Original Article

Lip line changes in Class III facial asymmetry patients after orthodontic camouflage treatment, one-jaw surgery, and two-jaw surgery: *A preliminary study*

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ABSTRACT

Objective: To evaluate the effects of orthodontic camouflage treatment (OCT), one-jaw surgery, and two-jaw surgery on the correction of lip line cant (LLC) and to examine factors affecting the correction of LLC in Class III craniofacial asymmetry patients.

Materials and Methods: A sample of 30 Class III craniofacial asymmetry patients was divided into OCT (n = 10), one-jaw surgery (n = 10), and two-jaw surgery (n = 10) groups such that the pretreatment LLC was similar in each group. Pretreatment and posttreatment cone-beam computed tomography scans were used to measure dental and skeletal parameters and LLC. Pretreatment and posttreatment measurements were compared within groups and between groups. Pearson's correlation tests and multiple regression analyses were performed to investigate factors affecting the amount and rate of LLC correction.

Results: The average LLC correction was 1.00° in the one-jaw surgery group, and in the two-jaw surgery group, it was 1.71°. In the OCT group it was –0.04°, which differed statistically significantly from the LLC correction in the other two groups. The amount and rate of LLC correction could be explained by settling of skeletal discrepancies or LLC at pretreatment with goodness of fit percentages of approximately 82% and 41%, respectively.

Conclusions: Orthognathic surgery resulted in significant correction of LLC in Class III craniofacial asymmetry patients, while OCT did not. (*Angle Orthod.* 2017;87:239–245)

KEY WORDS: Class III facial asymmetry; Lip cant; Two-jaw surgery; One-jaw surgery; Orthodontic camouflage; Cone-beam computed tomography

INTRODUCTION

Lip asymmetry is a chief complaint in facial asymmetry patients, along with menton and angle asymmetry.[1] Conventional treatment for facial asymmetry includes orthognathic surgery accompanied by orthodontic treatment to improve dentition and craniofacial morphology.[2,3] A Class III facial asymmetry patient undergoes one-jaw surgery on the mandible to be retruded asymmetrically, but if three-dimensional (3-D) repositioning of the maxilla is needed, two-jaw surgery can be conducted on both the maxilla and the mandible. It is standard to perform two-jaw surgery in cases of severe maxillary sagittal, vertical, and transverse disharmony. Many quantitative studies have reported that lip line cant (LLC) can be corrected via both one-jaw and two-jaw surgery, as can craniofacial skeleton and dentition.[4–9] Kim et al.[9] investigated the vertical asymmetry of LLC change in Class III asymmetry patients who underwent two-jaw surgery, using facial photograms and anteroposterior cephalograms. They reported that the mean LLC correction was 1.56 mm (1.18°), which is approximately 50% of the change in occlusal plane cant after surgery. Kim et al.[5] also reported that LLC was corrected 2.35

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Table 1. Age Distribution of Sample

Group	Age (y)/n			*P* value[a]
	Male	Female	Total	
Camouflage treatment	19.2 ± 2.6[b]/3	22.0 ± 6.6/7	21.2 ± 5.7/10	
1-jaw surgery	22.0 ± 4.7/7	21.3 ± 1.5/3	21.8 ± 3.9/10	.516
2-jaw surgery	21.4 ± 0.4/3	22.8 ± 3.6/7	22.4 ± 3.0/10	
Total	21.2 ± 3.7/13	22.2 ± 4.7/17	21.8 ± 4.2/30	
P value[a]	.784			

[a] A two-way analysis of variance was performed.
[b] Indicates mean ± standard deviation.

mm (2.56°) in facial asymmetry patients, using facial photograms, anteroposterior cephalograms, and 3-D facial scans. Few studies have been conducted on LLC correction in one-jaw surgery patients. Hwang et al.[4] reported that LLC was corrected by 1.9° on average in facial asymmetry patients who underwent one-jaw surgery.

Patients with relatively mild craniofacial asymmetry and therefore with acceptable facial morphology tend not to have orthognathic surgery, instead undergoing only orthodontic camouflage treatment (OCT) to resolve the sagittal and transverse dental discrepancies. Oral and maxillofacial surgeons as well as orthodontists should be prepared to inform them of the effects of each treatment option, including the effect of OCT on the change in LLC, because patients may want improved occlusal function without aggravating the facial soft tissue, including improvement of the LLC via alternative treatment options. Nevertheless, the effects of OCT, one-jaw surgery, and two-jaw surgery on the correction of LLC have not been reported. To investigate this, a study on the effects of the three treatment protocols on LLC change in Class III craniofacial asymmetry patients is required.

The aim of the current quantitative study was to compare the effects of three treatment options, OCT, one-jaw surgery, and two-jaw surgery, on changes in LLC in Class III craniofacial asymmetry patients via hard and soft tissue cone-beam computed tomography (CBCT) analysis. We also investigated the correlations between measurements and other factors affecting LLC correction.

MATERIALS AND METHODS

This retrospective study was performed with the approval of the institutional review board of the Gachon University Gil Medical Center (GDIRB 2015-290). A group of subjects was selected from patients who underwent pretreatment and posttreatment CBCT at Gachon University Gil Medical Center, Incheon, Korea, or Kyung Hee University Dental Hospital, Seoul, Korea. The inclusion criteria were (1) chief complaints involving skeletofacial asymmetry combined with an LLC of >1.0°, (2) both molar Angle Class III and A-point-nasion-B-point (ANB) of <0°, and menton deviation of >1.5 mm. The exclusion criteria were: (1) history of fracture or bone surgery on mandibular or panfacial bone, (2) cleft lip and/or palate, (3) missing maxillary first molar or second premolar, (4) prosthetics including mesiopalatal cusp of the maxillary first molar, or (5) distortion of the nose or lip as determined by 3-D CBCT imaging. The OCT group was treated with differential posterior movement between the maxillary and mandibular dentition with or without a temporary anchorage device (TAD) and with the application of Class III elastics and a precision lingual arch; in this group there was no intentional correction of the occlusal plane. The one-jaw surgery group underwent mandibular bilateral sagittal split ramus osteotomy (BSSRO), and the two-jaw surgery group underwent maxillary LeFort I osteotomy and BSSRO. A total of 30 subjects were selected, and 10 were allocated to each group. The subjects were intentionally (nonrandomly) allocated such that the average pretreatment LLC of each group was similar. Pretreatment age and sex distribution are shown in Table 1, and cephalometric skeletal sagittal and vertical patterns are shown in Table 2.

Exposure conditions for CBCT at the Gachon University Gil Medical Center (3-D eXam scanner; KaVo Dental GmbH, Bismarckring, Germany) were set at 120 kV, 5 mA, and a 0.3-mm voxel size, and the scope of the shot was set at 230 × 170 mm. Exposure conditions for CBCT at the Kyung Hee University Dental Hospital (Alphard VEGA 3030; Asahi Roentgen Ind. Co, Kyoto, Japan) were set at 80 kV, 10 mA, and a 0.39-mm voxel size, and the scope of the shot was set at 200 × 179 mm. In each subject, the CBCT conditions used at posttreatment were the same as those used at pretreatment.

The Digital Imaging and Communications in Medicine (DICOM) data obtained via CBCT were analyzed using InVivoDental 5.2 software (Anatomage Inc, San Jose, Calif). Each DICOM image was reoriented such that a plane that included three points (left porion, right porion, midpoint between the left and right orbitale) was set as the horizontal plane, and a plane that

Table 2. Comparison of Pretreatment Cephalometric Analysis of Sample

Group	ANB (°)[b]	SN-GoGn (°)[c]
Camouflage treatment	−1.17 ± 1.07[d]	35.80 ± 4.19[d]
1-jaw surgery	−2.14 ± 1.43	35.12 ± 7.09
2-jaw surgery	−1.90 ± 1.04	35.88 ± 7.09
Total	−1.74 ± 1.22	35.60 ± 6.06
P value[a]	.189	.956

[a] One-way analysis of variance was performed.
[b] Indicates angle formed by A-point, nasion, and B-point.
[c] Indicates angle formed by sella-nasion and gonion-gnathion.
[d] Indicates mean ± standard deviation.

included two points (nasion, midpoint between the left and right porion) and was orthogonal to the horizontal plane was set as the midsagittal plane. Finally, a plane that included nasion and was orthogonal to the horizontal plane and the midsagittal plane was set as the frontal plane.[10]

The landmarks used in this study are shown in Figure 1. Each landmark was marked tentatively on the 3-D image, and its final coordinate was confirmed via multiplanar reconstruction. Eight angular measurements and four linear measurements, their definitions, and the protocols used for assigning each sign are shown in Table 3. Rate of change in LLC was calculated from pretreatment and posttreatment data. Ten DICOM files were randomly selected from 60 DICOM files and measured again by the same examiner (GC Lee) after an interval of 2 weeks to calculate random errors via the Dahlberg formula.[11]

Statistical Analysis

Shapiro-Wilk normality tests and homogeneity of variance tests showed that pretreatment age, sagittal pattern, and vertical pattern satisfied the assumptions of normality and homogeneity of variance. Therefore, two-way analysis of variance (ANOVA) was performed to analyze pretreatment age and one-way ANOVA to analyze pretreatment sagittal and vertical patterns. Because 12 measurements were not normally distributed, nonparametric methods were adopted. The mean and standard deviation of each measurement, and the change (Δ, pretreatment–posttreatment) in each measurement were calculated, and Kruskal-Wallis tests followed by multiple comparison tests were used to compare the groups. A Wilcoxon rank-sum test was used to compare pretreatment and posttreatment measurements. The amount and rate of LLC correction was correlated with pretreatment measurements and changes in measurements via Pearson's correlation tests. Measurements with statistically significant correlation coefficients were used as independent variables in multiple regression analyses performed with a stepwise selection method. A Mann-Whitney test adjusted via the Bonferroni method for multiple comparisons was used to compare between groups at a significance level of 0.017, and the other tests were performed at a significance level of 0.05. All statistical tests were performed using the PASW Statistics for Windows statistical package (SPSS Inc, Version 18.0, Chicago, Ill.).

RESULTS

There were no statistically significant differences in pretreatment age between the two treatment groups or sexes, and the interaction effect was not statistically significant. Neither sagittal nor vertical patterns differed statistically significantly between the two groups (Tables 1 and 2). Random errors of each of the measurements are shown in Table 3. At pretreatment, the mean angles of the lips in the OCT, one-jaw surgery, and two-jaw surgery groups were 2.04°, 2.26°, and 2.60°, respectively, and did not differ significantly. Angles Me, Me Deviation, Diff Unit, and Diff Ramus

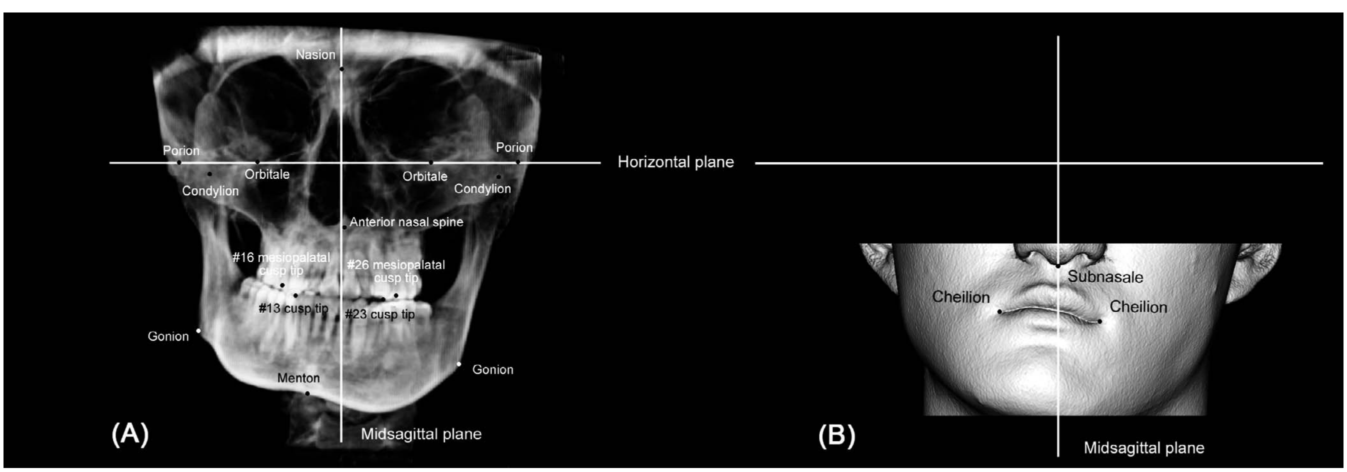

Figure 1. (A) Hard tissue landmarks on a cone-beam computed tomography (CBCT) image. (B) Soft tissue landmarks on a CBCT image.

Table 3. Definitions, Signs, and Method Errors of Angular and Linear Measurements

Measurement[a]	Definition	Sign	Method Error
Angle Or (°)	Angle between interorbitale line and horizontal line	+: A line cants upward on the menton-deviated side -: Indicates the opposite	0.33
Angle #6 (°)	Angle between intermesiopalatal cusp tip of maxillary first molar line and horizontal line		0.39
Angle #3 (°)	Angle between inter-cusp tip of maxillary canine line and horizontal line		0.24
Angle Lip (°)	Angle between intercheilion line and horizontal line		0.47
Angle Go (°)	Angle between intergonion line and horizontal line		0.86
Angle ANS (°)	Angle between nasion-anterior nasal spine line and midsagittal line	+: A line cants on the menton-deviated side -: Indicates the opposite	0.31
Angle Me (°)	Angle between nasion-menton line and midsagittal line		0.26
Angle Sn (°)	Angle between nasion-subnasale line and midsagittal line		0.25
Me deviation (mm)	Perpendicular distance from menton to midsagittal line	Positive sign for each value	0.41
Diff unit (mm)	Difference between distance from right condylion to menton and distance from left condylion to menton	+: Shorter length on the menton-deviated side -: Indicates the opposite	0.80
Diff body (mm)	Difference between distance from right gonion to menton and distance from left gonion to menton		1.20
Diff ramus (mm)	Difference between distance from right condylion to right gonion and distance from left condylion to left gonion		1.66

[a] Measurements were established on a frontal plane in each cone-beam computed tomography image.

differed significantly between the OCT group and the two-jaw surgery group at pretreatment (Table 4) (See Table 3 for definitions of these and other lines and angles.). At posttreatment, the mean angles of the lips in the OCT group, one-jaw surgery group, and two-jaw surgery group were 2.08°, 1.26°, and 0.89°, respectively, and did not differ significantly. None of the measurements differed significantly between the three groups at posttreatment (Table 4). Angle Me, Me Deviation, and Diff Unit showed statistically significant corrections (1.14°, 3.08 mm, and 2.28 mm on average, respectively) in the one-jaw surgery group, as did Angle Lip, Angle Me, Me Deviation, and Diff Unit (1.71°, 1.58°, 3.36 mm, and 2.96 mm on average, respectively) in the two-jaw surgery group. Multiple comparison tests for changes in measurements between the groups showed that the change in Angle Lip in the OCT group (–0.04°) differed statistically significantly from those in the one-jaw surgery group (1.00°) and the two-jaw surgery group (1.71°) (Table 5).

The pretreatment and posttreatment data of the 20 subjects who underwent surgery were used in correlation tests and regression analyses. Change in lip angle was significantly positively correlated with lip angle at pretreatment and with change in Diff Unit. Rate of change in lip angle was significantly negatively correlated with Angle #3 at pretreatment and significantly positively correlated with change in Angle Go (Table 6). Two regression analyses were performed, with change in lip angle and rate of change in lip angle set as dependent variables. Statistically significant parameters in correlation tests were incorporated as independent variables (Table 7). *F* tests for the final regression models showed statistical significance of fit. The R^2 of final model for Δ Angle Lip and for rate of Δ Angle Lip was 0.822 and 0.409, respectively. The final regression models were as follows:

$$\Delta \text{ Angle Lip } (^\circ) = 0.40 \times \text{pretreatment Angle Lip } (^\circ) + 0.18 \times \Delta \text{ Diff Unit (mm)}$$

$$\Delta \text{ Angle Lip } (^\circ)/\text{pretreatment Angle Lip } (^\circ) = 0.68 - 1.00 \times \text{pretreatment Angle \#3 } (^\circ) + 0.15 \times \Delta \text{ Angle Go } (^\circ)$$

DISCUSSION

The design of a craniofacial asymmetry study should incorporate a method that guarantees accuracy and reliability. To improve the accuracy of placing landmarks, recent researchers have adopted methods that use combinations of 3-D facial scan images,[5,12,13] 3-D CBCT images,[4,6,10,12,14,15] and conventional 2-D diagnostic tools such as facial photograms or anteroposterior cephalograms.[7–9,16,17] Those methods could be

Table 4. Comparison Among Orthodontic Camouflage Treatment, One-jaw Surgery, and Two-jaw Surgery at Pretreatment and Posttreatment

	Pretreatment										Posttreatment									
	Camouflage Treatment (n = 10)			1-Jaw Surgery (n = 10)			2-Jaw Surgery (n = 10)				Camouflage Treatment (n = 10)			1-Jaw Surgery (n = 10)			2-Jaw Surgery (n = 10)			
Measurements	Mean	SD	Mean Rank	Mean	SD	Mean Rank	Mean	SD	Mean Rank	*P* Value[a]	Mean	SD	Mean Rank	Mean	SD	Mean Rank	Mean	SD	Mean Rank	*P* Value[a]
Angle Or (°)	−0.11	0.70	15.05	−0.01	0.64	16.35	−0.05	0.68	15.10	.932	0.10	0.77	16.50	0.03	0.67	15.00	0.05	0.69	15.00	.908
Angle #6 (°)	1.10	1.58	18.15	−0.17	1.74	11.75	1.05	1.78	16.60	.237	1.49	1.39	17.90	0.07	1.76	12.00	1.18	1.20	16.60	.289
Angle #3 (°)	0.89	2.93	15.90	0.30	2.07	13.90	1.15	2.95	16.70	.765	1.77	1.77	18.50	0.90	1.65	13.90	0.97	2.23	14.10	.418
Angle Lip (°)	2.04	0.92	13.20	2.26	1.44	16.50	2.60	2.04	16.80	.598	2.08	0.87	20.40	1.26	1.04	13.30	0.89	1.47	12.80	.097
Angle Go (°)	0.52	1.42	12.60	0.81	2.38	14.80	1.92	1.78	19.10	.244	0.76	1.39	15.40	1.05	3.45	15.80	0.82	2.22	15.30	.991
Angle ANS (°)	0.16	0.82	12.45	0.56	0.86	15.90	0.78	0.89	18.15	.345	0.25	1.05	13.10	0.67	0.67	16.40	0.79	1.25	17.00	.566
Angle Me (°)	1.42	0.56	8.95[b]	2.41	1.46	15.80[bc]	3.48	1.71	21.75[c]	.005*	1.47	0.87	14.00	1.27	1.17	13.90	1.90	1.13	18.60	.394
Angle Sn (°)	0.69	0.98	13.60	0.68	1.20	13.40	1.24	0.84	19.50	.212	0.16	1.53	12.00	0.66	0.86	15.30	1.23	1.48	19.30	.178
Me Deviation (mm)	2.95	1.17	8.50[b]	5.20	3.09	16.40[bc]	7.20	3.48	21.60[c]	.004*	2.83	1.66	14.30	2.12	2.96	13.30	3.84	2.39	18.90	.316
Diff Unit (mm)	1.91	2.28	10.30[b]	3.35	3.10	14.70[bc]	5.82	2.82	21.50[c]	.016*	1.87	2.54	15.80	1.07	3.18	13.20	2.86	3.24	17.60	.525
Diff Body (mm)	1.49	2.51	13.40	0.88	2.38	12.70	2.87	1.82	20.40	.096	1.30	2.14	17.30	−0.32	5.40	13.20	0.94	6.38	16.00	.568
Diff Ramus (mm)	0.40	2.68	9.60[b]	2.45	4.15	15.90[bc]	4.52	2.90	21.00[c]	.015*	0.70	2.55	12.30	2.90	6.18	16.80	2.48	5.19	17.40	.367

[a] Kruskal-Wallis test was performed among camouflage treatment, 1-jaw surgery, and 2-jaw surgery groups.
[b,c] Mann-Whitney test with Bonferroni adjustment for each pairwise comparison. The groups sharing the same superscript (b, c) show that they are not significantly different.
* Statistically significant at 0.05 level of confidence.

acceptable because their primary concern was the changes in measurements between pretreatment and posttreatment within a single group. However, we needed to acquire both hard and soft tissue landmarks on a single coordination system to quantitatively evaluate the effect of pretreatment hard tissue measurements on both the amount and rate of change in LLC; in so doing, we could induce more reliable regression coefficients. Recent researchers suggest that 3-D facial scanning is sufficiently accurate for clinical use, but they also suggest that distortion of the paranasal or submandibular areas due to different head postures may occur when this modality is used due to its inherent overlapping image-combining system, which is based on three captures (anterior, right, and left).[12,13] However, there is much evidence that CBCT analysis guarantees the accuracy and reliability of evaluating facial hard and soft tissue

Table 5. Comparison of Pretreatment–Posttreatment Among Camouflage Treatment, One-Jaw, and Two-Jaw Surgery

	Orthodontic Camouflage Treatment (n=10)			1-Jaw Surgery (n = 10)			2-Jaw Surgery (n = 10)			
Measurements	Mean Difference (Pretreatment–Posttreatment)	*P* Value[a]	Mean Rank	Mean Difference (Pretreatment–Posttreatment)	*P* Value[a]	Mean Rank	Mean Difference (Pretreatment–Posttreatment)	*P* Value[a]	Mean Rank	*P* Value[b]
Δ[e] Angle Or (°)	−0.21	.053	12.00	−0.04	.799	18.40	−0.10	.444	16.20	.251
Δ Angle #6 (°)	−0.39	.575	15.00	−0.24	.575	15.30	−0.13	.959	16.30	.945
Δ Angle #3 (°)	−0.88	.327	14.60	−0.60	.386	14.60	0.18	.953	17.30	.731
Δ Angle Lip (°)	−0.04	.721	7.80[c]	1.00	.092	17.60[d]	1.71	.005*	21.20[d]	.002*
Δ Angle Go (°)	−0.24	.721	12.90	−0.24	.799	13.80	1.10	.169	19.80	.163
Δ Angle ANS (°)	−0.09	.284	14.10	−0.11	.575	16.20	−0.01	.959	16.30	.827
Δ Angle Me (°)	−0.05	.721	9.30[c]	1.14	.022*	17.80[cd]	1.58	.022*	19.40[d]	.022*
Δ Angle Sn (°)	0.53	.169	16.90	0.02	.646	14.30	0.01	.878	15.40	.796
Δ Me Deviation (mm)	0.12	.721	8.90[c]	3.08	.013*	18.60[d]	3.36	.022*	19.00[d]	.015*
Δ Diff Unit (mm)	0.04	.721	8.40[c]	2.28	.015*	17.70[cd]	2.96	.017*	20.40[d]	.006*
Δ Diff Body (mm)	0.19	.508	14.50	1.20	.760	14.50	1.93	.241	17.50	.679
Δ Diff Ramus (mm)	−0.30	.721	14.50	−0.45	.878	13.70	2.04	.285	18.30	.459

[a] Wilcoxon rank sum test between pretreatment and posttreatment. Significant values mean that the measurements showed statistical differences between pretreatment and posttreatment.
[b] Kruskal-Wallis test among camouflage treatment, 1-jaw surgery, and 2-jaw surgery. Significant values mean that the measurements showed statistical differences among the three treatment groups.
[c,d] Mann-Whitney test with Bonferroni adjustment for each pairwise comparison. The treatment groups sharing the same superscript (c, d) show that they are not significantly different.
[e] Δ indicates change between pretreatment and posttreatment (pretreatment–posttreatment).
* Statistically significant at 0.05 level of confidence.

Table 6. Pearson's Correlation Correlated with Change of Angle Lip, Rate of Change of Angle Lip of 1-jaw and 2-jaw Surgery Sample

	Δ Angle Lip (°)			Δ Angle Lip (°) / pretreatment Angle Lip (°)	
	Pearson's Correlation Coefficient	*P* Value		Pearson's Correlation Coefficient	*P* Value
Pretreatment Angle Lip (°)	0.689	.001*	Pretreatment Angle #3 (°)	−0.492	.028*
Δ[a] Diff Unit (mm)	0.462	.040*	Δ Angle Go (°)	0.537	.015*

[a] Δ means change between pretreatment and posttreatment (pretreatment-posttreatment).
* Statistically significant at 0.05 level of confidence.

asymmetry.[14,18,19] This is why we adopted a method using a single CBCT image from which we could acquire hard and soft tissue landmarks via a unique 3-D coordinate system. We also needed to exclude subjects with artifacts[4,5,7–9] on the CBCT image due to prosthodontics, orthodontic wires, brackets, or TADs. We therefore decided to use only pretreatment and posttreatment data in the study. The longer span between pretreatment and posttreatment than has been used in some other studies[4–6,14] meant that the current study could reflect latent relapses after orthognathic surgery and muscular adaptation.

The mean LLCs of the OCT group, one-jaw surgery group, and two-jaw surgery group did not differ significantly (2.04°, 2.26°, and 2.60°, respectively) at pretreatment. However, the mean corrections in LLC in the one-jaw surgery group and two-jaw surgery group were 1.00° and 1.71°, respectively, which were both significantly larger than that of the OCT group (−0.04°).

In a previous study of one-jaw surgery patients,[4] correction of LLC was positively correlated with pretreatment LLC (coefficient of 0.663) and with change in gonion line cant (coefficient of 0.448). Studies of two-jaw surgery patients have shown that correcting the LLC was positively correlated with correcting the maxillary canine line cant[5] and maxillary first molar line cant.[9] In our study, correcting the LLC in orthognathic surgery patients was positively correlated with pretreatment LLC (coefficient of 0.689) but not with correction of gonion line cant, maxillary canine line cant, or maxillary first molar cant. However, the rate of change in LLC was negatively correlated with pretreatment maxillary canine line cant (coefficient of −0.492) and positively correlated with change in gonion line cant (coefficient of 0.537), suggesting that pretreatment canine line cant may restrict correction the LLC. This discordant evaluation for the effect of maxillary cant on LLC correction may be explained by the relatively mild craniofacial severity of our sample. The maxillary mean first molar line cant was 3.32° in the study reported by Kim et al.,[5] whereas it was only 1.05° in our sample. Because our sample was intentionally selected such that the LLCs were similar in each group, there was a possibility that relatively severe craniofacial cases were excluded from the two-jaw surgery group. Another possible explanation for the discrepancy between the studies is the different span between pretreatment and posttreatment, which was longer in our study than the span used in previous studies. The maxillary cant could be accentuated intentionally by an orthodontist to increase the asymmetry correction of the mandible in a two-jaw surgery patient during presurgical orthodontic preparation, which may not have been reflected in our pretreatment data.

In some previous studies[4–6] as well as in our study, the amount of LLC correction was smaller than the amount of skeletal or dental correction, which has not yet been clearly explained. In our study, the R^2 values of the final regression models for both the amount and rate of correcting the LLC were 82.2% and 40.9%, respectively. This suggests that other factors that we did not consider affected correction of LLC, especially the rate of correcting the LLC. We reviewed past studies and included factors known to affect the correction of LLC as independent variables, but not the discrepancy index[17,20] of perioral muscular activity between the left and right sides. Activities of three adjacent muscle systems around the corner of the

Table 7. Multiple Linear Regression Analyses for Change of Angle Lip and Rate of Change of Angle Lip of One-Jaw and Two-Jaw Surgery Sample

Dependent Variable	Independent Variables	Unstandardized Coefficient β	Standard Error	*t*	*P* Value	Adjusted R^2
Δ[a] Angle Lip (°)	Pretreatment Angle Lip (°)	0.400	0.075	5.336	<.001*	0.822
	Δ Diff Unit (mm)	0.180	0.063	2.832	.011*	
Δ Angle Lip (°)/pretreatment Angle Lip (°)	(Constant)	0.680	0.108	6.286	<.001*	0.409
	Pretreatment Angle #3 (°)	−1.000	0.041	−2.429	.027*	
	Δ Angle Go (mm)	0.145	0.053	2.716	.015*	

[a] Δ indicates change between pretreatment and posttreatment (pretreatment–posttreatment).
* Statistically significant at.05 level of confidence.

mouth, including the depressor anguli oris, might further explain correction of the LLC.[21]

Some considerations relating to the sampling procedure used in the current study should be taken into account. In this preliminary study, the small sample size resulted in low power. Calculations made using the G-Power 3.1.9.2 program (Franz Faul, University of Kiel, Kiel, Germany) revealed that the minimum sample sizes for lip angle and Go angle required to guarantee a power of 0.8 and to control type I error at a level of 0.05 were 11 and 25, respectively, per group. Studies with larger sample sizes might yield the statistical significance of variables that did not show significance in this preliminary study. Including cases with more severe maxillary cant might enable predicting the effects of one-jaw surgery and two-jaw surgery in correcting LLC more precisely via regression analyses.

Despite the differences in LLC changes between the OCT and orthognathic surgery groups observed in the present study, our results do not imply that it is appropriate to apply a uniform treatment protocol to patients with similar LLC features. Rather, we suggest that clinicians employ orthognathic surgery based on their subjective soft tissue evaluation of each patient as well as their volition to improve soft tissue because there could be perceived differences in soft tissue asymmetry even among patients with similarly canted lip lines.[1]

CONCLUSIONS

- Average LLC correction values in the one-jaw and two-jaw surgery groups were 1.00° and 1.71°, respectively, which differed statistically significantly from those of the OCT group (−0.04°). Both the amount and rate of correcting the LLC could be explained by settling of skeletal discrepancies or pretreatment LLC with goodness of fit percentages of approximately 82% and 41%, respectively.
- We concluded that orthognathic surgery rather than OCT should be performed to significantly correct the LLC in Class III craniofacial asymmetry patients.

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