Original Article

Evaluation of canting correction of the maxillary transverse occlusal plane and change of the lip canting in Class III two-jaw orthognathic surgery

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ABSTRACT

Objective: To compare the effect of canting correction in anterior maxillary transverse occlusal planes (AMTOP) and posterior maxillary transverse occlusal planes (PMTOP) on the change of lip canting (LC) in two-jaw surgery (TJS) cases.

Materials and Methods: The samples consisted of eight young adult patients (three males and five females, mean age $= 24.1 \pm 4.5$ years) who had skeletal Class III malocclusion (CIII), facial asymmetry (FA), and LC and who underwent TJS. Two-dimensional lateral and posteroanterior cephalograms and three-dimensional facial scanning taken 1 week before (T1) and 6 months after TJS (T2) were combined using the Morpheus 3D program. Six linear and angular variables were measured and statistically analyzed.

Results: When comparing the values of the linear and angular variables at the T1 and T2 stages there was significant canting correction of AMTOP (1.7 mm vs -0.3 mm; 3.0° vs 0.1°), PMTOP (3.5 mm vs 0.1 mm, 3.3° vs -0.1°), and LC (3.0 mm vs 0.7 mm, 4.7° vs 2.1°) (all $P < .05$). Although the angular change ratios (ΔLC/ΔAMTOP and ΔLC/ΔPMTOP) did not exhibit a significant difference (0.99 vs 0.83), the linear change ratio of ΔLC/ΔAMTOP was significantly higher than that of ΔLC/ΔPMTOP (1.67 vs 0.74, $P < .05$). The angular change of ΔLC showed a significant correlation with ΔAMTOP ($r^2 = 0.64$; $P < .05$). However, the linear change of ΔLC was significantly correlated with both the angular and linear changes of ΔAMTOP ($r^2 = 0.62$ and 0.66; both $P < .05$). Therefore, the amount of LC change was more related to the canting correction of AMTOP than to that of PMTOP.

Conclusion: In TJS cases with CIII, FA, and LC, the amount of canting correction of the AMTOP should be considered to predict the actual LC change. (*Angle Orthod.* 2012;82:1092–1097.)

KEY WORDS: Class III malocclusion; Facial asymmetry; Two-jaw surgery; Lip canting; Maxillary transverse occlusal plane canting

INTRODUCTION

Recently the number of orthodontic patients who desire to correct facial asymmetry and lip canting (LC) has increased.[1] When setting the surgical treatment objectives for orthognathic surgery, the prediction of soft tissue change is difficult and inaccurate, especially in the frontal plane. Mild to moderate LC can remain even after correction of skeletal asymmetry by two-jaw surgery.[2,3]

Since soft tissue symmetry is dictated by the underlying skeletodental structures and muscles, LC can be a useful tool for the diagnosis and treatment planning of subjects with facial asymmetry despite a discrepancy between the canting correction of the maxillary transverse occlusal plane (MTOP) and change of LC.[4] Previous studies[3,5,6] have analyzed the pattern and amount of canting correction of MTOP and changes of LC before and after orthognathic

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surgery using two-dimensional posteroanterior (2D PA) cephalograms and frontal photographs. However, it is difficult to obtain proper accuracy because of the challenges in matching the PA cephalogram and frontal photograph with a 1:1 ratio and in reproducing the same head posture while taking the PA cephalogram and frontal photograph.

Even though three-dimensional computed tomography (3D CT) can be another option for the evaluation of canting, the low resolution of CTs (1.0-mm slice cut) can produce errors in measuring the canting correction of MTOP and the changes of LC. Therefore, 3D facial scanning can be regarded as a useful and accurate method with which to measure soft tissue change. Lim et al.[7] and Kim et al.[8] evaluated soft tissue change in 3D facial scanning images according to the skeletal movement of lateral cephalograms after one-jaw orthognathic surgery (mandibular setback only) in cases involving skeletal Class III malocclusion.

Recently, new technology to superimpose the 2D lateral and PA cephalograms with the 3D facial scanning image (Morpheus 3D program, version 2.0; Morpheus, Seoul, Korea) has been developed to overcome disadvantages, including enlargement of the image and head posture in the 2D biplanar cephalograms and low resolution of the hard and soft tissues in the 3D CT.

The MTOP can be divided into two parts: anterior and posterior. The posterior MTOP (PMTOP), which is established by connecting the maxillary first molars, has been used in most of the previous studies.[3,6,9] The anterior MTOP (AMTOP) is established by connecting the maxillary canines at both sides. Since the sagittal distance from the maxillary canine to the mouth corner (commissure) is relatively shorter than the sagittal distance from the maxillary first molar to the mouth corner, it is required that one evaluate the relationship between the canting correction of AMTOP and the change of LC.

Therefore, the purposes of this study were to compare the effect of canting correction in AMTOP and PMTOP on the change of LC in two-jaw orthognathic surgery cases with skeletal Class III malocclusion, facial asymmetry, and LC. The null hypothesis was that canting correction of AMTOP and PMTOP did not exhibit any significant difference in terms of change of LC in cases involving two-jaw orthognathic surgery.

MATERIALS AND METHODS

The samples consisted of eight young adult patients (three males and five females; mean age = 24.1 ± 4.5 years) who had skeletal Class III malocclusion, facial asymmetry, and LC and who underwent two-jaw surgery (LeFort I osteotomy for the maxilla and bilateral sagittal split ramus osteotomy for the mandible) at the Department of Oral and Maxillofacial Surgery, Seoul National University Dental Hospital in Seoul, Korea. The cephalometric data for the samples before two-jaw surgery are presented in Table 1.

Table 1. Cephalometric Analysis of the Patients[a]

	Mean	SD
SNA, °	79.27	3.18
SNB, °	82.55	5.21
ANB, °	−3.28	3.63
FMA, °	31.16	3.15
Chin deviation, mm	5.67	1.44

[a] SD indicates standard deviation.

Pre- and postoperative orthodontic treatments were performed by a single orthodontist and two-jaw surgery by a single surgeon. The study protocol was approved by the institutional review board at the Seoul National University Dental Hospital (SNUDH IRB CRI-11028).

2D lateral and PA cephalograms and 3D facial scanning were conducted 1 week before (T1) and 6 months after two-jaw surgery (T2). The Morpheus 3D program (version 2.0) was used to orthogonally overlap the 2D lateral cephalogram with the 2D PA cephalogram. The program was then used to combine the 3D facial scanning image with the 2D biplanar cephalograms in the 3D coordinates (Figure 1). These procedures can correct the magnification of the 2D radiographs by matching the actual linear distance between two reference points (pronasale and soft tissue pogonion) in the 3D facial scanning image and can allow us to obtain actual linear measurements of the corrected 2D cephalograms and 3D facial scanning. Choi et al.[10] reported a superimposition technique using the 2D biplanar cephalograms and the 3D virtual dental models (2.5D superimposition technique) and its accuracy test result. They[10] concluded that the 2.5D-technqiue can be regarded as an effective and efficient alternative to the 3D technique.

The definitions for the reference planes, landmarks, and linear and angular variables for measuring the LC, AMTOP, and PMTOP are enumerated in Figures 1 through 4, respectively. The AMTOP and PMTOP of 2D PA cephalograms and the LC of 3D facial scanning images were measured by a single operator using the Morpheus 3D program. All linear and angular variables at the T1 and T2 stages were measured in units of 0.01° and 0.01 mm, respectively.

All variables from three randomly selected subjects were reassessed at 2-week intervals by the same operator. The differences that were calculated using Dahlburg's formula[11] ranged from 0.12 mm to 0.16 mm for the linear measurements and from 0.06° to 0.13°

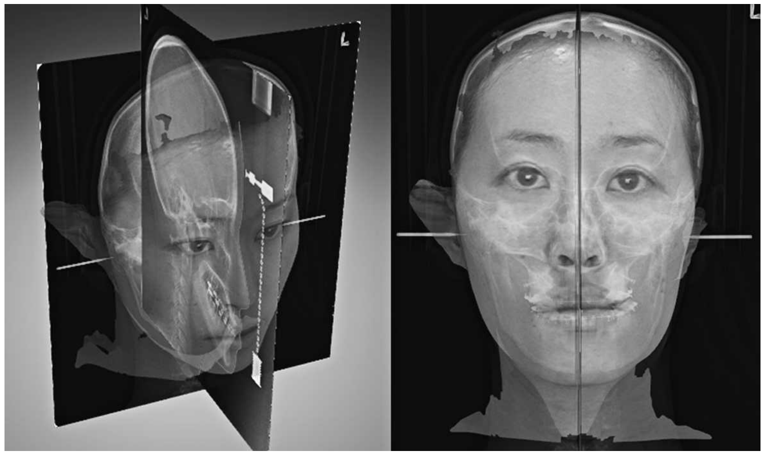

Figure 1. A new technology to superimpose the two-dimensional (2D) lateral and posteroanterior (PA) cephalograms with three-dimensional (3D) facial scanning image using the Morpheus 3D program (version 2.0). The 3D coordinates consisted of three reference planes: the horizontal plane, the plane constructed with the right orbitale, the right porion, and the left porion (Frankfort horizontal [FH] plane); the coronal plane, the plane constructed with the right porion and the left porion perpendicular to the FH plane; and the sagittal plane, the plane constructed with the nasion, perpendicular to the FH and coronal planes.

for the angular measurements. Therefore, the first set of measurements was used for this study.

The sample size determination was performed by a power analysis using the Sample Size Determination Program (version 2.0.1; Seoul National University Dental Hospital, Registration No. 2007-01-122-004453, Seoul, Korea). The Wilcoxon signed rank test, Mann-Whitney *U*-test, and Pearson correlation analysis were performed for statistical purposes.

RESULTS

In comparing the values of the linear and angular variables at the T1 and T2 stages, there were significant canting corrections for AMTOP (1.7 mm vs

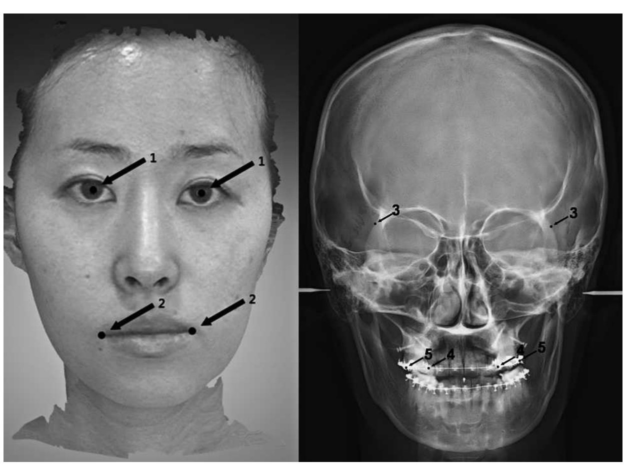

Figure 2. Soft tissue and skeletodental landmarks used in this study: (1) the center of the pupil (P); (2) the outermost point of the mouth (Ch); (3) the outer edge point of the fronto-zygomatic suture (FZ); (4) the midportion of the bracket and wire of the maxillary canine (C); (5) the midportion of the bracket and wire of the maxillary first molar (U6).

−0.3 mm; 3.0° vs 0.1°, all $P < .05$), PMTOP (3.5 mm vs 0.1 mm, 3.3° vs −0.1°, all $P < .05$), and LC (3.0 mm vs 0.7 mm, 4.7° vs 2.1°, all $P < .05$) (Table 2). The amounts of angular and linear canting correction in AMTOP (ΔAMTOP) were 3.0° and 1.9 mm; those in PMTOP (ΔPMTOP) were 3.4° and 3.4 mm; and those in LC change (ΔLC) were 2.6° and 2.4 mm, respectively (Table 2).

Although the angular change ratios (ΔLC/ΔAMTOP and ΔLC/ΔPMTOP) did not show a significant difference (0.99 vs 0.83, $P > .05$), the linear change ratio of ΔLC/ΔAMTOP was significantly higher than the linear change ratio of ΔLC/ΔPMTOP (1.67 vs 0.74, $P < .05$; Table 3).

A significant correlation was found between the angular canting change of LC and AMTOP (correlation coefficient [r^2] = 0.64, $P < .05$; Table 4). The linear canting change of LC was significantly correlated with the angular canting change of AMTOP ($r^2 = 0.62$, $P < .05$; Table 4) and the linear canting change of AMTOP ($r^2 = 0.66$, $P < .05$; Table 4). There was a high Pearson correlation coefficient for the linear change between ΔPMTOP and ΔAMTOP (0.69, $P < .05$; Table 5). Therefore, the amount of LC change was more related to the canting correction of the AMTOP than to that of the PMTOP.

DISCUSSION

Jung et al.[12] reported that deviation of the philtrum and mouth corner was significantly corrected after one-jaw orthognathic surgery (mandibular setback only) in cases with skeletal Class III malocclusion and facial asymmetry using 3D CT analysis. Lim et al.[7] found that 3D soft tissue changes in Class III patients after

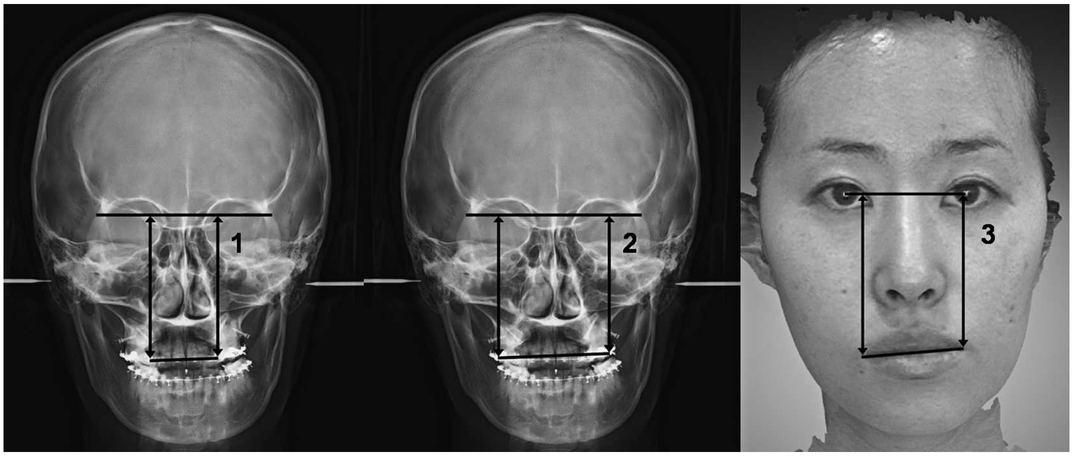

Figure 3. Linear variables: (1) fronto-zygomatic suture (FZ)–maxillary canine (C) distance (mm, the perpendicular distance between the midportion of the bracket and wire of the C and the inter-FZ line); (2) FZ–maxillary first molar (U6) distance (mm, the perpendicular distance between the midportion of the bracket and wire of the U6 and the inter-FZ line); (3) P-Ch distance (mm, the perpendicular distance between the most outer point of the mouth corner [Ch] and the interpupillary line).

mandibular setback surgery exhibited increased gradients from the upper lip and lower lip to the chin as well as from the stomodium to the mouth corner. Kim et al.[8] suggested that there were significant increases in the upper lip length and decreases in the lower lip length in the large setback, hypodivergent, and genioplasty groups in Class III cases with mandibular setback surgery. However, they did not include two-jaw orthognathic surgery cases in the samples. Therefore, it is necessary to investigate the effects of canting correction of MTOP on the change of LC by two-jaw orthognathic surgery.

LC is produced by the vertical height difference in the mouth commissures of the right and left sides. The vertical position of the mouth commissure is determined by two factors: the vertical proportion of the underlying skeletodental tissue and the balance between the upward pull from the zygomaticus major and levator anguli oris muscles and the downward pull of the depressor anguli oris muscle.[13,14] Therefore, the position of the maxillary canine, which is located more adjacent to the joining position of these muscles with the orbicularis oris muscle than with the maxillary first molar, can be regarded as having a greater correlation with LC than does the position of the maxillary first molar.

The findings that the angular change ratio of ΔLC/ΔAMTOP showed a higher value than that of ΔLC/ΔPMTOP (0.99 vs 0.83; Table 3) and that the linear change ratio of ΔLC/ΔAMTOP was significantly higher than that of ΔLC/ΔPMTOP (1.67 vs 0.74, $P < .05$; Table 3) indicate that there may be a possibility that

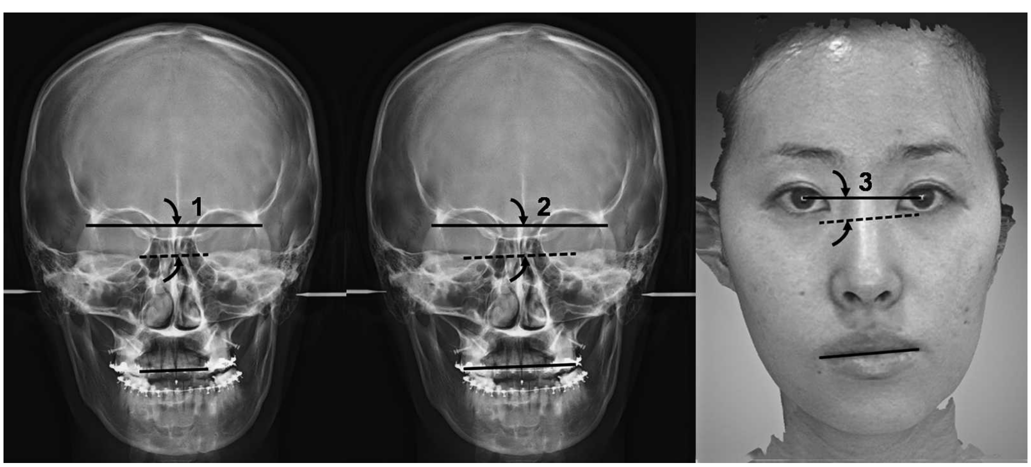

Figure 4. Angular variables: (1) fronto-zygomatic suture (FZ)–maxillary canine (C) (°, anterior maxillary transverse occlusal plane canting [AMTOPC] angle, the angle between the inter-FZ line and the inter-C line); (2) FZ–maxillary first molar (U6) (°, posterior maxillary transverse occlusal plane canting [PMTOPC] angle, the angle between the inter-FZ line and the inter-U6 line; (3) P–mouth corner (Ch) (°, Lip canting [LC] angle, the angle between the interpupillary line and the inter-Ch line).

Table 2. Changes of the Linear and Angular Variables Between the T1 and T2 Stages[a]

Variables	T1 Stage		T2 Stage		P Value	Amount of Change	
	Mean	SD	Mean	SD		Mean	SD
Linear							
Linear canting of AMTOP, FZ-C, mm							
Deviated side	83.30	5.59	82.79	4.98	.4838	0.50	3.62
Opposite side	84.96	6.20	82.52	5.39	.1069	2.44	3.60
Difference	1.66	0.96	−0.28	1.23	.0171*	1.94	1.65
Linear caning of PMTOP, FZ-U6, mm							
Deviated side	79.80	4.35	78.67	4.88	.1614	1.12	3.66
Opposite side	83.30	5.46	78.75	5.69	.0499*	4.5	4.30
Difference	3.51	1.57	0.08	1.65	.0180*	3.43	2.06
Linear LC, P-Ch, mm							
Deviated side	72.18	4.13	73.14	3.81	.4002	−0.96	2.14
Opposite side	75.18	3.99	73.79	3.27	.2076	1.39	2.57
Difference	3.00	1.16	0.65	0.85	.0117*	2.35	0.71
Angular							
Angular canting of AMTOP, FZ-C, °	3.03	1.31	0.05	1.27	.0117*	2.98	1.70
Angular canting of PMTOP, FZ-U6, °	3.32	1.23	−0.07	1.59	.0117*	3.39	1.52
Angular LC, P-Ch, °	4.65	1.69	2.09	0.64	.0117*	2.56	1.67

[a] Wilcoxon signed rank test was performed. T1 indicates 1 week before two-jaw orthognathic surgery; T2, 6 months after two-jaw orthognathic surgery; SD, standard deviation; * $P < .05$; AMTOP, anterior maxillary transverse occlusal plane; PMTOP, posterior maxillary transverse occlusal plane; LC, lip canting; FZ-C (mm), the perpendicular distance between the midportion of the bracket and wire of the maxillary canine (C) and the inter-FZ line; FZ-U6 (mm), the perpendicular distance between the midportion of the bracket and wire of the maxillary first molar (U6) and the inter-FZ line; P-Ch (mm), the perpendicular distance between the most outer point of the mouth corner (Ch) and the interpupillary line; FZ-C (°), the angle between the inter-FZ line and the inter-C line; FZ-U6 (°), the angle between the inter-FZ line and the inter-U6 line; P-Ch (°), the angle between the interpupillary line and the inter-Ch line; Amount of change, the value of the T1 stage minus the value of the T2 stage; and Difference, the value of the nonaffected side minus the value of the affected side.

the canting correction of AMTOP has an overcorrection tendency for the change of LC, while the canting correction of PMTOP has an undercorrection tendency for the change of LC.

Kim et al.[3] investigated the effects of canting correction of MTOP on the change of LC by two-jaw surgery using 2D PA cephalograms and frontal photographs. According to the results of Kim et al.,[3] the ratios of ΔLC/ΔPMTOP were 51.5% in the angular measurement and 48.8% in the linear measurement. However, the present study exhibited higher values of ΔLC/ΔPMTOP (83% in the angular measurement and 74% in the linear measurement; Table 3). This difference may be dependent on the surgical technique, surgeon, or samples. In addition, it seemed to be caused by ΔAMTOP rather than ΔPMTOP itself. This study showed a high Pearson correlation coefficient for the linear change between ΔPMTOP and ΔAMTOP (0.69, $P < .05$; Table 5). As a result of this high correlation, relatively higher ratios of ΔLC/ΔPMTOP were exhibited (Table 3).

In this study, the Pearson correlation coefficient between ΔLC and ΔPMTOP for linear change was 0.62 and marginally insignificant ($P = .0501$; Table 4), and that for the angular change was 0.33 and not significant ($P > .05$; Table 4). However, Kim et al.[3] reported that the Pearson correlation coefficients

Table 3. Ratio of the Lip Canting Change to the Maxillary Transverse Occlusal Plane Canting Correction[a]

Variables		Ratio		P Value
		Mean	SD	
Angular	ΔLC/ΔAMTOP	0.99	0.60	.7209
	ΔLC/ΔPMTOP	0.83	0.48	–
Linear	ΔLC/ΔAMTOP	1.67	1.23	.0379*
	ΔLC/ΔPMTOP	0.74	0.35	–

[a] Mann-Whitney *U*-test was performed. SD indicates standard deviation; * $P < .05$; Δ, the amount of change between the T1 (1 week before the two-jaw orthognathic surgery) and T2 (6 months after the two-jaw orthognathic surgery) stages; AMTOPC, anterior maxillary transverse occlusal plane canting; PMTOPC, posterior maxillary transverse occlusal plane canting; LC, lip canting; ΔLC/ΔAMTOP, ratio of LC change to the AMTOP canting correction; and ΔLC/ΔPMTOP, ratio of LC change to the PMTOP canting correction.

Table 4. Pearson Correlation Coefficient Values Among the Amount of Lip Canting Change (ΔLC) and the Degree of the Canting Correction of the Anterior and Posterior Maxillary Transverse Occlusal Planes (ΔAMTOP and ΔPMTOP, Respectively)[a]

Variables	ΔLC, °	P Value	ΔLC, mm	P Value
ΔAMTOP, °	0.64	.0443*	0.62	.0493*
ΔAMTOP, mm	0.50	.1026	0.66	.0363*
ΔPMTOP, °	0.33	.2100	0.38	.1783
ΔPMTOP, mm	0.07	.4389	0.62	.0501

[a] Pearson correlation analysis was performed. Δ indicates the amount of change between the T1 (1 week before two-jaw orthognathic surgery) and T2 (6 months after two-jaw orthognathic surgery) stages. * $P < .05$.

Table 5. Pearson Correlation Coefficient Values Between the Degree of the Canting Correction of the Anterior and Posterior Maxillary Transverse Occlusal Planes (AMTOP and PMTOP, Respectively)[a]

Variables	ΔAMTOP, °	*P* Value	ΔAMTOP, mm	*P* Value
ΔPMTOP, °	0.40	.1601	0.46	.1265
ΔPMTOP, mm	0.51	.0963	0.69	.0301*

[a] Pearson correlation analysis was performed. Δ indicates the amount of change between the T1 (1 week before two-jaw orthognathic surgery) and T2 (6 months after two-jaw orthognathic surgery) stages. * $P < .05$.

between ΔLC and ΔPMTOP were 0.87 for the angular measurement and 0.89 for the linear measurement ($P < .01$, both). These values were higher than expected. Since the distance between the maxillary first molar and the mouth corner is relatively longer than the distance between the maxillary canine and the mouth corner, it seems logical to have relatively lower Pearson correlation coefficient values than have been reported by Kim et al. (ΔLC and ΔPMTOP for the linear change = 0.62 in the present study vs 0.87 in Kim et al.; angular change = 0.33 in the present study vs 0.89 in Kim et al.).[3]

Although Kim et al.[3] did not measure the changes in AMTOP, the Pearson correlation coefficients between ΔLC and ΔAMTOP for the linear and angular changes were 0.66 and 0.64, respectively, in the present study (both $P < .05$; Table 4). In addition, the angular change of AMTOP was significantly correlated with the linear change of LC (correlation coefficient = 0.62, $P < .05$; Table 4). Therefore, these findings also support the concept that LC change was more related to AMTOP canting correction than to PMTOP canting correction.

However, this study has some limitations in terms of sample size and standardization of the amount or type of the surgical movement of the osteotomized maxillary bony segments. Although the same surgical methods (LeFort I and BSSRO) were used in cases with skeletal Class III malocclusion, facial asymmetry, and LC, there may be diverse anteroposterior, transverse, and vertical movements of the osteotomized maxillary bony segments. To overcome these limitations, further studies with a standardized protocol from multi-centers will be required to investigate the relationships associated with canting correction among AMTOP, PMTOP, and LC.

CONCLUSIONS

- The null hypothesis was rejected.
- In two-jaw orthognathic surgery cases involving skeletal Class III malocclusion, facial asymmetry, and LC, the amount of canting correction of the AMTOP, in addition to that of the PMTOP, should be considered to predict the actual LC change.

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