement in Two-Jaw Surgery

Jin-Young Choi[a]; Jae-Pyong Choi[b]; Seung-Hak Baek[c]

ABSTRACT
Objective: To compare the surgical accuracy of the maxillary repositioning according to the maxillary surgical movement type (SMT) in two-jaw orthognathic surgery (TJOS).
Materials and Methods: The samples consisted of 52 Korean young adult patients with skeletal Class III malocclusion treated with TJOS by one surgeon. Lateral cephalograms were taken 1 month before (T0) and 1 day after surgery (T1). The samples were allocated into maxillary advancement (MA), total setback (MS), impaction (MI), and elongation (ME) according to SMT. The distance from the upper incisor tip and the mesiobuccal cusp tip of the upper first molar to the horizontal and vertical reference lines at T0 and T1 were measured. Any discrepancy between the surgical treatment objective (STO) and the surgical result less than 1 mm was regarded as accurate. The accuracy rate (AR [number of the accurate sample/number of the sample] ×1000) and the surgical achievement ratio (SAR [amount of movement in surgical result/amount of movement in STO] ×100) were calculated. Analysis variance (ANOVA) and crosstab analyses were used for statistical analysis.
Results: Although the MS (69.2%) and MI (69.0%) showed a lower AR than the MA (87.5%) and ME (83.3%), there was no significant difference in the distribution of accurate and inaccurate samples among the groups. The mean discrepancy between the STO and the surgical result was less than 1 mm in all groups. Although the ME (93.54%) showed a tendency of undercorrection and the MS (107.10%) and MI (105.42%) a tendency of overcorrection, there was no significant difference in SAR among the groups.
Conclusions: If the surgical plan and procedure is done with caution, the MS and MI can be regarded as just as accurate a procedure as the MA and ME. (*Angle Orthod.* 2009;79:306–311.)

KEY WORDS: Surgical accuracy; Maxillary repositioning; Surgical movement type; Two-jaw surgery

INTRODUCTION

In correcting a dentofacial deformity, the team approach between a surgeon and an orthodontist is essential to obtain a good functional and esthetic outcome.[1,2] As a communicative and diagnostic tool, the surgical treatment objective (STO) can provide the surgeon and orthodontist with information about the amount and direction of the surgical movement of the hard tissue, resulting change of the soft tissue profile, and preoperative and postoperative orthodontic treatment plan.[3]

Many skeletal Class III malocclusions are known to require two-jaw surgery to get a mandibular setback and various new positions of the maxilla for an esthetic and stable result.[4,5] There have been a number of sophisticated techniques available for orthognathic surgical treatment planning.[6–18] However, despite good surgical technique, in cases of complex two-jaw surgery, anatomic obstacles, errors in mounting, model surgery and intermediate splint fabrication, unintended malpositioning of the mandibular condyle, and mistakes in measurement of the external and internal reference points in the operative procedure can make a significant discrepancy in the maxillary repositioning

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between the STO and surgical result.[10,17,19–27] In some instances, inaccurate placement of the maxilla results in an unwanted repositioning of the mandible and less than an ideal functional and esthetic outcome.[7,22,23,26,28] Therefore, it is important to compare the actual surgical results of the maxillary repositioning with the STO.

Ong et al[26] reported that in advancement of the maxilla, 87% of patients had a difference of 2 mm or less from the prediction in both the vertical and horizontal dimensions. Jacobson and Sarver[3] reported that the actual results of 80% of the maxillary impaction and advancement were within 2 mm of the prediction and 43% within 1 mm of the prediction. However, Semaan and Goonewardene,[29] in the cases with elongation, impaction, and advancement of the maxilla reported that 66% were within 2 mm of the prediction and only 26% within 1 mm of the prediction. This difference in accuracy seems to occur due to heterogenous samples, various surgical movement types, and multiple operators. To find out the precise accuracy rate according to the surgical movement type of the maxilla, it is important to classify the surgical movement type for the maxillary repositioning and to confine the samples to the same skeletal pattern, surgical technique, and surgeon.

Therefore, the purposes of the present study were to compare the surgical accuracy of the maxillary positioning according to surgical movement type in two-jaw surgery.

MATERIALS AND METHODS

The samples consisted of 52 Korean young adult patients with skeletal Class III malocclusion (26 men and 26 women; mean age: 22.6 years), who were treated with two-jaw orthognathic surgery from January 2006 to July 2007. The lateral cephalograms were taken 1 month before (T0, Figure 1A) and 1 day after surgery (T1, Figure 1B) and traced for superimposition.

Since the pattern of maxillary positioning could be variable according to the condition of the malocclusion, surgeon, and STO, the samples should be limited as follows:

—Surgeon: one surgeon to avoid surgeon-related bias;
—Skeletal pattern: Class III malocclusion to avoid skeletal pattern-related bias;
—Surgery method: two-jaw surgery (LeFort I osteotomy/bilateral sagittal split ramus osteotomy)

After the maxilla was down-fractured by a LeFort I osteotomy, vertical control of the mobilized maxilla was achieved by a combination of a nasion screw as the external reference point and bony marks above and below the osteotomy line as the internal reference points. Horizontal and transverse movements of the maxilla were controlled with intermediate surgical wafers.

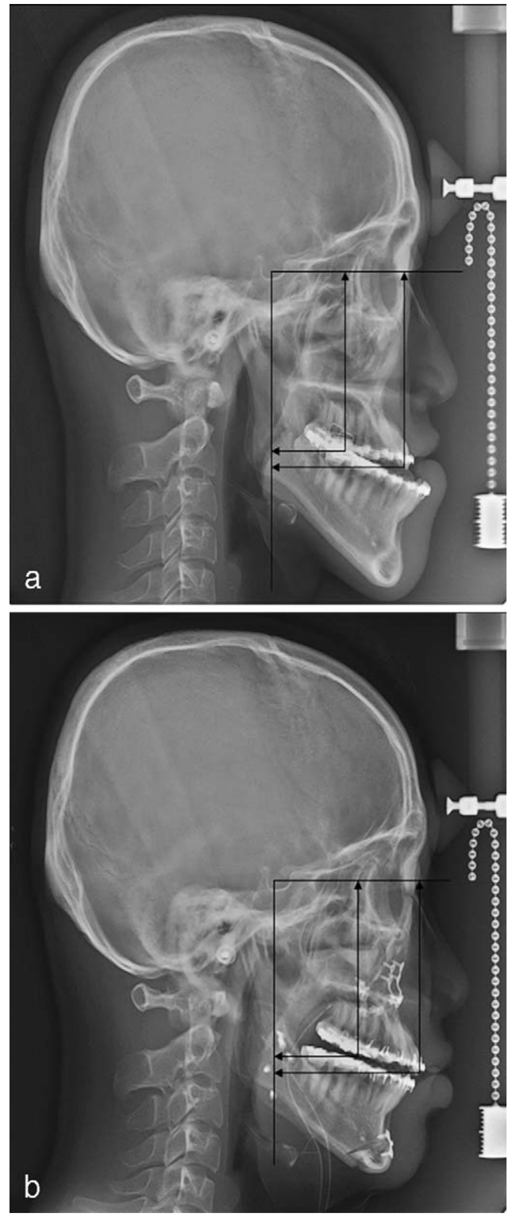

Figure 1. (A) Lateral cephalogram 1 month before surgery (one of the samples). (B) Lateral cephalogram of the same patient 1 day after surgery.

The samples were allocated into maxillary advancement (MA), maxillary total setback (MS), maxillary impaction (MI), and maxillary elongation (ME) according to surgical movement type. If one sample had a combination of the surgical movement types of the maxilla (for example, the maxilla was moved with posterior impaction and advancement), each movement was clas-

Table 1. Demographic Data According to the Surgical Movement Types of the Maxilla

Surgical Movement Types of the Maxilla	Number of Cases (%)	Mean ± SD, mm	Range, mm
Maxillary advancement (MA)	14 (21.5%)	2.79 ± 1.06	1.27–4.44
Maxillary setback (MS)	10 (15.4%)	2.78 ± 0.67	1.91–3.81
Maxillary impaction (MI)	31 (47.7%)	2.52 ± 1.03	0.76–5.08
Maxillary elongation (ME)	10 (15.4%)	2.14 ± 1.07	0.50–3.81
Total	65		

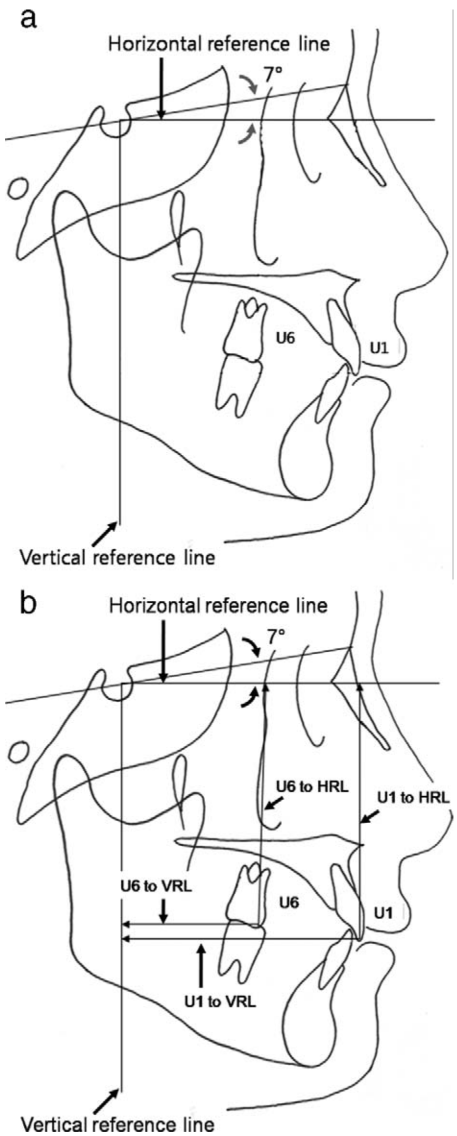

Figure 2. (A) Reference lines and points. U1 indicates the incisor tip of the upper central incisor; U6, the mesiobuccal cusp tip of the upper first molar; the horizontal reference line (HRL), a horizontal line that angulated 7° clockwise to the sella and nasion line passing through sella; the vertical reference line (VRL), a perpendicular line to the HRL passing through sella. (B) Variables. The distance from U1 to HRL for maxillary elongation (ME) and from U1 to VRL for maxillary advancement (MA), and maxillary total setback (MS), respectively, and distance from U6 to HRL for maxillary impaction (MI).

sified into the corresponding movement type (for example, MI and MA, respectively) (Table 1).

The horizontal reference line (HRL) was a line that angulated 7° clockwise to the sella-nasion line passing through sella and the vertical reference line (VRL), a perpendicular line to the HRL passing through sella (Figure 2A).[3,30,31] The distance from the tip of the upper central incisor (U1) to the HRL for ME and to the VRL for MA and MS, and the distance from the mesiobuccal cusp tip of the upper first molar (U6) to HRL for MI at T0 and T1 were measured. Measurements were done using a digitizer (Intuos2 graphic tablet, Wacom Technology Co, Vancouver, Canada) and V-Ceph program (Cybermed, Seoul, Korea) (Figure 2B). These distances were compared with those of the STO.

A discrepancy of less than 1 mm between the STO and actual surgical result (T1) was regarded as accurate. The accuracy rate ([number of accurate sample/number of sample] ×100) and the surgical achievement ratio ([amount of movement in surgical result/amount of movement] in STO ×100) were calculated. One-way analysis of variance (ANOVA) and crosstab analyses were done for statistical analysis.

RESULTS

Although the MS and MI showed a wider range than the MA and ME, the mean values of discrepancy were less than 1 mm in all groups (Table 2). In addition, there was no statistically significant difference in the mean value of discrepancies among groups (Table 2). Although the MS (69.2%) and MI (69.0%) showed a lower accuracy rate than MA (87.5%) and ME (83.3%), no significant difference existed in the distribution of the accurate ($\leq$1.0 mm) and inaccurate samples ($>$1.0 mm) among the groups (Table 2).

Although ME (93.54%) showed a tendency of undercorrection and the MS (107.10%) and MI (105.42%) a tendency of overcorrection, there was no statistically significant difference in the mean value of surgical achievement ratio among groups (Table 3). In addition, the MI and ME had a wider range of surgical achievement ratios than did the MA and MS (Table 3).

DISCUSSION

The stability and predictability of orthognathic surgical procedures is reported to vary by the direction of

Table 2. Comparison of Discrepancy Between the Surgical Treatment Objective (STO) and the Surgical Result[a]

Surgical Movement Type of the Maxilla	Mean, mm	SD, mm	Range, mm	Sig[b]	Distribution of Discrepancy[c]		Accuracy Rate, %
					Accurate: ≤1.0, mm	Inaccurate: >1.0, mm	
MA	−0.05	0.63	−1.09–+1.44		14	2	87.5%
MS	−0.02	0.97	−2.00–+1.18		10	3	69.2%
MI	−0.16	0.91	−2.00–+1.18	NS	30	12	69.0%
ME	−0.27	0.86	−1.73–+0.90		10	2	83.3%

[a] Discrepancy means the difference between the surgical treatment objective (STO) and the surgical result; Positive value indicates undercorrection compared with STO; negative value, overcorrection compared with STO. MA indicates maxillary advancement; MS, maxillary setback; MI, maxillary impaction; ME, maxillary elongation. Accuracy rate is the number of accurate sample/number of sample ×100.

[b] Significance. One-way analysis of variance (ANOVA) was done. NS indicates not significant. There was no statistically significant difference in mean value of discrepancy among groups ($P = .8823$).

[c] Crosstab analysis was done. There was no statistically significant difference in distribution of discrepancy among groups.

Table 3. Comparison of Surgical Achievement Ratio[a]

Surgical Movement Type of the Maxilla	Surgical Achievement Ratio			Sig[b]
	Mean, %	SD, %	Range, %	
MA	100.81	22.45	63.50–148.0	
MS	107.10	33.66	62.50–158.7	
MI	105.42	37.00	38.00–190.5	NS
ME	93.54	45.95	42.30–190.0	

[a] MA indicates maxillary advancement; MS, maxillary setback; MI, maxillary impaction; ME, maxillary elongation. Surgical achievement ratio (SAR) means the amount of movement in surgical result/amount of movement in surgical treatment objective (STO) ×100.

[b] Significance. One-way analysis of variance (ANOVA) was done. NS indicates not significant.

the surgical movement, the type of fixation, and the surgical technique employed, largely in that order of importance.[2] Therefore, classification of the surgical movement type according to direction would be important to assess the accuracy of repositioning of the maxilla.

Comparison of Overall Accuracy Rate and Surgical Achievement Ratio With Other Studies

The surgical complexity seems to be related with the result of the accuracy rate (AR) in this study with MA (87.5%), ME (83.3%), MS (69.2%), and MI (69.0%) in descending order (Table 2). In comparison of the AR with other studies, MS, MI, MA, and ME in this study showed higher values than Jacobson and Sarver[3] (43% within 1 mm of the prediction in cases with maxillary impaction and advancement of the maxilla) and Semaan and Goonewardene[29] (26% within 1 mm of prediction in cases with elongation, impaction, and advancement of the maxilla).[29]

The finding that the mean values of discrepancy were less than 1 mm in all groups (Table 2) seems to be in accord with Bryan and Hunt,[32] Csaszar and Niederdellmann,[11] and Gil et al,[33] who reported that there was no significant difference between the planned and actual maxillary positions following LeFort I osteotomy during bimaxillary surgery.

Comparison of MA and MS

Because there is no literature which reports AR and surgical achievement ratio (SAR) for MS, one of the purposes of this study was to compare MS and MA in terms of AR and SAR.

In the present study, MS (69.2%, 107.10%) showed a tendency toward lower accuracy and overcorrection than MA (87.5%, 100.81%), although there was no significant difference between them ($P = .5890$, Mann-Whitney test, Table 2; $P = .8859$, Mann-Whitney test, Table 3, respectively). These findings mean that precise control of the backward movement of the maxilla was more difficult than the forward one. It seems to be due to the anatomic obstacles such as the pterygoid plate of the sphenoid bone, the maxillary tuberosity and bony irregularity in the line of the LeFort I osteotomy in the posterior part of the maxilla, and the blood vessels such as descending palatine artery and pterygoid plexus. However, if the surgical plan and procedure is done with caution, the MS can be regarded as just as accurate a procedure as the MA.

Comparison of ME and MI

Friede et al[34] insisted that the postoperative vertical dimension appeared to be particularly hard to predict. Jacobson and Sarver[3] and Semaan and Goonewardene[29] reported that statistically significant differences were found between the predicted and actual postsurgical maxillary molar vertical position. The results from this study were in accord with them.

In the present study, the MI (69.0%, 105.42%) showed a tendency toward lower accuracy and overcorrection than the ME (83.3%, 93.54%), although there was no significant difference between them ($P = .5876$, Mann-Whitney test, Table 2; $P = .2861$, Mann-Whitney test, Table 3, respectively). These findings suggest that it would be more difficult to get precise vertical control of the posterior part of the maxilla in MI than of the anterior part of the maxilla in ME. This seems to occur by mistake in the linear measurement from the external reference point in the imaginary interpupillary line to the upper molars, and bony irregularity and uneven thickness of the osteotomy line of LeFort I osteotomy in the posterior part of the maxilla.

To measure the posterior and anterior vertical dimension of the maxilla during surgery, the distances from the midpalpebral fissure to the surgical wire of the upper first molar and from the nasion screw to the surgical wire of the upper central incisor are usually used. For the anterior vertical dimension, a relatively fixed landmark such as a nasion screw gives a stable result. However, the posterior landmark such as the midpalpebral fissure is movable, giving an unstable result. Since there is the anteroposterior movement of the maxilla along with the vertical movement in most cases of two-jaw surgery, it is difficult to measure the change in the vertical dimension exactly. However, if the surgical plan and procedure is done with caution, the MI also could be regarded as just as precise a procedure as the ME.

A possible explanation for a higher SAR in MI (105.42%) and MS (107.10%) than in ME (93.54%) and MA (100.81%) in the present study seems to be that, in some cases, bony obstacles in and around the LeFort I osteotomy line were removed more than enough to reposition the posterior part of maxilla passively. To guarantee the precise repositioning of the maxilla, we need to develop a reliable and accurate method to measure the vertical and sagittal movement of the posterior part of maxilla.

CONCLUSIONS

- Although there was no significant difference in accuracy rate and surgical achievement ratio among surgical movement types, a maxillary advancement could be regarded as relatively the most accurate and reliable surgical movement type.
- If the surgical plan and procedure is done with caution, maxillary total setback and maxillary impaction could be regarded as just as accurate a procedure as other types of surgical movement.

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