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Original Article

**MORPHOLOGICAL EVALUATIONS IN SKELETAL
CLASS III MALOCCLUSION REQUIRING
MAXILLOFACIAL SURGERY USING
ORTHOGNATHIC SURGICAL ANALYSIS**

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Abstract

The purpose of this study was to establish a Japanese standard norm for orthognathic surgical analysis to be used in clinical applications and to clarify maxillofacial morphological characteristics in skeletal Class III malocclusions requiring orthognathic surgery. The materials were pretreatment lateral cephalometric radiographs in the relaxed lip posture from 50 subjects with skeletal Class III malocclusions diagnosed as requiring orthognathic surgery. The control group consisted of 50 subjects with normal occlusion and well-balanced faces. Detailed cephalometric measurements were recorded and analyzed statistically. The skeletal, dental, and soft tissue measurements from the normal group did not reveal any marked differences between the sexes. The Class III group exhibited a more retrognathic maxilla and prognathic mandible, a steeper mandibular plane, a more prominent chin, and a larger lower facial height in the skeletal measurements; a significant lingual inclination of the mandibular incisor in the dental measurement; and a more concave profile with prognathic mandible, a larger lower facial height, a more acute nasolabial angle and chin in the soft tissue measurements. We suggest that this analysis can be clinically useful in diagnosis, treatment planning, and posttreatment evaluation for orthognathic surgical cases who are Class III patients.

Key words: Cephalometric analysis—Skeletal Class III malocclusion—
Orthognathic surgery—Diagnosis—Treatment planning

INTRODUCTION

The orthodontic treatment goal is to develop a treatment plan that produces the optimum in facial esthetics, occlusal function, and sta-

bility while addressing the patient's chief complaint. The orthodontic considerations in orthognathic surgical cases must be based on a detailed understanding of the malocclusion, particularly a differential diagnosis of

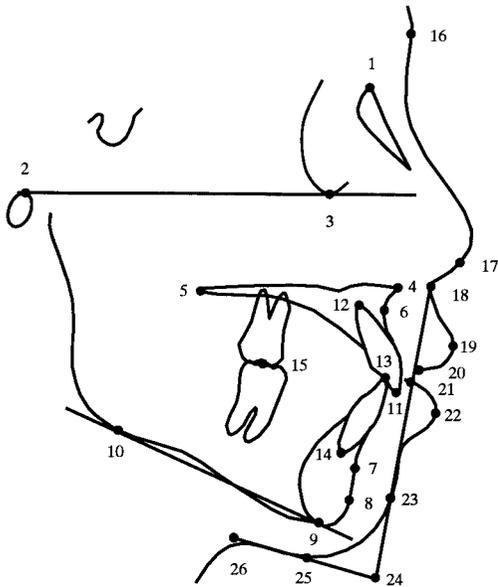


Fig. 1 Cephalometric landmarks used in this study
 1. Nasion, 2. Porion, 3. Orbital, 4. Anterior nasal spine, 5. Posterior nasal spine, 6. Point A, 7. Point B, 8. Pogonion, 9. Menton, 10. Gonion, 11. U1-tip, 12. U1-root, 13. L1-tip, 14. L1-root, 15. Molar, 16. Glabella, 17. Columella point, 18. Subnasale, 19. Labrale superius, 20. Stomion superius, 21. Stomion inferius, 22. Labrale inferius, 23. Soft tissue pogonion, 24. Soft tissue gnathion, 25. Soft tissue menton, 26. Cervical point

its facial, skeletal and dental components, along with a recognition of the limitations of current orthodontic therapy¹⁴⁾. A number of cephalometric assessments^{3,6,7,11,12)} are primarily designed to harmonize the position of the teeth with the existing skeletal pattern. These analyses are commonly used for orthodontic analysis. This analysis alone is inadequate for discerning dental and skeletal malocclusions of orthognathic surgical cases that affect the maxillo-mandibular relationship and the facial form and proportion. There have also been detailed studies of maxillofacial morphology in skeletal Class III cases^{5,8,13,15)}, but they would be difficult to apply routinely to the diagnosis and the treatment planning for these patients in clinics.

The purpose of this study was to establish a Japanese standard norm for orthognathic surgical analysis to be used in clinical applica-

tions and to clarify maxillofacial morphological characteristics in skeletal Class III malocclusions requiring orthognathic surgery.

MATERIALS AND METHODS

1. Subjects

The materials were pretreatment lateral cephalometric radiographs in the relaxed lip posture from 50 subjects (28 males and 22 females) with skeletal Class III malocclusions that were diagnosed as requiring orthognathic surgery. The control group consisted of 50 subjects (25 males and 25 females) with normal occlusion and well-balanced faces.

2. Cephalometric landmarks

As shown in Fig. 1, cephalometric landmarks were set at 15 locations on the hard tissue and 11 locations on the soft tissue as follows.

1) The hard tissue landmarks

Nasion (N): A point at the anterior limit of the nasofrontal suture.

Porion (Po): A point located at the most superior point of the external auditory meatus, tangent to the Frankfort horizontal plane.

Orbital (Or): A point located at the lowest point on the external border of the orbital cavity, tangent to the Frankfort horizontal plane.

Anterior nasal spine (ANS): Tip of the anterior nasal spine.

Posterior nasal spine (PNS): Tip of the posterior nasal spine.

Point A (Pt. A): The deepest point of the contour of the maxilla between the anterior nasal spine and the dental alveolus.

Point B (Pt. B): The deepest point of the contour of the mandibular symphysis between the infradentale and Pogonion.

Pogonion (Pog): The most anterior point of the contour of the chin.

Menton (Me): The lowest point of the contour of the mandibular symphysis.

Gonion (Go): A point located by bisecting the posterior ramus plane and the mandibular plane angle.

U1-tip: The incisal tip of the maxillary incisor.

U1-root: The root apex of the maxillary incisor.

L1-tip: The incisal tip of the mandibular incisor.

L1-root: The root apex of the mandibular incisor.

Molar: The midpoint on occlusal surface of the both first molars.

2) The soft tissue landmarks

Glabella (G): The most prominent point of the forehead.

Columella point (Cm): The most anterior point on the columella of the nose.

Subnasale (Sn): The point at which the nasal septum merges with the upper cutaneous lip.

Labrale superius (Ls): A point indicating the mucocutaneous border of the upper lip.

Stomion superius (Stms): The lowermost point on the vermilion of the upper lip.

Stomion inferius (Stmi): The uppermost point on the vermilion of the lower lip.

Labrale inferius (Li): A point indicating the mucocutaneous border of the lower lip.

Soft tissue pogonion (Pog'): The most anterior point on the soft tissue chin.

Soft tissue gnathion (Gn'): The constructed midpoint between the soft tissue pogonion and the soft tissue menton; it can be located at the intersection of the subnasale to soft tissue pogonion line and the line from C to Me'.

Soft tissue menton (Me'): The lowest point on the counter of the soft tissue chin; found by dropping a perpendicular from the FH plane through the menton.

Cervical point (C): The innermost point between the submental area and the neck located at the intersection of lines drawn tangent to the neck and submental area.

3. Cephalometric measurements

In all, 19 measurements were obtained: 6 skeletal measurements (Fig. 2), 4 dental measurements (Fig. 3), and 9 soft tissue measurements (Fig. 4). Landmarks were input with a digitizer, and measurements were performed using a cephalometric measuring sys-

tem (Versa-STAT; YASUNAGA Laboratory).

1) Skeletal measurements (Fig. 2)

N-A-Pog angle (Convexity angle): The angle formed by the N-Pt.A line and the Pt.A-Pog line. A clockwise angle is positive (+), and a counterclockwise angle is a negative (-).

A-NV, B-NV: The horizontal distance from Pt.A and Pt.B to a line perpendicular to FH plane through N, with positive (+) indicating anterior and negative (-), posterior.

B-Pog (MP): The distance from Pt.B to a line perpendicular to the mandibular plane through the pogonion.

Mandibular plane angle (MP angle): The angle formed by the mandibular plane and FH plane.

N-ANS/ANS-Me: The ratio of the distances from N to ANS and from ANS to Me.

2) Dental measurements (Fig. 3)

A-B (OP): The horizontal distance between these intersections of the perpendicular lines to the occlusal plane from Pt.A and Pt.B. When Pt.B projected posteriorly to Pt.A, it is negative(-).

OP-FH angle: The angle formed by the occlusal plane and the FH plane.

U1-PP angle: The angle formed by the palatal plane and the long axis of the upper incisor.

L1-MP angle: The angle formed by the mandibular plane and the long axis of the lower incisor.

3) Soft tissue measurements (Fig. 4)

G-Sn-Pog' angle (Facial convexity angle): The angle formed by the G-Sn line and the Sn-Pog' line. A clockwise angle is positive (+) and a counterclockwise angle is negative (-).

Sn-Gn'-C angle (Lower face-throat angle): The angle formed by the Sn-Gn' line and the Gn'-C line.

Sn-GV (Maxillary prognathism), Pog'-GV (Mandibular prognathism): The horizontal distance from Sn and Pog' to a line perpendicular to FH plane through G, with positive (+) indicating anterior and negative (-), posterior.

Cm-Sn-Ls angle (Nasolabiatl angle): The angle formed by the Cm-Sn line and the Sn-Ls line.

G-Sn/Sn-Me' (Vertical height ratio): The

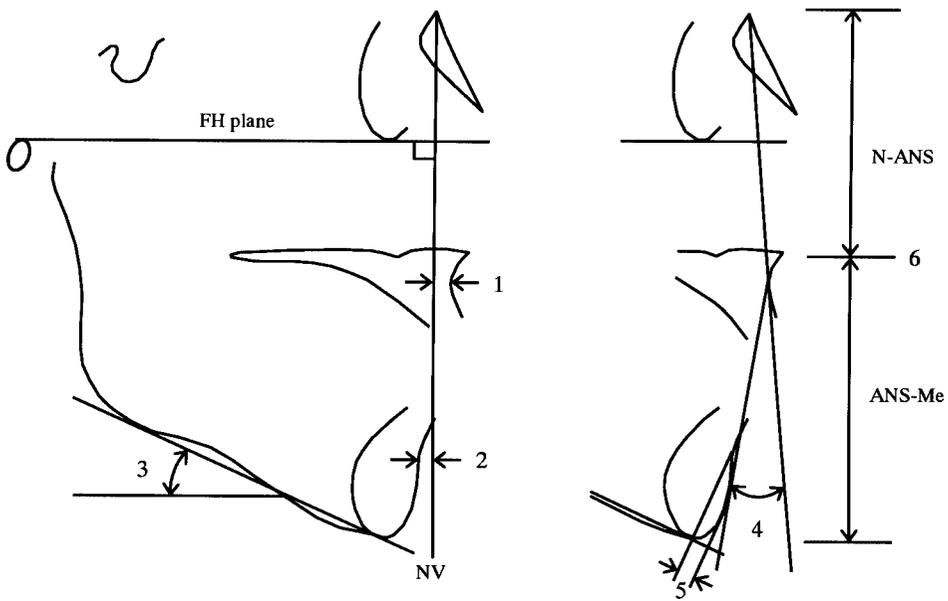


Fig. 2 Skeletal measurements
 (Left) 1: A-NV, 2: B-NV, 3: MP angle (Right) 4: N-A-Pog angle, 5: B-Pog (MP), 6: N-ANS/ANS-Me

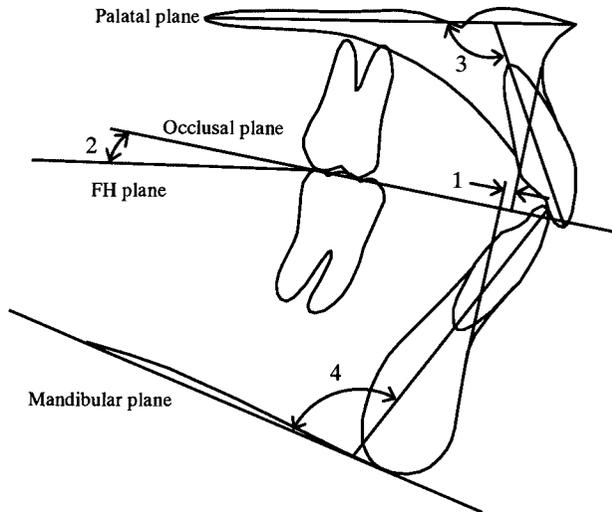


Fig. 3 Dental measurements
 1: A-B (OP), 2: OP-FH angle, 3: U1-PP angle, 4: LI-MP angle

ratio of the distances from G to Sn and from Sn to Me'.

Stms-U1 (Maxillary incisor exposure): The vertical distance of Stms to U1.

Interlabial gap: The vertical distance between Stms and Stmi.

Sn-Stms/Stmi-Me' (Vertical lip-chin ratio): The ratio of the distances from Sn to Stms and

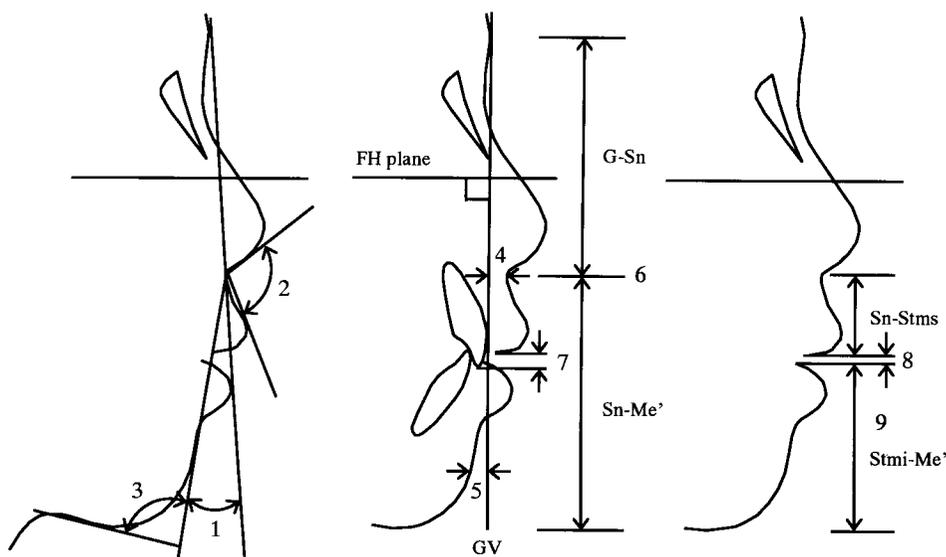


Fig. 4 Soft tissue measurements

(Left) 1: G-Sn-Pog' angle, 2: Sn-Gn'-C angle, 3: Cm-Sn-Ls angle (Middle) 4: Sn-GV, 5: Pog'-GV, 6: G-Sn/Sn-Me', 7: Stms-U1 (Right) 8: Interlabial gap, 9: Sn-Stms/Stmi-Me'

from Stmi to Me'.

4. Statistical analysis

Standard descriptive statistics (mean values and deviations) were calculated for both groups. Comparisons between the groups were performed by unpaired Student's *t*-test. The levels of significance used were $p < 0.01$ and $p < 0.05$. $p \geq 0.05$ was considered not significant.

RESULTS

Measurements results and Student's *t*-test results for the male and female control samples are summarized in Table 1. Of the 19 measurements, 2 were significantly different between the sexes. The LI-MP angle and the G-Sn/Sn-Me' ratio of the males were significantly smaller and larger than those of the females, respectively. There, however, were no statistical differences between the sexes in the other measurements.

Measurements results and Student's *t*-test

between the control and the Class III groups are summarized in Table 2. Composite diagrams of the Class III group are superimposed on that of the normal group along the S-N line and registered on S in Fig. 5. Significant skeletal differences were found in the linear measurements for A-NV, B-NV, and B-Pog (MP); in the angular measurements for the convexity angle and MP angle; and in the proportional measurement for N-ANS/ANS-Me. The Class III group exhibited a more retrognathic maxilla and prognathic mandible, a steeper mandibular plane, a more prominent chin and a larger lower facial height in the skeletal measurements.

There was a significant difference between the maxillomandibular horizontal relationships in relation to the occlusal plane, as measured by A-B (OP), whereas the OP-FH was not significantly different. The U1-PP angle was nearly the same in both groups, but the LI-MP angle in the Class III group demonstrated a significant lingual inclination.

Significant soft tissue differences were found in the facial form measurements for

Table 1 Comparison of the normal occlusion group means between male and female samples

Variable	Male		Female		Sig.
	Mean	S.D.	Mean	S.D.	
A. Skeletal					
1 M-A-Pog angle (deg.)	6.2	3.6	5.8	3.6	ns
2 A-NV (mm)	2.1	2.9	0.8	2.8	ns
3 B-NV (mm)	-3.3	3.9	-5.0	5.1	ns
4 B-Pog (MP) (mm)	6.0	1.6	5.9	1.2	ns
5 MP angle (deg.)	24.7	3.9	27.4	6.1	ns
6 N-ANS/ANS-Me	0.81	0.06	0.82	0.05	ns
B. Dental					
1 A-B (OP) (mm)	1.6	2.9	2.3	2.2	ns
2 OP-FH angle (deg.)	8.5	2.5	9.9	3.1	ns
3 U1-PP angle (deg.)	118.0	5.6	118.0	5.7	ns
4 L1-MP angle (deg.)	97.4	5.5	93.8	6.6	*
C. Soft tissue					
1 G-Sn-Pog' angle (deg.)	11.6	4.5	10.0	3.4	ns
2 Sn-Gn'-C angle (deg.)	108.6	6.9	105.3	6.6	ns
3 Sn-GV (mm)	6.8	3.6	5.0	3.1	ns
4 Pg'-GV (mm)	-1.1	4.8	-1.4	6.3	ns
5 Cm-Sn-Ls angle (deg.)	99.6	12.5	99.8	9.1	ns
6 G-Sn/Sn-Me'	1.00	0.07	1.06	0.08	*
7 Stms-U1 (mm)	1.7	1.7	2.0	1.7	ns
8 Interlabial gap (mm)	1.8	1.8	1.8	2.0	ns
9 Sn-Stm/Stm-Me'	0.48	0.04	0.47	0.05	ns

S.D.: Standard deviation, Sig.: Statistical significance

*: $p < 0.05$, ns: not significant

the facial convexity angle (G-Sn-Pog' angle), the lower face-throat angle (Sn-Gn'-C angle), the Pg'-GV, and the vertical height ratio (G-Sn/Sn-Me'), in the lip position and form measurements for the nasolabial angle (Cm-Sn-Ls angle), and in the vertical lip-chin ratio (Sn-Stms/Stmi-Me'). The Class III group in the soft tissue measurements exhibited a more concave profile with a prognathic mandible, a larger lower facial height, and a more acute nasolabial angle and chin, but the maxillary areas were not significantly different.

DISCUSSION

The aims of orthognathic surgery include improved facial esthetics, proper skeletal relationships to support the teeth, and good occlusal function. A majority of patients seeking treatment for mandibular prognathism

are particularly motivated by a desire for an improved appearance. Thus, the cephalometric analysis should be designed for properly evaluating and clearly characterizing the maxillofacial morphology in patients requiring orthognathic surgery to achieve these aims. This orthognathic surgical analysis, which is based on Burstone *et al.*²⁾ and Legan and Burstone⁹⁾, was developed for the Class II patients at the University of Texas. Irie *et al.*⁴⁾ stated that the COGS (Cephalometrics for orthognathic surgery) analysis designed by Burstone *et al.*²⁾ was especially useful in planning surgical procedures and in evaluating changes after surgery. However, the soft tissue measurements are not included in COGS analysis. The 19 measurements employed in this analysis consisted of 6 skeletal measurements, 4 dental measurements, and 9 soft tissue measurements. Because this analysis evaluates the horizontal and vertical relation-

Table 2 Comparison of variables between the normal occlusion and surgical groups

Variable	Normal occlusion group		Surgical group		Sig.
	Mean	S.D.	Mean	S.D.	
A. Skeletal					
1 N-A-Pog angle (deg.)	6.0	3.6	-8.0	7.2	**
2 A-NV (mm)	1.4	2.9	-1.5	3.8	**
3 B-NV (mm)	-4.1	4.7	4.5	8.8	**
4 B-Pog (MP) (mm)	5.9	1.4	6.9	1.4	**
5 MP angle (deg.)	26.0	5.3	32.2	6.6	**
6 N-ANS/ANS-Me	0.81	0.06	0.75	0.08	**
B. Dental					
1 A-B (OP) (mm)	2.0	2.6	13.7	6.8	**
2 OP-FH angle (deg.)	9.2	2.9	8.4	5.1	ns
3 U1-PP angle (deg.)	118.0	5.7	119.3	6.5	ns
4 LI-MP angle (deg.)	95.6	6.3	77.0	7.5	**
C. Soft tissue					
1 G-Sn-Pog' angle (deg.)	10.8	4.1	0.5	7.3	**
2 Sn-Gn'-C angle (deg.)	107.0	6.9	98.8	9.6	**
3 Sn-GV (mm)	5.9	3.4	5.5	4.1	ns
4 Pg'-GV (mm)	-1.3	5.6	8.8	8.9	**
5 Cm-Sn-Ls angle (deg.)	99.7	10.9	91.8	16.2	*
6 G-Sn/Sn-Me'	1.03	0.08	0.99	0.06	*
7 Stms-U1 (mm)	1.8	1.7	2.5	3.1	ns
8 Interlabial gap (mm)	1.8	1.9	2.1	1.7	ns
9 Sn-Stm/Stm-Me'	0.49	0.05	0.41	0.06	**

S.D.: Standard deviation, Sig.: Statistical significance
 *: $p < 0.05$, **: $p < 0.01$, ns: not significant

ships of the jaws and the profile by linear measurements and proportions, it could serve as a logical and accurate tool for constructing visual surgical treatment objectives and the surgical model. Our system features are a lot of soft tissue assessment, although there are no particularly novel measurements. Especially, this analysis makes possible the determination of treatment planning to improve profiles because of there are nine soft tissue measurements. It would be a mistake to believe that all patients should be treated according to the mean value compared with data obtained by lateral cephalometric radiograph. However, the standards presented are most helpful in determining the orthognathic surgical treatment planning in the Japanese population.

The inclination of the lower incisor in relation to the mandibular plane and the vertical height ratio exhibited a slightly significant difference between the sexes in the normal group. The skeletal, dental and soft tissue

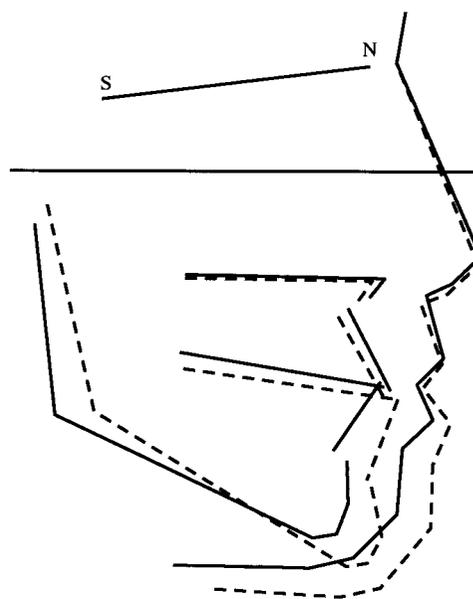


Fig. 5 Composite diagram of the Class III group superimposed on that of the normal group along the S-N line and registered on S. Solid line: normal group, Dashed line: Class III group

measurements, however, did not reveal any marked gender differences. This result confirmed the conclusions of previous investigations^{13,15)} that the facial shape patterns and proportions of male and female subjects within an ethnic sample are remarkably similar, although larger values were found for most linear measurements for the male subjects. Therefore, this normal group has validity as a control, and the comparison between the Class III group and the normal group was not separated by sex.

Compared with the Caucasian norm¹⁾, the Japanese norm demonstrated a slight forward position of the maxilla and a slightly retruded mandible and chin, indicating a more skeletal Class II tendency. The upper and lower incisors showed increased angulation. There was little difference in the horizontal position of the subnasal, the vertical balance in the profile, or the nasolabial angle. There, however, were no differences in the vertical skeletal and facial balances in the proportional measurements. Miyajima *et al.*¹⁰⁾ reported that the Japanese sample had a more vertical mandibular growth pattern, more protrusion dentally, and a greater tendency toward bilabial protrusion. Engle and Spolter³⁾ stated that Japanese people had more protrusive dentures and a more vertical mandibular growth pattern than Caucasians. In these reports, however, the assessment of soft tissue was only performed in the lip area which was changed by the orthodontic treatment. The results of comparison of Caucasians and Japanese were generally similar to the observations of other investigators^{3,10-12)}. Therefore, Nezu *et al.*¹²⁾ suggested that the frequency of Japanese extraction cases for in orthodontic treatment will increase because of the retruded chin, the bilabial protrusion, the limitation of the upper molar distalization, and the improvement of soft tissue.

In the Class III group, the mandible and the mandibular area in the profile were significantly positioned forward and downward. There were no differences in the vertical and horizontal relationship around the maxillary area in the profile, but this group has a

retruded maxilla and an acute nasolabial angle. Thus, the lower third facial height is increased. The Class III group had also developed lingual inclination of the mandibular incisor in order to compensate for antero-posterior skeletal disharmony between the maxilla and the mandible; this observation agrees with previous studies^{5,15)}. The nasolabial angle was an important measurement in assessing the facial esthetic⁹⁾. An acute nasolabial angle will often allow us to retract the maxillary incisors by extraction of the maxillary premolar. Data from this study indicate that the elimination of dental compensation for the lingual inclination of the mandibular incisor is necessary to increase the amount of mandibular total setback and to improve the nasolabial angle. In addition, consideration must be given to reconstructing the symphysis by reduction genioplasty as an additional surgical operation to decrease the lower third facial height and the prominent chin. Our analysis including soft tissue measurements can clarify the morphological characteristics of orthognathic surgical cases in the Class III group better than conventional cephalometric analyses^{3,6,7)} even though there are still some measurement variables.

In conclusion, lateral cephalometric measurements were established for adult Japanese to aid the orthodontists in the diagnosis and the treatment planning of orthognathic surgical cases. These norms were also compared with skeletal Class III malocclusions requiring orthognathic surgery. We suggest that this analysis can be clinically useful in diagnosis, treatment planning, and posttreatment evaluation for orthognathic surgical cases who are Class III patients.

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