Original Article

Evaluation of horizontal condylar angle in malocclusions with mandibular lateral displacement using cone-beam computed tomography

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ABSTRACT

Objectives: To evaluate the horizontal condylar angle (HCA) in mandibular lateral displacement (MLD).

Materials and Methods: HCA in MLD malocclusions were examined using cone-beam computed tomography data in subjects with MLD and control subjects.

Results: HCA in joints of control patients and contralateral side joints of MLD patients were not significantly different. The mean HCA on the shifted side was larger than on the contralateral side ($P < .001$) in the different HCA groups. HCA was significantly larger on the shifted side than on the contralateral side in skeletal Class I, Class II, and Class III groups ($P < .001$).

Conclusions: (1) There was no statistically significant difference between HCA in control patients and on the contralateral side in MLD patients. (2) HCA was significantly larger on the shifted side than on the contralateral side. (3) HCA on the shifted side and the contralateral side in MLD Class I, Class II, and Class III are significantly different. (*Angle Orthod.* 2021;91:815–821.)

KEY WORDS: Facial asymmetry; Mandibular lateral displacement; Horizontal condylar angle; CBCT

INTRODUCTION

A previous study of the morphological characteristics of mandibular lateral displacement (MLD) found that they were commonly characterized as having a deviation of the chin from the facial midline because of a mandibular shift to one side that caused both skeletal asymmetry and dental midline discrepancies, posterior crossbites, mandibular rotational displacement, condylar lateral displacement, and postural changes in temporal bone position.[1,2] Studies have reported that among all malocclusions, MLD has the highest probability to develop temporomandibular joint disorders (TMD) and that symptoms are more likely to develop on the shifted side (ie, the side of the laterally displaced bony chin) of the temporomandibular joint (TMJ).[3–5]

Several studies have addressed the relationship between occlusion and TMD.[6–8] Fushima et al.[5] showed that in patients with MLD and TMD, significant occlusal characteristics included a more distal occlusal relationship of the first molar on the mandibular shifted side as compared with that on the contralateral side (the opposite side of the laterally displaced bony chin), a midline discrepancy, and a right-left difference in the molar relationship.

Larheim[9] reported that patients with internal derangement of the TMJ showed morphological changes of the mandibular condyle. An easily quantifiable morphological marker associated with TMJ osteoarthrosis (OA) is the horizontal condylar angle (HCA). The HCA was found to be large in Class II cases[10] and has also been associated with OA of the TMJ.[11] Different studies have shown that a greater HCA was associated with disc displacement and degenerative changes.[11–16] Lee et al.[15] reported that a larger HCA was associated with moderate to severe OA. Their

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subsequent longitudinal study showed that the initial progression of OA preceded increases in HCA.[16]

The development of cone-beam computed tomography (CBCT) has markedly improved craniofacial skeletal evaluation.[17,18] The TMJ condyles are easily visible in CBCT images and allow both a more detailed analysis of TMJ osseous changes and a more accurate HCA measurement because of the ability to capture the condylar long axis with image reorientation. Therefore, HCA measurement by CBCT has the potential to provide a more consistent and objective means of describing OA.[19,20]

The results of a previous study noted that MLD was accompanied by three-dimensional (3D) rotation of the mandible and that load was applied to the joint on the shifted side.[2] These findings might provide information regarding the developmental mechanism of TMD and degeneration of the condyles by examining differences between the shifted side and contralateral side of HCA in patients with MLD. This retrospective 3D CBCT study aimed to evaluate and quantify the HCA in MLD malocclusions.

MATERIALS AND METHODS

The UNICOC Institutional Review Board (Acta–012) approved this study to protect human subjects. We obtained 3D data from CBCT scans of patients at a private orthodontic practice.

The retrospective convenience sample consisted of 58 patients (20 males, 38 females). The mean patient age was 26.1 years (SD 6.6 years; range 17–53 years) with Class I, Class II, and Class III MLD malocclusion based on the anteroposterior dysplasia indicator developed by Kim.[21] The control group consisted of 30 patients (12 males, 18 females) with Class I and non-MLD malocclusions and a mean age of 22.2 years (SD 4.2 years; range 18–38 years). The sample was selected from a database of pretreatment clinical examination records using photographs and CBCT scans. Subjects were of diverse ethnic backgrounds. They were selected based on the following inclusion criteria: (1) MLD observed by a chin deviation of 2.4° or more, such as evaluated by the angle formed by the ANS-Me line and the midsagittal reference plane (MSRP; N-ANS-Ba); (2) mismatched right and left molar relationships as well as noncoinciding dental midlines; (3) all permanent teeth erupted, including second molars; and (4) absence of pathological conditions affecting the TMJ.

The CBCT scans were performed with a Kodak 9500 Cone Beam (Rochester, NY, USA) and were imported into Anatomage Dental InVivo software, version 6.0.4 (San Jose, CA, USA) for rendering. The cases were anonymized by removing all patient identifiers. All patients included in the sample signed a consent to use their records.

A 3D cephalometric analysis was developed with 17 different landmarks accurately selected in the 3D volume and then refined in the axial, coronal, and sagittal slices. A single calibrated operator (Dr Velásquez) selected the anatomical landmarks and performed the cephalometric analysis. Angular 3D cephalometric measurement data were exported from the InVivo software to Microsoft Excel files. The measurements were then exported from the Excel files to SPSS v25 software for statistical analysis.

Four 3D reference planes were defined and established (Figure 1; Table 1). The most convex point of the lateral pole (lateral pole) and the most convex point of the medial pole (medial pole) of the condyle were selected in the axial view to measure the HCA. The condylar long axis was defined as its maximum mediolateral length from the medial pole and lateral pole. The coronal reference plane (CRP) was a plane through the Sella and perpendicular to the MSRP and anatomical horizontal. The HCA was defined as the angle between each condylar long axis and the CRP in axial views (Figure 1c).

In this study, MLD cases were divided into two groups: the different HCA group, in with a different HCA on the shifted side and the contralateral side (more than 3°), and the no different HCA group, with no HCA difference on the shifted side and the contralateral side (less than 3°).

Statistical Analysis

The group sample size (n = 58 for a *t*-test with two equal groups) was calculated using G*Power software version 3.1.9.2, which allowed for an alpha value = 0.05 and an effect size = 0.54 and provided an excellent power = 0.80.

The same investigator (Dr Velásquez) was calibrated as follows: two reliability assessment tests were done on two 15 subject groups taken 4 weeks apart. After the first evaluation, the discrepancies were examined to refine the measurements. The second reliability assessment test was then performed, and the resulting mean differences between paired differences and absolute differences were used to assess bias and precision. Reliability coefficients based on between-subject variability and within-subject variability were calculated, and variables with a reliability coefficient less than 0.85 were discarded in the second calibration.[22]

Statistical analyses were performed with Microsoft Excel 2013 and SPSS v25 using a confidence level of $P < .05$. The data were subjected to normality tests, using the Kolmogorov-Smirnov and Shapiro-Wilk tests.

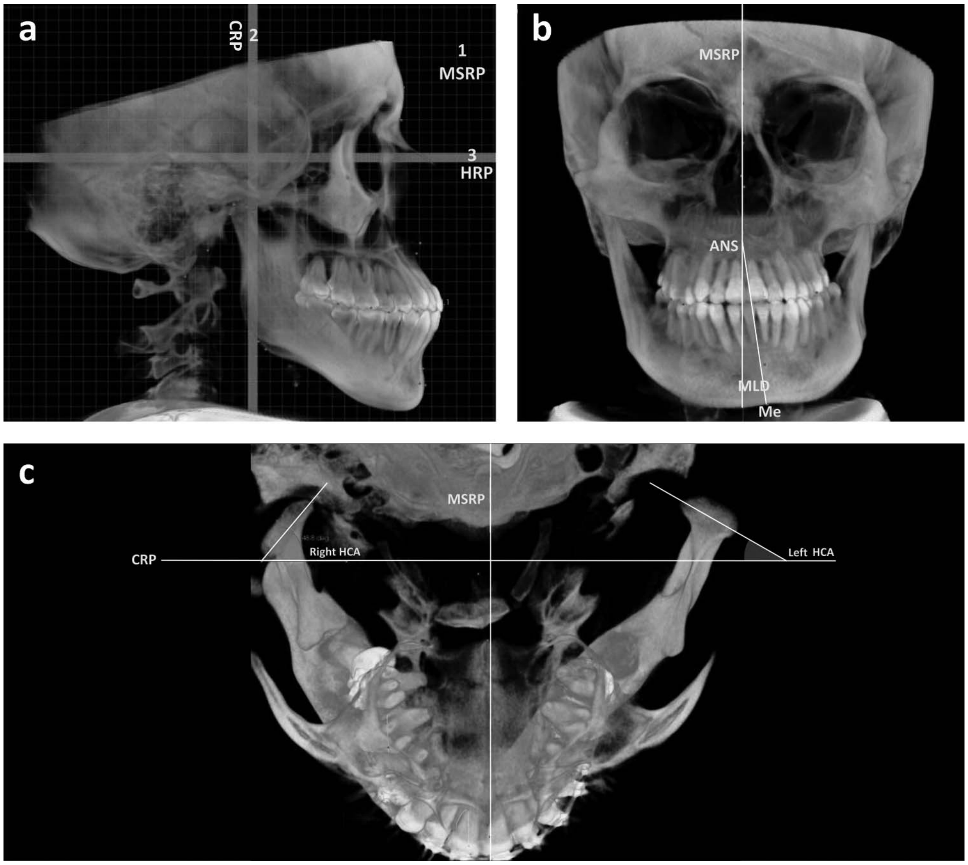

Figure 1. Graphic representation of the 3D reference planes. (a) Midsagittal reference plane (MSRP). (2) Coronal reference plane (CRP). (3) Horizontal reference plane (HRP). (b) Mandibular lateral displacement (MLD). (c) Horizontal condylar angles (HCAs).

The Mann-Whitney *U* test was used to compare two independent samples, the HCA in the Class I–non MLD group and the HCA in the MLD group. The HCA values on the shifted side and the contralateral side in the skeletal Class I and Class II MLD groups did not reject the hypothesis of normality when subjected to the Shapiro-Wilk test and, consequently, were analyzed through a paired *t*-test. When subjected to the same test, the skeletal Class III group rejected the hypothesis of normality, so the nonparametric Wilcoxon test was applied.

The entire sample data set was analyzed, and no significant differences were found between the sex variables.

RESULTS

In the classification of the skeletal morphology of MLD cases in the sample, Class III was the largest group (51.7%), followed by Class II (29.3%) and Class I (18.9%; Table 2). As a result of examining the combination of right and left Angle molar classification in each skeletal pattern, various combinations were seen. It was observed that Class I and Class II were the most frequently seen with 22 cases (37.9%), the combination of Class I and Class III was seen in 21 cases (36.2%), and the most severe MLD combination of Class III and Class II in 7 patients (12.1%; Table 2).

The HCA measurements in the Class I–non MLD group showed an average of 17.7° ± 4.1° in both condyles, whereas a clear shifted side–contralateral

Table 1. Definition of 3D Planes Used in the Analysis

Plane	Definition
Midsagittal reference plane (MSRP)	Plane through Basion, Nasion, and ANS
Anatomical horizontal (AH)	Plane that contains a posterior-anterior vector (PoR to OrR) that is perpendicular to the midsagittal reference plane (MSRP)
Coronal reference plane (CRP)	Plane through the Sella and perpendicular to the midsagittal reference plane (MSRP) and anatomical horizontal (AH)
Horizontal reference plane (HRP)	Plane through the Sella and perpendicular to the midsagittal reference plane (MSRP)

Table 2. Variation of Mandibular Lateral Displacement (MLD)

	Number of Cases	
	n = 58	%
Skeletal Class		
Class III	30	51.7
Class II	17	29.3
Class I	11	18.9
Combination of molar relation		
Class I and III	21	36.2
Class I and II	22	37.9
Class II and III	7	12.1
No difference	8	13.8

side difference was observed in the MLD group (Table 3). The HCA on the MLD shifted side was significantly larger, while the HCA on the MLD contralateral side was not significantly different from that of the Class I non-MLD control group (Table 3).

In the entire MLD group (n = 58), most of the cases (81.0%) showed a difference of more than 3° in the HCA of the shifted side vs the contralateral side, but there was no difference in the remaining 19%. Therefore, in this study, the HCAs of MLD were divided into two groups, those with a different HCA group (n = 47) and those with no difference in the HCA group (n = 11); these groups were then compared (Table 4). As a result, a highly significant difference was observed between the shifted and contralateral sides in the different HCA groups. These results indicated that the condyle on the shifted side in MLD cases had a large HCA, suggesting a strong tendency for morphological alterations in these condyles.

Table 5 shows the HCA values on the shifted and contralateral sides in skeletal Class I, Class II, and Class III MLD groups and the skeletal Class I control group with non-MLD. There were significant differences between the shifted and contralateral sides in the Class I, Class II, and Class III MLD groups. HCA was significantly larger on the shifted side than on the contralateral side in the Class I, Class II, and Class III MLD groups ($P < .001$).

DISCUSSION

MLD malocclusions are characterized not only by mandibular displacement but also by exhibiting the highest prevalence of TMD among all malocclusions.[2,4,5] The HCA is one of the essential indicators of degenerative joint disease and can be measured using CBCT. TMJ OA must be accurately established, and images are an integral part of the diagnostic algorithm.[19,20] Therefore, it is imperative to detect OA, and CBCT is the most useful imaging diagnostic tool currently available.[19,23]

In this study, 58 patients with MLD malocclusion and 30 patients in the control group with Class I and non-MLD malocclusion were examined using 3D CBCT scans to evaluate and clarify the relationship between MLD and HCA. The purpose of this evaluation was to develop a clearer understanding of the importance of occlusion and the development of TMD. This study showed that the HCAs on the shifted side and the contralateral side in MLD Class I, II, and III were statistically different (Table 5), with the shifted side being larger. The difference between the shifted side and the contralateral side was approximately 6° to 7°. The largest HCA found (32.4°) was in the shifted side in the skeletal Class II group, followed by the HCA (24.5°) in the skeletal Class I group, which was about 8° different from the other groups (Table 5). These findings suggested a possible developmental mechanism of TMD in MLD malocclusions.

In a previous CT study, Eisenberger et al.[24] reported that the intercondylar angles were not different from controls in the group of patients with TMD. One possible reason for that result is that they measured intercondylar angles, defined as the angle between the right and left long condylar axis instead of individual HCA, as measured in the current study.[24] In the current study, the HCA on the shifted side and the group's contralateral side did not differ from the group with a shifted side–contralateral side difference in the HCA of MLD cases. There were 47 cases (81.0%) in which HCA was different in the shifted side–contralateral side, and there were seven cases (Cl II and Cl III molar

Table 3. Median Horizontal Condylar Angle (HCA) in the Different Groups

Table 3. Median horizontal condylar angle (HCA) in different groups

	Number of the case	
	(n)	**HCA (Degree) (Median ± Standard deviation)**
Class I Non-mandibular lateral displacement (MLD)	30	17.7 ± 4.1
MLD - Shifted Side	58	24.4 ± 9.8
MLD - Contralateral Side	58	17.0 ± 4.1

*Statistically significantly differences between group (Man-Whitney U test, P < 0.0001)
† No statistically significantly differences between group (Man-Whitney U test, P = 0.822)

Table 4. Mean Horizontal Condylar Angle (HCA) in the Different Groups

Table 4. Mean horizontal condylar angle (HCA) in different groups			
	(Mean ± Standard deviation)	**Max.**	**Min.**
Different HCA group (n=47)			
HCA in Shifted Side	27.2 ± 9.7	48.8	11.4
HCA in Contralateral Side	19.2 ± 9.2	41.8	2.3
Difference	8.0 ± 1.9		
No Different HCA group (n=11)			
HCA in Shifted Side	19.6 ± 7.8	30.7	7.5
HCA in Contralateral Side	19.1 ± 9.3	35.3	7.6
Difference	0.5 ± 3.7		
*Statistically significantly differences between group (2-tailed t-test, P < 0.0001)			

relation) in which there was an overwhelming difference. The mean was 27.2° on the shifted side and 19.2° on the contralateral side in the group with shifted side–contralateral side difference in the group with shifted side–contralateral side 8.0° (Table 4). These findings indicated that the shifted side–contralateral side difference was manifested in structural changes of the joint. In a study using CT data, Lee et al.[15] showed that, in patients with unilateral TMJ OA, the average HCA in the unilaterally OA-affected joints was significantly greater than in the unaffected joints on the contralateral side. Their subsequent longitudinal study found that a greater HCA was associated with TMJ OA, and they concluded that the clinical progression of OA preceded the increases in HCA.[16] The findings in the present study of greater HCA in MLD on the shifted side joints than on the contralateral side joints using CBCT agreed with their conclusions. They were similar to the previous HCA results in patients with disc displacement as detected with magnetic resonance imaging (MRI).[13,14] Using MRI, Westesson et al.[11] found that the HCA was smallest in joints with a normal disc position and became larger in joints with disc displacement, degenerative joint disease, or both. Kurita et al.[14] reported that the HCA was increased in joints with disc displacement without reduction. Using MRI, Torres et al.[25] found that larger or smaller HCA showed a significant association with disc displacement, as compared with the mean HCA in their sample.

In the present study, the overall trend was to observe a higher HCA on the MLD patients' shifted side joints, 81% (47/58). However, in 18.9% (11/58) of the MLD patients, the HCA was smaller on the shifted side than on the contralateral side joints. Lee et al.[15] also reported similar findings: the affected joint angles were smaller than the unaffected contralateral joints in 22% (13/60) of the unilateral OA patients. These findings warrant further investigation.

There are several possible explanations for the increased HCA in MLD-shifted side joints. One reason could be that remodeling associated with disc displacement might result in a larger HCA.[14] Previous reports showed that the condyle of the shifted side was displaced in three dimensions: posteriorly, upward, and inward at the same time.[1,2] These findings suggest a possible mechanism for the increased HCA found in the shifted side joints; as the shifted side condyle is displaced distally, its lateral pole is supported by the strong lateral ligament that inhibits its distal displacement. Alternately, the medial pole, lacking this strong ligamentous support, is easily displaced backward, thus providing a rotational component of force on the

Table 5. Horizontal Condylar Angle (HCA) in Different Skeletal Mandibular Lateral Deviation (MLD) and Class I Non-MLD Groups

Skeletal Class	Shifted Side (SS) (Mean ± SD)	Contralateral Side (CLS) (Mean ± SD)	Difference (Mean ± SD)
Sk. Class I MLD (n = 11)	24.5 ± 8.9	18.0 ± 7.3*	6.5 ± 3.5
Sk. Class II MLD (n = 17)	32.4 ± 6.9	25.5 ± 6.8**	6.9 ± 2.3
Sk. Class III MLD (n = 30)	(Median ± SD) 19.1 ± 9.9	(Median ± SD) 14.1 ± 9.5***	(Median ± SD) 5.0 ± 2.5
	Right side (Median ± SD)	Left side (Median ± SD)	Total (Median ± SD)
Skeletal Class I non-MLD	17.7 ± 3.8	17.7 ± 4.7	17.7 ± 4.1

* Statistically significantly different from the shifted side (two-tailed *t*-test, $P < .0001$).
** Statistically significantly different from the shifted side (two-tailed *t*-test, $P < .0001$).
*** Statistically significantly different from the shifted side (Wilcoxon test, $P < .0001$).

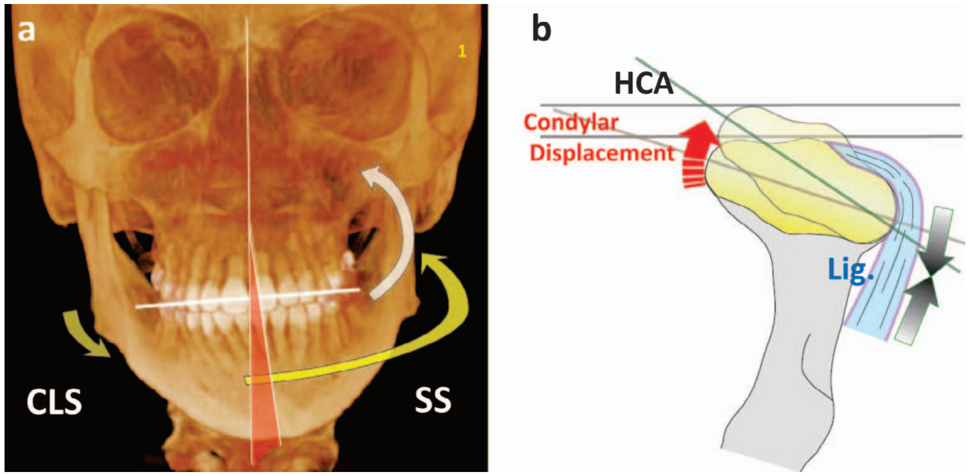

Figure 2. Illustration of a possible mechanism for the increased HCA found in the shifted side joints. (a) Previous reports showed that the condyle of a shifted side was three dimensionally displaced posteriorly upward and inward at the same time. (b) As the shifted side condyle was displaced distally, its lateral pole was supported by the strong lateral ligament that inhibited its distal displacement. Alternately, the medial pole, lacking this strong ligamentous support, was easily displaced backward, thus providing a rotational component of force on the condyle, which increased the HCA.

condyle, which increases the HCA. The compression placed on the distally displaced medial pole can also cause an anterior or anteromedial disc displacement and TMD development (Figure 2).

The results of both this and previous studies[10,11,26,27] demonstrated that skeletal Class II patients had a larger HCA than the regular occlusion patients and that the patients with Class III malocclusion had the smallest HCA of all the groups. Therefore, it can be construed that a larger HCA was consistent with a distal displacement of the mandible and a smaller HCA with mesial displacement. Therefore, when considering the Angle classification, the shifted side had more of a Class II molar relationship than the contralateral side did. A larger HCA on the shifted side joint might be consistent with the findings. However, the reasons why and how these differences in the HCA occurred between the malocclusion groups should be the subject of future research.

CONCLUSIONS

- There was no statistically significant difference between the HCA in the joints of the control patients and contralateral side joints in patients with MLD.
- The HCA was significantly larger on the shifted-side joints than on the contralateral-side joints.
- The HCA on the shifted side and the contralateral side in MLD Classes I, II, and III are significantly different.

REFERENCES

1. Ishizaki K, Suzuki K, Mito T, et al. Morphologic, functional, and occlusal characterization of mandibular lateral displacement malocclusion. *Am J Orthod Dentofacial Orthop*. 2010;137:454.e1–9.
2. Velásquez RL, Coro JC, Londoño A, McGorray SP, Wheeler TT, Sato S. Three-dimensional morphological characterization of malocclusions with mandibular lateral displacement using cone-beam computed tomography. *Cranio*. 2017;36:143–155.
3. Inui M, Fushima K, Sato S. Facial asymmetry in temporomandibular joint disorders. *J Oral Rehabil*. 1999;26:402–406.
4. Fushima K, Akimoto S, Takamoto K, et al. Incidence of temporomandibular disorders inpatient with malocclusion. *J Jpn Soc TMJ*. 1989;1:40–50.
5. Fushima K, Inui M, Sato S. Dental asymmetry in temporomandibular disorders. *J Oral Rehabil*. 1999;26:752–756.
6. Ingervall I, Mohlin B, Thilander B. Prevalence of symptoms of functional disturbances of the masticatory system in Swedish men. *J Oral Rehabil*. 1980;7:185–197.
7. Barghi N, Aguilar T, Martinez C, Woodall WS, Maaskant BA. Prevalence of types of temporomandibular joint clicking in subjects with missing posterior teeth. *J Prosthet Dent*. 1987;57:617–620.
8. Owen AH. Orthodontic: orthopedic treatment of craniomandibular pain dysfunction. Part 4: unilateral and bilateral crossbite. *Cranio*. 1985;3:145.
9. Larheim TA. Current trends in temporomandibular joint imaging. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 1995;80:555–576.
10. Sugisaki M, IKai J. A study of the horizontal condylar angle of the Japanese dry skull. *J Jpn Soc*. 1991;3:1–13.
11. Westesson PL, Bifano JA, Tallents RH, Hatala MP. Increased horizontal angle of the mandibular condyle in abnormal temporomandibular joints: a magnetic resonance imaging study. *Oral Surg Oral Med Oral Pathol*. 1991;72:359–363.
12. Westesson PL, Liedberg J. Horizontal condylar angle to internal derangement of the temporomandibular joint. *Oral Surg Oral Med Oral Pathol*. 1987;64:391–394.

13. Sulun T, Akkayan B, Duc JMP, Rammelsberg P, Tuncer N, Gernet W. Axial condyle morphology and horizontal condylar angle in patients with internal derangement compared to asymptomatic volunteers. *Cranio*. 2001;19:237–245.
14. Kurita H, Ohtsuka A, Kobayashi H, Kurashina K. Relationship between increased horizontal condylar angle and resorption of the posterosuperior region of the lateral pole of the mandibular condyle in temporomandibular joint internal derangement. *Dentomaxillofacial Radiol*. 2003;32: 26–29.
15. Lee PP, Stanton AR, Hollender LG. A greater mandibular horizontal condylar angle is associated with temporomandibular joint osteoarthritis. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2017;123:502–507.
16. Lee PP, Stanton AR, Hollender LG. Osteoarthritis of the temporomandibular joint and increase of the horizontal condylar angle: a longitudinal study. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2019;127:339–350.
17. Baumgaertel S, Palomo J, Hans M. Reliability and accuracy of cone-beam computed tomography dental measurements. *Am J Orthop Dentofacial Orthop*. 2009;136:19–25.
18. Damstra J, Fourie Z, Ren Y. Evaluation and comparison of posteroanterior cephalograms and cone-beam computed tomography images for detection of mandibular asymmetry. *Eur J Orthod*. 2013;35:45–50.
19. Ahmad M, Hollender L, Anderson Q, et al. Research diagnostic criteria for temporomandibular disorders (RDC/TMD): development of image analysis criteria and examiner reliability for image analysis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2009;107:844–860.
20. Look JO, Schiffman EL, Truelove EL, Ahmad M. Reliability and validity of axis I of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) with proposed revisions. *J Oral Rehabil*. 2010;37:744–759.
21. Kim Y. Anteroposterior dysplasia indicator: an adjunct to cephalometric differential diagnosis. *Am J Orthod*. 1978;73: 619–633.
22. Fleiss J. *The Design and Analysis of Clinical Experiments*. Hoboken, NJ: Wiley-Interscience; 1986.
23. Larheim TA, Abrahamsson AK, Kristensen M, Arvidsson LZ. Temporomandibular joint diagnostics using CBCT. *Dentomaxillofacial Radiol*. 2015;44:20140235.
24. Eisenberger M, Haubitz B, Schmelzeisen R, Wolter S, Tschernitschek H. The human mandibular intercondylar angle was measured by computed tomography. *Arch Oral Biol*. 1999;44:947–951.
25. Torres MG, Crusoé-Rebello IM, Rosário M, Albuquerque MC, Campos PS. Morphometric features of the mandibular condyle and association with disc abnormalities. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2016;121:566–572.
26. Kim HO, Lee W, Kook YA, Kim Y. Comparison of the condyle fossa relationship between skeletal class III malocclusion patients with and without asymmetry: a retrospective three-dimensional cone-beam computed tomography study. *Korean J Orthod*. 2013;43:209–217.
27. Ueki K, Nakagawa K, Takatsuka S, et al. Temporomandibular joint morphology and disc position skeletal class III patients. *J Craniomaxillofac Surg*. 2000;28:362–368.