연세대학교
YONSEI UNIVERSITY

# Diagnosis and treatment outcome of facial asymmetry according to the maxillary roll pattern


**Sun Mi Kwon**

**Department of Dentistry**
**The Graduate School, Yonsei University**

# Diagnosis and treatment outcome of facial asymmetry according to the maxillary roll pattern

Directed by prof. Yoon Jeong Choi, D.D.S., M.S.D., Ph.D.

The Master's Thesis
Submitted to the Department of Dentistry
and the Graduate School of Yonsei University
in partial fulfillment of the requirements for the degree of
Master of Dental Science

**Sun Mi Kwon**

**June 2017**

연세대학교
YONSEI UNIVERSITY

This certifies that the dissertation of
Sun-Mi Kwon is approved.

Yoon Jeong Choi

Thesis Supervisor : Yoon-Jeong Choi

Hyoung Seon Baik

Hyoung-Seon Baik

Hwi-Dong Jung

The Graduate School
Yonsei University
June 2017

# TABLE OF CONTENTS

# LEGEND OF FIGURES

# LEGEND OF TABLES

# Abstract

# Diagnosis and treatment outcome of facial asymmetry according to the maxillary roll pattern

Sun Mi Kwon

The Graduate School Yonsei University

Department of Dentistry

(Directed by prof. Yoon Jeong Choi, D.D.S., M.S.D., Ph.D.)

Facial asymmetry is one of the common craniofacial deformities, which requires 3-dimensional analysis for accurate diagnosis and correct treatment planning. Inclination of frontal occlusal plane (FOP) and lateral menton deviation are the main manifestations of the asymmetry of the maxilla and mandible, respectively. The FOP tends to incline toward the ipsilateral side of menton deviation, but there are patients whose FOP inclined toward the contralateral side of menton deviation.

This study was performed to investigate morphological differences between the ipsilateral type of facial asymmetry, whose FOP inclined toward the same side of the menton deviation, and the contralateral type, whose FOP inclined toward the opposite direction, by using cone beam computed tomography (CBCT) images. Additionally, this study aimed to compare treatment outcomes of the two types of facial asymmetry.

This retrospective study included a contralateral group (n = 12; 8 men and 4 women; mean age, 21.8 ± 2.2 years) and an ipsilateral group (n = 12; 8 men and 4 women; mean age, 21.2 ± 4.3 years). The subjects in the contralateral group were selected from a total of 296 patients who had been diagnosed as skeletal Class III malocclusion and facial asymmetry, had undergone bi-maxillary orthognathic surgery, and had taken serial CBCT before (T0), 1 month after (T1), and one year after (T2) surgery. The subjects in the ipsilateral group were selected from the same archive by matching age, gender, and degree of FOP cant with those in the contralateral group. CBCT images were reconstructed, and deviated and nondeviated sides were defined according to the menton deviation. Measurements for linear distance, angle, volume, and area were performed and compared between the deviated and nondeviated sides in each group and between the ipsilateral and contralateral groups

1. In the contralateral group, the mandibular body of the nondeviated side was longer than the deviated side ($p = 0.024$).

2. In the contralateral group, the asymmetry of vertical elements such as distances from the horizontal reference plane to gonion ($p < 0.01$) and mental foramen ($p = 0.044$) was more evident than that of horizontal elements such as distances from the midsagittal plane to gonion ($p = 0.744$) and mental foramen ($p = 0.224$).

3. Despite an improvement of facial asymmetry after the surgery in both groups, the improvement of menton deviation in the contralateral group was not statistically significant ($p = 0.265$).

4. In the contralateral group, the difference of hemi-lower facial area before surgery between deviated and nondeviated sides increased even after the surgery and did not improve one year after the surgery.

5. There were no other significant differences in the changes during retention period between the two groups.

There were skeletal morphological differences between the two groups before surgery. The existing asymmetry was improved after surgery in both groups, but in the contralateral group, there was remained asymmetry in some aspects even after the surgery. Therefore, orthognathic surgery in the contralateral group should be planned to improve the vertical asymmetry rather than horizontal asymmetry and to

prevent the horizontal asymmetry from being worsened after surgery. Moreover, clinicians should pay attention to the possibility of increase in the difference of bilateral hemi-lower facial area after surgery and consider the need of additional surgery when treating the contralateral type of asymmetry.

**Key words: Facial asymmetry, roll rotation, 3-dimensional analysis, orthognathic surgery**

# Diagnosis and treatment outcome of facial asymmetry according to the maxillary roll pattern

Sun Mi Kwon

The Graduate School Yonsei University

Department of Dentistry

(Directed by prof. Yoon Jeong Choi, D.D.S., M.S.D., Ph.D.)

## I. Introduction

Facial asymmetry is one of the common craniofacial deformities, exhibiting different dimensions between the left and right sides. Traditionally postero-anterior cephalogram has been used to diagnose facial asymmetry (Maeda et al., 2006; Reyneke et al., 1997), and several methods were proposed to classify facial asymmetry. Bruce and Hayward (Bruce and Hayward, 1968) classified facial asymmetry into 3 groups: deviation prognathism, unilateral condylar hyperplasia, and unilateral macrognathia. Obwegeser and Makek (Obwegeser and Makek, 1986) divided mandibular asymmetry into hemimandibular elongation and hemimandibular hyperplasia. However, the classification systems mainly focused on the mandibular morphology and analyzed the craniofacial structure using two-dimensional (2D) images.

Lateral deviation of the menton, which is a common feature of facial asymmetry, has a great impact on the perception of facial asymmetry (Kim et al., 2015). It often accompanies inclination of the frontal occlusal plane (FOP), which is defined as different distance of the mesiobuccal cusps of the maxillary first molars to a horizontal plane between the right and left sides (Chen et al., 2016). Previous studies reported lateral menton deviation is closely related with FOP inclination (Buranastidporn et al., 2006; Inui et al., 1999). The FOP tends to incline toward the ipsilateral side of lateral menton deviation, which is favorable for orthognathic surgery when roll rotation of the maxillo-mandibular complex is performed. However, there are patients whose FOP inclined toward the contralateral side of the menton deviation (Uesugi et al., 2014). In this type of patients, roll correction of the maxillo-mandibular complex makes the menton move further to the deviated side, worsening asymmetric facial appearance. Uesugi et al (Uesugi et al., 2016) classified facial asymmetry by FOP inclination and lateral menton deviation, and reported morphological and functional differences between the ipsilateral and contralateral types of asymmetry. However, the analysis was performed on 2D images, and mainly compared occlusal forces before treatment without observing treatment process or treatment outcomes.

Since facial asymmetry is a three-dimensional (3D) issue that affects not only the mandible but also the maxilla, it is essential to understand the overall craniofacial structure three-dimensionally (Habets et al., 1988). Recently, 3D analysis is widely performed in orthodontic diagnosis of facial asymmetry due to feasibility of linear and angular measurements as well as volumetric measurement by using 3D images (You et al., 2010). A previous study classified facial asymmetry into mandibular body asymmetry, universal lateral condylar hyperplasia asymmetry, atypical asymmetry, and C-shaped asymmetry using 3D computed tomography (CT) (Baek et al., 2012). The ipsilateral and contralateral types of asymmetry according to FOP inclination and menton deviation may include not only roll but also yaw problems of the maxilla and mandible, which requires 3D analysis for accurate diagnosis and correct treatment planning (Kim et al., 2015; Park et al., 2006). Moreover, 3D analysis for treatment outcomes would delivery valuable information to improve the facial asymmetry which might have been remained even after the surgery.

This study was performed to investigate the morphological differences between the contralateral type of facial asymmetry, whose FOP inclined toward the contralateral side of the menton deviation, and the ipsilateral type, whose FOP inclined toward the opposite direction, by using cone beam CT (CBCT) images. Additionally, this study aimed to compare treatment outcomes of the two types of facial asymmetry.

# II. Materials and methods

## 1. Study design and subjects

This retrospective study included a contralateral group whose FOP inclines toward the contralateral side of the menton deviation and an ipsilateral group whose FOP inclines toward the ipsilateral side of the menton deviation (Figure 1). The subjects in the contralateral group were selected from a total of 296 patients who had been diagnosed as skeletal Class III malocclusion and facial asymmetry and had undergone bi-maxillary orthognathic surgery from February 2012 to December 2016 at the Department of Oral and Maxillofacial Surgery at Yonsei University Dental Hospital, Seoul, Korea. The inclusion criteria were as follows: occlusal plane cant (i.e., the difference of the perpendicular distances of the right and left maxillary first molar mesiobuccal cusps to the Frankfort horizontal plane) more than 1 mm toward the contralateral side of the lateral menton deviation; skeletal Class III malocclusion (ANB $<0°$); age $\geq$ 18 years; Le Fort I osteotomy and bilateral intraoral vertical ramus osteotomy (IVRO); availability of serial CBCT images obtained before (T0), 1 month after (T1), and 1 year after (T2) surgery; absence of congenital anomalies; and no history of maxillofacial trauma. The subjects in the ipsilateral group were carefully selected by matching the age, gender, and degree of occlusal plane cant with the contralateral group from the above 296 patients. The same inclusion criteria were applied to the ipsilateral group except inclination of FOP toward the ipsilateral side (Table 1).

The minimum sample size was calculated based on the previous study of Chen et al(Chen et al., 2016), using G*Power 3 (Düsseldorf, Germany) with a significance level of $p<0.05$, a power of 80%, and an effect size of 1.26 and confirmed as 8. Based on the inclusion and exclusion criteria, we selected 12 subjects (8 men and 4 women; mean age, 21.8 ± 2.2 years) for the contralateral group and 12 subjects (8 men and 4 women; mean age, 21.2 ± 4.3 years) for the ipsilateral group. They underwent pre-surgical orthodontic treatment for on average 10.8 ± 5.7 months and started post-surgical orthodontic treatment approximately 6-8 weeks after orthognathic surgery. Adjunctive surgery such as genioplasty, mandible shaving, and zygoma reduction was also performed in some patients.

This study conformed to the Declaration of Helsinki and was approved by the institutional review board of Yonsei University Dental Hospital (Seoul, Korea).

**Table 1. Sample characteristics before surgery**

| | | Contralateral(n=12) | Ipsilateral(n=12) | p-value |
|---|---|---|---|---|
| Sex | Male | 8 | 8 | |
| | Female | 4 | 4 | |
| Age* (year) | | 22.3±4.2 | 20.8±2.5 | 0.59 |
| Menton deviation (mm) | | 2.0±2.2 | 5.8±3.3 | 0.003 |
| Occlusal plane cant (mm) | | 2.1±1.7 | 2.0±1.2 | 0.934 |
| Presurgical orthodontic treatment period (month) | | 10.8±3.6 | 10.8±7.2 | 0.973 |

Independent *t*-tests were performed.

*Mann-Whitney U test was performed.

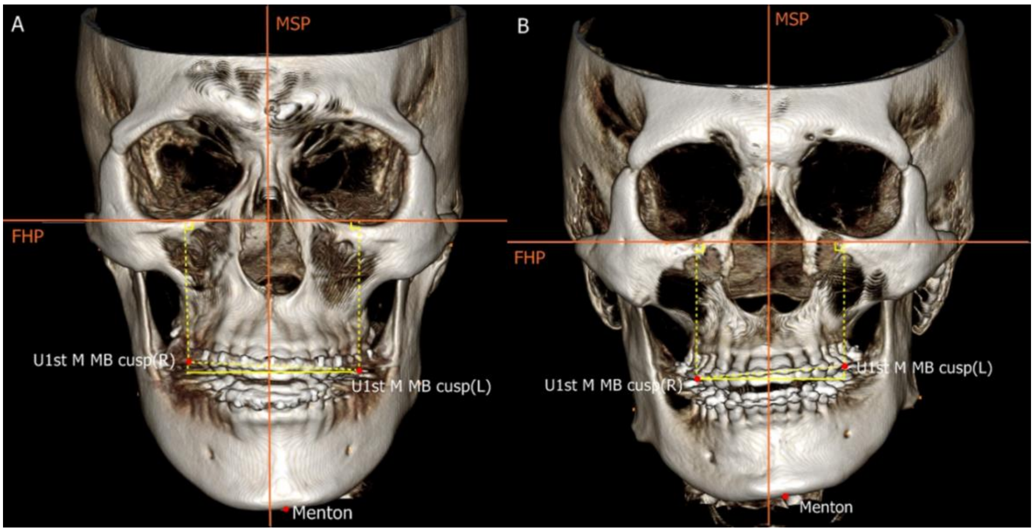


Figure 1. 3D features of subjects in (A) the contralateral group; and (B) the ipsilateral group. MSP, midsagittal plane; FHP, Frankfort horizontal plane; R, right; L, left; U1st M MB cusp, maxillary first molar mesiobuccal cusp.

## 2. Landmarks and measurements

The 3D images were obtained with a CBCT scanner (Alphard3030, Asahi Roentgen Inc., Kyoto, Japan) with a field of view of 200 × 179 mm at 80 kVp, 5 mA, and exposure time of 17s. The images were saved as DICOM files and reconstructed using InVivo software (version 5.4; Anatomage, San Jose, CA, USA). The CBCT images were reoriented using 3 reference planes: Frankfort horizontal plane (FHP) passing through the right and left porion and the left orbitale; the midsagittal plane passing through the nasion and sella and perpendicular to the FHP; and the coronal plane passing through the nasion and perpendicular to the FHP and the midsagittal plane (Figure 2). The landmarks were digitized and coordinated with nasion as a reference point (0, 0, 0). The side of the lateral menton deviation in relation to the midsagittal plane was defined as the deviated side and the opposite side as the nondeviated side.

Fifteen landmarks were indicated on the reconstructed CT images (Table 2), and eight linear measurements and two angular measurements were performed. Linear measurements include menton deviation, occlusal plane cant, mandibular body length, ramal length, distances from gonion to the midsagittal plane and FHP, and distances from mental foramen to the midsagittal plane and FHP (Table 3, Figure 3). Angular measurements include frontal ramal inclination (i.e., angulation of ramus lateral surface and the midsagittal plane) and lateral ramal inclination (i.e., angulation of ramus posterior surface and the FHP) (Table 3, Figure 4). Additonally, hemi-mandibular volume, which was the mandibular volume divided into half by the plane connecting Me, B, and G, and hemi-lower facial area bordered by the soft tissue outline, FHP, and the midsagittal plane were measured at each time point (Table 2, Figure 4).

### 3. Statistical analysis

SPSS software for Windows, version 21.0 (SPSS Inc., Chicago, IL, USA), was used for statistical analyses. The Shapiro-Wilk test was used to confirm normality of the data. The independent t tests were used to determine differences between the contralateral and ipsilateral groups, and the paired t tests were used to detect changes in the measurements over time and the difference in measurements between the deviated and nondeviated sides at each time point. A p-value less than 0.05 was considered statistically significant. All measurements of 6 randomly selected patients were re-digitized 1 week later by a single investigator to confirm reproducibility. The intra-examiner reproducibility was assessed by the intra-class correlation coefficient, which showed high reliability (range, 0.994–0.999).

Table 2. Description of landmarks

| Landmark | Definition |
| --- | --- |
| **Por** | Porion, the most superior point of external auditory meatus |
| **Or** | Orbitale, the most inferior point of the lower margin of the bony orbit |
| **N** | Nasion, middle point of nasofrontal suture |
| **S** | Sella, center of sella turcica |
| **Me** | Menton, the most inferior point in the symphysis |
| **U6** | The mesiobuccal cusp of maxillary first molar |
| **$Con_{post}$** | $Condylion_{post,}$ the most posterior point of the condylar head |
| **$Con_{sup}$** | $Condylion_{sup,}$ the most superior point of the condylar head |
| **$Con_{lat}$** | $Condylion_{lat,}$ the most lateral point of the condylar head |
| **$Go_{inf}$** | $Gonion_{inf,}$ a point between mandibular plane and ramus, the point which on the jaw angle is the most inferiorly directed |
| **$Go_{lat}$** | $Gonion_{lat,}$ a point between mandibular plane and ramus, the point which on the jaw angle is the most outwardly directed |
| **$Go_{post}$** | $Gonion_{post}$, a point between mandibular plane and ramus, the point which on the jaw angle is the most posteriorly directed |
| **MtF** | Mental foramen, the most superior point of mental foramen |
| **B** | B point, supramentale, the midpoint of the greatest concavity on the anterior border of the symphysis |
| **G** | Genial tubercle, the midpoint on genial tubercle |

**Table 3. Description of measurements**

| Measurement | Definition |
|---|---|
| *Linear measurement (unit: mm)* | |
| **Menton deviation** | Distance from Me to the midsagittal plane |
| **Occlusal plane cant** | Difference between the distances of mesiobuccal cusp of bilateral maxillary first molars to the FHP |
| **Mandibular body length** | Distance between $Go_{post}$ and Me |
| **Ramal length** | Distance between $Con_{sup}$ and $Go_{inf}$ |
| **Go-MSP** | Distance from $Go_{lat}$ to the midsagittal plane |
| **Go-HP** | Distance from $Go_{inf}$ to the FHP |
| **MtF-MSP** | Distance from MtF to the midsagittal plane |
| **MtF-HP** | Distance from MtF to the FHP |
| *Angular measurement (unit: °)* | |
| **Frontal ramal inclination** | Angulation between ($Con_{lat}$-$Go_{lat}$) and the midsagittal plane |
| **Lateral ramal inclination** | Angulation between ($Con_{post}$-$Go_{post}$) and the coronal plane |
| *Volume (unit: cc)* | |
| **Hemi-mandibular volume** | Mandibular volume divided into half by the plane connecting Me, B, and G |
| *Area (unit: $x10^3$ pixel)* | |
| **Hemi-lower facial area** | Half of the lower facial area bordered by the soft tissue outline, FHP and midsagittal plane |

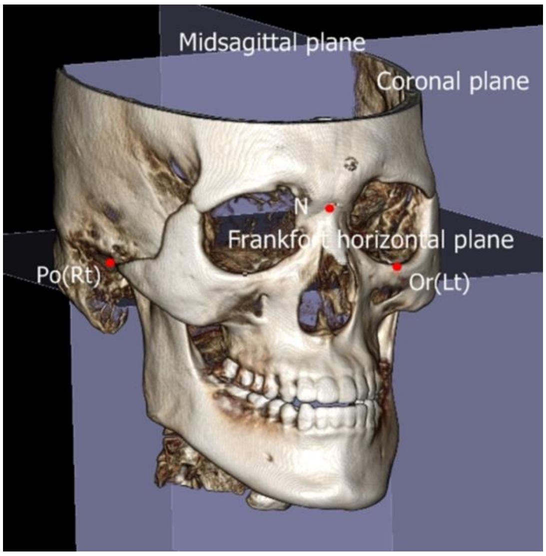


Figure 2. Reference planes. Po, porion; N, nasion; Or, orbitale; Rt, right; Lt, left.

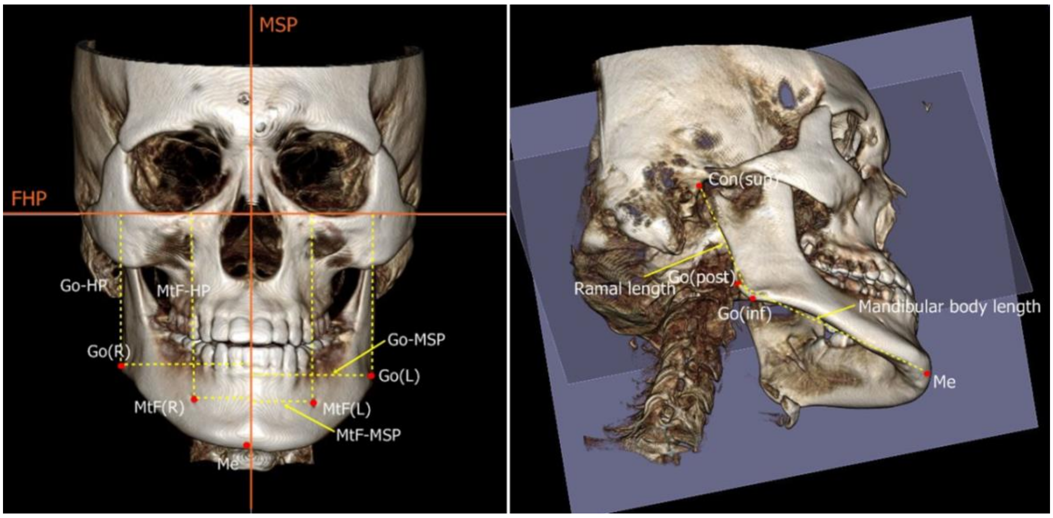


Figure 3. Linear measurements. MSP, midsagittal plane; FHP, Frankfort horizontal plane; R, right; L, left; Go, gonion; MtF, mental foramen; Con, condylion; Me, menton.

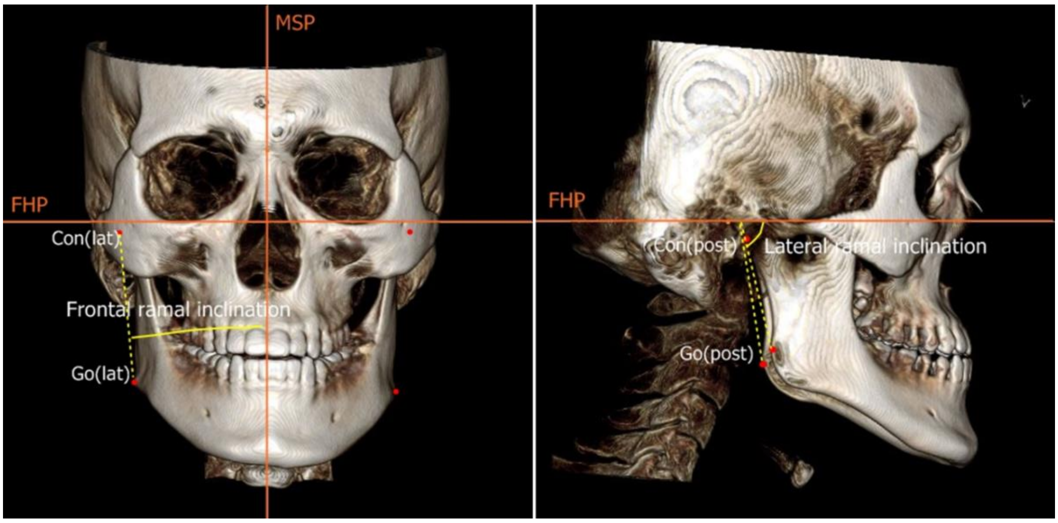


Figure 4. Angular measurements. MSP, midsagittal plane; FHP, Frankfort horizontal plane; Go, gonion; Con, condylion.

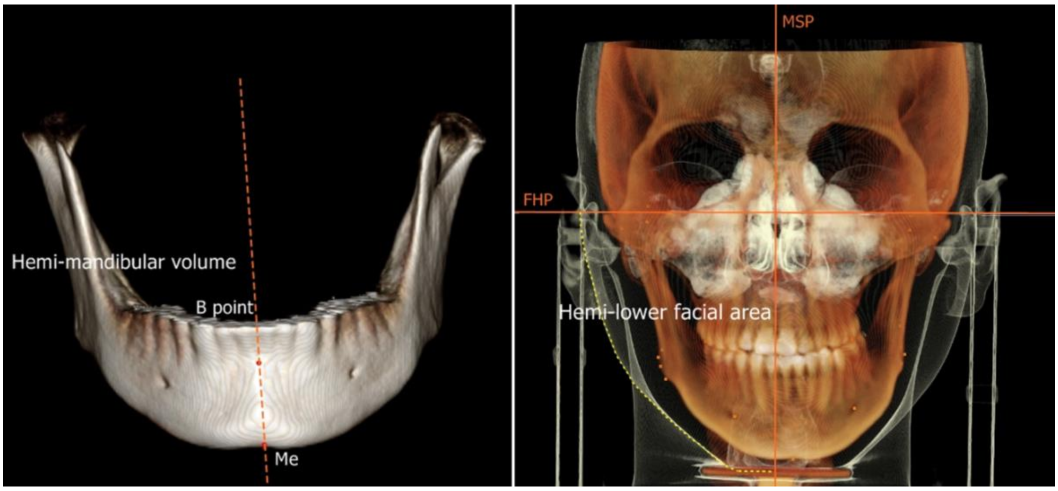


Figure 5. Area and volumetric measurements. MSP, midsagittal plane; FHP, Frankfort horizontal plane; Me, menton.

# III. Results

## 1. Comparisons before surgery: between deviated and nondeviated sides in each group and between the contralateral and ipsilateral groups

Even though we selected the ipsilateral group by matching age, sex, and degree of occlusal plane cant with the contralateral group, there was a significant difference of menton deviation between the two groups ($p < 0.01$; Table 1).

The mandibular body length of the nondeviated side was longer than deviated side ($p < 0.01$) and ramal length of the deviated side was longer than nondeviated side ($p < 0.05$) in the contralateral group. In the ipsilateral group, the mandibular body length showed no significant difference between the deviated and nondeviated sides ($p > 0.05$), and the ramal length of the nondeviated side was longer than that of the deviated side ($p < 0.05$).

The differences of horizontal distance from the deviated and nondeviated gonion and mental foramen to the midsagittal plane were significant in the ipsilateral group ($p < 0.05$), but not in the contralateral group ($p > 0.05$). The vertical positional differences of bilateral gonion and mental foramen were significant in the contralateral group ($p < 0.05$), but not in the ipsilateral group ($p > 0.05$).

In the ipsilateral group, ramus of the nondeviated side was inclined more medially ($p < 0.05$) and posteriorly ($p < 0.01$) than that of the deviated side. Otherwise, in the contralateral group, the frontal and lateral ramal inclination did not show significant differences between the deviated and nondeviated sides ($p > 0.05$).

There was no significant difference in hemi-mandibular volume between deviated and nondeviated side in both groups ($p > 0.05$). Hemi-lower facial area of the deviated side was larger than nondeviated side in both groups ($p < 0.05$).

Regarding to the between-group comparision, the asymmetric patterns of ramal length ($p < 0.01$) and distance from gonion to MSP ($p < 0.01$) showed significant differences between the two groups, in that the ramal length of the nondeviated side was longer than the deviated side in the ipsilateral group, but the tendency was reversed in the contralateral group. Likewise, the gonion of the nondeviated side was located lower in relation to the FHP than the nondeviated side in the ipsilateral group, and vice versa in the contralateral group. In addition, between-group comparison showed that the frontal ramal inclination of the nondeviated side and lateral ramal inclination of the deviated side were significantly different between the two groups ($p < 0.05$).Other variables showed that the degree of asymmetry of the two groups were similar (Table 4).

Table 4. Comparison of measurements at T0

| | Contralateral group | | | Ipsilateral group | | | Between groups |
|---|---|---|---|---|---|---|---|
| | D side | ND side | Difference | D side | ND side | Difference | p-value |
| **Linear measurement (mm)** | | | | | | | |
| Mandibular body length | 96.4±6.3 | 97.7±5.9 | -1.3±1.7** | 96.4±5.1 | 96.2±5.0 | 0.2±3.1 | 0.16 |
| Ramal length | 70.8±4.7 | 68.6±4.3 | 2.2±2.3* | 68.0±6.1 | 71.0±4.3 | -3.0±5.6 | <0.01 |
| Go-MSP | 51.2±3.6 | 50.1±3.2 | 0.3±3.4 | 51.4±3.8 | 48.0±4.3 | 3.4±4.5* | 0.07 |
| Go-HP | 68.7±3.8 | 66.1±4.5 | 2.7±2.2** | 66.1±4.8 | 68.2±3.5 | -2.0±4.7 | <0.01 |
| MtF-MSP | 24.9±3.5 | 23.0±2.3 | 1.9±5.1 | 28.4±3.8 | 19.3±3.0 | 9.2±6.2** | <0.01 |
| MtF-HP | 79.6±3.4 | 77.8±5.0 | 1.8±2.8* | 80.1±5.8 | 82.9±5.6 | -2.7±2.6** | 0.21 |
| **Angular measurement (°)** | | | | | | | |
| Frontal ramal inclination | 12.3±7.7 | 12.2±6.4 | 0.1±12.8 | 10.7±6.3 | 19.8±9.2 | -9.2±12.2* | 0.81/0.03 |
| Lateral ramal inclination | 99.6±3.0 | 101.6±4.2 | -2.0±3.4 | 95.3±3.8 | 98.7±4.3 | -3.4±2.5** | <0.01/0.11 |
| **Volume (㎤)** | | | | | | | |
| Hemi-mandibular volume | 18.6±2.5 | 18.9±2.8 | -0.3±1.1 | 18.9±2.8 | 19.8±3.8 | -0.1±1.6 | 0.28 |
| **Area (x10$^2$ pixel)** | | | | | | | |
| Hemi-lower facial area | 58.3±6.4 | 56.9±7.0 | 1.5±2.0* | 70.7±7.8 | 67.5±7.2 | 3.2±5.1* | 0.69 |

NS: non-significant, D: deviated side, ND: nondeviated side, Difference: measurement of deviation side - nondeviated side

*: P<0.05, **: P<0.01

Positive values indicate larger measurement on the deviated side and vice versa

Comparison between groups of frontal/lateral ramal inclination: difference of deviated side between groups/ difference of nondeviated side between groups

## 2. Surgical changes at T0-T1-T2

One month after surgery, the menton deviation was greatly improved in the ipsilateral group ($p < 0.01$), while it was not significantly changed in the contralateral group ($p > 0.05$). The ramal lengths and distances from gonion and mental foramen to the FHP decreased significantly ($p < 0.01$). The mental foramen of the deviated side moved significantly closer to the midsagittal plane in the ipsilateral group ($p < 0.01$). Hemi-mandibular volume of both deviated and nondeviated sides in both groups decreased significantly ($p < 0.01$). Hemi-lower facial area decreased significantly after surgery in the deviated side of the ipsilateral group and in the nondeviated side of the contralateral group ($p < 0.05$).

One year after surgery, the horizontal gonion width significantly decreased in both groups ($p < 0.05$). In the ipsilateral group, the ramal length of the deviated side was increased and the gonion moved downward ($p < 0.05$). There were no other significant differences in the retention period between the two groups.

From T0 to T2, the change between T0 and T1 was almost maintained. The menton deviation in the contralateral group which was not significantly changed after surgery did not show any significant change even after the retention period ($p > 0.05$) (Table 5).

**Table 5. Comparison of the measurements between T0, T1 and T2 in the two groups**

| | Contralateral group | | | Ipsilateral group | | |
|---|---|---|---|---|---|---|
| | T1-T0 | T2-T1 | T2-T0 | T1-T0 | T2-T1 | T2-T0 |
| Menton deviation | -0.4±1.7 | -0.2±0.8 | -0.6±1.8 | -3.7±2.1** | -0.3±0.5 | -4.0±2.2** |
| Occlusal plane cant | -0.9±1.1* | 0.1±0.5 | -1.0±1.1* | -1.2±1.1** | 0.3±0.6 | -0.9±1.0** |
| Mandibular body length(D) | -7.9±4.0** | 0.5±3.0 | -7.4±3.1** | -5.5±2.9** | 0.7±1.9 | -4.9±2.5** |
| Mandibular body length(ND) | -8.3±2.3** | -0.3±2.1 | -8.6±3.0** | -5.5±3.4** | -0.0±1.9 | -5.5±2.3** |
| Ramal length(D) | -12.8±4.2** | 2.6±5.1 | -10.2±3.0** | -10.1±4.0** | 3.1±2.6** | -6.9±3.1** |
| Ramal length(ND) | -10.8±3.5** | 2.1±3.4 | -8.7±3.0** | -12.0±3.8** | 2.1±4.0 | -9.9±2.2** |
| Go-MSP(D) | 4.1±2.6** | -2.1±2.7* | 2.1±3.6 | 3.4±3.0** | -1.3±1.7* | 2.2±2.6* |
| Go-MSP(ND) | 3.8±3.2** | -1.8±2.6* | 2.0±2.9* | 5.8±1.6** | -1.3±3.0 | 4.5±2.6** |
| Go-HP(D) | -11.4±3.5** | 2.0±4.7 | -9.4±3.0** | -8.2±3.6** | 2.2±2.3** | -6.1±3.1** |
| Go-HP(ND) | -9.0±2.9** | 1.2±2.9 | -7.8±2.2** | -10.5±3.6** | 1.9±3.6 | -8.6±2.2** |
| MtF-MSP(D) | -0.2±2.7 | 0.4±1.2 | 0.2±2.4 | -2.8±2.0** | 0.2±1.1 | -2.6±2.0** |
| MtF-MSP(ND) | -0.4±2.6 | 0.5±2.9 | 0.1±1.3 | 3.6±2.7** | -0.5±1.0 | 3.1±2.1** |
| MtF-HP(D) | -2.9±2.2** | -0.7±1.7 | -3.6±1.9** | -2.7±2.5** | -0.5±2.0 | -3.2±2.9** |
| MtF-HP(ND) | -1.2±2.8 | -1.1±2.0 | -2.3±2.4** | -4.3±2.6** | -0.2±2.1 | -4.5±2.4** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Frontal ramal inclination(D) | 0.6±10.5 | -0.9±8.3 | -0.2±8.3 | -0.2±8.8 | -0.5±11.2 | -0.7±10.7 |
| Frontal ramal inclination(ND) | 10.1±46.5 | 7.7±48.5 | 2.4±11.8 | -0.4±11.4 | 0.5±9.9 | -0.8±14.7 |
| Lateral ramal inclination(D) | -0.8±3.7 | 2.8±3.4* | 2.0±3.4 | -2.1±4.5 | 3.6±4.9* | 1.5±4.0 |
| Lateral ramal inclination(ND) | -1.8±4.3 | 3.6±1.8** | 1.8±3.5 | -2.2±4.0 | 1.2±4.5 | -1.0±5.8 |
| Hemi-mandibular volume(D) | -1.6±1.6** | 0.2±1.3 | -1.4±2.3 | -1.9±1.0** | 0.4±1.0 | -1.5±1.2** |
| Hemi-mandibular volume (ND) | -2.0±1.4** | 0.4±1.0 | -1.6±1.8* | -2.0±1.5** | 0.5±1.3 | -1.5±1.6* |
| Hemi-lower facial area(D) | -7.4±14.0 | 32.6±96.7 | 25.2±98.4 | -20.1±21.4** | -6.3±32.3 | -26.4±38.0* |
| Hemi-lower facial area(ND) | -6.5±9.4* | 29.6±92.7 | 23.1±90.0 | 9.9±29.7 | -11.9±29.5 | -2.0±31.4 |

T0, before surgery; T1, 1 month after surgery; T2, 1 year after surgery

*, P<0.05; **, P<0.01.

### 3. Comparisons one year after surgery: between deviated and nondeviated sides in each group and between the contralateral and ipsilateral groups

One year after surgery, unlike before surgery, most measurements did not show significant differences between the deviated and nondeviated sides in both groups. However, in the contralateral group, the hemi-facial area of the deviated side remained significantly larger than the nondeviated side ($p > 0.05$).

Comparison between the two groups showed that the degree of asymmetry of the two groups were similar except for the vertical position of mental foramen ($p > 0.05$) (Table 6).

**Table 6. Comparison of the measurements at T2**

| | Contralateral group | | | Ipsilateral group | | | Between groups |
|---|---|---|---|---|---|---|---|
| | D side | ND side | Difference | D side | ND side | Difference | p-value |
| **Linear measurement (mm)** | | | | | | | |
| Menton deviation | | 1.4±1.2 | | | 1.8±1.8 | | 0.45 |
| Occlusal plane cant | | 1.1±0.9 | | | 1.1±0.6 | | 0.98 |
| Mandibular body length | 89.0±6.9 | 89.1±5.2 | -0.1±3.7 | 91.5±5.4 | 91.5±5.4 | 0.9±3.1 | 0.50 |
| Ramal length | 60.6±6.1 | 59.9±5.4 | 0.8±3.9 | 61.1±6.6 | 61.2±4.8 | -0.0±3.9 | 0.63 |
| Go-MSP | 53.2±3.6 | 52.8±3.3 | 0.4±3.8 | 53.6±3.2 | 52.5±3.9 | 1.1±3.3 | 0.64 |
| Go-HP | 59.3±5.0 | 58.2±4.9 | 1.1±3.1 | 60.0±5.5 | 59.5±3.3 | 0.5±4.0 | 0.68 |
| MtF-MSP | 25.1±2.2 | 23.0±2.1 | 2.1±3.9 | 25.8±2.4 | 22.4±2.9 | 3.4±4.2* | 0.04 |
| MtF-HP | 76.0±3.4 | 75.5±4.1 | 0.6±1.8 | 76.9±5.7 | 78.4±5.1 | -1.4±2.5 | 0.42 |
| **Angular measurement (º)** | | | | | | | |
| Frontal ramal inclination | 12.1±8.2 | 14.6±11.1 | -2.5±18.0 | 12.5±19.0 | 18.6±12.6 | -6.0±12.5 | 0.94/0.42 |
| Lateral ramal inclination | 101.7±3.3 | 103.4±4.3 | -1.8±3.2 | 96.8±4.2 | 97.7±3.9 | -0.9±4.6 | <0.01/<0.01 |
| **Volume (㎤)** | | | | | | | |
| Hemi-mandibular volume | 17.3±3.3 | 17.3±3.2 | 0.0±0.9 | 18.3±3.6 | 18.3±3.6 | -0.0±1.1 | 0.92 |
| **Area (x$10^2$ pixel)** | | | | | | | |
| Hemi-lower facial area | 60.9±13.4 | 59.2±12.5 | 1.6±2.4* | 68.0±6.4 | 67.3±6.9 | 0.7±4.1 | 0.52 |

NS, non-significant; D, deviated side; ND, nondeviated side; Difference, measurement of deviation side - measurement of nondeviation side

*, P<0.05; **, P<0.01

Positive values indicate larger measurement on the deviated side and vice versa

Difference between groups of frontal/lateral ramal inclination, difference of deviated side between groups/difference of nondeviated side between groups

# IV. Discussion

In this study, we analyzed the morphological differences 3-dimensionally in the preoperative condition and compared the surgical changes one month after and one year after the surgery between the contralateral and ipsilateral groups. This study demonstrated that the different skeletal features, such as the length of the mandibular body and ramus, and the slope of the ramus contribute to the opposite direction of menton lateral deviation in relation to the inclination of FOP in the contralateral group. After orthognathic surgery, the facial asymmetry was improved in both groups, but the change in menton lateral deviation was not statistically significant in the contralateral group. Moreover, in evaluation of asymmetry including the soft tissue, there was residual asymmetry in the contralateral group one month after surgery and after one-year retention period.

The contralateral group had some morphological characteristics that were differentiated from the ipsilateral group. The ramus on the side of maxillary downward cant was longer, but the mandibular body on the nondeviated side was longer than the deviated side that the menton was deviated to the side of maxillary downward cant. In the ipsilateral group, the ramal length, like in the contralateral group, was longer on the side of maxillary downward cant, but the mandibular body length did not show statistically significant differences between the deviated and nondeviated sides. Therefore, the reason for the opposite direction of menton deviation in the contralateral group is due to the difference in the length of mandibular body between the deviated and nondeviated side of the contralateral group.

The differences of the horizontal linear measurements between the deviated and nondeviated sides were not statistically significant, while the differences of the vertical linear measurement were statistically significant in the contralateral group. In other words, in the contralateral group, asymmetry of the vertical elements is more prominent than asymmetry of the horizontal elements.

In the ipsilateral group, ramus of the nondeviated side inclined medially to the midsagittal plane, and which contributes to the deviation of the menton in the opposite direction. On the other hand, in the contralateral group, rami of both sides have similar inclination when viewed from the front.

Asymmetry types with similar features to the contralateral group of the present study have been mentioned in previous studies. Hwang et al. (Hwang et al., 2007) reported that this type of asymmetry occurs when menton is deviated toward the side of shorter ramus, and the cause of this asymmetry is independent of asymmetric condylar growth. Baek et al. (Baek et al., 2012) named this characteristic asymmetry as atypical asymmetry, and reported that maxillary canting and mandibular overriding on the opposite side of menton deviation are its two main characteristics. Kim et al. (Kim et al., 2014) also classified this type of asymmetry as M1 who had presence of menton deviation and maxillary cant in opposite directions. These features are also similar to those of patients in group 3 that was categorized by Chen et al. (Chen et al., 2016) and characterized by a yaw rotation of the mandible to the side with lesser growth of ramus. Considering all these studies, the differential growth of mandibular body rather than the ramus and yawing of the mandible toward the side of shorter ramus may cause the contralateral type of asymmetry.

Another possible cause was suggested by Tay (Tay, 1994) that unilateral mastication was related to a certain type of mandibular asymmetry, and by Ingervall (Ingervall, 1976) that masticatory muscle activity could influence facial morphology. Hwang et al. (Hwang et al., 2007) presumed that unilateral masticatory habit may cause the contralateral type of mandibular asymmetry: the chewing side of the mandible became low angle and the non-chewing side became high angle.

Occlusal plane cant was improved immediately after surgery in both groups and the improvement was maintained after one-year retention period. On the other hand, menton deviation of the contralateral group was not improved significantly. This is because, as previously assumed, the direction of the roll rotation of the maxillo-mandibular complex which improves the occlusal plane cant is reversed to the direction to correct menton lateral deviation. In addition, Kim et al. (Kim et al., 2014) mentioned that, because of the complexity and unpredictability of the soft tissue changes, degree of horizontal asymmetry and cant improvement apart from the menton correction, surgeons tend to compromise the degree of menton correction in this type of asymmetry. Another reason could be that the contralateral group did not have a large amount of menton deviation at the initial stage. However, menton deviation in the contralateral group showed a tendency to decrease. The reason for the decrease in menton deviation without deterioration was that other movement of the mandibular distal segment other than roll rotation, such as yaw rotation to the nondeviated side or adjunctive surgery like genioplasty and unilateral mandible shaving, was done during the surgery.

There was significant improvement in horizontal asymmetry in the ipsilateral group, but not in the contralateral group. This is because initial horizontal asymmetry of the contralateral group was not significant, and in the ipsilateral group the roll rotation of the maxillo-mandibular complex to correct vertical discrepancy was favorable for the correction of horizontal asymmetry. Therefore, orthognathic surgery in the contralateral group should be planned to focus on improving existing vertical asymmetry rather than horizontal asymmetry and preventing horizontal asymmetry from being worsened after surgery.

Good et al. (Good et al., 2006) have suggested a photographic method to evaluate mandibular asymmetry that is visible to bare eyes including the soft tissue outline. In the present study, we adopted a similar way using CBCT images. One month after surgery, the difference of the hemi-lower facial area of the two sides in the contralateral group became greater than before surgery. The tendency was maintained after the retention period. This may be due to the different soft tissue characteristics such as muscle running pattern, or different soft tissue adaptation after surgery between the two groups. Therefore, in patients with contralateral type of asymmetry, even after the skeletal correction, the difference in hemi-lower facial area including the soft tissue may be worsened, so the necessity of additional surgery such as augmentation of the narrow hemi-facial area should be considered when designing the STO.

Some limitations did exist in this study. The sample size was too small to generalize the findings. In addition, this study was performed retrospectively and did not observe the dental features such as dental compensation. Future prospective studies are required to analyze not only skeletal and soft tissue changes but also dental changes in both groups with larger sample sizes.

# V. Conclusion

In this study, we investigated the morphological differences and compared the treatment outcomes between the contralateral and ipsilateral types of facial asymmetry. In the contralateral group, long mandibular body length of the nondeviated side induces the lateral deviation of the menton to the opposite side, unlike in the ipsilateral group whose bilateral mandibular body did not show significant differences in length. After the orthognathic surgery, although there was an improvement of facial asymmetry in both groups, the changes in menton deviation in the contralateral group was not statistically significant. In addition, the difference of bilateral hemi-lower facial area before surgery increased even after the surgery and did not improve after the retention period. Therefore, surgeons should pay attention to the possibility of increase in the difference of bilateral hemi-lower facial area and consider the need of adjunctive surgery such as augmentation in the deficient side when treating patients with the contralateral type of facial asymmetry.

# VI. References


Baek C, Paeng JY, Lee JS, Hong J: Morphologic evaluation and classification of facial asymmetry using 3-dimensional computed tomography. *J Oral Maxillofac Surg* 70(5): 1161-1169, 2012.

Bruce RA, Hayward JR: Condylar hyperplasia and mandibular asymmetry: a review. *J Oral Surg* 26(4): 281-290, 1968.

Buranastidporn B, Hisano M, Soma K: Temporomandibular joint internal derangement in mandibular asymmetry. What is the relationship? *Eur J Orthod* 28(1): 83-88, 2006.

Chen YJ, Yao CC, Chang ZC, Lai HH, Lu SC, Kok SH: A new classification of mandibular asymmetry and evaluation of surgical-orthodontic treatment outcomes in Class III malocclusion. *J Craniomaxillofac Surg* 44(6): 676-683, 2016.

Good S, Edler R, Wertheim D, Greenhill D: A computerized photographic assessment of the relationship between skeletal discrepancy and mandibular outline asymmetry. *Eur J Orthod* 28(2): 97-102, 2006.

Habets LL, Bezuur JN, Naeiji M, Hansson TL: The Orthopantomogram, an aid in diagnosis of temporomandibular joint problems. II. The vertical symmetry. *J Oral Rehabil* 15(5): 465-471, 1988.

Hwang HS, Youn IS, Lee KH, Lim HJ: Classification of facial asymmetry by cluster analysis. *Am J Orthod Dentofacial Orthop* 132(3): 279 e271-276, 2007.

Ingervall B: Facial morphology and activity of temporal and lip muscles during swallowing and chewing. *Angle Orthod* 46(4): 372-380, 1976.

Inui M, Fushima K, Sato S: Facial asymmetry in temporomandibular joint disorders. *J Oral Rehabil* 26(5): 402-406, 1999.

Kim JY, Jung HD, Jung YS, Hwang CJ, Park HS: A simple classification of facial asymmetry by TML system. *J Craniomaxillofac Surg* 42(4): 313-320, 2014.

Kim SJ, Baik HS, Hwang CJ, H.S. Y: Diagnosis and evaluation of skeletal Class III pateints with facial asymmetry for orthognathic surgery using three-dimensional computed tomography. *Semin Orthod* 21(4): 274-282, 2015.

Maeda M, Katsumata A, Ariji Y, Muramatsu A, Yoshida K, Goto S, et al.: 3D-CT evaluation of facial asymmetry in patients with maxillofacial deformities. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 102(3): 382-390, 2006.

Obwegeser HL, Makek MS: Hemimandibular hyperplasia--hemimandibular elongation. *J Maxillofac Surg* 14(4): 183-208, 1986.

Park SH, Yu HS, Kim KD, Lee KJ, Baik HS: A proposal for a new analysis of craniofacial morphology by 3-dimensional computed tomography. *Am J Orthod Dentofacial Orthop* 129(5): 600 e623-634, 2006.

Reyneke JP, Tsakiris P, Kienle F: A simple classification for surgical treatment planning of maxillomandibular asymmetry. *Br J Oral Maxillofac Surg* 35(5): 349-351, 1997.

Tay DK: Physiognomy in the classification of individuals with a lateral preference in mastication. *J Orofac Pain* 8(1): 61-72, 1994.

Uesugi S, Yonemitsu I, Kokai S, Omura S, Ono T: Morphological feature of subjects with facial asymmetry with the frontal occlusal plane inclined toward the contralateral side of the mandibular deviation. *Jpn J Jaw Deform* 24: 27-36, 2014.

Uesugi S, Yonemitsu I, Kokai S, Takei M, Omura S, Ono T: Features in subjects with the frontal occlusal plane inclined toward the contralateral side of the mandibular deviation. *Am J Orthod Dentofacial Orthop* 149(1): 46-54, 2016.

You KH, Lee KJ, Lee SH, Baik HS: Three-dimensional computed tomography analysis of mandibular morphology in patients with facial asymmetry and mandibular prognathism. *Am J Orthod Dentofacial Orthop* 138(5): 540 e541-548; discussion 540-541, 2010.

국문요약

# 상악의 기울기 양상에 따른 안면 비대칭 환자의 진단과 치료 결과

<지도교수: 최 윤 정, D.D.S., M.S.D., Ph.D.>

연세대학교 대학원 치의학과

권 선 미

안면비대칭은 흔히 나타나는 현상이며, 안면비대칭의 정확한 평가를 위해서는 3차원적인 분석이 필요하다. 상악골의 비대칭은 주로 교합평면의 경사의 형태로 나타나며, 하악골에서는 주로 이부의 편위로 나타난다. 대부분의 경우 안면비대칭 환자에서는 교합평면이 편위된 방향과 이부의 편위 방향이 같지만, 일부 환자에서는 상악 교합평면과 이부가 편위된 방향이 반대로 나타나기도 한다.

본 연구에서는 악교정 수술을 받은 안면비대칭 환자를 상악 교합평면과 이부 편위 방향이 같은 그룹과 반대인 두 그룹으로 나누고, 3차원 CBCT 자료를 분석하여 두 그룹의 형태학적 차이와 악교정 수술의 결과를 비교해 보았으며, 이를 통해 비전형적

비대칭 양상을 보이는 환자들의 진단 정확성을 높이고 우수한 결과를 얻기 위해 고려할 점에 대해 고찰해보고자 하였다.

이번 연구에서는 2012년 1월부터 2016년 12월까지 연세대학교 치과대학병원 구강악안면외과에서 악교정 수술을 받았고, 수술 전(T0)과 수술 1개월 후(T1), 수술 1년 후(T2)에 안면부 CBCT를 촬영한 총 296명의 환자 중 교합평면 기울기 방향과 이부 편위 방향이 반대인 12명의 환자를 선정하여 contralateral group (남자 8명, 여자 4명, 평균 연령 22.3세)으로 명명하였으며, contralateral group과 나이, 성별 및 교합평면 기울기 정도가 비슷하며 교합평면 기울기 방향과 이부 편위 방향이 같은 환자 12명을 선정하여 ipsilateral group (남자 8명, 여자 4명, 평균 연령 20.8세)으로 구분하였다. 두 그룹에서 촬영한 CBCT 상을 3차원 영상으로 재구성하여 길이 및 각도, 부피, 면적 등의 계측치들을 측정하였고, 그룹 내 편위측과 비편위측간 비교 및 그룹간 차이를 비교, 분석하였다.

1. Contralateral group에서는 비편위측 하악체 길이가 편위측보다 매우 길게 나타나 menton이 교합평면 기울기와 반대방향으로 편위되었다($p = 0.024$).

2. Contralateral group에서는 양쪽 gonion과 mental foramen에서 정중 시상면까지의 수평적 거리 차이와 같은 수평적 비대칭 양은 유의하지 않았고($p > 0.05$), gonion과 mental foramen에서 FHP까지의 수직적 거리 차이 등 수직적 비대칭 양은 유의하게 나타났다($p < 0.05$).

3. 수술 1개월 후와 1년 후 두 그룹 모두 비대칭의 정도가 개선되었으나 contralateral group에서 menton deviation의 개선량은 통계적으로 유의하지 않았다 (p = 0.265).

4. 수술 1개월 후와 1년 후 contralateral group에서 연조직을 포함한 반안면 면적 차이는 수술 전에 비해 오히려 증가하였다.

5. 수술 직후부터 1년 후까지 유지기간 동안 두 그룹의 재발 양상은 큰 차이를 나타내지 않았다.

따라서 contralateral group에서의 비대칭 수술은 수평적 비대칭의 개선보다는 수직적 비대칭의 개선에 집중하고 이에 따라 나타날 수 있는 수평적 비대칭의 심화를 막는 방향으로 계획되어야 한다. 또한, 임상의는 contralateral group의 수술에서 연조직을 포함한 반안면 면적 차이가 증가할 수 있다는 가능성을 인지하고 이를 STO 시 고려해야 하며, 부가적 수술의 필요성을 염두에 두어야 할 것이다.

---

**핵심이 되는 말: 안면 비대칭, roll rotation, 3차원 분석, 악교정 수술**