Assessing soft-tissue characteristics of facial asymmetry with photographs

Mi-song Lee,a Dong Hwa Chung,b Jin-woo Lee,c and Kyung-suk Cha\textsuperscript{d}
Cheonan, Korea

Introduction: Precise diagnosis and treatment of facial asymmetry are important in orthodontics. The aims of this study were to determine the soft-tissue characteristics of patients perceived to have severe asymmetry requiring treatment and the soft-tissue factors affecting the subjective assessment of facial asymmetry.

Methods: In the first part of this study, 5 observers examined 1000 photographs of patients receiving orthodontic treatment and selected 100 for further assessment. These photographs showed 50 patients who were considered to have little or moderate asymmetry and 50 who were considered to have severe asymmetry. A pilot study was performed to select the reference photographs representing the most symmetric (score of 0) and the most asymmetric (score of 100). A panel of 9 orthodontists then rated the facial asymmetry of the 100 patients on a 100-mm visual analog scale. The scale was divided into 3 equal regions. Region 1 included patients with the least facial asymmetry; according to the orthodontists, these patients did not require treatment. Region 2 included patients with moderate facial asymmetry who did not require treatment. Region 3 included patients with the most facial asymmetry who did require treatment. Results: One-way analysis of variance showed that lip canting, chin deviation, body inclination difference, and gonial angle difference had significant differences between the groups. Chin deviation and gonial angle difference were significant factors affecting the assessment of facial asymmetry, according to stepwise linear regression analysis. Conclusions: These results will help in the diagnosis and treatment planning for patients with asymmetry. (Am J Orthod Dentofacial Orthop 2010;138:23-31)

About 80% of adults who seek orthodontic treatment want to improve facial aspects that are not associated with structural or functional problems.\textsuperscript{1} Patients who do not perceive their facial asymmetry in the early stage of orthodontic treatment might begin to recognize it as treatment progresses.\textsuperscript{2,3} De Smit and Dermault\textsuperscript{4} and Foster\textsuperscript{5} reported that faces with ideal proportions and symmetry are not beautiful. On the other hand, they reported that abnormal proportions and asymmetric faces have unfavorable aspects.

The correction of facial asymmetry is becoming an important goal of orthodontic treatment and orthognathic surgery. It has been reported that all patients have some craniofacial asymmetry, including those perceived as normal.\textsuperscript{6} Ferrario et al\textsuperscript{7} found variable degrees of soft-tissue facial asymmetry in healthy white dental students with normal dentition. Therefore, it is widely recognized that facial asymmetry is often present in the normal craniofacial complex. In addition, it was reported that an occlusal cant of 0° to 3° has been observed in normal, healthy patients.\textsuperscript{8,9} There is no invisible demarcation line, or even a range, marking the distinction between normal and abnormal asymmetry in terms of soft-tissue characteristics. A demarcation line determining the necessity of orthognathic surgery for facial asymmetry is also unknown. The borderline between normal and abnormal asymmetry might be determined by subjective evaluation such as the patient’s, or the orthodontist’s, perception of facial asymmetry.

Although cephalometric measurements address skeletal symmetry,\textsuperscript{10} subjective evaluations, such as the perception of facial asymmetry, might be based on soft-tissue features, including the outline of the face. Robinson et al\textsuperscript{11} reported that a beautiful face should be harmonious with comparable size and position of the skeletal structures and soft tissues. They stated that a favorable face can be shown by the soft tissues.

A diagnosis of facial asymmetry is normally made based on the measurements from a posteroanterior cephalogram or 3-dimensional (3D) skeletal computed tomography (CT) images by a clinician. However, the
patient’s decision for treatment or satisfaction with the
result is subjective and can be assessed by a perceptive
assessment. There is a gap between the patient and the
clinician in terms of the assessment of facial asymmetry.
Therefore, the first assessable tool for patients with
facial asymmetry must be the soft tissues.

There has only been 1 study on the correlation
between the perception of facial asymmetry and the
cephalometric measurements, and no reports of the
relationship between the perception of facial asymmetry
and the soft-tissue measurements.

The aims of this study were to survey the facial fron-
tal photographs by subjectively evaluating facial asym-
metry with a visual analog scale (VAS) and to determine
the differences in soft-tissue measurements between the
groups. The next steps were to determine the soft-tissue
characteristics of patients perceived as having severe
asymmetry and the borderline of abnormal asymmetry.
Finally, the factors affecting the severity of the subjec-
tive assessment of facial asymmetry were determined.
This study should help clinicians make a differential
diagnosis of asymmetric patients and develop an
appropriate treatment plan.

MATERIAL AND METHODS

Five observers screened 1000 standardized facial
frontal photographs and selected 50 with little or no fa-
cial asymmetry and another 50 with moderate or severe
facial asymmetry. The inclusion criteria were as
follows: over 18 years of age, no congenital abnor-
malities in the maxillofacial region, no prior surgery for an
injury involving the maxilla or the mandible, and stan-
dardized facial photographs taken before treatment
with sufficient quality for evaluation.

The final sample consisted of photographs of 61
women and 39 men (ages, 18.0-30.1 years; mean, 25.1
years). The photographs had been taken with a digital
camera (350D, Canon, Seoul, Korea) with a distance of
1.5 m between the patient and the focus. The patients
were seated upright on a special chair, with the Frank-
fort plane parallel to the floor. The patients looked
directly at the camera lens. Both ears were exposed,
and the right and left distances between the exocanthus
and the hairline were the same. The patients were in
occlusal rest position.

The color photographs were printed individually on
size A4 paper. The printed photographs were used to
measure several soft-tissue measurements.

Five orthodontists in the Department of Orthodontics,
Dankook University, Cheonan, Korea, selected the 5 most
symmetric facial photographs and the 5 most asymmetric
facial photographs. The photographs selected most
frequently were called the reference photographs to
represent the most symmetric and the most asymmetric
faces; they were assigned scores of 0 and 100.

A panel of 9 orthodontists from the Department of Or-
thodontics, Dankook University, were asked to judge the
100 frontal photographs. The photographs were pre-
sented for 1 minute each, in random order. The orthodon-
tists rated the facial asymmetry on a 100-mm VAS,
marked “most symmetric” (0) on the left and “most
asymmetric” (100) on the right. A 100-mm ruler was di-
vided into 3 equal regions, and the meaning of the regions
was explained to the panel. Region 1 included patients
with little or no facial asymmetry and not requiring treat-
ment. Region 2 included patients with moderate facial
asymmetry but still not requiring treatment. Region 3 in-
cluded patients with the most facial asymmetry who re-
quired treatment. All assessments were subjective.

During the session, the 2 reference slides represent-
ing 0 and 100 on the VAS were projected continuously.
The panel was told of these set scores. The assessments
were repeated twice with 2 weeks between sessions.

When each judge had finished, the 100-mm VAS
values were measured to the nearest 0.1 mm by using a
caliper and recorded on a data sheet. The raw data
were entered in an Excel spreadsheet (Microsoft,
Redmond, Wash).

The 9 assessment scores of each patient were aver-
aged. The average scores from first and second sessions
of each patient were compared by using the Student t
test. The difference between assessments was not signif-
ificant. Therefore, the second-session scores were used.

The patients were classified into 3 groups according
to the average assessment scores in the previously fixed
regions. Group I patients had scores of 0 to 33.3, group
II patients had scores of 33.4 to 66.7, and group III
patients had scores of 66.8 to 100. The printed frontal
photographs were measured to analyze the soft-tissue
characteristics of each group.

The soft-tissue landmarks used in this study are
described in Table I and Figure 1. Most points used in
this study were proposed by Farkas.

The midsagittal reference line was defined as the
line from glabella to subnasale. The horizontal refer-
ence line was the line perpendicular to the midsagittal
line passing through the midpoint of both pupils. Ten
lines, except for the midsagittal and horizontal reference
lines, were established. These lines were used for the
angular measurements. These were the bipupillary
line, otobasion inferius line, lip line, gonion line, pronas-
ale line, chin line, ramus line (right and left), and mand-
ibular body line (right and left) (Table II).

Nine angular and 2 linear measurements were made.
The angular measurements were eye canting, otobasion
canting, lip canting, gonion canting, nose deviation, chin deviation, ramal inclination difference, body inclination difference, and gonial angle difference. Table III gives the definitions of these measurements. Eye canting, otobasion canting, lip canting, and gonion canting were measured by using the horizontal reference line. Nose deviation, chin deviation, ramal inclination, and body inclination were measured by using the midsagittal reference line. The ramal inclination difference, body inclination difference, and gonial angle difference were measured to calculate the difference between the right and left angles. All angular measurements were used as absolute quantities.

Statistical analysis

The linear measurements were calculated by using the asymmetry index (Table III). Each distance for right and left soft-tissue gonion (Gó) was measured from the midsagittal and horizontal reference planes, respectively. The asymmetry indexes were calculated with the following formula:

\[ \text{asymmetry index (\%) = } \frac{|R - L|}{M} \times 100, \]

where \( R \) is the value of the right distance, \( L \) is the value of the left, and \( M \) is the average of the right and left values.

The distance for Gó from the midsagittal plane was defined as the horizontal Gó value. The distance from the horizontal plane was defined as the vertical Gó value. Therefore, there were 2 types of asymmetry indexes: for horizontal Gó and vertical Gó. The asymmetry index for horizontal Gó is the ratio of the right and left horizontal Gó lengths; the horizontal Gó length means the length from the midsagittal reference line to Gó (right and left). The asymmetry index for vertical Gó is the ratio of the right and left vertical Gó length; the vertical Gó length means the length from the horizontal reference line to Gó (right and left).

The SPSS software program (version 10.0, SPSS, Chicago, Ill) was used. One-way analysis of variance (ANOVA) was used to analyze the differences among the 3 groups. Bonferroni tests were performed for post-hoc analysis of the differences. The sex differences were examined with the Student \( t \) test.

Stepwise linear regression analysis was performed to determine the independent variables that were associated most closely with the assessment of facial asymmetry (dependent variables). The linear regression equation was:

\[ Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k \]

where, \( \alpha, \beta_1, \) and \( \beta_2 \ldots \beta_k \) are constants, and \( X_1, X_2 \ldots \), and \( X_k \) are independent variables that are combined linearly to explain the variation in the dependent variable (\( Y \)).

Reliability was assessed by using duplicate measures on a subset of randomly selected photographs scored 2 weeks apart. Systemic error, assessed by comparing the mean differences between replicates to the standard error, was not statistically significant. The random technical error was calculated by using Dahlberg’s formula.\(^{18}\) The method error was <2.0° for all measurements except for ramus inclination difference, which was 2.5°.

RESULTS

The patients were classified into 3 groups by using the assessment scores of facial asymmetry. Group I included patients with little or no facial asymmetry, not requiring treatment. Group II included patients with moderate facial asymmetry but not requiring treatment. Group III included patients with severe asymmetry, requiring treatment. One-way ANOVA showed that lip canting, chin deviation, body inclination difference, and gonial angle difference were significantly different between the groups. In group I, the mean scores of the

<table>
<thead>
<tr>
<th>Landmark</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pp (pupil)</td>
<td>The apparently black circular opening in the center of the iris of the eye</td>
</tr>
<tr>
<td>G (glabella)</td>
<td>The most forward projecting point of the forehead in the midline of the supraorbital ridges</td>
</tr>
<tr>
<td>Na’ (soft-tissue nasion)</td>
<td>The middle point of the soft-tissue frontonasal suture</td>
</tr>
<tr>
<td>O (otobasion inferius)</td>
<td>The inferior insertion of the ear</td>
</tr>
<tr>
<td>Sn (subnasale)</td>
<td>The point at which the columella merges with the upper lip in the midsagittal plane</td>
</tr>
<tr>
<td>Pr (pronasale)</td>
<td>The middle point of the outline of the nose tip</td>
</tr>
<tr>
<td>Ch (cheilion)</td>
<td>The most lateral extent of the outline of the lips</td>
</tr>
<tr>
<td>Me´ (soft-tissue menton)</td>
<td>The most inferior point of the soft-tissue outline on the chin</td>
</tr>
<tr>
<td>Gó (soft-tissue gonion)</td>
<td>The most everted point of the soft-tissue outline of the angle of the mandible</td>
</tr>
<tr>
<td>Pre (preauriculare)</td>
<td>The most lateral point of the soft-tissue facial outline in front of tragus</td>
</tr>
<tr>
<td>Zero point</td>
<td>The intersection of midsagittal line and horizontal line</td>
</tr>
</tbody>
</table>
factors for lip canting, chin deviation, body inclination difference, and gonial angle difference were 1.61°, 1.11°, 2.80°, and 2.31°, respectively. In group II, the mean scores were 2.29°, 2.00°, 3.75°, and 3.05°, respectively. In group III, the mean scores were 3.09°, 3.64°, 7.11°, and 6.14°, respectively (Table IV).

The sex differences were not significant statistically according to the Student t test. Chin deviation tendency of each group was evaluated in Table V. Pearson correlation coefficients were examined to determine the factors affecting the assessment of facial asymmetry (Table VI). The affecting factors were found to be lip canting, chin deviation, ramus inclination difference, body inclination difference, and gonial angle difference. The Pearson correlation coefficients for lip canting, chin deviation, ramus inclination difference, body inclination difference, and gonial angle were 0.33°, 0.59°, 0.21°, 0.48°, and 0.44°, respectively.

Stepwise linear regression analysis was used to understand the affecting factors better (Table VII). The analysis showed that chin deviation and gonial angle difference significantly affected the assessment of facial asymmetry. Therefore, 2 regression equations were made. The following regression equation was used to include both factors:

\[ Y = 6.8X_1 + 1.7X_2 + 27.9 \]

where \( Y \) means the assessment of facial asymmetry (scores), \( X_1 \) means chin deviation (degrees), and \( X_2 \) means gonial angle difference (degrees). The coefficients of these factors were 6.8° and 1.7° for chin deviation and gonial angle difference, respectively, and the constant was 27.9.

If we include the most powerful independent factor, we can make a simple equation about chin deviation and the assessment of facial asymmetry (Fig 2).

**DISCUSSION**

Facial asymmetry was investigated subjectively in relation to the soft-tissue features by using frontal photographic measurements. Naoya reported a subjective evaluation of facial asymmetry using frontal photographs. In that study, 10 orthodontists classified 100 facial frontal photographs; there was a correlation between the subjective evaluation of facial asymmetry and the cephalometric indexes. However, the author did not report the soft-tissue factors responsible for the assessment. We examined the relationship between the assessment of facial asymmetry and the soft-tissue characteristics using frontal facial photographs. Nine orthodontists were asked to score the frontal photographs using a VAS, and the factors that affect facial asymmetry assessment were established. The frontal photographs were classified into 3 groups according to the assessment scores.

Group I contained patients considered almost symmetric who needed no treatment. Group II included...
patients with moderate asymmetry who did not require treatment. Group III comprised patients with severe asymmetry who required treatment.

ANOVA (Table IV) showed that chin deviation, body inclination difference, gonial angle difference, and lip canting were significantly distinct variables between the groups. The mean values in group III were 3.1°/C14, 3.6°/C14, 7.1°/C14, and 6.1°/C14 for lip canting, chin deviation, body inclination difference, and gonial angle difference, respectively. These values from experts suggest criteria for assessing asymmetric patients.

Skeletal analysis with x-rays has been used to diagnose facial asymmetry. Generally, orthodontists evaluate facial asymmetry by analyzing the facial skeleton quantitatively using frontal cephalometry. They establish a midsagittal reference plane and compare the difference between the right and left values. Ricketts et al19 and Svanholt and Solow20 evaluated facial asymmetry by measuring the angles in frontal cephalometry. Solow21 and Nakasima and Ichinose22 measured height and dimensions. Vig and Hewitt23 measured areas and compared both sides. These authors basically used the skeletal measurements of asymmetric faces.

However, Michaels and Tourne24 and Yogosawa25 reported that skeletal deformities can be hidden by soft tissues such as muscles and skin. Peck et al26 suggested that many people with skeletal asymmetry have a symmetric face, and that there are differences between skeletal and soft-tissue asymmetries. In addition, Haraguchi et al27 reported differences between the degrees of actual skeletal asymmetry and soft-tissue asymmetry perceived in Class III patients. They emphasized the necessity of soft-tissue analysis. It has been suggested that people considered to be symmetric and harmonious in a clinical examination have some facial asymmetry, as shown in radiographic examinations.7,8,10,23,27,28 Ferrario et al7,8 and Haraguchi et al27 suggested that soft-tissue asymmetry appeared to be less severe than skeletal symmetry. Lee29 evaluated facial asymmetry using facial photographs and frontal cephalometric

| Table III. Definitions of angular and linear measurements used in this study |
|-----------------------------|---------------------------------|
| **Measurement**             | **Definition**                  |
| Eye canting (°)             | ΔHorizontal reference line-bipupillary line |
| Otobasion canting (°)       | ΔHorizontal reference line-otobasion inferius |
| Lip canting (°)             | ΔHorizontal reference line-lip line |
| Gonion canting (°)          | ΔHorizontal reference line-gonion line |
| Nose deviation (°)          | ΔMidsagittal reference line-pronasale line |
| Chin deviation (°)          | ΔMidsagittal reference line-chin line |
| Ramus inclination difference (°) | The difference of right and left Δmidsagittal reference line-ramus line |
| Body inclination difference (°) | The difference of right and left Δmidsagittal reference line-mandibular body line |
| Gonial angle difference (°) | The difference of right and left ΔPre-Gó-Mé |
| Asymmetry index for horizontal Gó (%) | The ratio of right and left horizontal Gó’ length |
| Asymmetry index for vertical Gó (%) | The ratio of right and left vertical Gó’ length |

<table>
<thead>
<tr>
<th>Table IV. Comparisons of measurements among the groups</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group I</strong></td>
</tr>
<tr>
<td><strong>Mean</strong></td>
</tr>
<tr>
<td>Eye canting</td>
</tr>
<tr>
<td>Otobasion canting</td>
</tr>
<tr>
<td>Lip canting</td>
</tr>
<tr>
<td>Gonion canting</td>
</tr>
<tr>
<td>Nose deviation</td>
</tr>
<tr>
<td>Chin deviation</td>
</tr>
<tr>
<td>Ramus inclination difference</td>
</tr>
<tr>
<td>Body inclination difference</td>
</tr>
<tr>
<td>Gonial angle difference</td>
</tr>
<tr>
<td>Asymmetry index of H-Gó</td>
</tr>
<tr>
<td>Asymmetry index of V-Gó</td>
</tr>
</tbody>
</table>

According to 1-way ANOVA, H-Gó and V-Gó indicate horizontal and vertical Gó.

*P<.01; NS, not significant.
radiographs, and reported less difference in the horizontal and vertical lengths on the soft tissues than on the hard tissues.

Therefore, we suggest that there is a difference between the asymmetry perceived in the soft tissues and the actual skeletal asymmetry in patients with facial asymmetry. Examining the subjective assessments for facial asymmetry is an important clinical procedure for orthodontic diagnosis.

The soft-tissue features can be quantified by measuring frontal facial photographs or 3-dimensional (3D) CT images. Patients with a chief complaint of facial asymmetry visit the clinic after seeing their images in the mirror or photographs of themselves. Furthermore, photographs are easy to take, feasible, cheap, and useful compared with 3D CT images. Therefore, a frontal photograph would be an effective tool for diagnosing facial asymmetry and making a decision for treatment.

Few studies have examined the reference plane for photographs in facial asymmetry analysis. Most studies on soft-tissue facial asymmetry suggested reference planes related to the eyes (horizontal) and nose (vertical). Ras et al.\textsuperscript{30,31} used a horizontal plane passing through the exocanthis and pupils, and a vertical plane perpendicular to and bisecting a line connecting the exocanthis. O’Grady and Antonyshyn\textsuperscript{32} defined a vertical midsagittal plane passing through nasion, pronasale, and labrale superius, and an axial plane connecting the exocanthis and the bridge of the nose.

Determining a midsagittal reference plane is essential for diagnosing asymmetry, because all differences between the right and left sides are measured and compared from the midsagittal plane. Paek et al.\textsuperscript{33} suggested the midsagittal reference plane as a line connecting glabella and anterior nasal spine because the differences between the right and left measurements with this line were the smallest in normal subjects. Therefore, in this study, the midsagittal reference plane was defined as a line connecting soft-tissue nasion and subnasale. Soft-tissue nasion was chosen because glabella is difficult to identify in frontal photographs, and subnasale is the counter-landmark of the anterior nasal spine. The horizontal reference plane was then determined perpendicular to the midsagittal plane, bisecting the bipupillary line. The reason that the vertical reference plane was set in advance was that the effects of eye canting could not be evaluated if the horizontal plane was determined first by using the eyes. The landmarks defined in this study described the facial soft tissues with almost the same weight for all features (eyes, ears, nose, mouth, gonion). People can mask facial asymmetry by their posture.

A VAS was used to subjectively assess facial asymmetry. VAS values provide rapid, convenient, valid, reproducible, and representative ratings of dental and facial appearance.\textsuperscript{34} For quantification of the subjective assessments, Faure et al.\textsuperscript{35} suggested 3 methods for assessing facial esthetics: plane VAS, ratio scale, and ranking scale. The plane VAS has no reference or no ranking; it just scores the subjective evaluation. The ratio scale uses the reference photograph with a score of 60 with the typical procedure for the VAS. The ranking scale is used to arrange the photographs from the least to the most esthetic.

Phillips et al.\textsuperscript{36} used the ranking scale. However, it was less preferable because it allowed for too many tied scores, which impaired the assumption of continuous data. In addition, the plane VAS tends to lack objectivity and reproducibility. Therefore, among the 3 methods, the ratio scale with a typical VAS procedure was used, giving the reference photographs scores of 0 and 100 scores.

Johnston et al.\textsuperscript{37} standardized the raw scores to z-scores to remove interexaminer variations in scale while removing any differential effects between panels and judges. However, Schlosser et al.\textsuperscript{38} reported no significant difference between raw scores and z-scores. Therefore, the raw scores were used as the data in this study.

Farkas\textsuperscript{39} suggested that the maximum normal asymmetry would furnish a threshold value for identifying asymmetric subjects. Obviously, this threshold is
important, particularly in borderline patients whose facial asymmetry is not clinically discernible. Ferrario et al. suggested a borderline for normal facial asymmetry. They examined 314 normal patients, identified landmarks on their facial soft tissues directly, measured the distance from central point to the landmark to obtain the length and percentage differences between the right and left sides, and defined the asymmetric borderline. However, they used a 3D method—3D computerized electromagnetic digitizer—that is difficult to use as a standard. Hence, their borderline is difficult to apply generally. In this study, we attempted to detect the borderline between normal and abnormal asymmetry as in previous studies but in a feasible way. The mean values in the 3 groups were suggested instead of the borderlines. The values we obtained are significant and should be helpful in diagnosing asymmetry because they distinguish specific groups. Groups I and II were considered to have normal asymmetry, and group III had abnormal asymmetry because of the need for treatment. The need for treatment reflects the perception of facial asymmetry and could be a clinical guideline for treating facial asymmetry.

Head tilting might slightly correct a deviated chin. Kim and Hwang reported that asymmetric patients tended to tilt their heads to compensate for a deviated menton. The more asymmetric the patients, the more they tilted their heads. Those authors suggested that, in a patient’s clinical examination, some tilting of the eyes can create doubt as to whether the patient has asymmetry. Therefore, it was hypothesized that eye canting might be an affecting factor of facial asymmetry and is clinically meaningful. However, eye canting was not a significant factor affecting the assessment of facial asymmetry (Tables VI and VII). In addition, nose deviation and otobasion canting were not significant factors.

The Bonferroni post-hoc analysis (Table V) showed that only chin deviation was different between the groups. We suggest that chin deviation is the most influencing factor in assessing facial asymmetry. The difference in body inclination and gonial angle showed some dissimilarity between groups I and III, and between groups II and III. There were differences lip canting between groups I and III. Chin deviation, body inclination difference, gonial angle difference, and lip canting are all associated with asymmetry of the mandible in the lower third of a face. Asymmetry of the lower third of the face, the mandibular area, tends to be perceived more than asymmetry in the upper or middle third of the face. Lip canting was reported to be associated with mandibular asymmetry as well as maxillary height differences and occlusal plane canting. At the resting position, lip canting (deviated labial comissure or alar base) on 1 side often indicates vertical skeletal asymmetry.

The Pearson correlation coefficient and stepwise linear regression analysis were used to examine the factors affecting the assessment of facial asymmetry (Tables VI and VII). The factors significantly related to facial asymmetry in descending order according to the Pearson correlation coefficients were chin deviation, body inclination difference, gonial angle difference, and lip canting. The body inclination difference was excluded after stepwise linear regression analysis because it was closely related to chin deviation.

### Table V. Differences in photometric measurements among the groups

<table>
<thead>
<tr>
<th></th>
<th>Group I vs group II</th>
<th>Group I vs group III</th>
<th>Group II vs group III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye canting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Otobasion canting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lip canting</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Gonial anting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nose deviation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chin deviation</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Ramus inclination difference</td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Body inclination difference</td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Gonial angle difference</td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Asymmetry index of H-Gó</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asymmetry index of V-Gó</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to 1-way ANOVA, H-Gó and V-Gó indicate horizontal and vertical Gó. Bonferroni post-hoc analysis: *P <0.05; †P <0.001.

### Table VI. Correlation coefficients between the assessment of facial asymmetry and photographic measurements

<table>
<thead>
<tr>
<th>Measurement</th>
<th>r</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye canting</td>
<td>–0.09</td>
<td>NS</td>
</tr>
<tr>
<td>Otobasion canting</td>
<td>–0.07</td>
<td>NS</td>
</tr>
<tr>
<td>Lip canting</td>
<td>0.33</td>
<td>0.00†</td>
</tr>
<tr>
<td>Gonial anting</td>
<td>0.05</td>
<td>NS</td>
</tr>
<tr>
<td>Nose deviation</td>
<td>0.05</td>
<td>NS</td>
</tr>
<tr>
<td>Chin deviation</td>
<td>0.59</td>
<td>0.00†</td>
</tr>
<tr>
<td>Ramus inclination difference</td>
<td>0.21</td>
<td>0.02*</td>
</tr>
<tr>
<td>Body inclination difference</td>
<td>0.48</td>
<td>0.00†</td>
</tr>
<tr>
<td>Gonial angle difference</td>
<td>0.44</td>
<td>0.00†</td>
</tr>
<tr>
<td>Asymmetry index of H-Gó</td>
<td>0.14</td>
<td>NS</td>
</tr>
<tr>
<td>Asymmetry index of V-Gó</td>
<td>0.02</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS, not significant. *P <0.05; †P <0.001.
Asymmetric indexes of Gó and linear measurements were not significantly affecting factors. Only the angular measurements affected the assessment of facial asymmetry. With all these significant affecting factors, mandibular factors were overwhelming in surveying facial asymmetry. This finding has been suggested in several studies.

Lee et al. and Ahn and Hwang reported that the mandibular chin point deviation has the most effect on facial asymmetry assessment. Severt and Proffit found that most differences were in the lower third of the lateral facial surface. In the normal population, the lowest mean frequency of asymmetry was observed in the orbital region (<2%), followed by the nose (7%) and mouth (approximately 12%). In addition, Severt and Proffit reported the frequencies of facial asymmetry in the facial portions: 5%, 36%, and 74% in the upper, middle, and lower thirds of the face, respectively. Therefore, they concluded that most asymmetry occurred in the mandible. Vig and Herwitt, Shah and Joshi, Grayson et al., and Peck et al. suggested that craniofacial asymmetry becomes more severe from the deep portion to the superficial portion by the reference plane as the sagittal plane, such as from the cranium to the mandible. Many studies reported that, overall, gonion and tragion were the most asymmetric landmarks, and endocanthion was the most symmetric landmark. These results are consistent with previous studies.

In our study, the observers were experts. Therefore, the results should be helpful in diagnosis and treatment planning. However, nonexperts’ opinions and patients’ perceptions are important because the decision about treatment for asymmetry is up to each patient.

Therefore, nonexperts’ assessments of facial asymmetry are worthwhile. Bonnie suggested that the differences in the detection of occlusal canting in a clinical examination depend on the degree of canting and not necessarily on the level of expertise of the observers. Therefore, the experts’ assessments of facial asymmetry might be similar to those of nonexperts. However, since their study was restricted to lip canting, further studies on the difference in the assessment of facial asymmetry on the overall facial aspects between experts and nonexperts are needed.

### Table VII. Factors affecting the assessment of facial asymmetry

<table>
<thead>
<tr>
<th>Step</th>
<th>Constant (a)</th>
<th>Variable 1</th>
<th>β</th>
<th>Variable 2</th>
<th>$R^2$</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>31.06</td>
<td>Chin deviation</td>
<td>8.00</td>
<td>Gonial angle difference</td>
<td>1.65</td>
<td>0.41</td>
</tr>
<tr>
<td>2</td>
<td>27.86</td>
<td>Chin deviation</td>
<td>6.77</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stepwise linear regression analysis.

**CONCLUSIONS**

We examined the soft-tissue characteristics of asymmetric patients assessed by orthodontists to determine the soft-tissue factors affecting the recognition of facial asymmetry. In the view of experts, chin deviation, body inclination difference, gonial angle difference, and lip canting had significant differences in the 3 groups according to the assessment of facial asymmetry. In group III, containing patients with severe asymmetry requiring treatment, the mean values were 3.1°, 3.6°, 7.1°, and 6.1° for lip canting, chin deviation, body inclination difference, and gonial angle difference, respectively. Chin deviation and gonial angle difference affected the assessment of facial asymmetry. Overall, we believe that these results will help clinicians make differential diagnoses and treatment plans for patients with facial asymmetry.

**REFERENCES**