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Original research

RELATIONSHIP BETWEEN THE DEGENERATIVE CHANGES IN THE MANDIBULAR CONDYLE AND ARTICULAR EMINENCE INCLINATION, HEIGHT, AND SHAPE: A CBCT STUDY

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ABSTRACT

Objectives: This study aimed to analyze any relationship between the articular eminence inclination, height and shape and degenerative condylar changes using cone-beam computed tomography (CBCT).

Materials and Methods: The assessments were established on CBCT images of 566 temporomandibular joints (TMJ) that were included from the archive. Age and sex were recorded for all individuals. Degenerative changes were examined on the articular surface of the condyle. The articular eminence (AE) inclination and height measurements were performed on central parasagittal slices of the TMJs. The shape of the AE was classified as box-shaped, sigmoid, flattened, and deformed.

Results: The prevalence of degenerative changes in the condyle was higher in males, but no significant difference was found ($p>0.05$). Mean AE inclination and height were greater in males than females ($p<0.05$). Reduced mean eminence inclination and height values were detected in the +50-year-old group ($p<0.05$). Sigmoid and box-shaped articular eminence morphologies were more common. The eminence with a deformed shape was related to two or more degenerative alterations in the condylar head.

Conclusion: The eminence inclination and height are associated with the presence and types of degenerative condylar changes. There are significant relationships between sex-AE morphology and age-AE morphology.

Keywords: Articular eminence, Cone-beam computed tomography, Degenerative change, Mandibular condyle, Temporomandibular joint.

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INTRODUCTION

The temporomandibular joint (TMJ) is known as the most complex articular system in the human organism, and connects the mandible to the temporal bone.[1] It has the capability of moving in the three planes of space, and the structures of the TMJ are important to sustain a balanced stomatognathic system. The mandibular condylar process constitutes the inferior bone part and the glenoid fossa constitutes the superior bone part of the TMJ.[2]

The articular eminence (AE) is a part of the temporal bone on which the mandibular condyle and the articular disc complex slides in the course of the opening and closing cycles of the mouth. The morphology of the AE enables the path of the condylar movements to flow naturally; it varies within the population and can also change due to age, sex, and masticatory function.[2,3-6] The eminence inclination is an essential component in the entire masticatory system and biomechanics of the TMJ.

In TMJ disorders, several changes can be detected in the subarticular surfaces of the condyle and the glenoid fossa.[7] Increased loading of the TMJ generally results in degenerative bone changes of the articular surface of the condyle and fossa.[8] Condylar bone changes such as loss of articular cortex, various degrees of flattening, erosion of the articular surfaces, osteophyte formation, and sclerosis may be correlated with the AE inclination, as close relationships exist between these structures.[7]

Several imaging techniques or different modalities have been used to analyze the eminence inclination, such as computed tomography (CT),[7] dry skull measurements,[8] conventional radiography[9] and tomography,[10] and magnetic resonance imaging (MRI).[11,12]

The Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) state that scanning is the reference standard for the diagnosis of degenerative joint disease.[13] Recently, cone-beam computed tomography (CBCT) has been accepted as an alternative to conventional CT to diagnose hard tissue components of the dentomaxillofacial region. CBCT allows for a shorter scanning time and lower radiation dose, reduced cost, smaller machine, and easier access than conventional CT.[14] CBCT is the imaging modality of choice to visualize the bony elements and pathologies of the TMJ in all three dimensions without superposition and structural distortion.[15]

The current study firstly aimed to specify the association between the eminence inclination and height with AE shapes, and the degenerative condylar changes. Secondly, factors that may affect these variables, such as sex and age groups, were evaluated.

MATERIAL AND METHODS

Study design

The Institutional Ethical Review Board of X University, Faculty of Dentistry approved this retrospective multicenter study with decision number: 14/3 (Ref: 36290600/124), and the study followed the Declaration of Helsinki on medical protocol and ethics.

The G*POWER 3.1 (Heinrich-Heine University of Dusseldorf, Germany) program was performed to determine the sample size. A power analysis revealed that a minimum of 532 cases would provide >80% power to detect significant differences with an effect size of 0.34 at a significance level of $\alpha = 0.05$.

CBCT images of patients who were referred to the clinics of three university hospitals for several reasons such as orthodontic therapy, TMD, impacted teeth, and airway evaluation without a history of any systemic diseases during the period from 2013 to 2019 were retrospectively evaluated.

The inclusion criteria were images with completely visible TMJs, all posterior teeth present and degenerative bone changes of the mandibular condyle in at least one TMJ in CBCT images. Low quality images were not evaluated. The radiologic evidence of bone disease (especially osteoporosis), noticeable periodontal diseases, skeletal asymmetries or trauma, developmental or congenital disorders, systemic diseases that may affect joint morphology such as rheumatoid arthritis, prosthetic restorations, a history of surgery as well as any tumor or malignancy were exclusion criteria for the study. The final sample was narrowed to 289 cases and 566 TMJs were analyzed in this study.

Imaging procedures

The same standardized scanning protocols were performed for acquiring CBCT images. Technical parameters and dedicated software of the CBCT machines used are summarized in Table 1.

Table 1: Technical parameters and dedicated software of used CBCTs

		CBCT Units		
		ProMax®3D Max	**NewTom 3G®**	**Veraviewepocs 3D®**
Technical parameters	**FOV sizes**	90x100 mm, 230x160 mm	12-inch	40x80 mm
	voxel size	0.200 mm^3, 0.400 mm^3	0.300 mm^3	0.125 mm^3
	kVp	96	120	90
	mA	8-12	3-5	5
	scan time (s)	9-15		9.4
Software programs		Romexis 3.7[a]	NNT 3.0[b]	3D Tomo X[c]
Monitor		NEC MultiSync[d] 21.3-inch flat-panel 2048 x 2560 pixel resolution	Nio Color 3MP[e] 2048 x 1536 pixel resolution	EIZO RadiForce[f] MS230W 23 inch LCD monitor

CBCT cone beam CT, *FOV* field of view, *kVp* Kilovoltage peak, *mA* milliampere, *s* second
Promax 3D Max by Planmeca, Helsinki, Finland;
NewTom 3G by Quantitative Radiology, Verona, Italy;
Veraviewepocs 3D by J Morita MFG Corp., Kyoto, Japan
[a]Romexis 3.7, by Planmeca Oy, Helsinki, Finland; [b]NNT 3.0 by Quantitative Radiology, Verona, Italy; [c]3D Tomo X by IORB, Brasilia DF Brazil
[d]NEC MultiSync by Munchen, Germany; [e]Nio Color 3MP by Barco, Kortrijk, Belgium; [f]EIZO RadiForce MS230W by Eizo Nanao Corporation, Ishikawa, Japan

CBCT evaluations

The images were analyzed by one informed and calibrated oral radiologist (CG with six years of experience, Mİ and SA with over ten years of experience) at each center by using the scanner's software programs. Before the evaluation, a standard positioning was defined and each image was placed in that position by the examiners.

In the axial view, the patient's sagittal median plane was adjusted to the vertical reference line. In the sagittal view, the hard palate was positioned so that the investigator could view the anterior nasal spine and the posterior nasal spine and was then tilted to overlap the horizontal reference line. Thus, the reference line was aligned with the palatine plane (PP).

For secondary reconstruction, the axial view on which the condylar processes were seen with their widest mediolateral extent was used as a reference view. The paracoronal slices (1 mm thick) were made along the long axis of the condyle, and the parasagittal slices were obtained perpendicular to the paracoronal plane (Figure 1).

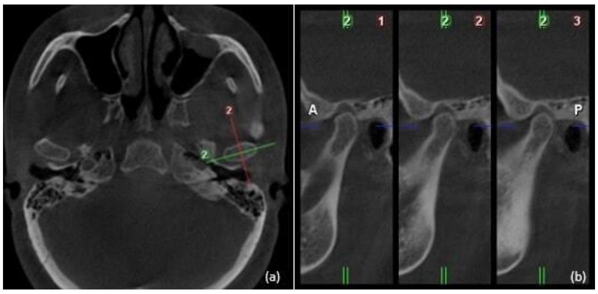

Figure 1: (a) Axial view showing the longest mediolateral length of the condyle. Paracoronal slice of the condyle (green line) and parasagittal slice of the condyle (red line). (b) Parasagittal reconstruction of the temporomandibular joint in maximum intercuspation.

Age, sex, condylar bone changes, articular eminence shapes, and measurements were noted on an evaluation sheet for each case. To prevent misinterpretation, the observed degenerative changes had to be detected in at least two consecutive slices. The image excluded any doubt about which classification choice was decisive. The three examiners were asked to assess the following radiographic characteristics:

Diagnostic Classification for Condylar Bone Change

The degenerative changes of the condyles were classified according to previously reported definitions as follows:[16] flattening (Figure 2a);

sclerosis (Figure 2b); erosion (Figure 2c); osteophytes (Figure 2d); and combination of two or more degenerative condylar changes (Figure 2e).

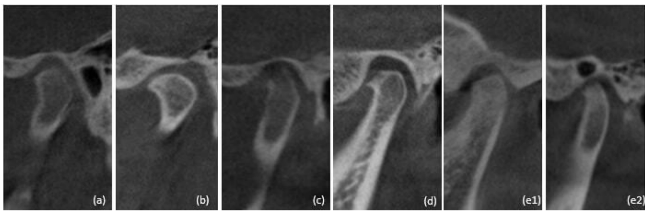

Figure 2: The classification of the degenerative condylar bone changes (a) flattening; (b) sclerosis; (c) erosion; (d) osteophyte; (e) combination of two or more degenerative changes. e1: flattening and sclerosis, e2: flattening, sclerosis, and erosion.

Measurements

All measurements were performed on the central parasagittal slice of the TMJ. The eminence height was measured by tracing two parallel lines that were parallel to the PP, one tangent to the highest point of the glenoid fossa and another tangent to the lowest point of the articular eminence. Between those two lines, the distance was measured as the eminence height (Figure 3a).

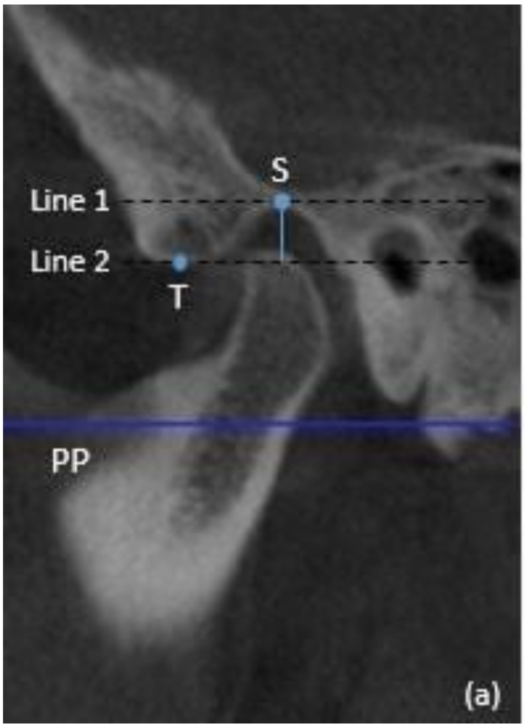

Figure 3a: Articular eminence height.

To detect the eminence inclination, the same parallel lines were used as reference. The internal angle formed between line A (passing through the highest point in the roof of the glenoid fossa and the lowest point at the crest of the articular eminence) and line B (parallel to the palatine plane) was used to define the value of AE inclination (Figure 3b).

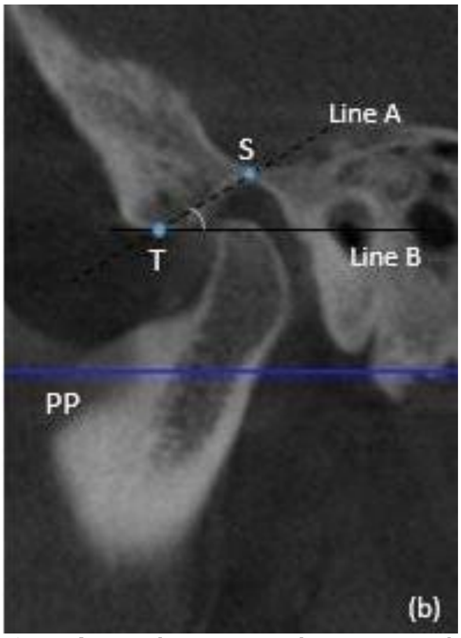

Figure 3b: Articular eminence inclination. Line 1: the parallel line to the PP passing through the highest point of the glenoid fossa, Line 2: the parallel line to the PP passing through the lowest point of the articular eminence. *PP* palatal plane, *S* highest point of glenoid fossa, *T* lowest point of articular eminence.

Articular Eminence Morphology

The AE morphology was classified into four types, according to the classification of Kurita *et al*. [17] (2000): box-shaped, sigmoid, flattened or deformed. In the closed-mouth position, the central parasagittal TMJ slices were evaluated. The box shape represents a deep fossa with a steep posterior articular eminence inclination, while the sigmoid shape represents a continuously S-shaped slope. The flattened eminence has a smooth eminence and therefore a shallow fossa. If the eminence morphology failed to fit one of these three categories, it was classified as deformed (Figure 4).

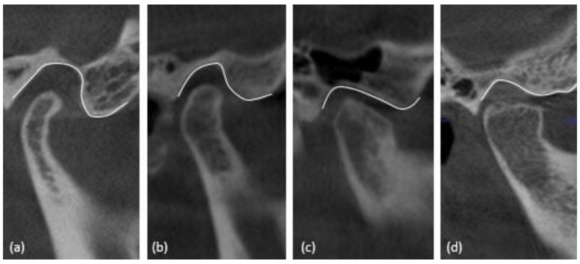

Figure 4: Articular eminence shapes. CBCT images and outline drawings to represent the four shapes of the eminence classified in this study. (a) box-shaped, (b) sigmoid, (c) flattened, (d) deformed.

Statistical Analysis

Data analysis was performed using the IBM SPSS Statistics 21.0 (Statistical Package for Social Sciences) program. The Student *t*-test and/or Mann-Whitney U test were performed for the comparison of two independent groups.

Comparison among three or more groups was performed by analysis of variance (ANOVA test) and/or Kruskal-Wallis H test. The categorical variables were analyzed using the Chi-square test. A probability level of less than 0.05 (p<0.05) was considered to be significant.

RESULTS

Degenerative condylar changes were observed in 480 of the 566 joints. Eighty-six TMJs had no changes. The distributions of the presence and types of the degenerative changes in TMJs according to sex and age groups are presented in Figure 5 and Figure 6.

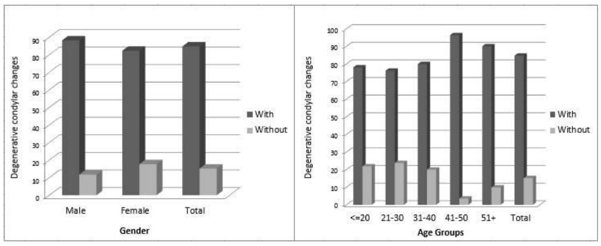

Figure 5: Bar graphs show the distribution of the presence of degenerative condylar changes according to sex and age groups.

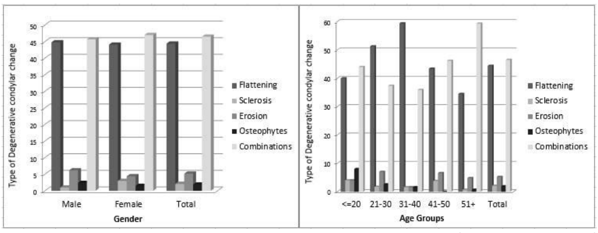

Figure 6: Bar graphs show the distribution of the types of degenerative condylar changes according to sex and age groups.

Regarding the age groups, individuals aged 30 years and older showed higher prevalence of degenerative condylar changes and this difference was statistically significant (p = 0.001). For sex, the prevalence of degenerative findings was higher in males (88.2%) than in females (82.3%) but, this difference was not statistically significant (p=0.053). The prevalence of the degenerative change types was higher for combination (46.5%) followed by flattening (44.4%), erosion (5.2%), sclerosis (2.1%), and osteophytes (1.9%).

The mean results of eminence inclination and height according to sex and age groups are shown in Table 2. There was a significant difference between the metric variables of the AE according to sex. The eminence inclination and height in males were higher than those of females (p = 0.0001). Additionally, the mean values of eminence inclination and height in the +50-year-old group were found to be statistically lowest among age groups (p=0.0001).

Table 2: The mean eminence inclination and eminence height values according to sex and age groups

		n	Eminence inclination mean ± sd	p value	Eminence height mean ± sd	p value
Sex	Female	328	33.6 ± 9.3		6.22 ± 1.96	0.0001*
	Male	238	**37.0 ± 8.6**	0.0001*	**6.87 ± 1.75**	
	Total	566	35.0 ± 9.2		6.49 ± 1.90	
Age Groups	≤20	64	35.5 ± 9.5	0.001**	7.16 ± 2.07	0.0001**
	21-30	151	35.5 ± 9.5		6.79 ± 1.91	
	31-40	80	36.6 ± 8.5		6.67 ± 1.67	
	41-50	110	36.7 ± 9.1		6.80 ± 1.89	
	51≤	161	**32.4 ± 8.6**		**5.65 ± 1.68**	
	Total	566	35.0 ± 9.2		6.49 ± 1.90	

* Statistically significant differences (p< 0.05), *sd* standard deviation, *n* number of TMJs ,by Student's *t*-test
**Statistically significant differences (p<0.05), sd standard deviation, n number of TMJs, by one-way ANOVA

The most common AE shape was the box-shape (223 cases; 39.4%), followed by sigmoid (191 cases; 33.7%), flattened (111 cases; 19.6%), and deformed (41 cases; 7.2%). Concerning the variations in the shape of the AE, there was a significant difference between sexes (p>0.05). Box-shaped eminences were observed most frequently in males; sigmoid-shaped eminences were observed most frequently in females. The prevalence of AE morphology according to sex and age groups are shown in Table 3.

Table 3: Distribution of the articular eminence morphology with sex and age groups

Articular Eminence morphology	Sex			Age Groups					
	Male n (%)	Female n (%)	Total n (%)	≤20 n (%)	21-30 n (%)	31-40 n (%)	41-50 n (%)	51≤ n (%)	Total n (%)
Box	83 (34.9)	**140 (42.7)**	223 (39.4)	27 (42.2)	68 (45.0)	24 (30.0)	40 (36.4)	64 (39.8)	223 (39.4)
Sigmoid	**101 (42.4)**	90 (27.4)	191 (33.7)	19 (29.7)	45 (29.8)	37 (46.3)	44 (40.0)	46 (28.6)	191 (33.7)
Flattened	32 (13.4)	79 (24.1)	111 (19.6)	13 (20.3)	29 (19.2)	16 (20.0)	20 (18.2)	33 (20.5)	111 (19.6)
Deformed	22 (9.2)	19 (5.8)	41 (7.2)	5 (7.8)	9 (6.0)	3 (3.8)	6 (5.5)	18 (11.2)	41 (7.2)
Total	238 (100.0)	328 (100.0)	566 (100.0)	64 (100.0)	151 (100.0)	80 (100.0)	110 (100.0)	161 (100.0)	566 (100.0)
***p* value**	0.0001*			0.168					

* Statistically significant differences (p< 0.05), n number of TMJs, by the Chi-square test

No association was found between the AE shape and age groups. (*p*>0.05). Additionally, the metric variables of the AE were significantly higher in sigmoid and box-shaped groups compared to other groups (*p* = 0.0001) (Table 4).

Table 4: The mean eminence inclination and eminence height values according to articular eminence morphology

		n	Eminence inclination mean ± sd	*p* value	Eminence height mean ± sd	*p* value
Articular Eminence morphology	Box	191	**41.3 ± 7.0**	0.0001*	**7.67 ± 1.57**	0.0001*
	Sigmoid	223	**34.2 ± 7.3**		**6.17 ± 1.65**	
	Flattened	111	27.4 ± 8.4		5.33 ± 1.87	
	Deformed	41	30.8 ± 9.2		5.93 ± 1.83	
	Total	566	35.0 ± 9.2		6.49 ± 1.90	

* Statistically significant differences (p<0.0001), sd standard deviation, n number of TMJs, by one-way ANOVA

The mean values of eminence inclination and height were analyzed, and the results are presented according to presence and types of the degenerative changes (Table 5).

Table 5: The eminence inclination and eminence height values according to presence and types of degenerative condylar changes

		n	Eminence inclination mean ± sd	*p* value	Eminence height mean ± sd	*p* value
Degenerative Condylar Changes	*Without*	86	36.9 ± 8.7	0.073	**6.90 ± 1.71**	0.049*
	With	480	34.7 ± 9.2		6.42 ± 1.93	
	Total	566	35.0 ± 9.2		6.49 ± 1.90	
Types of Degenerative Condylar Changes	Flattening	213	36.0 ± 9.2	0.015**	6.60 ± 1.90	0.089
	Sclerosis	10	**38.6 ± 9.0**		7.07 ± 2.0	
	Erosion	25	35.0 ± 11.6		6.41 ± 2.21	
	Osteophytes	9	35.0 ± 4.7		7.10 ± 1.82	
	Combinations	223	**33.2 ± 8.9**		6.20 ± 1.91	
	Total	480	34.7 ± 9.2		6.42 ± 1.93	

* Statistically significant differences (p<0.05), sd standard deviation, n number of TMJs, by the Mann-Whitney U test
** Statistically significant differences (p<0.05), sd standard deviation, n number of TMJs, by the Kruskall-Wallis H test

No significant differences were observed between the eminence inclination and condyles either with bone change or without (*p*>0.05). Considering the eminence height values, there was a significant difference according to the presence or absence of degenerative alterations (*p*=0.049), which showed higher values in condyles *without* change group (Table 5). The mean values of eminence inclination were significantly higher in the sclerosis-type degenerative change group compared to other groups and were significantly lower in the combination-type group compared to the flattening, erosion and osteophyte groups ($p<0.05$). There was no statistical relationship between the eminence height and types of degenerative condylar change.

In terms of the AE morphology, sigmoid and box shapes were the most common forms, although no statistically significant difference was found between both groups ($p > 0.05$) (Table 6). Additionally, the combination of two or more degenerative alterations in the condyle was associated with the deformed form, but flattening was observed most frequently in the box-shaped and sigmoid forms (Table 7).

Table 6: Distribution of the articular eminence shapes on with and without degenerative changes groups.

Articular Eminence morphology	***Presence of Degenerative condylar changes***							
	Without		**With**		**Total**			
	n	**%**	**n**	**%**	**n**	**%**	**χ^2**	***p* value**
Box	30	15.7	161	84.3	191	100.0		
Sigmoid	**47**	21.1	**176**	78.9	223	100.0		
Flattened	9	8.1	102	91.9	111	100.0	17,6	0.0001*
Deformed	0	0.0	41	100.0	41	100.0		
Total	86	15.2	480	84.8	566	100.0		

* Statistically significant differences (p<0.0001), n number of TMJs, by the Chi square test

Table 7: Distribution of the AE morphology according to types of degenerative change present in the condyles

Articular Eminence morphology	***Types of Degenerative Bone Changes***						
	Flattening n (%)	**Sclerosis** n (%)	**Erosion** n (%)	**Osteophytes** n (%)	**Combinations** n (%)	**Total** n (%)	***p* value**
Box	78 (36.6)	7 (70.0)	9 (36.0)	2 (22.2)	65 (29.1)	161 (33.5)	0.0001*
Sigmoid	86 (40.4)	2 (20.0)	12 (48.0)	4 (44.4)	72 (32.3)	176 (36.7)	
Flattened	44 (20.7)	0 (0.0)	4 (16.0)	1 (11.1)	53 (23.8)	102 (21.3)	
Deformed	5 (2.3)	1 (10.0)	0 (0.0)	2 (22.2)	33 (14.8)	41 (8.5)	
Total	213 (100.0)	10 (100.0)	25 (100.0)	9 (100.0)	223 (100.0)	480 (100.0)	

* Statistically significant differences ($p< 0.0001$), *n* number of TMJs, by the Chi square test with Monte Carlo simulation

DISCUSSION

In the literature, the two main ways to measure the AE inclination are defined as follows: the *best-fit line method*, which involves adjusting a line drawn to the posterior slope of the eminence, and the *top-roof line method*, which involves connecting the highest point of the glenoid fossa and the lowest point of the eminence. The angle is established by measurement between the selected line and a horizontal reference plane. Both techniques have been used in various studies and result in similar values for AE angulation.[18-20] It has been suggested that the top-roof line method considers the position of the eminence crest relative to the glenoid fossa roof, whereas the other method considers the posterior surface of the AE. Thus, the actual condylar path can be determined by the best-fit line method, while the top-roof line figures out the morphology of the eminence better. The current study aimed to analyze the TMJ morphology, so the top-roof line technique was preferred.[21]

The inclination of the AE is described as the angle between the posterior wall of the eminence and a horizontal reference plane such as the Frankfort horizontal plane, occlusal plane or palatal plane.[22] The Frankfort horizontal plane has been commonly preferred in the previous studies.[12,18,21] In this study, the evaluations were made to refer to the palatal plane, since some of the FOV sizes of images did not cover the anterior part of the orbital floor. Also, the PP is a useful indicator for image orientation in the axial and sagittal slices.[22]

It is important to use standardized protocols that can make accurate and reliable measurements in the best representation of the evaluated structure. Sülün *et al*.[12] (2001) and Ren *et al*.[23] (1995) performed the measurements of the AE on central, lateral, and medial slices. The central sagittal section of the condylar process is the steepest part of the AE, and therefore the most appropriate slice for analyzing. Several studies used this section for obtaining accurate results.[18,21,22] In our analysis, measurements were made on a single parasagittal section.

The TMJ allows a large range of mandibular movements and exposes the functional loads from different types of activities, and provides the transmission of forces and loads to the cranial base.[24] The AE is an important structure in the biomechanics of the TMJ and consists of thick and dense bone, which is suitable for mechanical forces and loads.[1] The relationship between the AE inclination and several factors such as TMD or internal derangement[12,17,25], sex[19,20], age[19,22], malocclusion[6], and changes in dentition[24] has been evaluated in previous studies. However, there is limited data related to degenerative condylar changes and the eminence inclination.

In a study with dry human skulls, Pirttiniemi *et al*.[27] (1990) confirmed a functional dependence relationship between the mandibular condyle and articular eminence. In an animal experiment with mouse models, it was suggested that glenoid fossa growth was initiated, but that the continuous development of this structure could not be sustained in the case of absence or dislocation of the condyle.[28]

In the literature, the AE inclination and height have been assessed according to the presence of osteoarthritic changes. Some investigators reported that AE inclination in condyles with osteoarthritic changes was significantly lower than without changes. Sa *et al*.[22] (2017) mentioned that condylar changes did not affect the value of eminence inclination, but an average reduction in eminence inclination was detected when combination-type degeneration was present. Similarly, we could not find any significant difference between the AE inclination and presence of condylar change. However, steeper inclination was observed in the sclerosis-type condylar change group than in other groups. In the combination-type (two or more condylar changes) group, more shallow inclination was detected, a result that may be due to the more serious effects of two or more bone changes.

In this study, the mean eminence height value was lower in individuals with degenerative condylar change ($p<0.05$). The eminence height in cases with osteophytes had higher values, while in the combination-type group, a reduced eminence height value was detected. However, no significant difference was found when all types were evaluated together ($p=0.089$).

Previous studies evaluated the influencing factors for stress distribution in the condylar region and concluded that morphological alterations in the head of the condyle may change the mechanical loading in the roof of the fossa.[19] The same relation could be established between the AE and mandibular condyle. In addition to this, Lee *et al*.[29] (2019) hypothesized that osteoarthritic changes can develop in the articular eminence after condylar changes when osteoarthritic alterations are more advanced. The greater values in individuals with sclerotic and osteophytic changes in the articular surface of the condyle may be related to mechanical stimulation. Sclerosis and osteophytes are advanced stages of degenerative changes, reflecting the body’s adaptation to repair the TMJ. These degenerative alterations can increase the bone thickness in the articular eminence, as well as change in the stress distribution. Following this, when the combination of two or more changes occurs in the mandibular condyle, adaptation capacity may be insufficient and morphologic alteration in the AE can be detected.

The comparison between the eminence shapes revealed no significant differences in the presence of degenerative changes ($p>0.05$). Nevertheless, eminence forms were mainly related to the types of alterations in the condyle. In agreement with this study, Kurita *et al*.[17] (2000) stated that greater eminence height and inclination values were related to box-shaped eminences and lower values were related to flattened eminences.

It should be noted that the architectural features of the AE and mandibular condyle are different. The eminence has thick cortices with transversely oriented trabeculae, while the mandibular condyle has vertically oriented fine bony trabeculae. Therefore, these two structures of the TMJ may be affected by the same movements and muscle activities differently.[30]

In the literature, some of the studies associated the articular eminence morphology and internal derangements of the TMJ. Several authors have reported the eminence as a predisposing factor for internal derangement.[12,25] In contrast, Ren *et al*.[23] (1995) concluded that a steeper eminence was detected in symptom-free individuals than in patients with internal derangement. It is also suggested that condylar bone change is more related to the eminence inclination than to the disc displacement condition. The more advanced the disc displacement present, the more frequent bone changes become. Kurita *et al*.[17] (2000) observed flattened eminence in TMJs with disc displacement. Nevertheless, whether a greater eminence could be an effect of internal disorders or whether flattened eminence could be a result is still controversial.

It has been reported that morphologic changes can occur in the AE with advanced age, which results from flattening of the eminence in the long term.[12,17] When analyzing the eminence inclination and height in different age groups, we verified that both mean eminence inclination and height significantly decreased in cases aged over 50 years. In contrast, some authors found no correlation between advanced age and eminence morphometry.[8,19,20]

In the present study, the frequency of degenerative alterations was higher in males than in females, but no significant difference was detected. We suggested that the finding could be due to sex differences in willingness to seek help. The rate of seeking treatment may be lower in men than women, and men may only refer to the hospital at an advanced stage of the disease. These results can be attributed to the fact that the study was designed with randomized subjects at a time interval. Furthermore, the analysis of sex differences in degenerative change frequency resulted in a borderline *p*-value ($p=0.053$, small effect size=0.0814). However, this difference was limited due to the low number of subjects in the study groups.

The relationship between sex and morphometric measurements of the AE has been evaluated in earlier research studies. Some of these stated a relationship between the eminence inclination and sex[20,23], while others did not.[4,19] Authors who suggested that the inclination changed with sex revealed that males presented higher inclination values. Many studies affirmed a higher eminence height in males compared with females.[4,20,21] These results agree with those of our study. For the AE morphometry, sex had a statistically significant influence, the mean results being higher for males ($p<0.05$). The shapes of condylar pathways were also significantly different between females and males. The box shape was significantly more common in males, while in females the most prevalent eminence shape was detected as sigmoid-type. The box shape represents a larger articular eminence or a deeper articular fossa than sigmoid shapes, and the box-shaped eminence presents high AE inclination and height values. The greater results and morphology in males may be relevant to the relatively larger cranio-caudal sizes in males.

The discrepancy between results may be caused by racial/ethnic diversity of populations or methodological differences in the studies, such as the diagnostic criteria and techniques used, sample size, measurement methods, and age range. Furthermore, decreased adaptive capacity of the articular elements or excessive or sustained loading in the TMJ are predisposing factors in the development of disorders.[31,32] Even if the biomechanical behaviors are within physiological ranges, ageing, systemic disorders and hormonal changes can affect the remodeling of the TMJ. Mechanical factors, including parafunction, trauma, unstable occlusion, and functional overloading affect TMJ internal derangement and osteoarthrosis. These factors can exist alone or be interrelated, interdependent, and/or coexistent.[31-33]

The present study is not free of limitations. Firstly, the soft tissue component of the TMJ, which can play a role in the articular eminence morphology, was not evaluated. Secondly, due to the observational design of the study, the long-term relationship between articular eminence morphology and degenerative changes of the condylar articular surface was not analyzed directly. In addition, this observational design limits the degree of cause-and-effect relationships. Further longitudinal and stratified research with larger sample sizes is necessary to resolve this issue.

CONCLUSIONS

The presence of two or more degenerative changes in the mandibular condyle resulted in reduced eminence inclination and height and it was more prominent in the deformed eminence shape. The AE inclination and height were influenced by age and sex. It is believed that further studies on this subject will provide a better understanding of the relationships and more definitive conclusions.

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INFORMED CONSENT

For this type of study, formal consent is not required.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

FINANCIAL DISCLOSURE

The authors declared that this study received no financial support.

Mandibular Kondildeki Dejeneratif Değişiklikler ile Artiküler Eminensin Eğimi, Yüksekliği ve Şekli Arasındaki İlişki: Bir KIBT Çalışması

ÖZ

Amaç: *Bu çalışma, konik ışınlı bilgisayarlı tomografi (KIBT) kullanılarak artiküler eminens (AE) eğim ve yüksekliğini analiz etmeyi, elde edilen sonuçları eminens şekilleri ve dejeneratif kondiler değişiklikler ile ilişkilendirmeyi amaçlamaktadır.* ***Gereç ve Yöntemler:*** *Toplam 566 temporomandibular eklemin (TME) KIBT görüntüleri değerlendirildi. Tüm bireylerin yaşları ve cinsiyetleri kaydedildi. Kondil yüzeyindeki dejeneratif değişiklikler incelendi. Artiküler eminens eğim ve yükseklik ölçümleri TME'nin santral parasagital kesitleri üzerinde yapıldı. AE'nin şekli kutu, sigmoid, düz ve deforme olarak sınıflandırıldı.* ***Bulgular:*** *Kondildeki dejeneratif değişikliklerin prevalansı erkeklerde daha fazlaydı, ancak cinsiyet ile kondilin dejeneratif değişiklikleri arasında anlamlı bir fark bulunamadı (p>0,05). AE eğim ve yükseklik ortalamaları erkeklerde daha fazlaydı (p<0,05). Elli yıl üzeri yaş grubunda diğer yaş gruplarına göre eminens eğim ve yüksekliğinin ortalama değerlerinin azalmış olduğu tespit edildi (p<0,05). Sigmoid ve kutu şekilli artiküler eminens morfolojileri diğerlerine göre daha yaygındı. Deforme eminens şekilli grupta kombinasyon tip kondiler dejeneratif değişiklikler daha fazla bulundu.* ***Sonuç:*** *Kondildeki dejeneratif değişikliklerin varlığı ve tipleri ile eminensin ortalama eğim ve yükseklik sonuçları arasında anlamlı farklılıklar tespit edilmiştir. AE morfolojisi cinsiyet ve yaşa göre istatistiksel olarak anlamlı seviyede değişmektedir.* ***Anahtar Kelimeler:*** *Artiküler eminens, konik ışınlı bilgisayarlı tomografi, dejeneratif değişiklik, mandibular kondil, temporomandibular eklem.*

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