치의학박사 학위논문

Evaluation of Lip Cant Change by Two-Jaw Surgery in Class III Asymmetry Cases Using Three-Dimensional Facial Scan in Conjunction with Computed Tomographic Images

3 차원 CT 와 안면스캐닝을 이용한 골격성 III 급 비대칭 양악수술 환자의 입술경사변화 분석

2015 년 8 월

서울대학교 대학원
치의과학과 치과교정학 전공

고 정 민

ABSTRACT

Evaluation of Lip Cant Change by Two-Jaw Surgery in Class III Asymmetry Cases Using Three-dimensional Facial Scan in Conjunction with Computed Tomographic Images

Jeong-Min Ko, DDS, MSD

Department of Orthodontics, Graduate School,
Seoul National University
(Directed by Professor Seung-Hak Baek, DDS, MSD, PhD)

Objective: The aim of this study was to evaluate the effect of cant correction in the anterior (AMXTOP) and posterior maxillary transverse occlusal planes (PMXTOP) on the change in lip cant (LC) using three-dimensional facial scan (FS) in conjunction with computed tomographic (CT) images.

Materials and Methods: Thirty-five class III asymmetry patients treated with two-CT surgery were selected. Three-dimensional CT and three-dimensional FS images were taken before (T1) and after orthognathic surgery (T2, mean= 5.5 ± 1.6 months). After obtaining the same head orientation between 2 images, bracket slot midpoints of the maxillary right and left canines as well as the first molars, point A, point B, and menton on three-dimensional CT images and the right and left lip commissures on three-dimensional FS images were located. Linear and angular variables of AMXOP, PMXOP, and LC were measured and statistically analyzed.

Results: At the T1 stage, linear and angular LC showed significant correlations with linear and angular cant of AMXTOP and PMXTOP, as well as menton deviation (all $P < 0.001$). During T1-T2, significant linear and angular cant corrections were observed: △AMXTOP (1.3mm, 1.9°), △PMXTOP (1.9mm, 1.7°), and △LC (1.5mm, 1.8°) (all $P < 0.001$). Although angular change ratios of △LC/△AMXTOP and △LC/△PMXTOP did not exhibit a significant difference (1.0 vs. 0.7), linear change ratio of △LC/△AMXTOP was higher than that of △LC/△PMXTOP (3.0 vs. 0.5, $P < 0.05$). The vertical changes in commissures were related to that in MXC or MXM1 and the extent of mandibular setback (all $P < 0.01$).

Conclusion: The three-dimensional approach using three-dimensional FS images in conjunction with three-dimensional CT revealed more precise change ratio of △LC/△AMXTOP and △LC/△PMXTOP than traditional two-dimensional approach. With the linear regression analysis, the vertical positions of lip commissures were shown to be related to the vertical change in the maxillary teeth and the setback amount of mandible.

Keywords: Lip cant, maxillary transverse occlusal plane cant, three-dimensional facial scan, three-dimensional CT

Student number: 2013-30624

Evaluation of Lip Cant Change by Two-Jaw Surgery in Class III Asymmetry Cases Using Three-dimensional Facial Scan in Conjunction with Computed Tomographic Images

Jeong-Min Ko, DDS, MSD

Department of Orthodontics, Graduate School, Seoul National University
(Directed by Professor Seung-Hak Baek, DDS, MSD, PhD)

3 차원 CT 와 안면스캐닝을 이용한 골격성 III 급 비대칭 양악수술 환자의 입술경사변화 분석

서울대학교 대학원 치의과학과 치과교정학 전공
(지도교수: 백 승 학)

고 정 민

-CONTENTS-

I. INTRODUCTION

Patients with facial asymmetry typically exhibit cants of the maxillary transverse occlusal plane and the lip, which are usually treated with orthognathic surgery. However, some patients still complain of a lip cant remaining after surgery. Kim et al.[1] reported a correction ratio of only approximately 50% between the lip cant and the posterior maxillary transverse occlusal plane by two-jaw surgery. Therefore, greater emphasis should be placed on the investigation of the relationship between the maxillary occlusal plane cant and the lip cant for determining the amount of surgical correction necessary for cases with facial asymmetry.

There are three ways to evaluate the cant correction of the lip and occlusal plane in orthognathic surgery patients as follows: First, two-dimensional (2D) approaches with posteroanterior (PA) cephalogram and frontal photograph have been traditionally used to evaluate cant corrections.[1,2] However, 2D PA cephalometric analysis methods have inevitable projection errors, including distortion and magnification, and difficulties in identifying the landmarks due to superimposition of dentofacial structures.[3,4]

Second, three-dimensional computed tomography (3D-CT) can be used for quantitative evaluation of soft tissue changes in the face following orthognathic surgery.[5,6] However, the noise and blurring artifacts from the metal brackets and dental restorations,[7] and the low resolution in the soft tissue view,[8] are the main obstacles to using 3D-CT for determining the correction ratio between lip cant and occlusal plane by two-jaw surgery.[9,10]

Third, 3D-facial scan (3D-FS) has been applied to evaluate the facial soft tissue. This technology has the advantages of natural color and texture information, adequate accuracy, and absence of radiation, even though it cannot provide information about the underlying facial skeleton.[11,12] In order to view the hard and soft tissue simultaneously, Kim et al.[13] proposed the superimposition method using the 2D-lateral and PA cephalograms in addition to 3D-FS images. They evaluated the lip cant change according to skeletal movements in Class III two-jaw surgery patients. However, more accurate 3D data describing the underlying hard tissue are still required for assessment of the soft tissue change around the lip area.

Considering the advantages and shortcomings of each imaging technique, use of 3D-FS in conjunction with 3D-CT can be an effective tool to analyze the hard and soft tissue changes following orthodontic treatment and orthognathic surgery. Therefore, there have been attempts to develop superimposition methods using 3D-CT and 3D-FS.[14,15] However, few studies have analyzed the changes in the maxillary transverse occlusal plane and the lip cant using 3D-CT and 3D-FS images. Therefore, the purpose of this study was to evaluate the effect of cant correction in the anterior (AMXTOP) and posterior maxillary transverse occlusal planes (PMXTOP) on the change in lip cant (LC) in Class III asymmetry patients using 3D-FS in conjunction with 3D-CT images.

II. REVIEW OF LITERATURE

1. Perception of lip cant

Peck et al.[16] insisted that there are no objective classification criteria for facial asymmetry into normal and abnormal ones and that even “esthetically pleasing faces” have always measureable asymmetries. Although Padwa et al.[17] reported that occlusal cant over 4° could be recognized with more than 90% frequency and cant over 3° could be detected only with 50% frequency, some people regarded the minor lip cant as an abnormal deformity that must be corrected.

2. Facial asymmetry in skeletal Class III patients

Facial asymmetry is known to be more common in the adult patients with skeletal Class III compared with other facial deformities.[18-20]

Baek et al.[21] reported that facial asymmetry in skeletal Class III patients seems to occur from more growth of the ramus and vertical excess of the maxilla of the one side. This leads to directional asymmetry,[22] that is, the facial structures on one side are generally larger than the opposite side. This directional asymmetry composes major phenotype of facial asymmetry.[23]

Previous studies with skeletal Class III subjects showed a left side dominance in the direction of facial asymmetry (66~81%).[2,20,24] Left side dominance can also be found in samples including other facial types (68~ 80%).[19,25]

3. Treatment modality for lip cant

Correction of lip cant can be attempted by non-surgical methods such as botulinum toxin[26] or surgical methods.[13,27,28] Reportedly, occlusal cant correction can be achieved by use of miniimplants without surgical intervention but this approach cannot ensure the correction of lip cant.[29] Conversely, the use of botulinum toxin can only achieve the improvement of lip cant in motion without occlusal cant correction. Therefore, patients with facial asymmetry have been mainly treated with orthognathic surgery.[13,27] In addition to the traditional orthognathic surgeries, Choi et al.[28] proposed a combinational use of orthognathic surgery and face lift procedure to correct the lip cant in cases with severe facial asymmetry.

4. Analyses of lip cant correction using two-dimensional approaches

Although the hard tissue movement can produce the positional change in the soft tissue, it cannot occur with 1:1 ratio due to influence of the skin and muscles.[30] Therefore, difference between cant correction of MXOP and LC can be existed.

To assess the ratio of soft tissue to hard tissue change, 2D approaches including facial photographs and PA cephalograms[1,2] have been used. There have been a few studies on lip cant correction in orthognathic patients using 2D approaches. Among these researches, Kim et al.[1] investigated the ratio of lip and occlusal cant (posterior maxillary transverse occlusal plane) change after two-jaw surgery and reported that it was 51.5% in the angular measurement and 48.8% in the linear measurement.

However, when compared 2D measurements from posteroanterior cephalogram to 3D measurements from CBCT with Class III malocclusion patients with facial asymmetry, significant differences were found in several corresponding measurements including cants.[23] In addition to inaccurate measurements because of geometric distortions, overlapping of dentofacial structures in 2D images makes identifying landmarks difficult.[3,4] Therefore, it is not easy to obtain accurate relationship between skeletal movements and soft tissue changes.

5. Asymmetry analysis studies using 3D-CT

3D-CT can be used for evaluation of change in lip cant. However, there are few literatures concerning quantitative analysis of change of soft tissue asymmetry.[5,6,31,32] Literatures concerning the lip cant to occlusal cant ratio of two-jaw surgery using 3D-CT only have not been reported.

The artifacts from the metal brackets and dental restorations within the field of view,[7] and low resolution in soft-tissue view[8] result in missing of the soft tissue data, which limits the use of 3D-CT to analyze lip cant.[9,10]

6. Asymmetry analysis studies using 3D-FS

Recently, 3D-FS was also applied to evaluate the facial asymmetry with its adequate accuracy, color information, and free of radiation, although it cannot provide information of the underlying facial skeleton simultaneously.[11,12]

Commercially available optical scanners can be classified into mainly three types based on different scanning principles: stereophotogrammetry, laser-based scanners, and white structured light scanners.

Stereophotogrammetry utilizes multiple images of a subject captured from different angle to create three-dimensional image.[33] This type of scanner has the advantage of high-resolution color representation and also has limitations including complicated operation and difficulty in capturing soft tissue details.[34]

Laser-based scanners can provide accurate 3D images but the safety for eye by using laser beams was not verified. Image acquisition time is relatively slow accordingly, image distortion can frequently occur due to patient's movement during scanning.[35]

The same type of scanner used for this study is the white structured light scanner being widely used in clinic to compare the changes in the face after treatment. It projects structured patterned light and quickly acquires deformed patterns of returned light. The visible light from light-emitting diodes in scanner is known to be harmless to eyes. In addition, white structured light scanner is superior to laser-based scanners in terms of resolution and image acquisition time.[36]

Ahn et al.[37] investigated the 3D perioral soft tissue changes in dentoalveolar protrusion cases after orthodontic treatment using the same kind of visible light scanner used in our study. They showed that facial scanner can efficiently evaluate the soft tissue change in the perioral area.[37] Kim et al.[27] also used 3D-FS images to investigate lip length changes after mandibular setback surgery in skeletal Class III patients, but there are few studies on lip cant change after orthognathic surgery using 3D-FS only.

7. Attempts to take advantages of both 3D-CT and 3D-FS for study on asymmetry

Considering the strengths and weaknesses of imaging technique above mentioned, 3D-FS combined with 3D-CT can be used as effective tool because 3D-FS has strengths in analyzing the soft tissues and 3D-CT can give information of the underlying hard tissues.

For this reason, many researchers have attempted to develop the automatic superimposition methods of 3D-CT and 3D-FS.[14,15] Nonetheless, to the authors knowledge, few study has yet been conducted on the relationship between occlusal and lip cant with 3D approach using both 3D-CT and 3D-FS images.

Most 3D-CT and 3D-FS images were not captured simultaneously in clinical setting and whole face superimposition of these non-simultaneously taken images using a surface-based registration scheme can cause large discrepancies.[38] According to Maal et al.,[39] the least variable regions were nose and forehead regions after analyzing 3D-FS of the same individual that are acquired at different times. Therefore, the landmarks in the upper two-thirds of the face that are less vulnerable to the change from surgery or facial expression can be used to manually align the facial soft tissue of 3D-CT with that of 3D-FS images with the same orientation using the same reference planes of the 3D-coordinate.

8. Positional change of upper lip after orthognathic surgery

Baik and Kim[40] investigated the changes in the several soft tissue landmarks including oral commissures in Class III patients using 3D-FS and reported that the oral commissures moved posteroinferiorly after two-jaw surgery. This result is consistent with previous studies that showed inferior movement tendency of the central portion of the upper lip[41] and commissures after orthognathic surgery[13,40] in Class III patients.

Both setback of the mandible and posterior impaction of the maxilla during two-jaw surgery in skeletal Class III patients seem to contribute to formation of the redundant tissues in perioral area, and consequently more downward position of the upper lip.

III. MATERIALS AND METHODS

The sample set consisted of 35 adult patients (15 males and 20 females; mean age, 22.7 ± 4.3 years). The inclusion criteria were as follows: (1) The subjects were diagnosed as Class III with facial asymmetry (ANB<0°; menton deviation > 1 mm); (2) The direction of chin point deviation coincided with that of facial asymmetry; (3) Two-jaw surgery (one-piece LeFort I osteotomy for the maxillary posterior impaction and bilateral sagittal split ramus osteotomy for the mandibular setback) was performed by a single surgeon (Choi JY); (4) No motor dysfunction was reported around the lip after orthognathic surgery; (5) The subjects received advancement and/or reduction genioplasty only, resulting in no lateral movement of the chin; (6) The subjects were imaged using 3D-CT and 3D-FS one month before (T1) and at least 3 months after orthognathic surgery (T2, mean= 5.5 ± 1.6 months). The exclusion criteria were as follows: (1) Subjects who exhibited a deformed upper lip at rest position in 3D-CT and 3D-FS images; (2) Subjects whose chins moved laterally by genioplasty; (3) Subjects who underwent soft tissue surgery adjunctive to two-jaw surgery; (4) Subjects with congenital craniofacial anomalies. This study protocol was reviewed and approved by the Institutional Review Board at the Seoul National University Dental Hospital (SNUDH IRB CRI-14010).

3D-CT images were obtained by SOMATOM Sensation 10, (Siemens, Forchheim, Germany) using a slice thickness of 0.75 mm. 3D-FS images were taken using a Morpheus 3D optical facial scanner (Morpheus Co., Ltd., Seoul, Korea; data accuracy, ±0.2mm).To obtain the same head orientation between 3D-CT and 3D-FS images, a two-step procedure was performed (Fig. 1). First, the profile contour line from the forehead to the subnasale was used to coincide the pitch of head orientation. Second, five landmarks including the right and left exocanthi, the subnasale, and the right and left alar bases were used for coinciding the yaw and roll of head orientation. In this way, changes in the 3D-CT images could be matched with those in the 3D-FS images using 3D coordinates.

In the 3D-CT images, three reference planes were constructed: the axial plane [Frankfort horizontal (FH) plane, connecting the right and left orbitales and the porion of the opposite side of the chin point deviation]; the midsagittal plane (a perpendicular plane passing through the nasion and the basion, and positioned perpendicular to the axial plane); and the coronal plane (a plane that is perpendicular to the previous two planes and passing the sella). On the 3D-CT images, seven landmarks including bracket slot midpoint of the upper canines and first molars on the right and left sides, point A, point B, and menton were located using InVivo 5 software (Anatomage, San Jose, CA, USA). On the 3D-FS images, two landmarks, the right and left lip commissures, were located using Morpheus 3D software (version 3.0, Morpheus, Seoul, Korea) (Fig. 2).

The AMXTOP and PMXTOP were established by connecting the bracket slot midpoints of the maxillary canines and those of the maxillary first molars of the right and left sides, respectively. The LC was also established by connecting the lip commissures of the right and left sides. The perpendicular distances between the FH plane and each landmark of the right and left sides were measured as the linear variables of the AMXTOP, PMXTOP and LC. For the angular variables, the angles between the FH plane and the AMXTOP, between the FH plane and the PMXTOP, and between the FH plane and the LC, were measured, respectively. The sagittal distances from the coronal plane were measured to obtain the movements of point A and point B. The menton deviation was measured as the horizontal distance from the midsagittal plane. The definitions of reference planes, landmarks, cephalometric and 3D variables are described in Fig. 2 and Tables 1 to 3.

For repeatability testing, intraclass correlation coefficients (ICCs) were calculated. After 10 patients were randomly selected, all of their measurements were re-obtained by the same operator (Ko JM) at a 2-week interval from their initial measurement. The mean ICCs of all values were found to have sufficient reproducibility (vertical axis, 0.987; anteroposterior axis, 0.989; transverse axis, 0.993), and the lower 95% confidence level of the ICCs was greater than 0.949. Therefore, the first set of data was used for the further analyses in the present study. Paired and independent *t* tests, Pearson correlation analysis, and linear regression analysis were performed as statistical analyses.

IV. RESULTS

1. Changes in the skeletodental variables between the T1 and T2 stages from cephalometric analysis

Prior to surgery (T1 stage), the samples exhibited a Class III hyperdivergent pattern with facial asymmetry (SNA, 80.7°; SNB, 82.3°; ANB, -1.6°; SN-GoMe, 38.8°; menton deviation, 4.7 mm; Table 1). Although inclination of the maxillary incisor was within normal range (U1-SN, 108.8°), the mandibular incisor showed a lingual inclination (IMPA, 85.7°, Table 1). Dominance of the left side laterality was found (68.6%, n=24).

Compared with the T1 stage, since the change in point B was significant (SNB, 82.3° vs. 79.4°, $P < 0.001$, Table 1), the skeletal pattern was corrected from Class III to Class I by surgery (ANB, -1.6° vs. 1.7°, $P < 0.001$, Table 1). Because of the posterior impaction of the maxilla, the hyperdivergent pattern remained and the maxillary incisor demonstrated a lingual inclination (SN-GoMe, 38.8° vs. 40.0°; U1-SN, 108.8° vs. 104.8°, $P < 0.001$, Table 1). Anterior crossbite and openbite were corrected significantly (overjet, -2.6 mm vs. 3.5 mm; overbite, -1.4 mm vs. 2.4 mm; both $P < 0.001$, Table 1).

2. Amounts of the changes in each variable from measurement of 3D-CT and 3D-FS between the T1 and T2 stages

Although the extent of point A advancement was not significant (-0.6 mm), the extents of point B setback and of menton deviation correction were significant (5.2 mm, 3.7 mm, respectively; all $P < 0.001$, Table 2). The types of genioplasy performed for the samples were advancement (n=9, 25.7%); reduction (n=10, 28.6%); and advancement with reduction (n=4, 11.4%). Twelve patients did not receive genioplasty (34.3%). There was no lateral movement of the chin by advancement and/or reduction genioplasty, and the difference in the extents of anteroposterior movement between point B and pogonion was not significant (0.14 mm, Tables 1 and 2). Therefore, point B was used to evaluate the effect of mandibular setback on lip cant in the subsequent analyses. When the T1 and T2 stages were compared, there were significant cant corrections in the AMXOP (linear, 1.3 mm vs. 0.0 mm; angular, 1.8° vs. -0.1°), the PMXOP (linear, 2.0 mm vs. 0.1 mm; angular, 1.9° vs. 0.2°), and the LC (linear, 1.7 mm vs. 0.2 mm; angular, 2.1° vs. 0.3°) (all $P < 0.001$, Table 3).

3. Correlation between LC and skeletal variables at the T1 stage

Linear and angular LC showed significant correlations with those cants of the AMXOP and PMXOP as well as the menton deviation (all $P < 0.001$, Table 4).

4. Comparison of the ratios of cant correction between △LC/△AMXTOP and △LC/△PMXTOP

Although there was no significant difference between the angular change ratio of △LC/△AMXOP and △LC/△PMXOP (0.98 vs. 0.66), the linear change ratio of △LC/△AMXOP was significantly higher than that of △LC/△PMXOP (2.95 vs. 0.52, $P < 0.05$, Table 5).

5. Correlation of the amounts of cant correction among LC, AMXTOP and PMXTOP

The angular and linear changes in △LC showed significant correlations with those in △AMXOP and △PMXOP ($P < 0.01$ and $P < 0.001$, respectively; Table 6). There were significantly high correlations with the angular and linear cant corrections between △AMXOP and △PMXOP, respectively (both $P < 0.001$, Table 7).

6. Correlation between the amount of linear cant correction of LC and the amount of change in point A, point B and menton deviation

Although both lip commissures moved downward according to mandibular setback (△point B; r = -0.453 on the deviated side, -0.457 on the opposite side; both $P < 0.01$, Table 8), the downward movement of each commissure did not result in any significant LC change (Table 8). Also, there was no significant correlation between the linear change in LC and point A (Table 8). However, a significant correlation was observed between the linear change in LC and correction of menton deviation (r = 0.452, $P < 0.01$, Table 8).

7. Factors affecting the vertical position of lip commissures on the deviated and opposite sides

The movement of point A was excluded from the equation because it was not significantly related to the lip commissure position from the stepwise linear regression models. The vertical changes in lip commissures were related to the vertical change in the maxillary canine or first molar and the setback amount of the mandible (maxillary canine, $P < 0.01$, and maxillary first molar, $P < 0.001$, in the deviated and opposite sides, respectively; Table 9). Therefore, the following regression equation was established: *Change in the vertical position of commissure =* $(\beta_1) \times$ (vertical position of the maxillary canine or 1st molar) + $(\beta_2) \times$ *(Anteroposterior position of point B) + (constant)* (maxillary canine, $R^2 = 0.32 \sim 0.34$, $P < 0.01$; maxillary first molar, $R^2 = 0.48 \sim 0.49$, $P < 0.001$; Table 9).

V. DISCUSSION

Two dominant issues should be considered when evaluating LC using 2D and 3D-methodology. First, 2D methodology that includes PA cephalograms and frontal photographs cannot provide more reliable data for the cant correction of the MXTOP and LC than 3D methodology using 3D-CT and 3D-FS due to following reasons: 1) 2D methodology provides somewhat over- or under-estimation of the MXTOP cant due to projection errors caused by tilting of the head (pitch and yaw); 2) The 2D methodology has difficulty in identifying specific landmarks, especially in the cases of overlapped and curved structures; and 3) a 2D PA cephalogram and a frontal photograph cannot be matched with each other in the 3D-coordinate system. Therefore, the interpupillary line for LC measurement in the frontal photograph and the bifrontozygomatic suture line for MXTOP measurement in the PA cephalogram cannot be used for direct comparison of the amounts and ratios of cant correction. Second, to compare the values of variables from 3D-CT and 3D-FS images, the values of variables measured from 3D-FS images should be nearly identical to those from 3D-CT images or direct anthropometry. Cavalcanti et al.[42] asserted that there were no significant differences in 3D-CT measurements and anthropometric manual measurements of the hard and soft tissue landmarks. Eder et al.,[43] when comparing manual and 3D-FS measurements, reported that the accuracy of most 3D facial scanners was acceptable, ranging from -0.17 to -0.59 mm. Since the accuracy of the 3D scanner used in this study was reported as about 0.2 mm,[14,37] comparing the values between 3D-CT and 3D-FS in the same 3D-coordinate system seems to be clinically acceptable.

When we compared the values of LC, AMXTOP and PMXTOP in the T1 with T2 stages, the amounts of linear and angular cant correction were 1.5 mm, 1.3 mm, and 1.9 mm and 1.8°, 1.9° and 1.7°, respectively (Table 3). In terms of surgical movement for Class III hyperdivergent patients with facial asymmetry, cant correction of MXTOP was usually achieved by impaction of the longer side in the anterior region and differential reduction of both longer and shorter sides in the posterior region. However, correction of LC appeared to occur a different way: it was observed to be achieved mainly by the downward movement of lip commissure in the shorter side rather than the upward movement of lip commissure in the longer side due to soft tissue properties (Table 3). This tendency can be explained that the upward movement of lip commissures by impaction of maxilla was offset by the more downward movement by redundant tissues in the perioral area due to mandibular setback in the mandibular prognathic patients.

At the T1 stage, LC showed significant positive correlations with linear and angular cant among AMXOP, PMXOP, and menton deviation (all $P < 0.001$, Table 4). This result was in accordance with the findings of Baek et al.,[21] which had suggested that facial asymmetry in skeletal Class III patients might occur from more growth of the ramus and vertical excess of the maxilla of the one side than the opposite side, resulting in directional asymmetry.[22] Because directional asymmetry composes a major phenotype of facial asymmetry,[44] this group was used in this study to increase the sample purity and to avoid obscurities of data analysis. In addition, dominance of the left side laterality (68.6%) in this study was consistent with previous studies of skeletal class III subjects (66.7% - 80.6%).[2,20,24]

Since the hard tissue movement cannot produce a positional change in the soft tissue landmarks as a 1:1 ratio due to the influence of skin and muscles,[6,13] differences in the amounts of cant correction between MXTOP and LC can exist. When frontal photographs and PA cephalograms of two-jaw surgery patients with facial asymmetry were evaluated, Kim et al.[1] reported that the cant correction ratios of ΔLC/ΔPMXTOP were approximately 50%. However, Kim et al.[23] reported that there were significant differences in cants when 2D measurements from PA cephalograms were compared with 3D measurements from CBCT for Class III asymmetry patients. In addition, since the distance from the maxillary first molar to the lip commissure is longer than the distance from the maxillary canine to lip commissures, surgical movement of the maxilla might have different effects on the LC correction according to the anterior and posterior maxilla.[13] Therefore, the MXTOP should be divided into AMXTOP and PMXTOP to achieve accurate evaluation of their effects on correction of the LC.

In the present study, the findings that there was no significant difference in angular cant correction ratios between △LC/△AMXOP and △LC/△PMXOP (0.98 vs. 0.66, Table 5) and a significantly higher linear cant correction ratio of △LC/△AMXOP in comparison with △LC/△PMXOP (2.95 vs. 0.52, $P < 0.05$; Table 5), were in accordance with the results from Kim et al.[13] Using 3D-FS and 2D-cephalograms of Class III two-jaw surgery patients, they also exhibited no difference in the angular ratios of △LC/△AMXTOP and △LC/△PMXTOP (0.99 vs. 0.83, $P > 0.05$) and a significantly higher linear ratio of △LC/△AMXOP than that of △LC/△PMXOP (1.67 vs. 0.74, $P < 0.05$).[13]

The angular and linear cant correction ratios of △LC/△PMXTOP were less than 1 (0.66 and 0.52, Table 5). However, those values of the cant correction ratios of △LC/△AMXTOP can be assumed to be greater than 1 (0.98 and 2.95, Table 5). These findings were in accordance with the results from Kim et al.[13] (0.83 and 0.74 for △LC/△PMXTOP; 0.99 and 1.67 for △LC/△AMXTOP). Also observed were a high correlation of the linear and angular values between △LC with △AMXOP and △PMXOP ($P < 0.01$ and $P < 0.001$, respectively, Table 6) and between the △AMXTOP and △PMXTOP (both $P < 0.001$, Table 7). Therefore, it can be stated that LC tends to be under-corrected compared with changes in PMXTOP, and that AMXTOP may be a better predictor than PMXTOP for correction of LC.

The finding that the amounts of the vertical movement of the maxillary teeth and of the mandibular setback were distinct predictors for the change in vertical position of the mouth corner (Tables 8 and 9) was similar to the result from Baik and Kim,[40] which reported that the lip commissures moved downward and backward after two-jaw surgery. When posterior impaction of the maxilla is performed with setback of the mandible in skeletal Class III patients, it can produce a larger amount of mandibular setback, resulting in more redundant tissues in the perioral area and consequently more downward repositioning of the upper lip and commissures.

The subjects recruited in this study were diagnosed as hyperdivergent facial pattern with openbite tendency after excluding the subjects who exhibited a deformed upper lip in lip resting position. However, further studies are required to classify the samples by the facial pattern and amount of asymmetry, surgical method, and amount/direction for the maxillary repositioning for more accurate prediction of LC correction in Class III asymmetry patients. Additionally, larger sample sizes should be employed, using multi-center studies.

VI. CONCLUSIONS

In 3D evaluation of Class III asymmetry, for patients treated with two-jaw surgery, the three-dimensional approach using three-dimensional FS images in conjunction with three-dimensional CT revealed more precise change ratio of ΔLC/ΔAMXTOP and ΔLC/ΔPMXTOP than traditional two-dimensional approach. With the linear regression analysis, the vertical positions of lip commissures were shown to be related to the vertical change in the maxillary teeth and the setback amount of mandible.

REFERENCES

1. Kim YH, Jeon J, Rhee JT, Hong J. Change of lip cant after bimaxillary orthognathic surgery. *J Oral Maxillofac Surg* 2010;68:1106-1111.
2. Ko EW, Huang CS, Chen YR. Characteristics and corrective outcome of face asymmetry by orthognathic surgery. *J Oral Maxillofac Surg* 2009;67:2201-2209.
3. Major P, Johnson D, Hesse K, Glover K. Landmark identification error in posterior anterior cephalometrics. *Angle Orthod* 1994;64:447-454.
4. Malkoc S, Sari Z, Usumez S, Koyuturk AE. The effect of head rotation on cephalometric radiographs. *Eur J Orthod* 2005;27:315-321.
5. McCance AM, Moss JP, Fright WR, James DR, Linney AD. A three dimensional analysis of soft and hard tissue changes following bimaxillary orthognathic surgery in skeletal III patients. *Br J Oral Maxillofac Surg* 1992;30:305-312.
6. Jung YJ, Kim MJ, Baek SH. Hard and soft tissue changes after correction of mandibular prognathism and facial asymmetry by mandibular setback surgery: three-dimensional analysis using computerized tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2009;107:763-771.
7. Ahlqvist J, Eliasson S, Welander U. The cephalometric projection. Part II. Principles of image distortion in cephalography. *Dentomaxillofac Radiol* 1983;12:101-108.
8. Swennen GRJ, Schutyser F, Hausamen JE. *Three-dimensional cephalometry: A color atlas and manual.* Heidelberg: Springer 2005.
9. Sanders MA, Hoyiberg C, Chu CB, Leggitt VL, Kim JS. Common orthodontic appliances cause artifacts that degrade the diagnostic quality of CBCT images. *J Calif Dent Assoc* 2007;35:850-857.
10. Perrella A, Lopes PM, Rocha RG, Fenyo-Pereira M, Cavalcanti MG. Influence of dental metallic artifact from multislice CT in the assessment of simulated mandibular lesions. *J Appl Oral Sci* 2010;18:149-154.
11. Soncul M, Bamber MA. Evaluation of facial soft tissue changes with optical surface scan after surgical correction of class III deformities. *J Oral Maxillofac Surg* 2004;62:1331-40.

12. Moss JP, Ismail SF, Hennessy RJ. Three-dimensional assessment of treatment outcomes on the face. *Orthod Craniofac Res* 2003;6:126-131.
13. Kim SJ, Choi JY, Baek SH. Evaluation of canting correction of the maxillary transverse occlusal plane and change of the lip canting in Class III two-jaw orthognathic surgery. *Angle Orthod* 2012;82:1092-1097.
14. Nahm KY, Kim Y, Choi YS, Lee J, Kim SH. Accurate registration of cone-beam computed tomography scans to 3-dimensional facial photographs. *Am J Orthod Dentofacial Orthop* 2014;145:256-264.
15. Naudi KB, Benramadan R, Brocklebank L, Ju X, Khambay B, Ayoub A. The virtual human face: superimposing the simultaneously captured 3D photorealistic skin surface of the face on the untextured skin image of the CBCT scan. *Int J Oral Maxillofac Surg* 2013;42:393-400.
16. Peck S, Peck L, Kataja M. Skeletal asymmetry in esthetically pleasing faces. *Angle Orthod* 1991;61:43-48.
17. Padwa BL, Kaiser MO, Kaban LB. Occlusal cant in the frontal plane as a reflection of facial asymmetry. *J Oral Maxillofac Surg* 1997:55;811-816.
18. Proffit WR, Phillips C, Dann CT. Who seeks surgical-orthodontic treatment? *Int J Adult Orthodon Orthognath Surg* 1990;5:153-160.
19. Severt TR, Proffit WR. The prevalence of facial asymmetry in the dentofacial deformities population at the University of North Carolina. *Int J Adult Orthodon Orthognath Surg* 1997;12:171-176.
20. Haraguchi S, Takada K, Yasuda Y. Facial asymmetry in subjects with skeletal Class III deformity. *Angle Orthod* 2002;72:28-35.
21. Baek SH, Cho IS, Chang YI, Kim MJ. Skeletodental factors affecting chin point deviation in female patients with Class III malocclusion and facial asymmetry: a three-dimensional analysis using computed tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2007;104:628-639.
22. Pirttiniemi PM. Associations of mandibular and facial asymmetries-a review. *Am J Orthod Dentofacial Orthop* 1994;106:191-200.

23. Kim EJ, Ki EJ, Cheon HM, Choi EJ, Kwon KH. 3-Dimensional analysis for Class III malocclusion patients with facial asymmetry. *J Korean Assoc Oral Maxillofac Surg* 2013;39:168-174
24. Kim EJ, Palomo JM, Kim SS, Lim HJ, Lee KM, Hwang HS. Maxillofacial characteristics affecting chin deviation between mandibular retrusion and prognathism patients. *Angle Orthod* 2011;81:988-993
25. Fong JH, Wu HT, Huang MC, Chou YW, Chi LY, Fong Y, Kao SY. Analysis of facial skeletal characteristics in patients with chin deviation. *J Chin Med Assoc* 2010;73:29-34.
26. Loyo M, Kontis TC. Cosmetic botulinum toxin: has it replaced more invasive facial procedure? *Facial Plast Surg Clin North Am* 2013;21:285-298.
27. Kim MJ, Lee DY, Lim YK, Baek SH. Three-dimensional evaluation of soft tissue changes after mandibular setback surgery in class III malocclusion patients according to extent of mandibular setback, vertical skeletal pattern, and genioplasty. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2010:109;e20-e32.
28. Choi JY, Choi JP, Lee YK, Baek SH. Simultaneous correction of hard- and soft-tissue facial asymmetry: combination of orthognathic surgery and face lift using a resorbable fixation device. *J Craniofac Surg* 2010;21:363-370.
29. Jeon YJ, Kim YH, Son WS, Hans MG. Correction of a canted occlusal plane with miniscrews in a patient with facial asymmetry. *Am J Orthod Dentofacial Orthop* 2006;130:244-252.
30. Pélissier P, Pistre V, Bustamante K, Martin D, Baudet J. The modiolus. Comparative anatomy, embryological and physiological review, surgical importance. *Ann Chir Plast Esthet* 2000;45:41-47.
31. Hwang DS, Kim YI, Park SB, Lee JY. Midfacial soft tissue changes after leveling Le Fort I osteotomy with differential reduction: Cone-beam computed tomography volume superimposition. *Angle Orthod* 2012;82:424-431.
32. Lee JY, Kim YI, Hwang DS, Park SB. Effect of setback Le Fort I osteotomy on midfacial soft-tissue changes as evaluated by cone-beam computed tomography superimposition for cases of skeletal class III malocclusion. *Int J Oral Maxillofac Surg* 2013;42:790-795.

33. Lane C, Harrell Jr W. Completing the 3-dimensional picture. *Am J Orthod Dentofacial Orthop* 2008;133:612-620.

34. Weinberg SM, Kolar JC. Three-dimensional surface imaging: limitations and considerations from the anthropometric perspective. *J Craniofac Surg* 2005;16:847-851.

35. Halazonetis DJ. From 2-dimensional cephalograms to 3-dimensional computed tomography scans. *Am J Orthod Dentofacial Orthop* 2005;127:627-637.

36. Ma L, Xu T, Lin J. Validation of a three-dimensional facial scanning system based on structured light techniques. *Comput Methods Programs Biomed* 2009;94:290-298.

37. Ahn HW, Chang YJ, Kim KA, Joo SH, Park YG, Park KH. Measurement of three-dimensional perioral soft tissue changes in dentoalveolar protrusion patients after orthodontic treatment using a structured light scanner. *Angle Orthod* 2014;84:795-802.

38. Ayoub AF, Xiao Y, Khambay B, Siebert JP, Hadley D. Towards building a photo-realistic virtual human face for craniomaxillofacial diagnosis and treatment planning. *Int J Oral Maxillofac Surg* 2007;36:423-428.

39. Maal TJJ, Verhamme LM, van Loon B, Plooij JM, Rangel FA, Kho A, Bronkhorst EM, Bergé SJ. Variation of the face in rest using 3D stereophotogrammetry. *Int J Oral Maxillofac Surg* 2011;40:1252-1257.

40. Baik HS, Kim SY. Facial soft-tissue changes in skeletal Class III orthognathic surgery patients analyzed with 3-dimensional laser scanning. *Am J Orthod Dentofacial Orthop* 2010;138:167-178.

41. Jeong MH, Choi JH, Kim BH, Kim SG, Nahm DS. Soft tissue changes after double jaw rotation surgery in skeletal class III malocclusion. *J Korean Assoc Oral Maxillofac Surg* 2006;32:559-565.

42. Cavalcanti MG, Rocha SS, Vannier MW. Craniofacial measurements based on 3D-CT volume rendering: implications for clinical applications. *Dentomaxillofac Radiol* 2004;33:170-176.

43. Eder M, Brockmann G, Zimmermann A, Papadopoulos MA, Schwenzer-Zimmerer K, Zeilhofer HF, Sader R, Papadopulos NA, Kovacs L. Evaluation of precision and accuracy

assessment of different 3-D surface imaging systems for biomedical purposes. *J Digit Imaging* 2013;26:163-172.

44. Kim JY, Jung HD, Jung YS, Hwang CJ, Park HS. A simple classification of facial asymmetry by TML system. *J Craniomaxillofac Surg* 2014;42:313-320.

FIGURE LEGENDS

Figure 1. A method to match the facial soft tissue in a three-dimensional computed tomograph (3D-CT) image and that of a 3D facial scanning (3D-FS) image using 3D coordinates. The profile contour line from the forehead to the subnasale, and five landmarks (right and left exocanthi, subnasale, and right and left alar bases) were used for coinciding the pitch, yaw and roll of head orientation.

Figure 2. The definitions of reference planes and landmarks used in this study. In the 3D-CT image: AP (Axial plane), a plane connecting the right and left orbitales and the porion of the opposite side of the chin point deviation; MSP (Midsagittal plane), a plane passing through the nasion and the basion, and situated perpendicular to the axial plane; CP (Coronal plane), a plane that is perpendicular to the AP and MSP and passing the sella; 1, the bracket slot midpoint of the maxillary canine; 2, the bracket slot midpoint of the maxillary first molar; 3, point A; 4, point B; 5, menton. In the 3D-FS image: 6, lip commissural point.

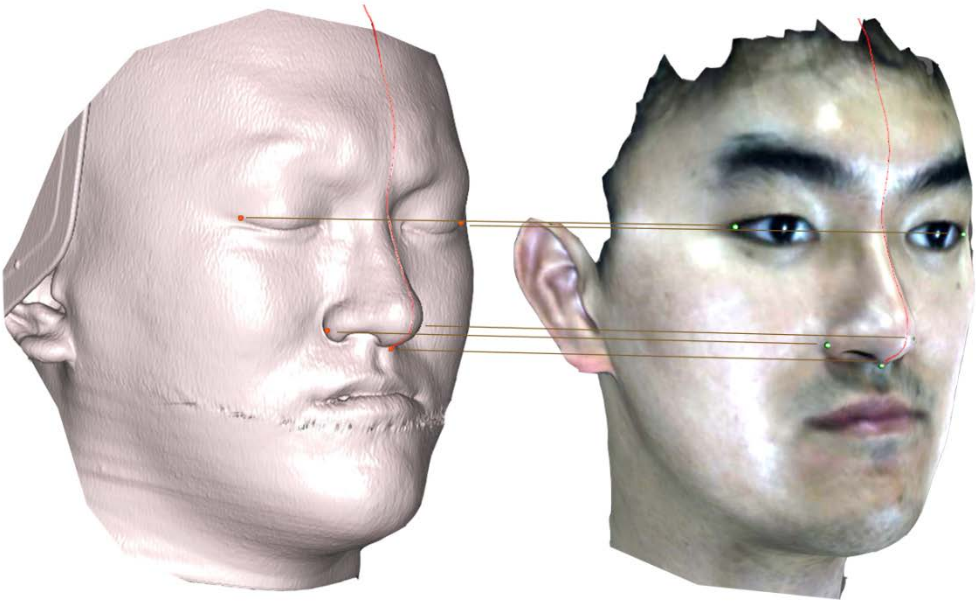

Figure 1. A method to match the facial soft tissue in a three-dimensional computed tomographic (3D-CT) image and that of a 3D facial scanning (3D-FS) image using 3D coordinates. The profile contour line from the forehead to the subnasale, and five landmarks (right and left exocanthi, subnasale, and right and left alar bases) were used for coinciding the pitch, yaw and roll of head orientation.

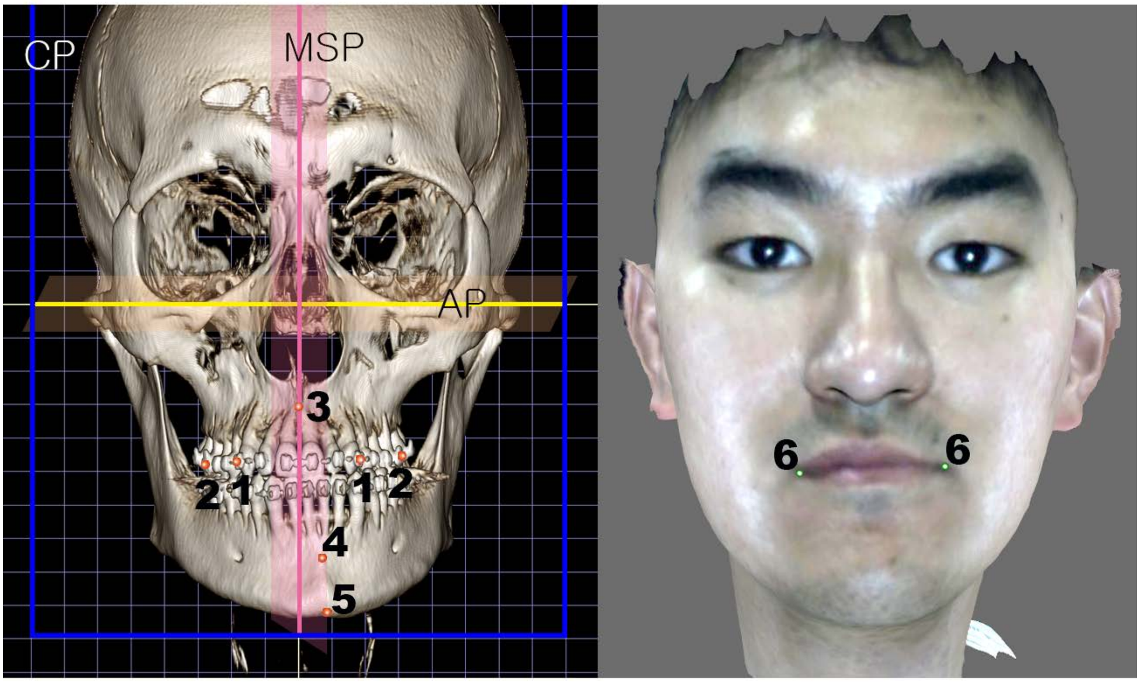

Figure 2. The definitions of reference planes and landmarks used in this study. In the 3D-CT image: AP (Axial plane), a plane connecting the right and left orbitales and the porion of the opposite side of the chin point deviation; MSP (Midsagittal plane), a plane passing through the nasion and the basion, and situated perpendicular to the axial plane; CP (Coronal plane), a plane that is perpendicular to the AP and MSP and passing the sella; 1, the bracket slot midpoint of the maxillary canine; 2, the bracket slot midpoint of the maxillary first molar; 3, point A; 4, point B; 5, menton. In the 3D-FS image: 6, lip commissural point.

Table 1. Changes in the skeletodental variables between the T1 and T2 stages from cephalometric analysis

Cephalometric Measurements	T1		T2		P value
	Mean	SD	Mean	SD	
SNA (°)	80.7	4.0	81.1	3.8	0.2721
SNB (°)	82.3	4.3	79.4	3.4	0.0000 ***
ANB (°)	-1.6	3.0	1.7	2.1	0.0000 ***
A-N perpendicular (mm)	-2.4	3.7	-1.8	3.3	0.2859
Pog-N perpendicular (mm)	-0.4	7.9	-5.8	6.2	0.0000 ***
Wits appraisal (mm)	-11.5	6.4	-5.0	3.8	0.0000 ***
SN-GoMe (°)	38.8	8.1	40.0	5.8	0.1544
U1-SN (°)	108.8	6.1	104.8	6.8	0.0001 ***
IMPA (°)	85.7	7.4	84.4	7.6	0.2333
Overjet (mm)	-2.6	3.9	3.5	0.9	0.0000 ***
Overbite (mm)	-1.4	3.0	2.4	1.2	0.0000 ***

Paired *t* test was performed. ***, P < 0.001.

T1 indicates before two-jaw surgery; T2, after two-jaw surgery; SD, standard deviation.

Table 2. Amounts of the changes in point A, point B and menton deviation from measurements of 3D-CT between the T1 and T2 stages

3D-CT Measurements	T1 Stage		T2 Stage		P value	Amount of Change	
	Mean	SD	Mean	SD		Mean	SD
point A	64.17	3.95	64.76	4.79	0.1297	-0.59	3.40
point B	68.09	5.21	62.86	5.23	0.0000 ***	5.23	3.42
Menton deviation	4.67	3.32	0.93	2.12	0.0000 ***	3.74	2.92

Paired *t* test was performed. ***, $P < 0.001$.

The amount of change indicates the value of the T1 stage minus that of the T2 stage.

Table 3. Amounts of the changes in AMXTOP, PMXTOP and LC from measurement of 3D-CT and 3D-FS between the T1 and T2 stages

Variables			T1 Stage		T2 Stage		P value	Amount of Change	
			Mean	SD	Mean	SD		Mean	SD
AMXTOP	Angular cant		1.75	1.94	-0.07	1.39	0.0000 ***	1.82	1.90
	Linear cant	Deviated side	47.30	4.08	47.38	3.47	0.5945	-0.08	1.51
		Opposite side	48.57	4.08	47.34	3.28	0.0015 **	1.23	1.87
		Difference	1.26	1.42	-0.04	1.00	0.0000 ***	1.31	1.37
PMXTOP	Angular cant		1.87	1.57	0.20	1.52	0.0000 ***	1.67	1.93
	Linear cant	Deviated side	45.07	3.60	43.95	3.15	0.0004 ***	1.12	1.52
		Opposite side	47.07	3.76	44.07	3.44	0.0000 ***	3.00	1.85
		Difference	2.00	1.65	0.12	1.53	0.0000 ***	1.88	1.94
LC	Angular cant		2.13	1.54	0.29	1.25	0.0000 ***	1.84	1.37
	Linear cant	Deviated side	50.07	4.60	51.26	3.80	0.0017 **	-1.19	1.92
		Opposite side	51.74	4.21	51.48	3.80	0.3177	0.26	2.03
		Difference	1.67	1.12	0.22	0.99	0.0000 ***	1.44	1.02

Paired *t* test was performed. **, $P < 0.01$; ***, $P < 0.001$.

AMXTOP, anterior maxillary transverse occlusal plane; PMXTOP, posterior maxillary transverse occlusal plane; LC, lip cant; amount of change, the value of the T1 stage minus that of the T2 stage; and difference, the value of the opposite side minus that of the deviated side.

Table 4. Correlation between LC and skeletal variables at the T1 stage

		Linear cant		Angular cant		Menton deviation	point A	point B
		AMXTOP	PMXTOP	AMXTOP	PMXTOP			
Linear LC	PCC	0.683	0.639	0.688	0.661	0.710	0.035	-0.081
	P value	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.8431	0.6445
Angular LC	PCC	0.697	0.646	0.702	0.669	0.727	0.003	-0.121
	P value	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***	0.9884	0.4869

PCC, Pearson correlation test.

Pearson correlation test was performed. ***, P < 0.001.

Table 5. Comparison of the ratios of cant correction between △LC/△AMXTOP and △LC/△PMXTOP

Variables		Ratio		P value
		Mean	SD	
Angular	△LC/△AMXTOP	0.98	4.65	0.3689
	△LC/△PMXTOP	0.66	1.45	
Linear	△LC/△AMXTOP	2.95	13.11	0.0350 *
	△LC/△PMXTOP	0.52	1.11	

Independent *t* test was performed. *, $P < 0.05$.

Table 6. Correlation of the amounts of cant correction between LC, AMXTOP and PMXTOP

		△LC (°)	△LC (mm)
△AMXTOP (°)	PCC	0.521	0.478
	P value	0.0013 **	0.0037 **
△AMXTOP (mm)	PCC	0.510	0.467
	P value	0.0017 **	0.0047 **
△PMXTOP (°)	PCC	0.615	0.594
	P value	0.0000 ***	0.0001 ***
△PMXTOP (mm)	PCC	0.638	0.612
	P value	0.0000 ***	0.0000 ***

PCC, Pearson correlation test.

Pearson correlation test was performed. **, $P < 0.01$; ***, $P < 0.001$.

Table 7. Correlation of the amounts of cant correction between AMXTOP and PMXTOP

		△AMXTOP (°)	△AMXTOP (mm)
△PMXTOP (°)	PCC	0.841	0.838
	P value	0.0000 ***	0.0000 ***
△PMXTOP (mm)	PCC	0.869	0.867
	P value	0.0000 ***	0.0000 ***

PCC, Pearson correlation test.

Pearson correlation test was performed. ***, $P < 0.001$.

Table 8. Correlation between the amount of linear cant correction of LC and the amount of change in point A, point B, and menton deviation

△ linear LC		△ A point	△ B point	△ Menton deviation
Deviated side	PCC	0.115	-0.453	-0.187
	P value	0.5124	0.0062 **	0.2824
Opposite side	PCC	0.168	-0.457	0.049
	P value	0.3353	0.0057 **	0.7780
Difference	PCC	0.119	-0.057	0.452
	P value	0.4961	0.7446	0.0064 **

PCC, Pearson correlation test.

Pearson correlation test was performed. **, $P < 0.01$.

Table 9. Factors affecting the vertical position of lip commissures on the deviated and opposite sides

Dependent variable	Constant (α)	Predictor 1	β_1	Predictor 2	β_2	R^2	P value
Lip commissure of the deviated side	-0.09	Max. Canine	0.47	point B	-0.20	0.3347	0.0014 **
	-0.46	Max. 1st molar	0.52		-0.50	0.4780	0.0000 ***
Lip commissure of the opposite side	0.83	Max. Canine	0.35		-0.33	0.3142	0.0023 **
	-0.34	Max. 1st molar	0.54		-0.37	0.4878	0.0000 ***

Linear regression analysis was performed. **, $P < 0.01$; ***, $P < 0.001$.

국문 초록

삼차원 CT와 얼굴스캐닝을 이용한 골격성 III 급 비대칭 양악수술 환자의 입술경사변화 분석

고 정 민

서울대학교 대학원 치의과학과 치과교정학 전공

(지도교수: 백 승 학)

목적: 본 논문의 목적은 전방 상악횡적교합평면 (anterior maxillary transverse occlusal plane, AMXTOP)과 후방 상악횡적교합평면 (posterior maxillary transverse occlusal plane, PMXTOP) 경사의 변화가 입술의 경사 (lip cant, LC) 변화에 미치는 영향을 삼차원 얼굴스캐닝 (facial scan)과 삼차원 전산화단층사진 (computed tomographic image, CT)을 이용하여 평가하기 위함이다.

연구대상 및 방법: 양악 악교정수술을 받은 35 명의 골격성 III 급 비대칭 환자들을 연구대상으로 선택하였다. 악교정수술전 (T1) 과 수술후 (T2, mean= 5.5 ± 1.6 months) 에 삼차원 얼굴스캐닝과 삼차원 CT 영상을 채득하였다. 두 영상이 같은 두부 위치를 갖도록 한 다음, 삼차원 CT 영상에서는 상악 좌우측 견치와 상악 좌우측 제 1 대구치에 위치한 브라켓 슬롯의 중점들과 point A, point B, menton 을, 삼차원 얼굴스캐닝 영상에서는 연조직인 좌우측 구각점 (lip commissure)의 위치를 digitization 하였다. AMXTOP, PMXTOP, LC 의 길이 및 각도 변수들을 측정하여 분석하였다.

결과: 이 연구의 결과는 다음과 같았다. 첫째, T1 단계에서 LC 의 길이변수와 각도변수는 AMXTOP 및 PMXTOP 의 길이변수와 각도변수뿐 아니라 menton 의

변이량과 유의한 상관관계가 있었다 ($P < 0.001$). 둘째, T1 에서 T2 단계 동안에, 교합평면 및 입술 경사의 길이 및 각도값이 유의하게 변화됨이 관찰되었다: △AMXTOP (1.3 mm, 1.9˚), △PMXTOP (1.9 mm, 1.7˚), △LC (1.5 mm, 1.8˚)($P < 0.001$). 셋째, 비록 △LC/△AMXTOP 와 △LC/△PMXTOP 의 각도 변화비는 유의한 차이를 보이지 않았지만 (1.0 vs. 0.7), △LC/△AMXTOP 의 길이 변화비는 △LC/△PMXTOP 의 길이 변화비에 비해 높았다 (3.0 vs. 0.5, $P < 0.05$). 넷째, 구각점의 수직적인 길이 변화는 상악견치 또는 상악제 1 대구치의 수직길이 변화량 및 하악의 후퇴량과 유의한 상관관계가 있었다 ($P < 0.01$).

결론: 이 연구는 삼차원 CT 와 삼차원 얼굴스캐닝을 동시에 이용하여 악교정수술환자의 상악 횡적 교합평면과 입술의 경사 변화에 대한 보다 정확한 정보를 제공함과 더불어 구각점의 수직적인 길이 변화가 상악 치아들의 수직길이 변화량 및 하악의 후퇴량과 관련되어 있음을 보여주었다.

주요어: 입술경사; 상악횡적교합평면경사; 삼차원 안면스캐닝; 삼차원 CT

학 번: 2013-30624