The condyle and fossa morphology according to the types of temporomandibular disorders on cone beam computed tomography images

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The Master's Thesis

submitted to the Department of Dentistry

the Graduate School of Yonsei University

in partial fulfillment of the requirements for the degree of

Master of Dental Science

Hyun Mi Park

June 2018

This certifies that the Master's Thesis

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June 2018

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Temporomandibular disorders (TMD) affect the complex components of the temporomandibular joint (TMJ): muscle, ligament, the retrodiscal tissue, and bone. TMD with the disc derangement can progenerate osteoarthritis, avascular necrosis, or degenerative remodeling, which are associated with changes in size, shape, and positional relationships of the joint components. TMD, the condyle-fossa anatomy, and maxillomandibular skeletal pattern all those three elements are interrelated. This study evaluated the condyle-fossa anatomy of three types of TMD patients and asymptomatic

control group patients and then compared the differences among these patients using cone-beam computed tomography (CBCT) images. From these measurements, we verified an association between the types of TMD and quantified condyle-fossa anatomy. Additionally, we analyzed the correlation between condyle-fossa anatomy and maxillomandibular skeletal pattern. The null hypothesis was that condyle-fossa anatomy does not differ according to the types of TMD.

Eighty-eight subjects were retrospectively enrolled and classified into four groups: Control (n = 16); Myofascial pain (MPD, n = 25); Disc displacement with reduction (DDwR, n = 23); Disc displacement without reduction with no limited opening (DDwoR, n = 24) group. The inclusion criteria were 1) availability of CBCT images with closed-mouth position including TMJ structure and lateral cephalogram; 2) age over 18 years; 3) diagnosed for TMD by the orofacial pain specialists according to the diagnostic criteria for temporomandibular disorders (DC/TMD). The TMD subjects were divided into three groups; MPD, DDwR, and DDwoR with no limited opening depending on the diagnosis of orofacial pain specialists. And they were compared with the control group. For comparing the condyle-fossa anatomy and maxillomandibular skeletal pattern among the four groups, we measured 9 variables (condyle volume, condyle height, condyle length, condyle width, fossa height, fossa length, and anterior, superior, and posterior joint spaces) from CBCT images and 8 variables (ANB angle, SN-GoGn angle, Articular angle, Gonial angle, Ramus height, PFH/AFH ratio, Overbite, Overjet) from lateral cephalogram. We performed one-way analysis of variance and Scheffe post-hoc test to compare the four groups. For dealing with variables which did not show normal distribution, Kruskal-Wallis test, and Mann-Whitney post-hoc test were used. In addition, Pearson correlation analysis was done to determine a relationship between condyle-fossa anatomy and maxillomandibular skeletal pattern.

The results were as follows:

1. There were significant differences of condyle volume, condyle width, superior joint space, SN-GoGn angle, and PFH/AFH ratio among the four groups. The MPD, DDwR, and DDwoR group showed a smaller value of condyle volume and larger condyle width than the control group ($P<0.001$). The DDwR group showed smaller superior space than the MPD group ($P<0.05$). Also, the DDwR group showed lager Sn-GoGn angle ($P<0.05$) and smaller PFH/AFH ratio ($P<0.01$) than the MPD and control group. Finally, the DDwR group showed shorter ramus height than the control group ($P<0.05$).
2. In the Pearson correlation analysis, the condyle volume showed a negative correlation with the Sn-GoGn angle and showed a positive correlation with ramus height, PFH/AFH ratio and overbite ($P<0.05$). The condyle height showed a strong negative correlation with ANB, Sn-GoGn angle, articular angle and overjet, and it showed a positive correlation with ramus height and PFH/AFH ratio ($P<0.05$). Similarly, the condyle width was negatively correlated with ANB, Sn-GoGn angle, articular angle and overjet ($P<0.05$), and it was positively correlated with ramus height and PFH/AFH ($P<0.01$). Posterior space showed a positive correlation with ANB and fossa length showed a negative correlation with ANB and overjet ($P<0.05$).

Compared with the control group, the MPD, the DDwR, and the DDwoR groups showed smaller condyle volume and broader width. Although there are not many variables showing significant differences according to subdiagnosis of TMD, the DDwR group had the significantly narrower superior joint space, larger Sn-GoGn angle and smaller PFH/AFH ratio than the MPD group. Through these findings, we suggest that superior position of condyle contribute to hyperdivergent skeletal pattern meaning the mandibular backward position. Therefore, the type of TMD has limited relations with the condyle-fossa anatomy and maxillomandibular skeletal pattern. From the correlation analysis, we also found that condyle height, width, and volume of TMD patients are associated with sagittal and vertical skeletal pattern.

Key words: Temporomandibular disorders; Cone-Beam Computed Tomography; Condyle volume; Condyle-Fossa anatomy; Maxillomandibular skeletal pattern

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Ⅰ. Introduction

Temporomandibular disorders (TMD) affect the complex components of the temporomandibular joint (TMJ): muscle, ligament, the retrodiscal tissue, and bone. TMD with the disc derangement can progenerate osteoarthritis, avascular necrosis, or degenerative remodeling, which are associated with changes in size, shape, and positional relationships of the joint components [1]. Although the mechanism remains unclear, these alterations eventually influence the jaw positions and occlusion. Also, the continuous muscle hyperaction might result in positional and morphologic bony change of mandible. Michala et al. [2] found that masticatory muscle force changes according to the fossa eminence inclination, from which we suggest muscle disorder could be associated with condyle-fossa structure changes. In TMD patients, dysfunctional condyle remodeling may be accelerated as the occlusion changes due to dental treatment [3,4]. It is essential to be cautious and consider TMJ structure when planning the clinical procedure.

TMD, the condyle-fossa anatomy and maxillomandibular skeletal pattern all those three elements are interrelated. As for the relation of TMD and condyle-fossa anatomy, the previous study showed that condyle position in fossa tends to be superior and posterior as disc displacement (DD) become worsen [5-8]. For the relationship between TMD and maxillomandibular skeletal pattern, increased incidence of internal derangement and degenerative disorders presented in patients with skeletal Class II profiles and hyperdivergent skeletal pattern [9-11]. Others found that condylar-fossa anatomy varies according to the vertical and sagittal maxillomandibular skeletal pattern [12-14]. Since other studies have barely dealt with three relevant components simultaneously: TMD, condyle-fossa anatomy, and maxillomandibular skeletal pattern, this study was designed to deal with all three components. Although not only the disc displacement but also myofascial pain are the prevalent subdiagnosis of TMD [15], most previous studies concentrated on disc displacement of TMD patients. Meanwhile, the volume measurement of the condyle with

TMD have barely reported yet. So this study included the TMJ with the myofascial pain in the subjects and performed volumetric measurements.

For evaluating condyle anatomy, many studies used two-dimensional tomogram or magnetic resonance imaging (MRI). Even including CBCT studies, condyle position was numerically assessed, but condyle morphology was just categorized; convex, flattened, osteophyte, erosion[16-18]. CBCT enables to select a view among multislice sections, to quantify the real size of condyle structure and to measure a volume of it. Therefore, in this study, CBCT was chosen to assess the TMJ structure and condyle volume.

This study evaluated the condyle-fossa anatomy of three types of TMD patients and asymptomatic control group patients and then compared the differences among these patients using CBCT images. From these measurements, we verified an association between the types of TMD and quantified condyle-fossa anatomy. Additionally, we analyzed the correlation between condyle-fossa anatomy and maxillomandibular skeletal pattern. The null hypothesis was that condyle-fossa anatomy does not differ according to the types of TMD: the control group, the MPD group, the DDwR group, and the DDwoR group.

Ⅱ. Materials and methods

1. Subjects

The eighty-eight subjects were retrospectively chosen from patients who had visited Yonsei university dental hospital from 2010 to 2017. The inclusion criteria were 1) availability of CBCT images with closed-mouth position including TMJ structure and lateral cephalogram; 2) age over 18 years; 3) diagnosis with TMD by the orofacial pain specialists according to the diagnostic criteria for temporomandibular disorders (DC/TMD) (Table. 2)[19]. The other inclusion criteria for the control group were no signs and symptoms and normodivergent skeletal pattern ($30^\circ < \text{SN-GoGn} < 38^\circ$) in the lateral cephalogram. Those subjects had taken CBCT for a detailed examination of TMD or orthognathic surgery planning and taken lateral cephalogram for orthodontic diagnosis. The exclusion criteria were; TMD patients due to ankylosis, trauma or neoplasm formation; congenital craniofacial deformity; severe facial asymmetry with more than 4mm of menton deviation[20]; and history of orthodontic or orthognathic treatment.

The TMD subjects were divided into three groups: Myofascial pain(MPD), disc displacement with reduction (DDwR), and disc displacement without reduction with no limited opening (DDwoR) depending on the diagnosis of orofacial pain specialists. And they were compared with the control group.

Being a retrospective study, written informed patient consent to participate was waived. This study was approved by Yonsei University Dental Hospital Institutional Review Board (No.2-2015-0063).

Table1. Demographic features of the study subjects

	Control (n=16)	MPD (n=25)	DDwR (n=23)	DDwoR (n=24)
Sex (male/female)	6/10	10/15	6/17	6/18
Age (years)	21.09± 3.41	34.12 ± 12.1	25.22 ± 7.32	35.92 ± 16.51

Table 2. Taxonomic Classification for Temporomandibular Disorders

I. TEMPOROMANDIBULAR DISORDERS

- **1. Joint pain**
  - A. Arthralgia
  - B. Arthritis
- **2. Joint disorders**
  - A. Disc disorders
    - 1. Disc displacement with reduction
    - 2. Disc displacement with reduction with intermittent locking
    - 3. Disc displacement without reduction with limited opening
    - 4. Disc displacement without reduction without limited opening
  - B. Other hypermobility disorders
    - 1. Adhesion/ adherence
    - 2. Ankylosis
      - a. Fibrous
      - b. Osseous
  - C. Hypermobility disorders
    - 1. Dislocations
      - a. Subluxation
      - b. Luxation
- **3. Joint disease**
  - A. Degenerative joint disease
    - 1. Osteoarthrosis
    - 2. Osteoarthritis
  - B. Systemic arthritides
  - C. Condylysis/idiopathic condylar resorption
  - D. Osteochondritis dissecans
  - E. Osteonecrosis
  - F. Neoplasm
  - G. Synovial chondromatosis
- **4. Fractures**
- **5. Congenital/developmental disorders**
  - A. Aplasia
  - B. Hypoplasia
  - C. Hyperplasia

II. MASTICATORY MUSCLE DISORDERS

- 1. Muscle pain
  - A. Myalgia
    - 1. Local myalgia
    - 2. Myofascial pain
    - 3. Myofascial pain with referral
  - B. Tendonitis
  - C. Myositis
  - D. Spasm
- 2. Contracture
- 3. Hypertrophy
- 4. Neoplasm
- 5. Movement disorders
  - A. Orofacial dyskinesia
  - B. Oromandibular dystonia
- 6. Masticatory muscle pain attributed to systemic/central pain disorders
  - A. Fibromyalgia/ widespread pain

III. HEADACHE

- 1. Headache attributed to TMD

IV. ASSOCIATED STRUCTURES

- 1. Coronoid hyperplasia

Table developed in collaboration with Peck and Colleagues [19].

2. Measurements

Using a CBCT device (Alphard VEGA, ASAHI Roentgen IND, Kyoto, Japan) set at 5.0-8.0 mA and 80 kV, three-dimensional images were captured for 17s, with a 0.30-mm voxel size and of which the field of view was 154 X 154 mm^2. And then, the images were transformed to DICOM format, reconstructed and analyzed with OnDemand3D™ (Cybermed Co., Seoul, Korea). All CBCT images were reoriented with the Frankfort horizontal (FH) plane determined by the right and left porion, and the left orbitale and the midsagittal plane going through Nasion which is perpendicular to constructed FH plane. The measurements of the normal group were performed on both sides of TMJ and averaged. For the MPD, DDwR, DDwoR group, we measured an affected side of TMJ in each patient. When both TMJ were concerned with TMD, the side of joint showing more severe radiographic features was selected for measurements.

For morphometric analysis of condyle-fossa anatomy, following twelve anatomic landmarks were identified, and nine radiologic outcome variables were assessed in three planes (Table 3, Table 4).

Table 3. Definition of the landmarks used in this study

Landmark		Abbreviation	Definition
Condyle	Superior	Cd-sup	The most superior point of the condylar head in the axial and sagittal planes
	Medial	Cd-med	The most mesial point of the condylar head in the coronal plane
	Lateral	Cd-lat	The most lateral point of the condylar head in the coronal plane
	Anterior	Cd-ant	The most anterior point of the condylar head within a 5-mm radius from Cd-sup in the sagittal plane
	Posterior	Cd-post	The most posterior point of the condylar head within a 5-mm radius from Cd-sup in the sagittal plane
Sigmoidal	Inferior	Sig-inf	The most inferior point of the sigmoid notch
	Posterior	Sig-post	The perpendicular point from the Sig-inf to the tangent line of the Ramal posterior surface in the sagittal plane
Fossa	Superior	Fs-sup	The point having the shortest distance from Cd-sup to the superior wall of the glenoid fossa
	Anterior	Fs-ant	The point having the shortest distance from Cd-ant to the anterior wall of the glenoid fossa
	Posterior	Fs-post	The point having the shortest distance from Cd-post to the posterior wall of the glenoid fossa
Articular tubercle		At-inf	The most inferior point of the articular tubercle
Auditory meatus		Am-inf	The most inferior point of the auditory meatus

Table 4. Definition of the measurements used in this study

Measurement		Definition
Condyle	Volume	A volume of separated condyle between the line across the most superior condylar point and the tangent line to the Sig-inf., which is parallel to the FH plane
	Width	The widest distance between Cd-med. and Cd-lat. in selected coronal section
	Length	The longest distance between Cd-ant. and Cd-post. in selected sagittal section
	Height	A perpendicular distance from Cd-sup. to the line between Sig-inf. and Sig-post. in selected sagittal section
Fossa	Length	A distance from At-inf. to the point that the line is connecting At-inf. and Am-inf. meets to the posterior wall of the glenoid fossa in selected sagittal section
	Height	A perpendicular distance from Fs-sup. to the line connecting At-inf. and Am-inf. in selected sagittal section
Joint space	Superior	The shortest distance from Cd-sup. to the corresponding glenoid fossa
	Anterior	The shortest distance from Cd-ant. to the corresponding glenoid fossa
	Posterior	The shortest distance from Cd-post. to the corresponding glenoid fossa

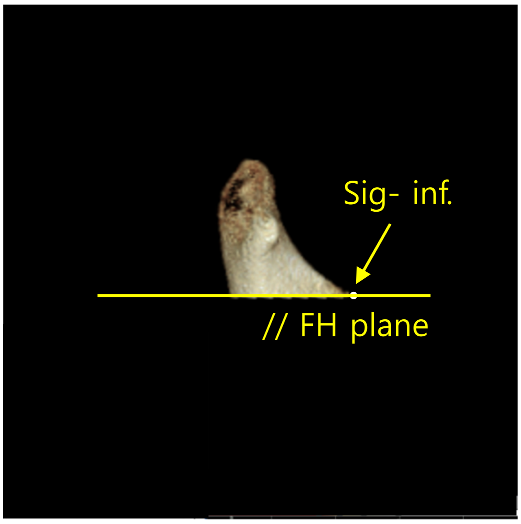
To measure a condyle volume, a plane that goes through the most inferior point of the sigmoid notch and runs parallel to the FH plane was constructed, and then the volume of interest was determined by the constructed plane [21]. This condyle segmentation was done on the sagittal view first and then remove other parts except the condyle on axial and coronal views. The volumetric assessment was performed through an automatic function by OnDemand3D™ for the volume of interest (Fig. 1A) [22]

On the axial view, the Cd-sup was determined where the first radiopaque point appeared while scrolling the image from the upper to the lower region of the joint space. After that, a sagittal section including this Cd-sup point, showing the precise border of TMJ structure, and being near mid sagittal section of condyle head was selected. On this selected sagittal view, the condyle height and length [14,22,23], the fossa height and length [24] and three joint spaces[12] were estimated (Figs. 1B and 1C). The condyle width was measured in a coronal view which showed widest and distinct condyle border (Fig. 1D). The distance between the most medial and lateral point was measured.

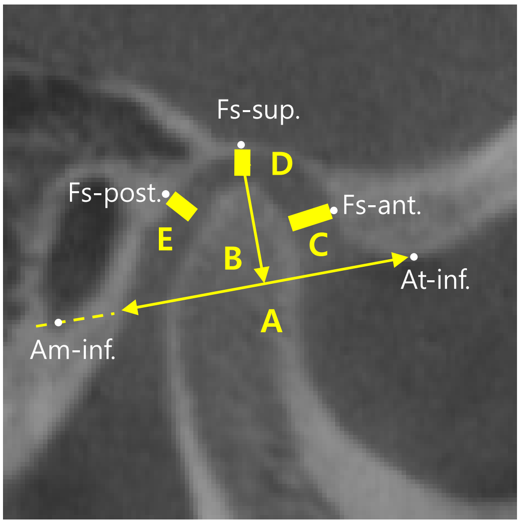
For evaluating skeletal and dental features of the subjects, we traced lateral cephalogram using V-ceph 7.0 (Osstem, Seoul, Korea) and obtained seven measurements: ANB, SN-GoGn angle, Articular angle, Gonial angle, Ramus height, PFH/AFH ratio, Overbite(OB), and Overjet(OJ).

Fig 1. Condyle measurements from CBCT **A]** 3D condyle reconstruction using OnDemand3D™ for volume measurement, **B]** Fossa length (A), height (B), and joint spaces (C, anterior joint space; D, superior joint space; E, posterior joint space) (sagittal view), **C]** Condyle length (A) and height (B) (sagittal view), **D]** Condyle width (coronal view)

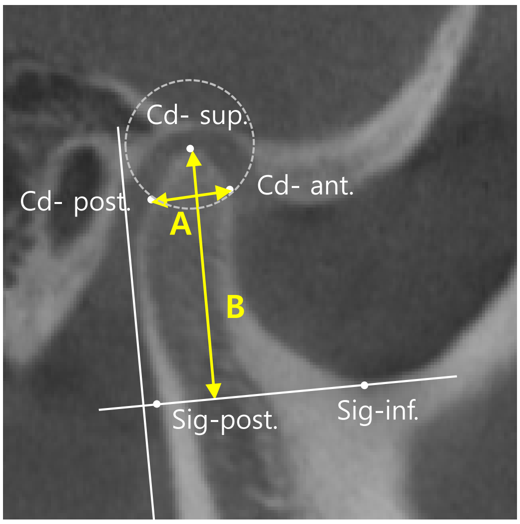
A]



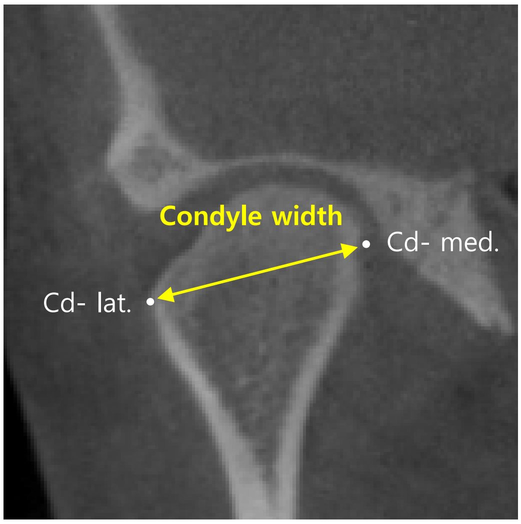
B]



C]



D]



3. Statistical analysis

The data were analyzed with SPSS software (version 23.0 for Windows; SPSS Inc., Chicago, IL, USA). For the tests of normality, Shapiro-Wilk test and outlier test were executed. And then, we performed one-way analysis of variance and Scheffe post-hoc test to compare four groups. For dealing with variables which did not show normal distribution, Kruskal-Wallis test and Mann-Whitney post-hoc test were used. In addition, Pearson correlation analysis was done to determine a relationship between condyle-fossa anatomy from the CBCT images and maxillomandibular skeletal pattern from the lateral cephalogram. The results were considered statistically significant for values of $P < 0.05$.

Ⅲ. Results

This retrospective study included eighty-eight subjects having TMD or no signs and symptoms: normal (Control, n = 16), myofascial pain (MPD, n = 25), disc displacements with reduction (DDwR, n = 23), disc displacement without reduction (DDwoR, n = 24). The subjects consisted of 28 male and 60 female, ranging in age from 18-68, mean 29.91±12.68 years (Table 1).

There were significant differences among four groups for condyle volume, condyle width, superior space, SN-GoGn angle, and PFH/AFH ratio (Table 5). The MPD, DDwR, and DDwoR group showed a smaller value of condyle volume and larger condyle width than the control group ($P<0.001$). The DDwR group showed smaller superior space than the MPD group ($P<0.05$). Also, the DDwR group showed lager Sn-GoGn angle ($P<0.05$) and smaller PFH/AFH ratio ($P<0.01$) than the MPD and control group. Finally, the DDwR group showed shorter ramus height than the control group ($P<0.05$).

In the Pearson correlation analysis, the condyle volume showed a negative correlation with the Sn-GoGn angle ($r=-.241$, $P<0.05$) and showed a positive correlation with ramus height, PFH/AFH ratio, and overbite ($r=.370$, $.292$, $.296$ respectively, $P<0.05$) (Table 6). The condyle height showed a negative correlation with ANB, Sn-GoGn angle, articular angle, and overjet ($r=-.477$, $-.301$, $-.491$, $-.364$ respectively, $P<0.05$), and it showed a positive correlation with gonial angle, ramus height, and PFH/AFH ratio ($r=.247$, $.412$, $.299$ respectively, $P<0.05$). Similarly, the condyle width was negatively correlated with ANB, Sn-GoGn angle, articular angle, and overjet (r=-.362, -.306, -.323, -.286 respectively, P<0.05), and it was positively correlated with ramus height and PFH/AFH ratio (r=.490, .308 respectively, P<0.01). Posterior space showed a positive correlation with ANB (r=.267, P<0.05) and fossa length showed a negative correlation with ANB and overjet (r=-.285, -238 respectively, P<0.05).

Table 5. Condyle-fossa measurements and cephalometric measurements

	Control (N=16)	MPD (N=25)	DDwR (N=23)	DDwoR (N=24)	*P* value
Condyle volume (㎣)	1184.90 ± 297.63 ^{A}	936.25 ± 218.11^{B}	797.9 ± 183.30^{B}	845.13 ± 252.01^{B}	0.000***
Condyle length (㎜)	7.51 ± 0.93	7.73 ± 1.10	7.37 ± 0.97	7.79 ± 1.28	0.580
Condyle height (㎜)	23.41 ± 4.14	22.6 ± 3.32	20.43 ± 4.75	21.67 ± 3.76	0.109
Condyle width (㎜)	15.58 ± 3.36^{A}	19.26 ± 2.38^{B}	18.31 ± 2.88^{B}	20.2 ± 2.98^{B}	0.000***
Ant.space (㎜)	2.58 ± 0.50	2.18 ± 0.65	2.28 ± 1.17	2.36 ± 0.73	0.473
Sup.space (㎜)	3.11 ± 1.02^{AB}	3.74 ± 1.45^{A}	2.66 ± 0.93^{B}	3.27 ± 1.18^{AB}	0.031*
†Post.space (㎜)	2.83 ± 1.05	2.8 ± 1.09	2.73 ± 0.9	3.41 ± 1.41	0.370
†Fossa length (㎜)	19.9 ± 2.03	20.04 ± 2.13	19.98 ± 2.07	20.24 ± 1.55	0.904
Fossa height (㎜)	8.32 ± 1.44	8.53 ± 1.41	8.24 ± 1.01	8.38 ± 1.35	0.886
ANB angle (˚)	2.55 ± 1.23	1.58 ± 3.21	3.28 ± 4.14	4.14 ± 3.22	0.050
SN-GoGn (˚)	33.4 ± 3.03^{A}	33.42 ± 6.12^{A}	39.4 ± 8.2^{B}	36.22 ± 7.31^{AB}	0.010*
Articular angle(˚)	152.25 ± 7.19	156.91 ± 6.84	153.92 ± 11.87	154.79 ± 6.99	0.371
Gonial angle(˚)	118.19 ± 4.44	116.84 ± 6.59	121.29 ± 6.93	117.79 ± 6.94	0.107
†Ramus height (㎜)	49.98 ± 5.5^{A}	47.17 ± 8.00^{AB}	44.56 ± 6.15^{B}	46.53 ± 5.22^{AB}	0.049*
PFH/AFH (%)	67.19 ± 2.63^{A}	67.6 ± 5.05^{A}	62.76 ± 5.73^{B}	65.21 ± 5.49^{AB}	0.007**
†OB (㎜)	1.15 ± 1.27	2.04 ± 1.55	1.04 ± 2.18	0.8 ± 2.42	0.204
†OJ (㎜)	3.21 ± 1.85	2.44 ± 1.48	2.76 ± 2.90	2.97 ± 1.15	0.676

OB, overbite; OJ, overjet; PFH/AFH, Posterior facial height/Anterior facial height.
†: Variables were compared by Kruskal-Wallis test because they did not show normal distribution.
The letters are indicating Scheffe post hoc test and Mann-Whitney test result with the different letters representing statistically significant differences.
**P*<0.05, ***P*<0.01, ****P*<0.001

Table 6. Pearson correlation coefficients in TMD groups

	Condyle volume	Condyle length	Condyle height	Condyle width	Ant.space	Sup.space	Post.space	Fossa length	Fossa height
ANB	-.052	.094	-.477**	-.362**	.043	.151	.267*	-.285*	-.080
SN-GoGn angle	-.241*	.116	-.301*	-.306**	-.129	-.130	.146	-.155	-.155
Articular angle	-.181	-.188	-.491**	-.323**	.110	.055	.123	-.066	.171
Gonial angle	-.092	.241	.247*	.045	-.189	-.152	.103	.038	-.175
Ramus height	.370**	.138	.412**	.490**	-.015	.213	-.052	.131	.216
PFH/AFH	.292*	-.069	.299*	.308**	.111	.192	-.134	.127	.176
OB	.296*	-.028	.053	-.065	.135	.116	-.065	.050	-.057
OJ	-.036	.118	-.364**	-.286*	.156	.094	.205	-.238*	-.083

*P<0.05, **P<0.01

Ⅳ. Discussion

The present study was carried out to compare the condyle-fossa anatomy differences according to the types of TMD. The MPD, DDwR, and the DDwoR group showed a smaller condyle volume and a wider condyle width than the control group, irrespective of the subdiagnosis of TMD (Table 5). This result corresponds with the previous studies [16,25] in that pathologic condyle resorption is involved in patients having TMD. Although it did not show significant differences, the condyle volume of MPD group was smaller than the normal group and bigger than the DDwR and DDwoR groups, This might be because the myofascial pain is related to the muscles of TMJ or craniofacial area, so it affects more weakly on the osseous anatomic change of TMJ than the articular disorder does. Meanwhile, there was a study showing that the condyle volume tends to decrease as DDwR progress from normal to DDwoR (normal>DDwR>DDwoR) [26]. This study showed the same tendency when comparing the normal group with the DDwR group, but showed opposite trend when comparing the DDwR group with the DDwoR group (normal>DDwoR>DDwR). Presumably, this different result could be explained by an influence of the age of samples. Since the DDwoR group was older than the normal and DDR group in this study, the DDwoR group had sufficient time for the adaptive process by a regressive remodeling [27,28] or a functional remodeling of condyle head [3,4]. Therefore, not only the types of the TMD but also the age may relate to a condyle volume.

In spite of the smaller condyle volume in the MPD, DDwR, and DDwoR groups, the condyle width was wider in these groups. It seems that the condyle width increase for bearing force loading and adaptation to an applied force in the circumstances of abnormal TMJ function or anatomy. Through this study, we may suggest the condyle is remodeled by increasing its width in the TMD patients.

The DDwR group showed narrower superior joint space than the MPD group and showed a narrowest superior joint space among the study groups. This is because the condyle is superiorly positioned relative to the normal position, as the disc displaces to the anterior and inferior direction in the DDwR patients. Also, the DDwR group showed the largest Sn-GoGn angle and the smallest PFH/AFH ratio. When combining these findings of condyle-fossa anatomy and maxillomandibular skeletal pattern, we may suggest the superior position of the condyle is associated with a large Sn-GoGn angle which means hyperdivergent skeletal pattern. The previous studies have been reported the relationship only between DD and hyperdivergent maxillomandibular skeletal pattern [9,10], but this study clarified the condyle-fossa anatomic features are mediating this relation.

Two-dimensional tomogram study showed deeper fossa and narrower superior joint space in the DDwoR patients rather than the DDwR patients [6]. Also, as TMJ pathologies became severe, the higher prevalence of flattened condyle and osteophyte was reported [17,18]. In several studies, superior and/or posterior condyle position was frequently shown in the DD state and intensified as the DD became severe, although there were no consistent results [5-7,29-32]. However, in our study, a superior condyle position was significantly observed in the DDwR group, but the posterior position was not observed. Moreover, the superior space of the DDwoR was not smaller than the DDwR, unlike previous studies. This result may be attributed to the older age of the DDwoR group than the DDwR group in which the temporal bone was allowed to have sufficient time to be remodeled dominantly by the temporal bone resorption so that the superior space may be normalized again by a regressive remodeling.

In the correlation analysis between condyle-fossa anatomy and maxillomandibullar skeletal pattern of the TMD groups (Table 6), the condyle height and width showed a relationship with skeletal Class III and hypodivergent pattern: ANB, overjet, Sn-GoGn angle, Articular angle, and PFH/AFH ratio. Also, the condyle volume was associated with the hypodivergent pattern: Sn-GoGn angle, ramus height, PFH/AFH ratio, and overbite. That is, the height and width of condyle were related to the sagittal and vertical skeletal pattern, and the volume of the condyle was related to the vertical skeletal pattern. This was partly consistent with the previous study which was conducted for symptom-free subjects [14]. Therefore, we could conclude that even in the TMD patients, the association between the condyle-fossa anatomy and the maxillomandibular skeletal pattern showed similar trends shown in the symptom- free patients.

The 12 common TMD include arthralgia, myalgia, local myalgia, myofascial pain, myofascial pain with referral, four disc displacement disorders, degenerative joint disease including osteoarthritis, subluxation, and headache attributed to TMD [19,33], of which our study included myofascial pain and disc displacement disorders. Although we did not classify the study group according to the presence of osteoarthritis, most subjects of the DDwoR group involved with the osteoarthritis, and only four subjects of them did not show osteoarthritis. Considering these and the fact that the DDwoR group of this study did not show limited mouth opening, we might suggest that the DDwoR group had already been in a chronic state of TMD. This also explained the remodeling of TMJ in DDwoR group because a tendency of the larger condyle volume, condyle width and superior joint space than DDwR group; a larger dimension of condyle-fossa anatomy in the DDwoR means that they have experienced condyle-fossa area remodeling.

The present study has following limitations. Although TMD is classified into three groups according to the DC/TMD [19] in this study: MPD, DDwR, and DDwoR, we did not differentiate more in detail according to the presence of the referral pain, the intermittent locking and the limited opening. Secondly, we were not informed about the duration of TMD. So we could not consider exact chronicity of the pathology, and we infer the chronicity of DDwoR group from the signs and symptoms instead. Third, this study included TMD subjects had taken a lateral cephalogram, which means they have some orthodontic or orthognathic problems and show exaggerated maxillomandibular skeletal features. The further prospective study is required to clarify the relationship among the TMD types, the condyle-fossa anatomy, and the skeletal pattern.

Ⅴ. Conclusion

This study was performed to evaluate the associations between the types of TMD and the condyle-fossa anatomy. Compared with the control group, the MPD, the DDwR, and the DDwoR groups showed smaller condyle volume and broader width. Although there are not many variables showing significant differences according to subdiagnosis of TMD, the DDwR group had the significantly narrower superior joint space, larger Sn-GoGn angle and smaller PFH/AFH ratio than the MPD group. Through these findings, we suggest that superior position of condyle contribute to hyperdivergent skeletal pattern meaning the mandibular backward position. Therefore, the type of TMD has limited relations with the condyle-fossa anatomy and maxillomandibular skeletal pattern. From the correlation analysis, we also found that condyle height, width, and volume of TMD patients are associated with sagittal and vertical skeletal pattern.

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국문 요약

측두하악관절장애의 유형에 따른 과두와 측두와의 형태에 대한 Cone-beam CT 연구

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측두하악관절장애는 저작근, 측두하악관절과 그 주변 구조와 관련된 여러가지 요소들로 인해 발생한다. 관절원판변위를 동반하는 측두하악관절장애의 경우, 골관절염, 무혈성괴사, 또는 퇴행성 재형성으로 진행될 수 있으며, 이로 인해 하악골의 위치 변화가 발생될 수 있다. 지속적인 근육의 과활성 역시 하악골의 위치나 형태에 변화를 야기할 수 있다. 기존 연구는 측두하악관절 부위의 형태 분석 없이 관절성 측두하악관절장애 증상에 따른 측모두부방사선사진 상의 변화를 연구하였고, 측두하악관절장애의 한 종류이면서 빈발하는 근육성 장애를 포함하는 연구는 거의 없었다. 또한 지금까지의 과두-측두와 분석은 대부분 영상의 신뢰성이 떨어지는 2차원 영상으로 진행되었다. 따라서 측두하악관절장애 환자들의 과두-측두와의 변화를 3차원 cone-beam

computed tomography (CBCT)를 통해 관찰하고 과두-측두와 구조가 측모두부방사선사진의 상하악 골격 형태와 연관성이 있는지를 평가하고자 한다.

본 연구는 후향적 연구로 측모두부방사선사진과 과두를 포함한 CBCT 촬영을 시행한 환자 중 구강내과에서 측두하악관절장애로 진단받은 환자 72명과, 측두하악관절장애 증상이 없고 상하악골의 수직, 수평적 위치가 정상인 16명을 대상으로 하였다. 위의 대상을 다음과 같이 네 군으로 나누었다: 대조군 (n = 16), 근육성군 (MPD, n = 25), 정복성 관절원판변위군 (DDwR, n = 23), 비정복성 관절원판변위군 (DDwoR, n = 24). 네 군에서 과두-측두와의 형태 및 위치 관계를 비교하기 위하여 CBCT에서 9가지 항목(과두 부피, 과두 높이, 과두 길이, 과두 폭, 측두와 높이, 측두와 길이, 전관절강,상관절강,후관절강)과 측모두부방사선사진에서 8가지 항목(ANB angle, SN-GoGn angle, Articular angle, Gonial angle, Ramus height, PFH/AFH ratio, Overbite, Overjet)을 계측하였다. 각 그룹 간 차이를 비교하기 위하여 one-way analysis of variance와 Scheffe 사후검정을 하였고, 정규성을 보이지 않는 변수에 대해서는 Kruskal-Wallis test와 Mann-Whitney 사후검정을 시행하였다. 또한, Pearson 상관관계 분석을 통하여 과두-측두와 구조와 상하악 골격 형태 사이의 관계를 분석하여 다음과 같은 결과를 얻었다.

1. 과두 볼륨, 과두 폭, 상관절강, SN-GoGn angle, PFH/AFH ratio에서 네 군간에통계적 유의차를 보였다. 측두하악관절장애 세 군 모두에서 대조군에 비해 작은 과두 볼륨, 넓은 과두 폭을 보였다($p<0.01$). DDwR군은 MPD군에 비해 좁은 상관절강을 보였고, MPD군과 대조군에 비해 큰 Sn-GoGn 각도와 작은 PHF/AFH 값을 나타냈으며, 대조군에 비해 짧은 하악지를 보였다 ($p<0.05$).

2. 대조군을 제외한 측두하악관절장애 환자군 (MPD, DDwR, DDwoR)에 대하여 상관관계 분석을 시행한 결과 과두 높이와 폭은 ANB, Sn-GoGn, Articular angle, 수평피개와 음의 상관관계, Gonial angle, Ramus height, PFH/AFH과는 양의 상관관계를 보였다. 또한 후관절강과 ANB의 양의 상관관계가 나타났고, 측두와 길이는 ANB, 수평피개와 유의한 양의 상관관계를 보였다.

측두하악관절장애 환자 세 군 모두 정상군에 비해 과두 볼륨은 작지만 넓은 과두 폭을 보이는데, 과두에 가해지는 힘에 저항하기 위한 과두의 재형성에 의한 결과로 생각된다. 측두하악관절장애의 유형에 따라 유의한 차이를 보이는 변수는 많지 않았고 DDwR 군에서 MPD 군에 비해 좁은 상관절강, 큰 Sn-GoGn angle, 작은 PFH/AFH ratio를 보였다. 만성화된 MPD, DDwoR 군에 비해 DDwR 군에서 과두-측두와 구조 차이가 두드러지게 나타난 것으로 보이며, 과두의 상방으로의 위치변화가 하악의 후방위치, hyperdivergent 골격 형태와 관련 있음을 추측할 수 있다. 또한 상관관계 분석을 통하여 큰 과두의 높이와 폭은 골격성 Ⅲ급, 단안모 양상과 관계있고, 큰 과두 볼륨은 단안모 양상과 유의한 관련이 있음을 확인하였다. 즉 측두하악관절장애 환자의 과두 높이, 폭, 볼륨은 상하악 골격의 수직적, 시상적 형태와 관련있다.

핵심되는 말: 측두하악장애; 콘빔씨티; 과두 부피; 과두-측두와 구조; 상하악 골격 형태