Original Article

Dentofacial characteristics of women with oversized mandible and temporomandibular joint internal derangement

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ABSTRACT

Introduction: To analyze dentofacial characteristics of temporomandibular joint internal derangement (TMJ ID) in orthodontic patients with oversized mandible (skeletal Class III pattern).

Materials and Methods: The sample consisted of 66 women whose mandibular body length to anterior cranial base ratio is greater than 1.12. They were divided into three groups based on magnetic resonance images of bilateral TMJs: bilateral normal disk position (BN), bilateral disk displacement with reduction (DDR), and bilateral disk displacement without reduction (DDNR). Thirty-five cephalometric variables regarding their lateral cephalograms were analyzed by Kruskal-Wallis test to evaluate differences in dentofacial morphology among the three groups.

Results: Subjects with TMJ ID had a clockwise rotation of the ramus, with backward position of mandible, labial tipping of mandibular incisors, and protrusion of upper and lower lips. However, TMJ ID did not significantly influence vertical skeletal relationships. Most of the significant dentofacial changes were found between BN and DDR, and dentofacial changes between DDR and DDNR were minimal.

Conclusions: This study suggests that dentofacial changes associated with TMJ ID begin to appear when TMJ ID develops to DDR from BN in patients with oversized mandible. (*Angle Orthod.* 2011;81:469–477.)

KEY WORDS: Dentofacial characteristics; Oversized mandible; Temporomandibular joint; Internal derangement

INTRODUCTION

Internal derangement (ID) of the temporomandibular joint (TMJ) is defined as an abnormal relationship of the articular disk to the mandibular condyle, fossa, and articular eminence.[1] ID is the most common type of temporomandibular disorder and is characterized by progressive displacement of the articular disk, which can lead to TMJ clicking, crepitus, pain, and limited jaw movement.[1] ID generally progresses from reduction to nonreduction.[2]

Various methods are used to diagnose TMJ ID, including radiography such as arthrography and tomography and methods that rely on assessment of sound, pain, and jaw movement.[3] Recently, magnetic resonance imaging (MRI) has been used to obtain information on articular disk position within the TMJ. In contrast to indirect imaging by arthrography, MRI provides a direct way of visualizing soft tissue. Moreover, MRI is extremely sensitive in identifying TMJ ID and produces no soft tissue distortion, because a contrast-enhancing medium does not have to be injected into the joint space.[4] It also offers many other advantages, such as noninvasiveness, minimal pain, minimal risk, and no exposure to ionizing radiation.[5] MRI detected TMJ ID in 33% of asymptomatic volunteers and in 84% of symptomatic subjects.[6,7]

Many studies have investigated the relationship between TMJ ID and dentofacial morphology. TMJ ID contributes to changes in dentofacial morphology by altering condylar and mandibular morphologies.[8–11] The cephalometric characteristics of TMJ ID patients include backward rotation of the ramus and mandible,

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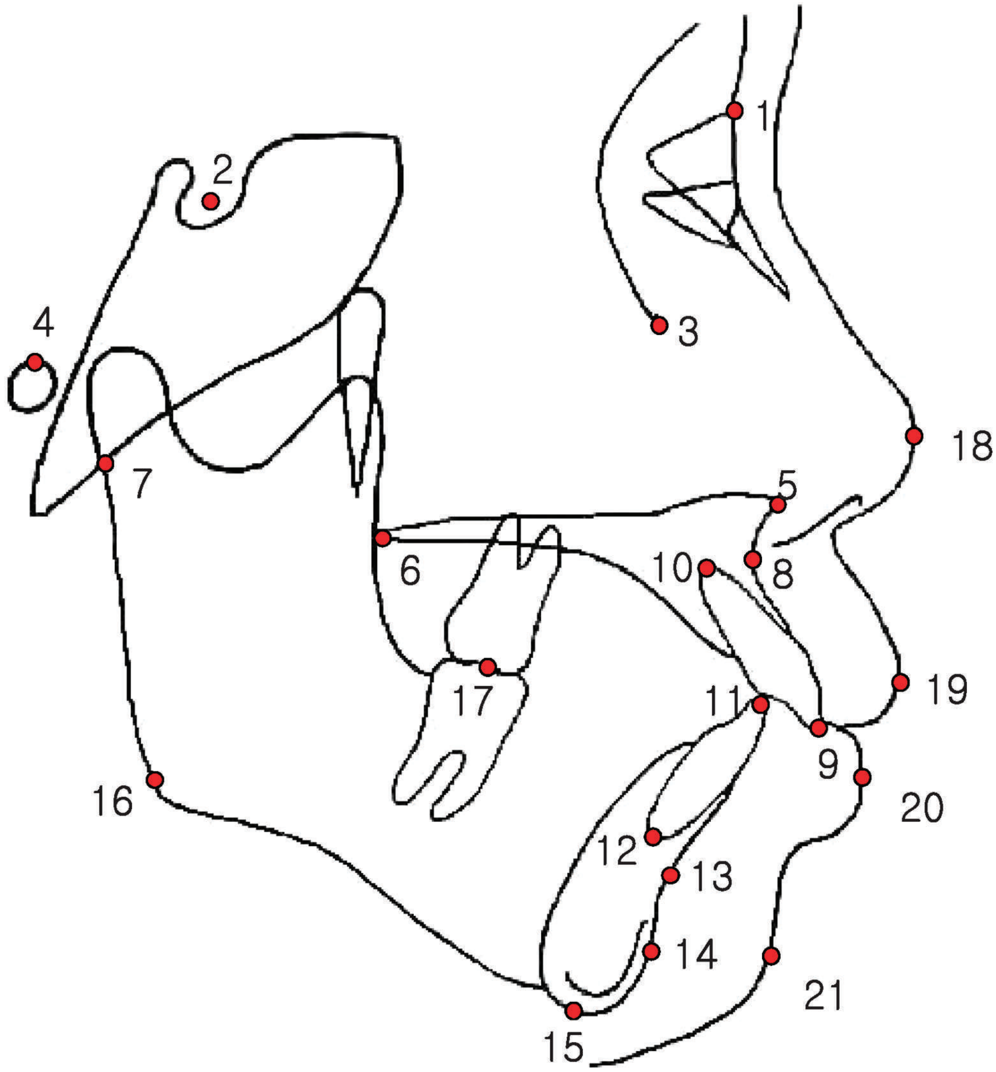

Figure 1. Landmarks used in study: 1, nasion; 2, sella; 3, orbitale; 4, porion; 5, anterior nasal spine; 6, posterior nasal spine; 7, articulare; 8, point A; 9, incisal end of maxillary incisor; 10, apex of maxillary incisor; 11, incisor end of mandibular incisor; 12, apex of mandibular incisor; 13, point B; 14, pogonion; 15 menton; 16, gonion; 17, articulation of maxillary and mandibular molars; 18, tip of the nose; 19, upper lip; 20, lower lip; 21, soft tissue pogonion (chin).

decreased ramus height, and decreased effective mandibular length (Ar-Pog).

Much research about TMJ ID and patients with Class II skeletal pattern or anterior open bite has been conducted, but only a few studies have investigated relationships between TMJ ID and dentofacial changes in patients with skeletal Class III pattern. Although a previous study reported relationships between Class III malocclusions and TMJ pathologies,[12] these reports evaluated TMJ using subjective signs of TMJ ID, such as sounds, limited mouth opening, and palpatory tenderness or pain of TMJs. The relationships between TMJ ID and skeletal Class III pattern would have been clearer if MRI had been used, because greater accuracy of TMJ ID diagnosis is obtained with MRI than with clinical examination.[13] The aim of this study was to analyze dentofacial characteristics in patients with oversized mandibles (skeletal Class III pattern).

MATERIALS AND METHODS

Women older than 17 years were included in this study to avoid growth-related size differences, because growth of Korean females is almost completed after the age of 16.[14] Men were excluded to avoid the skewing of cephalometric measurements by gender-related size differences. Subjects with congenital anomalies, severe facial asymmetry, juvenile rheumatoid arthritis, and a history of previous orthodontic treatment and trauma were also excluded. All subjects had primary complaints of malocclusion, and routine lateral cephalograms were taken using Asahi CX-

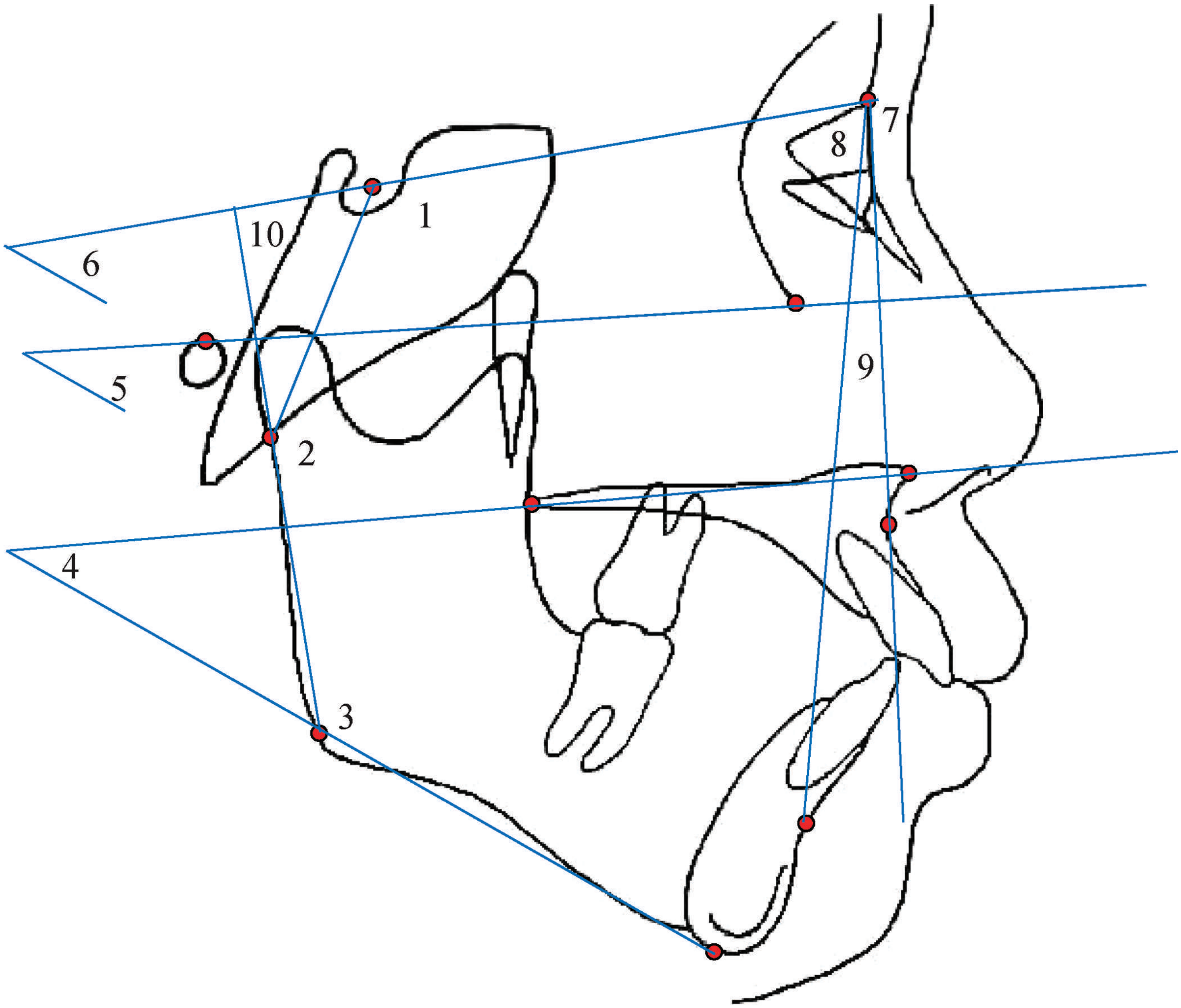

Figure 2. Angular measurements used in study: 1, saddle angle (Na-S-Ar); 2, articular angle (S-Ar-Go); 3, gonial angle (Ar-Go-Me); 4, maxillomandibular plane angle; 5, FH to mandibular plane angle (FMA); 6, SN to mandibular plane angle; 7, SNA angle; 8, SNB angle; 9, ANB angle; 10, ramus inclination (N-S to Ar-Go).

90SP II (Asahi Roentgen, Kyoto, Japan). Irrespective of TMJ status, all subjects consented to a bilateral high-resolution MRI in the sagittal (opened and closed) and coronal (closed) planes to evaluate the TMJ. The research protocol was reviewed and approved by the institutional review board of the University Hospital.

Radiologists and orthodontists experienced in TMJ MRI interpreted the images without obtaining clinical information on the subjects. TMJ disk status was divided into three categories as follows: normal disk position, disk displacement with reduction, and disk displacement without reduction. A total of 255 subjects were originally selected and analyzed. Only subjects with bilateral normal disk status (BN), bilateral disk displacement with reduction (DDR), and bilateral disk displacement without reduction (DDNR) were included in this study, because possible dentofacial changes associated with unilateral ID would have been obscured by the averaging of right and left landmarks used in determining their locations.[15]

All cephalograms were traced by a single investigator and recorded using a digitizer with a desktop computer. Twenty-one landmarks were digitized on each radiograph, from which 35 variables were calculated. For convenience of analysis, these variables were subdivided into six categories: cranial base relationships, maxillomandibular relationships, vertical skeletal relationships, size and form of mandible, dental relationships, and soft tissue relationships. The positions of all landmarks are shown in Figure 1,

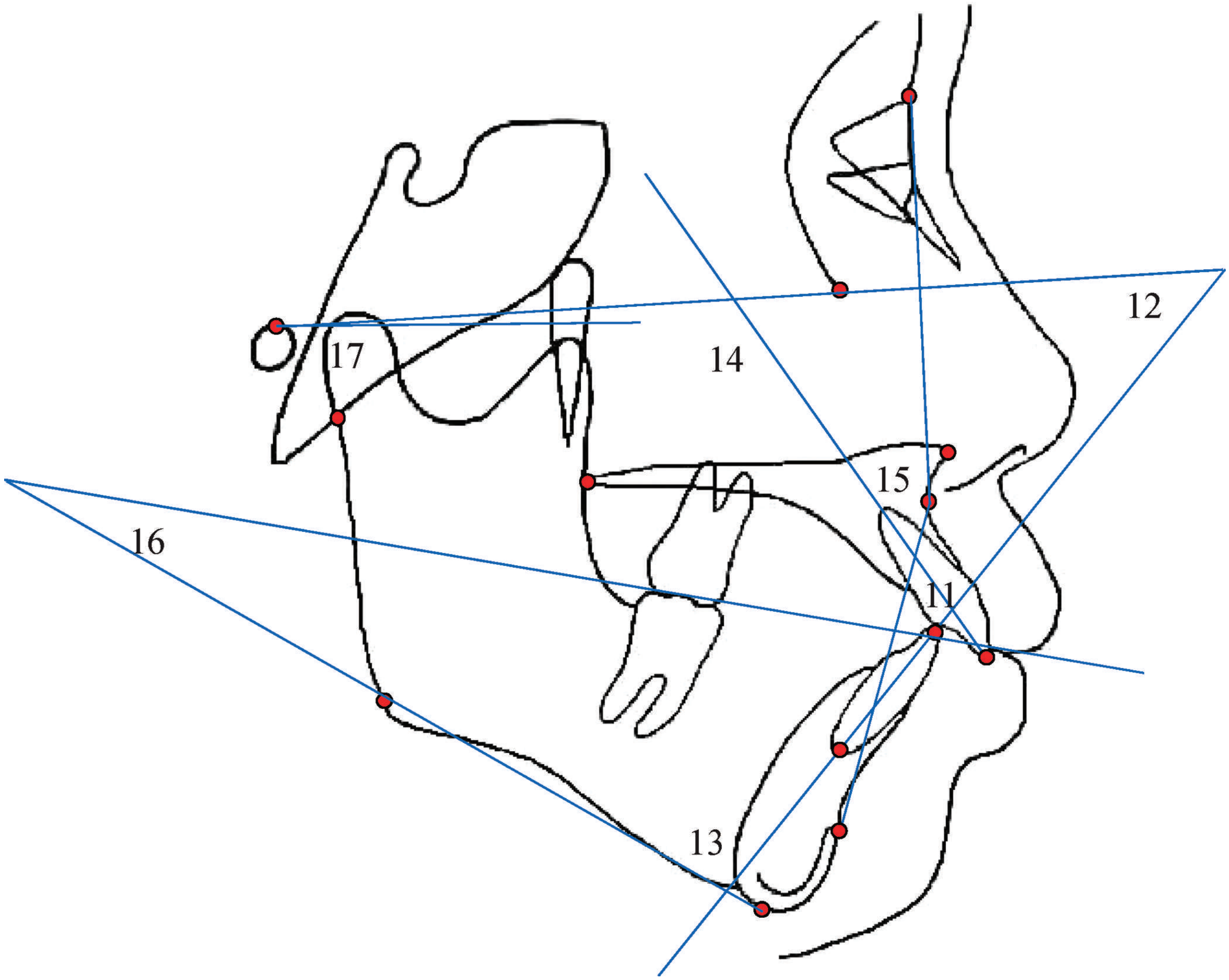

Figure 3. Angular measurements used in study (continued): 11, interincisal angle; 12, mandibular incisor to FH plane angle; 13, mandibular incisor to mandibular plane angle; 14, maxillary incisor to FH plane; 15, facial convexity; 16, occlusal plane to mandibular plane angle; 17, FH to palatal plane angle.

and their measurements are shown in Figures 2, 3, and 4.

To analyze relationships between TMJ ID and alteration of dentofacial characteristics in patients with a skeletal Class III pattern, subjects should be classified and selected using an anteroposterior cephalometric parameter. However, we could not discriminate a skeletal Class III pattern using traditional skeletal parameters, such as ANB, SNB, facial convexity, and Wits appraisal, because these parameters are significantly influenced by backward rotation of the mandible and decreased ramus height—the main skeletal signs of TMJ ID.[9–11] As a result, TMJ ID subjects may show skeletal Class I or II ranges of SNB, ANB, pogonion to N perpendicular, facial convexity, and Wits appraisal despite their skeletal Class III pattern. Instead, subjects were classified on the basis of mandibular body length to anterior cranial base ratio (MNACBR), because MNACBR is one of the important markers of the skeletal Class III pattern[16] and would not be influenced by TMJ ID. Therefore, only subjects with MNACBR greater than 1.12 were chosen, because MNACBR of normal Korean women was 1.08 $\pm$ 0.04. These subjects may be equivalent to Class III skeletal pattern without alteration of skeletal patterns by TMJ ID. Sixty-six women were finally selected. No significant difference in age distribution was noted among the three groups (Table 1).

Before data were analyzed, duplicate determinations were performed on 15 cephalometric radiographs, from which the measurement error was calculated by intraclass correlation coefficient. The reliability of tracing, landmark identification, and

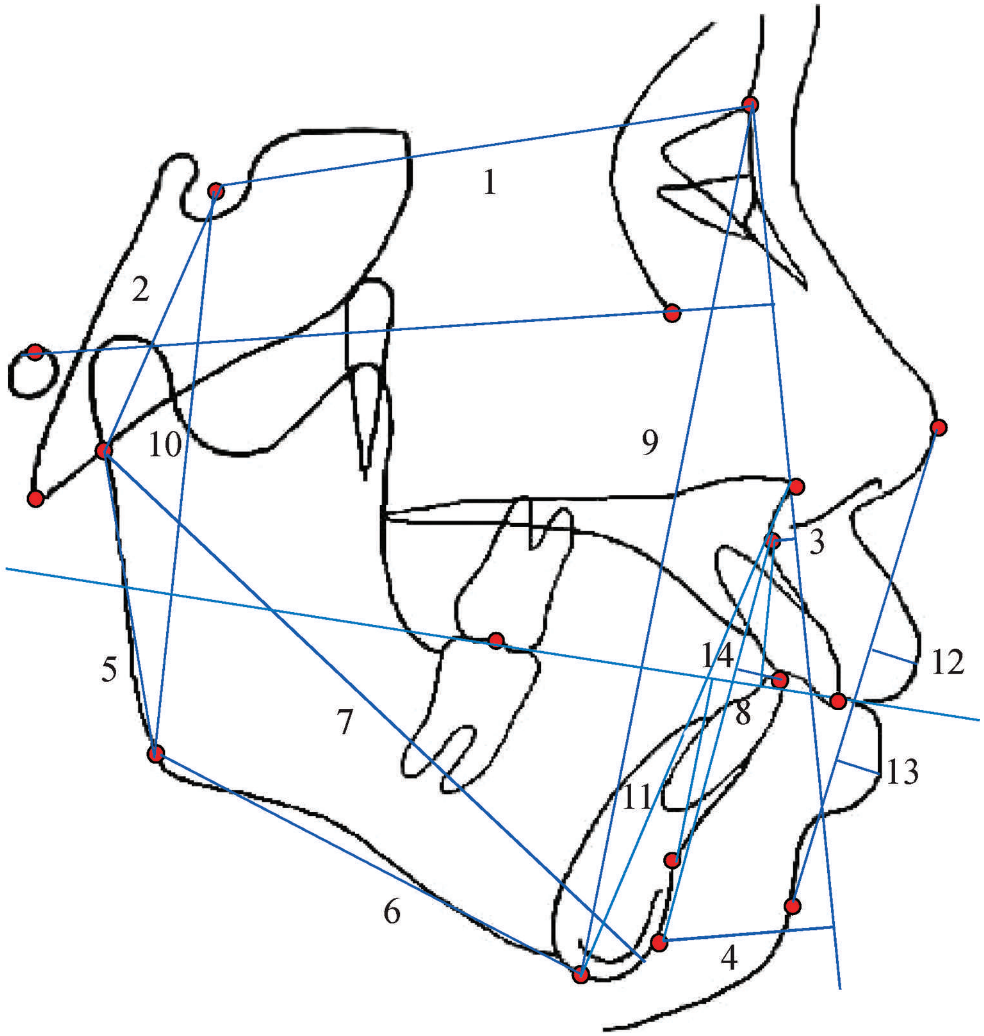

Figure 4. Linear measurements used in study: 1, anterior cranial base length (S-N); 2, posterior cranial base length (S-Ar); 3, N perpendicular to Point A; 4, N perpendicular to pogonion; 5, ramus height (Ar-Go); 6, mandibular body length (Go-Me); 7, effective mandibular length (Ar-Pog); 8, mandibular incisor to A-Pog; 9, total anterior facial height (N-Me); 10, total posterior facial height (S-Go); 11, lower anterior facial height (ANS-Me); 12, upper lip thickness (Ricketts' E-line); 13, lower lip thickness (Ricketts' E-line); 14, Wits appraisal.

analytical measurements had intraclass correlation coefficients greater than 0.98.

The Kruskal-Wallis test was used to determine any significant differences among the three groups. Mann-Whitney *U*-test with Bonferroni correction was performed with a significance level of $\alpha = .05$ to compare differences between groups.

Table 1. Numbers and Age Ranges of Skeletal Class III Subjects With Mandibular Body Length to Anterior Cranial Base Ratio Greater Than 1.12

	BN[a] (n = 33)	DDR[b] (n = 16)	DDNR[c] (n = 17)	Significance[d]
Age, years				
Mean (SD)	23.1 (5.1)	24.3 (4.5)	23.0 (3.7)	NS

[a] BN, bilateral normal disk position.

[b] DDR, bilateral disk displacement with reduction.

[c] DDNR, bilateral disk displacement without reduction.

[d] A Kruskal-Wallis test was used to analyze differences in age between the three groups at a significance level of $\alpha = .05$. NS indicates no statistical significance.

RESULTS

Table 2 shows differences in dentofacial variables with respect to TMJ ID status (BN, DDR, and DDNR). Eighteen variables among a total of 35 cephalometric variables showed statistically significant differences. Most significant differences were found between BN and DDR or DDNR.

Among the three groups, none of the variables in the cranial base relationships and the vertical skeletal relationships showed statistical significance. Although subjects with TMJ ID tended to show backward rotation of the mandible, no statistically significant

Table 2. Cephalometric Variables of Skeletal Class III Patients With Mandibular Body Length to Anterior Cranial Base Ratio Greater Than 1.12

Variables	Korean Norm, Mean (SD)	BN[a], Mean (SD)	DDR[b], Mean (SD)	DDNR[c], Mean (SD)	Significance[d]
Cranial Base Relationships					
Anterior cranial base length, mm	69.4 (3.6)	66.8 (2.5)	66.6 (3.1)	66.4 (2.4)	NS
Posterior cranial base length, mm	37.7 (2.7)	35.3 (3.3)	35.6 (2.6)	35.8 (4.8)	NS NS
Saddle angle, degrees	125.5 (5.3)	123.7 (5.3)	126.3 (5.9)	122.0 (4.3)	NS
Maxillomandibular Relationships					
SNA angle, degrees	81.1 (3.7)	82.3 (2.9)	82.1 (4.1)	82.4 (3.9)	NS
SNB angle, degrees	78.0 (3.8)	82.4 (4.1)	76.7 (3.8)	75.7 (4.2)	***(BN > DDR=DDNR)
Point A to N perpendicular, mm	0.4 (2.3)	2.5 (2.7)	3.4 (2.6)	1.6 (3.4)	NS
Pogonion to N perpendicular, mm	−1.8 (4.5)	5.1 (8.73)	−4.7 (5.5)	−10.8 (6.9)	***(BN > DDR > DDNR)
Facial convexity, degrees	3.7 (4.6)	−0.5 (7.8)	10.8 (6.1)	13.0 (5.7)	***(BN < DDR = DDNR)
ANB angle, degrees	3.5 (1.9)	−0.1 (3.5)	5.4 (2.4)	6.7 (2.6)	***(BN < DDR = DDNR)
Wits appraisal, mm	−2.7 (2.3)	−9.6 (6.4)	−1.5 (3.5)	0.0 (4.9)	***(BN < DDR = DDNR)
Vertical Skeletal Relationships					
FMA, degrees	29.6 (5.7)	29.2 (5.4)	30.0 (3.9)	34.1 (6.1)	NS
SN to mandibular plane angle, degrees	34.3 (6.4)	39.1 (5.7)	41.0 (4.0)	43.1 (7.1)	NS
FH to palatal plane angle, degrees	1.2 (4.7)	0.4 (3.1)	0.3 (3.7)	0.3 (3.1)	NS
Maxillomandibular plane angle, degrees	28.4 (5.2)	28.9 (5.7)	29.8 (5.9)	33.8 (6.6)	NS
Occlusal plane to mandibular plane angle, degrees	19.1 (4.7)	20.3 (6.0)	18.6 (5.8)	20.4 (4.9)	NS
Total anterior facial height, mm	128.7 (6.3)	133.5 (5.5)	133.2 (5.3)	133.3 (7.5)	NS
Total posterior facial height, mm	82.8 (5.3)	83.7 (5.5)	82.3 (6.7)	80.6 (8.2)	NS
Lower anterior facial height, mm	71.4 (4.4)	76.7 (5.7)	75.9 (4.5)	77.6 (5.6)	NS
Total anterior facial height/ total posterior facial height, %	65.3 (8.8)	62.8 (4.0)	61.7 (3.8)	60.5 (5.4)	NS
Size and Form of Mandible					
Ramus height, mm	49.1 (4.9)	51.6 (3.9)	48.6 (5.7)	46.0 (5.4)	**(BN > DDNR)
Ramus inclination, degrees	93.1 (5.2)	92.4 (5.7)	102.9 (5.8)	104.5 (7.0)	***(BN < DDR = DDNR)
Mandibular body length, mm	75.0 (4.9)	79.6 (3.5)	78.4 (4.4)	77.1 (3.5)	NS
Effective mandibular length, mm	113.4 (6.7)	118.7 (5.0)	110.8 (6.8)	106.9 (5.8)	***(BN < DDR = DDNR)
Mandibular body length/ anterior cranial base ratio, %	1.08 (0.4)	119 (0.5)	118 (0.4)	116 (0.3)	NS
Gonial angle, degrees	124.3 (5.4)	126.7 (6.6)	118.2 (5.7)	118.6 (6.5)	***(BN > DDR = DDNR)
Articular angle, degrees	147.7 (5.3)	148.7 (5.5)	156.6 (7.0)	162.6 (7.9)	***(BN < DDR = DDNR)
Dental Relationships					
Maxillary incisor to FH plane, degrees	113.8 (6.4)	122.5 (6.5)	118.8 (8.1)	117.4 (8.8)	NS
Mandibular incisor to FH plane, degrees	56.8 (6.0)	66.3 (9.8)	54.4 (7.7)	49.9 (5.5)	***(BN > DDR = DDNR)
Interincisal angle, degrees	125.4 (9.2)	123.8 (10.7)	115.6 (12.3)	112.5 (10.0)	**(BN > DDNR)
Mandibular incisor to mandibular plane angle, degrees	91.6 (5.2)	84.5 (9.7)	95.6 (7.0)	95.9 (6.4)	***(BN < DDR = DDNR)

Table 2. Continued

Variables	Korean Norm, Mean (SD)	BN[a], Mean (SD)	DDR[b], Mean (SD)	DDNR[c], Mean (SD)	Significance[d]
Mandibular incisor to A-Pog, mm	4.6 (2.1)	8.7 (4.0)	3.3 (3.7)	0.9 (4.2)	***(BN > DDR = DDNR)
Overbite, mm	1.8 (1.1)	−0.8 (2.7)	0.4 (2.9)	0.1 (2.8)	NS
Overjet, mm	3.5 (1.0)	0.0 (3.0)	5.2 (2.0)	6.5 (2.2)	***(BN < DDR = DDNR)
Soft Tissue Relationships					
Ricketts' E-line to upper lip, mm	0.9 (2.4)	−2.2 (3.2)	1.1 (2.3)	3.2 (2.9)	***(BN < DDR = DDNR)
Ricketts' E-line to lower lip, mm	5.9 (2.9)	1.7 (2.8)	2.5 (2.7)	4.5 (3.2)	*(BN < DDNR)

[a] BN, bilateral normal disk position.
[b] DDR, bilateral disk displacement with reduction.
[c] DDNR, bilateral disk displacement without reduction.
[d] A Kruskal-Wallis test was used to analyze differences in variables between the three groups at a significance level of $\alpha = .05$. NS, not significant; * $P < .05$; ** $P < .01$; *** $P < .001$.

difference in vertical skeletal relationships was noted between BN and DDR or DDNR (Table 2).

The variables associated with the mandible were statistically significant, but the variables associated with the maxilla (SNA and Points A to N perpendicular) were not statistically significant in the maxillomandibular relationships (Table 2). Generally, subjects with TMJ ID had a smaller SNB and pogonion to N perpendicular, and a larger facial convexity, ANB, and Wits appraisal than those with BN. This means that subjects with TMJ ID had a retrognathic mandible compared with those with BN. Between-group comparisons indicated that statistical differences were found mainly between BN and DDR or DDNR, except for pogonion to N perpendicular. The pogonion to N perpendicular discriminated the differences between DDR and DDNR, as well as between BN and DDR.

Among the variables that represent size and form of the mandible, all except MNACBR were statistically significant (Table 2). Generally, subjects with TMJ ID showed smaller ramus height, effective mandibular length (Ar-Pog) and gonial angle, and larger ramus inclination and articular angle. This indicates that subjects with TMJ ID had a clockwise rotation of ramus and small size of mandible compared with those with BN. Results of between-group comparisons showed that differences in ramus inclination, effective mandibular length, articular angle, and gonial angle were found mainly between BN and DDR or DDNR, and ramus height did not evidently change until ID progressed to DDNR (BN > DDNR).

In terms of dental relationships, the variables associated with position of mandibular incisors were statistically significant between BN and DDR or DDNR. Subjects with TMJ ID showed smaller mandibular incisor to FH plane angle and mandibular incisor to A-Pog, and larger mandibular incisor to mandibular plane angle and overjet, than those with BN (Table 2). This means that subjects with TMJ ID had a relatively backward position of the mandibular incisors accompanied by significant labial tipping compared with those with BN.

All variables demonstrated strong statistical significance in terms of soft tissue relationships. Generally, subjects with TMJ ID had relative protrusion of the upper and lower lips.

DISCUSSION

TMJ ID has been reported to be associated with an altered facial morphology, such as backward rotation and position of ramus and mandible, which is skeletal Class II relationship with a retrognathic mandible.[9,10,17] This means that patients with TMJ ID may have a high possibility of showing a skeletal Class II pattern, and TMJ ID may be difficult to find in those with skeletal Class III pattern. This is consistent with our data which show that the prevalence of TMJ ID was difficult to estimate in subjects with skeletal Class III pattern when discriminating among subjects using traditional skeletal parameters, such as ANB, Wits appraisal, and facial convexity (Table 3). This may be due to the fact that compared with MNACBR, traditional anteroposterior skeletal parameters are significantly influenced by TMJ ID. These issues may justify using MNACBR as a discriminating variable to choose skeletal Class III patients with TMJ ID. In this study, the ranges of SNB, ANB, pogonion to N perpendicular, facial convexity, and Wits appraisal in Class III subjects with TMJ ID may overlap those of the variables in Class I or II subjects with BN (Table 2). Therefore, skeletal Class III patients with TMJ ID may be misdiagnosed as skeletal Class I or II pattern despite their larger mandibles.

Table 3. Numbers and Distribution of Skeletal Class III Subjects Out of the Sample Frame (Total 167 Subjects) According to Different Discriminating Criteria: ANB Angle, Wits Appraisal, Facial Convexity, and Mandibular Body Length to Anterior Cranial Base Ratio (MNACBR)

Variables	BN[a]	DDR[b]	DDNR[c]	Total
ANB $<$ 1.0 degree	29 (96.7%)	1 (3.3%)	0 (0.0%)	30 (100.0%)
Wits appraisal < -5.0 mm	31 (75.7%)	8 (19.5%)	2 (4.8%)	41 (100.0%)
Facial convexity < -1.0 degree	22 (100.0%)	0 (0.0%)	0 (0.0%)	22 (100.0%)
MNACBR $>$ 1.12	33 (50.0%)	16 (24.2%)	17 (25.8%)	66 (100.0%)

[a] BN, bilateral normal disk position.
[b] DDR, bilateral disk displacement with reduction.
[c] DDNR, bilateral disk displacement without reduction.

Although cause-effect relationship may be unclear, this study showed an association between TMJ ID and dentofacial changes in subjects with skeletal Class III pattern. Altered preexisting dentofacial problems may cause TMJ ID, and TMJ ID may cause altered dentofacial morphologies. Some patients may have TMJ ID even before dentofacial discrepancies occur. Nevertheless, this study suggests that TMJ ID may affect dentofacial morphology, specifically, mandibular morphology. This is consistent with recent studies indicating that TMJ disk displacement can cause dentofacial changes approaching a retrognathic mandible with reduced ramus height.[18,19]

Changes in mandibular morphology may be due to osseous changes in the condylar head by TMJ ID. Previous studies have reported bony changes on the articular surface of the mandibular condyle in subjects with TMJ ID, specifically, decreased condylar height with a distally inclined condylar head.[20,21] Changes in condylar and mandibular morphology may also influence changes in maxillomandibular relationships, manifesting decreases in SNB and Pog to N perpendicular, and increases in ANB angle and facial convexity, among patients with TMJ ID (Table 2). The skeletal changes already described can influence dental and soft tissue relationships. Labial tipping of the lower incisor may be due to dental compensation of the lower incisor as a result of clockwise rotation of the ramus and backward position of the mandible. The protrusive upper and lower lips may also be related to a retrognathic position and backward rotation of the mandible. A large overjet indicates a skeletal Class II tendency with a retrognathic mandible in subjects with TMJ ID.

However, the dentofacial changes associated with TMJ ID were greater between subjects with BN and DDR than between those with DDR and DDNR. The cephalometric signs of TMJ ID, such as backward rotation of the ramus, a retruded position of the mandible, and labial tipping of the mandibular incisors, were significantly different only between BN and DDR. Subjects with DDNR did not present more significant dentofacial changes than those with DDR, even though they had a more severe ID condition. It seems that in skeletal Class III patients, the dentofacial system begins to change significantly at an initial stage when ID develops to DDR from BN, and the initial changes associated with TMJ ID are not evidently advanced during TMJ ID progress. Therefore, it is recommended that orthodontists be careful not to overlook these early changes at the initial examination when diagnosing patients with skeletal Class III pattern.

It is interesting to note that TMJ ID did not significantly influence vertical skeletal relationships despite significant changes in horizontal maxillomandibular relationships among subjects with skeletal Class III pattern. These changes in skeletal relationships can explain a significant decrease in overjet with minimal changes in overbite in patients with TMJ ID (Table 2). However, this is not consistent with previous studies, which showed that patients with TMJ ID had severe vertical skeletal discrepancy, seen by decreased posterior facial height compared with those with normal disk position.[8,9] Although subjects with DDNR tended to have larger FMA, SN to mandibular plane angle, and maxillomandibular plane angle than those with BN (Table 2), no significant difference in these skeletal parameters was observed between them. The insignificant relationship between TMJ ID and vertical skeletal relationships may be explained in part by the fact that patients with skeletal Class III patterns already have severe vertical discrepancies compared with skeletal Class I or Class II patterns,[22] which may diminish the effects of TMJ ID on vertical skeletal relationships. However, this may be due mainly to the decrease in gonial angle noted in skeletal Class III subjects with TMJ ID (Table 2).

Decreased gonial angle is associated with bone remodeling in the gonial region, which may result from localized alteration in the functional environment created by TMJ ID. This is supported in part by a previous study, which showed excessive bone growth in the gonial area as compensation for decreased ramus height induced by disk displacement.[19] The change in gonial angle would be one of the key factors indicating a potential TMJ ID in subjects with an oversized mandible, because no significant change in gonial angle was seen in TMJ ID subjects with other malocclusions.[8,9] Additional studies will be needed to dissect the relationships between TMJ ID and gonial angle in patients with Class III skeletal pattern.

CONCLUSIONS

- Skeletal Class III subjects with TMJ ID showed clockwise rotation of ramus, backward position of mandible, labial tipping of mandibular incisors, and protrusion of upper and lower lips.
- Significant dentofacial changes were found mainly between BN and DDR, indicating that dentofacial morphologies may begin to change during the initial stage of TMJ ID.
- TMJ ID did not significantly influence vertical skeletal relationships in subjects with skeletal Class III patterns.
- Skeletal Class I or II maxillomandibular relationships accompanied by an oversized mandible can be a potential sign of TMJ ID.

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