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Original Research

Relationship between the condyle morphology and clinical findings in terms of gender, age, and remaining teeth on cone beam computed tomography images

Shiva Daneshmehr[1,*], Tahmineh Razi[2], Sedigheh Razi[2]

[1] Faculty of Dentistry, Tabriz University of Medical sciences, Daneshgah Street, Tabriz, Iran.

[2] Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Tabriz University of Medical sciences, Daneshgah Street, Tabriz, Iran.

Aim: This study aimed to evaluate the relationship between clinical findings and some factors such as age, gender, and remaining teeth on the anatomy of the temporomandibular joint in order to diagnose normal variations from abnormal cases. **Methods:** In this cross-sectional study, cone-beam computed tomography (CBCT) images of 144 patients referring to Tabriz Dental School for various reasons were selected and evaluated. The different aspects of the clinical parameters and the morphology of the condyle were evaluated on coronal, axial, and sagittal views. The CBCT prepared using the axial cross-sections had been 0.5 mm in thickness. The sagittal cross-sections had been evaluated perpendicular to the lengthy axis of the condyle at a thickness of 1 mm and the coronal cross-sections had been evaluated parallel to the lengthy axis of the condyle at a thickness of 1 mm. Data were analyzed with descriptive statistical methods and t-test, chi-squared test, using SPSS 20. The significance level of the study was $p < 0.05$. **Results:** There was a significant relationship between the condyle morphology, number of the teeth, and mastication side ($p = 0.040$). There were significant relationships between the condyle morphology, age between 20-40, and occlusion class I on the all the three views (coronal, axial, sagittal) ($p = 0.04$), ($p = 0.006$), ($p = 0.006$). Also, significant relationships were found in the condyle morphology and location of pain according to age, the number of remaining teeth, and gender. ($p = 0.046$) ($p = 0.027$) ($p = 0.035$). **Conclusion:** There are significant relationships between the clinical symptoms and condyle morphology based on age, gender, and the number of remaining teeth. The clinical finding that has the most significant relationship between the condyle morphology, remaining teeth (9-16 teeth), all of the age range (20-80 year), and gender was mastication side.

Keywords: Cone beam computed tomography. Mandibular condyle. Temporomandibular joint.

Corresponding author:
Dr. Shiva Daneshmehr, D.D.S.
Address: Faculty of Dentistry, Tabriz university of Medical sciences, Daneshgah Street, Tabriz, Iran
Office phone: +98 (41) 328 86333
Phone number: +98935 212 2461
E-mail: shivadaneshmehr@yahoo.com

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Introduction

The temporomandibular joint (TMJ) is one of the sophisticated structures in the body that allows the mandible to move in several directions[1]. Mastication patterns have a crucial role in preserving the functional balance of the TMJ[2]. Forces exerted on the craniomandibular joint might affect the bony components, which might change the thickness and shape of these parts. Excessive loads are considered abnormal, thus some patients require to eliminate the causative agent[3-5]. The degenerative disorders have a great importance in temporomandibular joint remodeling. In the TMJ, degenerative joint disease might be defined as a local condition or be a part of a systemic disease[6]. One of the other factors that affect mandibular condyle structure is tooth loss. Posterior crossbite and tooth loss might be associated with mandibular condyle structural alterations[7]. The other factor is age rising. Radiographic changes in the condylar morphology have increased with age. In addition, gender is one of the factors that will help to reproduce the appropriate TMJ structure[8]. All in all, several factors, including age, gender, number of remaining teeth, mastication patterns, etc, were found to affect TMJ morphology[9,10]. Therefore, we need paraclinical examinations to evaluate the variation of condylar morphology.

It is difficult to carry out thorough radiographic evaluations of the maxillofacial region due to its complex anatomy and superimposition of the images of adjacent structures[11]. Because of the complexity of maxillofacial anatomy and superimposition of the images of adjacent structures, radiographic images do not precisely replicate the anatomy that is being assessed. Therefore, different imaging techniques are used to evaluate the craniofacial defects. Recent research has indicated that cone-beam computed tomography (CBCT) is an efficient imaging technique for determining fractures in the facial and skull bones[12,13].

CBCT imaging technique has been introduced for imaging of the hard tissues of the maxillofacial region. The technique evaluates the structure of the bones, the articular spaces, and the dynamic performance in all three spatial dimensions without superimposition and deformity. Although CBCT is a suitable technique for the evaluation of osteoarthritic changes of the temporomandibular joint (TMJ), it is not a proper tool for the evaluation of articular disk displacement. In addition, soft tissue tumors cannot be properly evaluated on CBCT images. One of the disadvantages of the CBCT technique, compared to the MRI technique, is the poor contrast of soft tissues[14,15].

Although clinical examinations usually are adequate to reach an accurate diagnosis of TMJ disorders, supplementary imaging examinations should be considered to diagnose and determine the origin of TMJ disorders and structural alterations and functional disorders. Thus, it is recommendable to use a combination of clinical and radiographic examinations to reach a definite diagnosis[16,17].

In recent years, several studies have evaluated the morphology of the TMJ and condyle. These studies have investigated the morphology of the TMJ in subjects with malocclusion, the overall shape of the condyle head in different individuals, the relationship between age and morphologic changes in the condyle bone, the prevalence of TMJ changes in asymptomatic cases, etc[18-20]. Considering the paucity of studies on the morphology of the condyle with the CBCT technique, the purpose of this study was to investigate the relationship between the condyle morphology and clinical findings in terms of gender, age, and remaining teeth on CBCT images.

Materials and Methods

Study type and the subjects

A total of 144 patients referring to the Department of Maxillofacial Radiology, Faculty of Dentistry, Tabriz University of Medical Sciences (Iran) between 2019 and 2020, were included in the present cross-sectional study. The Ethics Committee of Tabriz University of Medical Sciences approved the protocol of the study under the code IR.TBZMED.REC.1396.310. The patients had been referred to the radiology department for CBCT examinations for various reasons and were 20–80 years of age. All the radiographic examinations were carried out for other diagnostic purposes, including implant placement. The inclusion criteria consisted of no history of surgery, fracture and congenital anomalies of the TMJ, and no pathologic lesions of the jaws. Subjects with faulty restorations, complete and partial dentures, edentulous patients, patients with a history of systemic diseases or use of medications affecting the joints, and subjects with a history of trauma, surgery, and jaw lesions were excluded from the study.

Procedural steps

The CBCT images were taken with a NewTom VGi CBCT unit (NewTom, Verona, Italy) in the Department of Oral and Maxillofacial Radiology. This CBCT unit has a cone-shaped x-ray beam, a flat panel detector, a pixel of 1536×1920, a pixel size of 127×127 μm^2, a pixel depth of 14 bits, a rotation of 360º, a scan time of 18 s, and kVp of 110. NNT viewer (Version 2.17) software was used for the initial and final reconstruction of images. The exposure conditions were set to "automatic." The CBCT images were viewed by two oral and maxillofacial radiologists and a dental student. The kappa correlation coefficient for the inter-examiner agreement was excellent for the two radiologists in 20 samples; therefore, only one radiologist proceeded with the evaluations. The results of all the clinical and radiographic examinations were recorded on a research-made checklist, which consisted of three sections: clinical findings, radiographic findings, and possible findings. The different aspects of the clinical parameters consisted of the following: parafunctional habits, mastication side, deviation of the jaw during mouth opening and closing, the type of occlusion, and the history of pain and tenderness to palpation. The radiographic parameters consisted of the shape of the condyle on coronal, sagittal, and axial views. Any possible findings were recorded in the three categories of joint erosion, osteophytes, and articular mouse.

The remaining teeth were reconstructed by panoramic radiographic images. To prepare the CBCT images, 0.5 mm axial sections were used.

Based on our previous study, the morphology of the condyle is classified into six groups on the coronal view: convex, round, flat with on effect on the glenoid fossa, flat with no effect on the glenoid fossa, angled, and heart-shaped (Figure 1)[21].

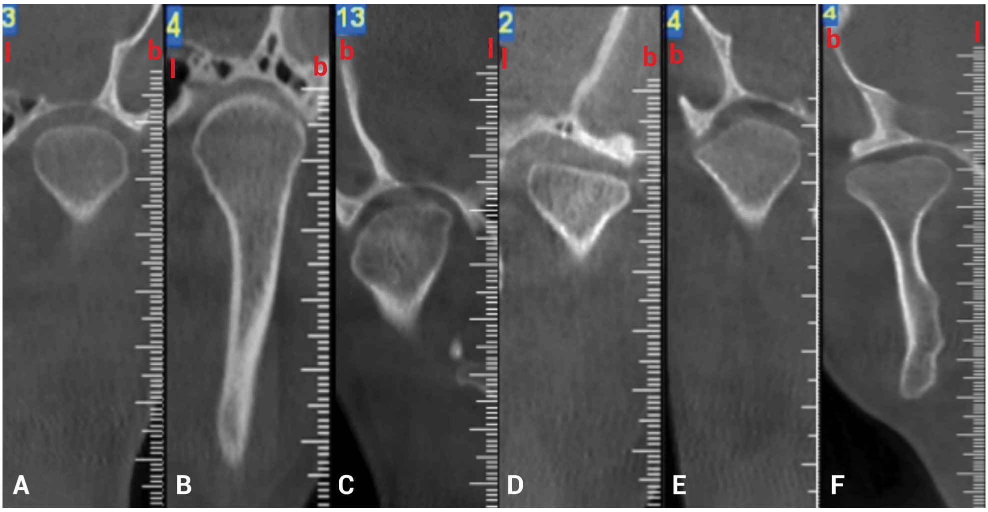

Figure 1. Different shapes of the condyle on the coronal view from the left to right: convex, round, flat with on effect on the glenoid fossa, flat with no effect on the glenoid fossa, angled, and heart-shaped.

On the sagittal view, the morphology of the condyle was classified into four groups: round, intermediate (between round and flat), flat with an effect on the glenoid fossa, and flat with no effect on the glenoid fossa (Figure 2)[21].

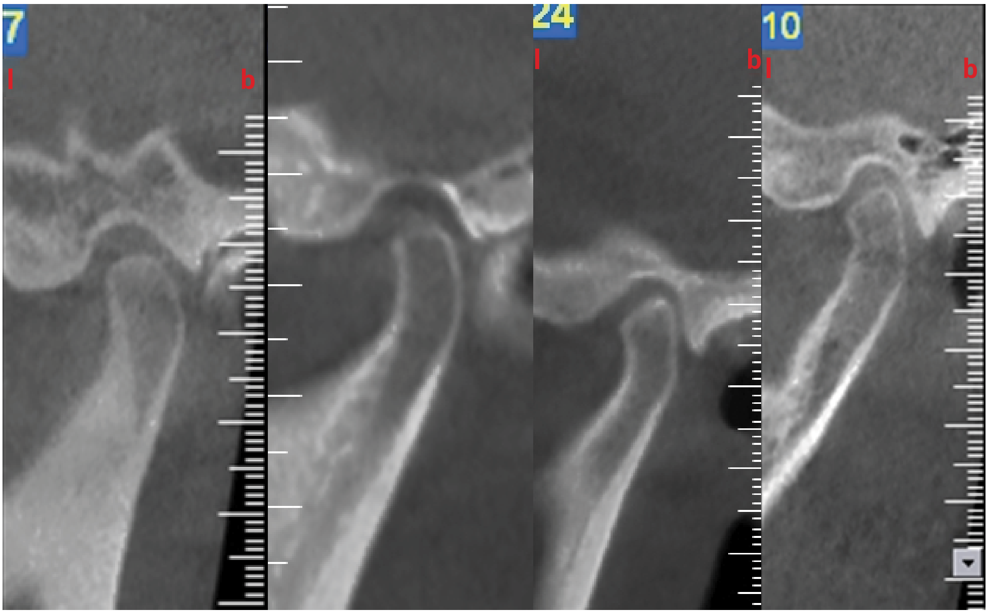

Figure 2. Different shapes of the condyle on the sagittal view from the right to left: round, intermediate (between round and flat), flat with an effect on the glenoid fossa, and flat with no effect on the glenoid fossa.

On the axial view, the morphology of the condyle was classified into three groups: oval, bean-shaped, and conical (Figure 3)[21].

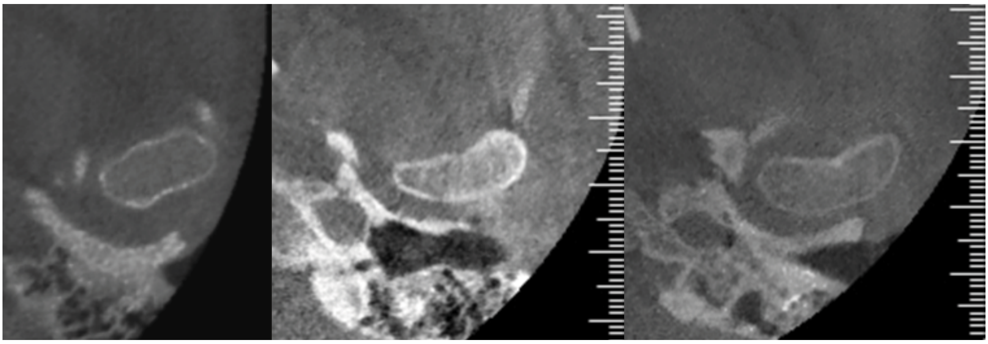

Figure 3. Different shapes of the condyle on the axial view from the left to night: oval, bean-shaped and conical.

Statistical Analysis

Data were analyzed with descriptive statistics, and t-test, chi-squared test, correlation test, one-way ANOVA, and multi-variate ANOVA, using SPSS 20. The SPSS statistics package program (IBM SPSS for Windows, ver.25, Armonk, NY) was used for statistical analysis. Statistical significance was set at $p < 0.05$.

Results

In the present study, 144 subjects were evaluated, with 71 males (49.3%) and 73 females (50.7%); respectively, with an age range of 20–80 years. Table 1 presents the correlation between the condyle morphology and mastication side, based on age and the number of remaining teeth and gender.

Table 1. Correlation among the condyle morphology and mastication side, based on age and the number of remaining teeth and gender.

Variable	Cross-section	Condyle shape	Mastication side	P-value
9-16 remaining teeth	Axial	Bean-shaped	Right side	0.040
Age range: 20-40	Axial	Bean-shaped	Anterior	0.044
Age range: 20-40	Sagittal	Flat with no effect on the glenoid fossa	Bilateral	0.013
Age range: 41-60	Sagittal	Flat with no effect on the glenoid fossa	Bilateral	0.045
Age range: 61-80	Sagittal	Flat affecting the glenoid fossa	Bilateral	0.002
Male	Coronal	Heart-shaped	Posterior	0.023
Female	Axial	Bean-shaped	Anterior	0.037

There was a significant relationship between the condyle morphology, 9-16 remaining teeth, and mastication side in the axial view on the right side (p = 0.040). Also, there was a significant relationship between the condyle morphology, age range 20-40, and mastication side in the axial view on the anterior side (p = 0.044). There was a significant relationship among the condyle morphology, age range 20-40, 41-60, 61-80, and mastication side in the sagittal view on the bilateral side (p = 0.013), (p = 0.045), (p = 0.002). In addition, a significant relationship was found between the condyle morphology, female, and mastication side in the axial view on the anterior side (p = 0.037). In males, there was a significant relationship between the condyle morphology and mastication side in the coronal view on the posterior side (p = 0.023).

Table 2 presents the relationships among the condyle morphology and occlusion, based on age and the number of remaining teeth and gender.

Table 2. Relationships among the condyle morphology and occlusion, based on age and the number of remaining teeth and gender.

Variable	Cross-section	Condyle shape	Occlusion	P-value
Age range: 20-40	Coronal	Convex	Class I	0.04
Age range: 20-40	Sagittal	Flat with no effect on the glenoid fossa	Class I	0.006
Age range: 20-40	Axial	Oval	Class I	0.006
9-16 remaining teeth	Coronal	Convex	Class I	<0.001
25-32 remaining teeth	Axial	Oval	Class I	0.031
Male	Axial	Oval	Class I	0.034

There were significant relationships among the condyle morphology, age between 20-40, and occlusion class 1 in the axial, sagittal and coronal view (p = 0.006), (p = 0.006), (p = 0.04). In addition, there was a significant relationship between the condylar morphology, 9-16 remaining teeth, and occlusion class 1 in the coronal view. Both variation include of male and 25-32 remaining teeth have significant relationship with occlusion class 1 in the axial view (p = 0.031), (p = 0.034).

Table 3 presents the correlation among the condyle morphology and location of pain, based on age and the number of remaining teeth and gender.

Table 3. Correlation among the condyle morphology and location of pain, based on age and the number of remaining teeth and gender.

Variable	Cross-section	Condyle shape	Location of pain	P-value
9-16 remaining teeth	Coronal	Flat with an effect on the glenoid fossa	The right side	0.027
Age range: 61-80	Coronal	Flat with no effect on the glenoid fossa	The left side	0.046
Male	Coronal	Heart-shaped	The right side	0.035

All of the variables in table 3 have significant relationships between the condyle morphology and the location of pain in the coronal view. There was a significant relationship between the condyle morphology, location of pain, and 9-16 remaining teeth and male in the coronal view on the right side ($p = 0.027$), ($p = 0.035$). Also, a significant relationship was found between the condyle morphology, location of pain, and age range 61-80 in the coronal view on the left side. ($p = 0.046$).

In our study, there was no significant relationship between the condyle morphology, parafunctional habits, the number of remaining teeth, age, and gender ($p > 0.05$). In addition, no significant relationship was found between the mandibular deviation during mouth opening and closing and the condyle morphology based on the number of remaining teeth, age and gender ($p > 0.05$).

Discussion

Morphologic changes because of the effects of estrogen, testosterone, and metabolic activity during adulthood result in differences between male and female[22]. Tecco et al.[23] and Al-koshab et al.[24] evaluated the morphology of the mandibular condyle and reported that the condyle is larger in men compared to women, irrespective of the clinical signs and symptoms.

Tabatabaian evaluated the prevalence of temporomandibular disorders and did not report any significant relationship between temporomandibular disorders and gender[25]. In addition, Razi did not report a significant relationship between the thickness of the glenoid fossa roof and gender on the left and right sides which is similar to the present study[21]. In the present study, the morphology of the condyle was evaluated solely by classification of the condyle shapes at different cross-sections. The findings in this study suggest that the males might be associated with the morphological alterations of the mandibular condyle and clinical findings more than females.

Shahidi did not report any significant relationships between the articular eminence slope and joint disorders[26], which is different from the results of the present study. This discrepancy between the results might be attributed to the smaller sample size in the study above and the differences in research methodologies.

Few studies have assessed the relationship between tooth loss and condyle morphology. People with single missing teeth might have a decreased articular eminence inclination angle and the unipartite missing teeth may reduce the craniocervical angle[9,27].

Ejima et al.[28] evaluated the relationship between the thickness of the glenoid fossa and the shape of the condyle and did not report any significant relationship between the two variables in terms of the number of remaining teeth in asymptomatic patients. Zabarović et al.[29] showed that loss of teeth has no statistically significant correlation with the eminence inclination.

In the present study, 9-16 remaining teeth seems to be associated with condyle morphology and clinical findings more than the categories with a higher number of remaining teeth.

A study was conducted by Alhammadi et al.[30] in which the TMJ joint of 90 patients aged 18 to 25 years with class I occlusion was measured and analyzed by using a three-dimensional CBCT image. The position, slope, and width of the glenoid fossa and the articular height of the eminence, the position and the slope and dimensions of the condyle and the measurement of the joint space and how the joint was placed in the glenoid fossa were evaluated and finally the left and right joints of each patient were compared. In this study, there was no difference in the depth of the left and right glenoid fossa[30]. The results of this study are different from the results of the present study. This discrepancy between the results might be attributed to the smaller sample size in the study above and the differences in research methodologies.

In addition, one of the factors affecting the morphology of the condyle is aging; articular degenerative changes have been recorded in older subjects[31]. Katsavrias[32] evaluated the condyle morphology at a young age with a small sample size, similar to the study by Merigue et al.[2], and reported that the size of the condyle reaches its maximum at a young age, with the oval shape being the most prevalent shape in the anteroposterior dimension[32]. In the present study, we found out that the patients in the age range 20-40 have the most meaningful relationship with condylar morphology and clinical findings. Nevertheless, this study had certain limitations. Therefore, additional studies are needed to investigate more detail in this regard.

Based on the results, there were significant relationships between the condyle morphology and the clinical findings based on age, gender and the number of remaining teeth. Of all the results concerning the relationship between the clinical symptoms and condyle morphology based on age, gender, and the number of remaining teeth, the most significant relationship was detected on the mastication side especially on the bilateral side. There were no significant relationships between parafunctional habits and the condyle morphology based on number of remaining teeth, age, and gender.

Data availability

Datasets related to this article will be available upon request to the corresponding author.

Conflict of Interests

None.

Author Contribution

Conceptualization: Shiva Daneshmehr. Methodology: Sedigheh Razi, Formal analysis: Tahmineh Razi. Investigation: Shiva Daneshmehr. Resources: Shiva Daneshmehr. Data curation: Tahmineh Razi. Writing—original draft preparation: Shiva Daneshmehr. Writing—review and editing: Shiva Daneshmehr. Visualization: Shiva Daneshmehr. Supervision: Tahmineh Razi. Project administration: Tahmineh Razi. Funding acquisition: none. All authors have read and agreed to the published version of the manuscript.

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