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ORIGINAL ARTICLE / ARAŞTIRMA MAKALESİ

Evaluation of Mandibular Condyle Shape Distribution Using Digital Panoramic Images

Temporomandibuler Eklem Kondil Şekillerinin Dağılımlarının Dijital Panoramik Radyograflar ile İncelenmesi

Elvan ÖNEM ÖZBİLEN[1], Begüm TURAN[2], Ece BAŞAL[1], Gamze YILDIRIM[2]

ABSTRACT

Objective: The human condyle is capable of remodelling over time as numerous factors such as age, sex, occlusal force, malocclusion, and skeletal relationship influence this remodelling. This change in shape can lead to the numerous symptoms of degenerative joint disease. The aim of this study was to investigate the different morphologies of the condyle in different age groups at the Faculty of Dentistry, Marmara University, Department of Orthodontics, using orthopantomography.

Materials and Methods: A total of 681 panoramic radiographs obtained for this study. The study group consists of 399 female and 282 male individuals aged between 15-55 years. Articular eminence and glenoid fossa regions of the mandibular condyle was traced. The mandibular condyle morphology was classified into six types such as oval, birdbeak, diamond, flat, crooked finger and bifid. Intergroup differences were evaluated with Chi-square and McNemar tests. ($p<0.05$)

Results: A total of 1362 right and left condyles of 681 patients were examined. The most common shape among the six condylar types – regardless of age and gender – was oval condylar morphology, followed by flat, diamond-shaped, crooked finger, birdbeak, and bifid.

Conclusions: As a result of the examination of condyle shapes in individuals with different ages on panoramic radiographs, the process of remodelling of the temporomandibular joint condyle over time was observed. The differences found between the age groups are interpreted to be related to the cumulative increase in the amount of functional loading to which the condyle is exposed with increasing age.

Keywords: Condyle shape, mandibular condyle, orthopantomogram

ÖZ

Amaç: Temporomandibular eklem kondili, yaş, cinsiyet, oklüzal kuvvet, maloklüzyon ve iskeletsel patern gibi birçok sayıda faktörün etkisiyle zaman içinde yeniden şekillenebilmektedir. Kondil şeklinde oluşan bu değişiklik, dejeneratif eklem hastalığının çeşitli semptomlarına yol açabilir. Bu çalışmanın amacı, Marmara Üniversitesi Diş Hekimliği Fakültesi'ne başvuran hastalarda farklı yaş gruplarında mandibuler kondilin farklı morfolojilerini panoramik radyografi yardımıyla araştırmaktır.

Gereç ve Yöntemler: Toplam 681 panoramik radyografi ile yapılan bu çalışmada, çalışma grubu 15-55 yaş arası 399 kadın ve 282 erkek bireyden oluşmaktadır. Mandibular kondilin artiküler eminens ve glenoid fossa bölgeleri incelenerek şekilleri belirlenmiştir. Mandibular kondil morfolojisi oval, kuş gagası, elmas, düz, çarpık parmak ve bifid olmak üzere altı tipte sınıflandırılmıştır. Gruplar arası farklar Ki-kare ve McNemar testleri yardımıyla analiz edilmiştir. ($p<0,05$)

Bulgular: 681 hastaya ait toplam 1362 sağ ve sol kondil incelenmiştir. Altı kondil tipi arasında yaş ve cinsiyet farkı gözetmeksizin en yaygın görülen şekil oval kondil morfolojisi olarak saptanırken, bunu sırasıyla düz, elmas, çarpık parmak, kuş gagası ve bifid kondil şekilleri izlenmiştir.

Sonuç: Farklı yaşlardaki bireylerde kondil şekillerinin panoramik radyograflarda incelenmesi sonucunda, temporomandibular eklem kondilinin zaman içinde yeniden şekillenme süreci gözlenmiştir. Yaş grupları arasında tespit edilen farklılıkların, bireyin artan yaşı ile birlikte kondilin maruz kaldığı fonksiyonel yükleme miktarının birikimsel artışı ile ilişkili olduğu düşünülmektedir.

Anahtar Kelimeler: Kondil şekli, mandibular kondil, ortopantomogram

INTRODUCTION

The temporomandibular joint (TMJ) is the most intricate and significant component of the body and masticatory system. It helps with speech, swallowing, and food chewing. The condylar process, glenoid fossa, articular disc, and articular prominence form the majority of the mandible (Ulhuq, 2008). Between normal and abnormal conditions, dentists — especially orthodontists and maxillofacial

Elvan Önem Özbilen (✉)
Asst. Prof. Department of Orthodontics, Faculty of Dentistry, Marmara University, Istanbul, Turkey; Mail: elvanonem89@gmail.com

Ece Başal
Asst. Prof. Department of Orthodontics, Faculty of Dentistry, Marmara University, Istanbul, Turkey.

Gamze Yıldırım / Begüm Turan
Research Assistant Department of Orthodontics, Faculty of Dentistry, Marmara University, Istanbul, Turkey.

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radiologists — need to have a thorough knowledge of the anatomy and morphology of the TMJ (Sonal et al., 2016). The management of temporomandibular disorders (TMD) is carried out by dentists with a variety of specializations. Due to its multifactorial character, it necessitates a comprehensive evaluation and treatment strategy. In orthodontics, the location of the condyle may be important for two reasons: to diagnose and treat TMJ dysfunctions or to differentiate the body of mandible postures (Westesson, 1993).

Panoramic radiographs (OPG) are the most frequently used diagnostic instrument by dental clinicians to obtain general information about teeth, the mandible, and other related structures of the jaw (Momjian et al., 2011). It provides clinician important information about the osseous changes or flattening that occur over time, as well as the anatomical diversity of the maxilla and mandible (Honda et al., 1994). Moreover, the American Academy of Oral and Maxillofacial Radiology has also suggested routine panoramic view for evaluating the structural components of the temporomandibular joint due to the low cost and risk of the relatively low radiation exposure compared to computed tomography (Epstein et al., 2001).

Various condyle shapes have been discussed by a number of authors from around the globe (Ahn et al., 2006; Ribeiro et al., 2015; Sonal et al., 2016; Khanal & Pranaya, 2020). Condyle variation in size and form aids in the diagnosis of TMDs linked to malocclusions like cross bite, deep bite, and open bite (Al-Saedi et al., 2020). The mandibular condyle has an oval and biconvex upper surface and a rounded head in healthy people. The human condyle has the ability to change over time due to a variety of influences, including age, sex, occlusal force, dental and skeletal malocclusion (Bae et al., 2017). With age, this remodeling is seen to become more pronounced as the TMJ is subjected to increasing amounts of occlusal loading from grinding and chewing (Hegde et al., 2013). It is thought to be the result of a long-lasting inflammatory process that causes a number of biomechanical adjustments in the joint's hard and soft tissues, causing the immune system to release inflammatory mediators like cytokines and chemokines (Egloff et al., 2012; Wang et al., 2012). As a result of the process, the complement system is activated and cartilage-degrading substances like matrix metalloproteinase (MMPs) and prostaglandin E (PGE) are released, further damaging the joint cartilage. As a consequence, the bone changes and the joint cartilage eventually deteriorates and is abraded (Tanaka et al., 2008; Egloff et al., 2012). By flattening the condyle head, this remodelling can alter the condyle's shape from being rounded or oval to diamond shape, pointed, birdbeak shape, or crooked finger shape.

The most prevalent classification method used in the majority of prior studies comprises the oval, birdbeak, diamond, and crooked finger types of condyles (Sonal et al., 2016; Jawahar & Maragathavalli, 2019; Khanal & Pranaya, 2020; Shaikh et al., 2022). Two other studies had used the second most common classification consisting of the condyles with rounded, angled, flattened, and mixed types (Ribeiro et al., 2015; Singh & Chakrabarty, 2015).

The aim of the present research is to document the types of typical morphological variations of the condyle by using OPG and to determine how frequently various condylar morphological variations occur in patients who had applied to Marmara University.

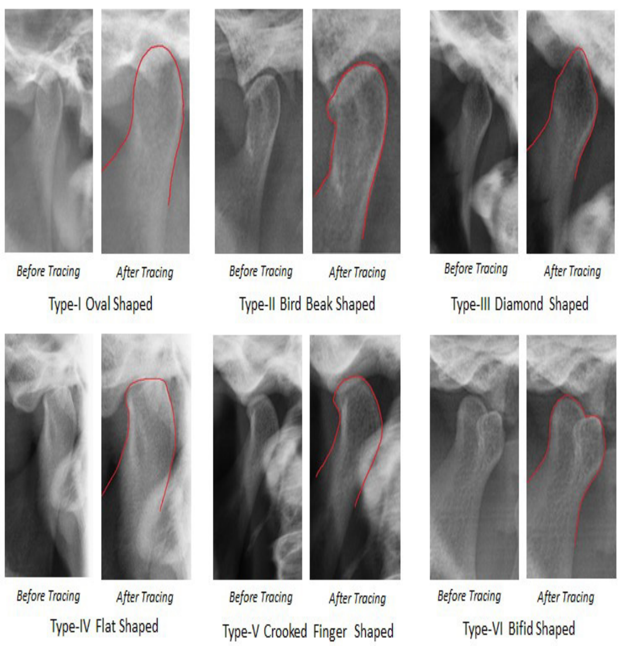
MATERIALS AND METHODS

A retrospective cross-sectional study that included radiographic evaluation of 681 patients was approved by the Ethical Committee of Marmara University, Faculty of Medicine (09.2022.1464, 30/05/2023) and conducted in Faculty of Dentistry, Department of Orthodontics. All recoverable OPGs of the individuals who had visited the department between November 2018 to March 2023 were retrieved from the faculty archive together with the other required information about age, gender. The selected digital OPGs revealed a complete view of the condyle on either side with the best density and contrast. Planmeca ProMax 2D (Planmeca, Helsinki, Finland) with exposure parameters of 5 Ma and 66 Kv was used to get OPGs. The inclusion criteria were as follows: i) panoramic radiographs of patients aged 15 years and older with demographic information (age and gender), ii) showing a full view of either side of the mandible with optimal density and contrast, iii) no projection errors that would distort the image. Panoramic radiographs showing any pathology (osteomyelitis, osteoporosis, etc.) in the maxilla or mandible or showing any indication of fracture in the mandible, developmental anomalies of the jaws, craniofacial syndromes, plating for fractures, odontogenic cysts or tumors of the jaws, complete dentures, and edentulous dental arches were excluded.

A number of 681 OPGs were visualized by two orthodontists (BT and GY) to ascertain the condyle's morphology. The sample consisted of 1362 condyles of 681 patients. The subjects' ages ranged from 15 to 55 years, with

399 female patients and 282 male patients among the 681 cases. A 10-year age gap was used to categorize panoramic radiographs into 4 groups: 15–25, 26–35, 36–45, and 46–55 years. There were 222 panoramic radiographs in group I (15-25 years), 147 in group II (26-35 years), 170 in group III (36-45 years), and 142 in group IV (46-55 years). The mandibular condyle morphology was classified into six types – oval (Type-I), birdbeak (Type-II), diamond (Type-III), flat (Type-IV), crooked finger (Type-V) and bifid (Type-VI) (Fig. 1).

Figure 1: Six types of condyle shapes.



All statistical analyses were performed using IBM SPSS Statistics 22.0 software (Armonk, NY, USA). In addition to descriptive statistical methods, Chi-Square and McNemar tests were used to compare qualitative data. The significance was evaluated at $p<0.05$ level.

RESULTS

Amongst six condyle types, oval condylar morphology (57.2%) was the most prevalent and followed by flat (19.3%), diamond (10.3%), crooked finger (7.3%), birdbeak (4.9%), and bifid (0.95%).

There was a statistically significant difference between the right and left condyles in terms of condylar morphology (p=0.001). The proportion of oval morphology in the right condyle (60.2%) was significantly higher than in the left condyle (54.2%) (Table 1).

Table 1. Evaluation of right and left condyle differences

	Right condyle	Left condyle	
	n (%)	n (%)	p
Bifid	8 (1.2%)	5 (0.7%)	
Birdbeak	26 (3.8%)	41 (6%)	
Crooked finger	**42 (6.2%)**	**57 (8.4%)**	**0.001*** **
Diamond	66 (9.7%)	75 (11%)	
Flat	129 (18.9%)	134 (19.7%)	
Oval	**410 (60.2%)**	**369 (54.2%)**	

*McNemar Test *p<0.05 **p<0.01 ***p<0.001*
Bold letters mean statistically significant differences.

A statistically significant difference was found between the genders regarding the condylar morphology in both right and left condyles (p=0.003, p=0.001 respectively). While flat morphology rate in men (25.5%) was significantly higher than in women (14.3%), crooked finger morphology rate in women (7.8%) was significantly higher than in men (3.9%) for the right condyle (Table 2). For the left condyle, while flat morphology rate in men (24.5%) was significantly higher than in women (16.3%), crooked finger and diamond morphology rates in women (11.5%, 13.3% respectively) were significantly higher than in men (3.9%, 7.8% respectively) (Table 3).

Table 2. Evaluation of the right condyle according to gender

	Male	Female	
Right condyle	n (%)	n (%)	p
Bifid	4 (1.4%)	4 (1%)	
Birdbeak	11 (3.9%)	15 (3.8%)	
Crooked finger	**11 (3.9%)**	**31 (7.8%)**	**0.003** **
Diamond	22 (7.8%)	44 (11%)	
Flat	**72 (25.5%)**	**57 (14.3%)**	
Oval	162 (57.4%)	248 (62.2%)	

*Chi-square test *p<0.05 **p<0.01 ***p<0.001*
Bold letters mean statistically significant differences.

Table 3. Evaluation of the left condyle according to gender

	Male	Female	
Left condyle	n (%)	n (%)	p
Bifid	2 (0.7%)	3 (0.8%)	
Birdbeak	18 (6.4%)	23 (5.8%)	
Crooked finger	**11 (3.9%)**	**46 (11.5%)**	**0.001*** **
Diamond	**22 (7.8%)**	**53 (13.3%)**	
Flat	**69 (24.5%)**	**65 (16.3%)**	
Oval	160 (56.7%)	209 (52.4%)	

*Chi-square test *p<0.05 **p<0.01 ***p<0.001*
Bold letters mean statistically significant differences.

Moreover, there was a statistically significant difference between the age groups for the right condyle distribution (p=0.001). The birdbeak morphology rate in the group 2 (26-35 years) (8.8%) was significantly higher than in the group 1 (15-25 years) (1.4%) and group 4 (46-55 years) (1.4%). Crooked finger rate in the group 4 (46-55 years) (2.1%) was significantly lower than in the group 1 (15-25 years) (7.2%) and group 3 (36-45 years) (8.2%). The diamond rate (15.9%) in the group 3 (36-45 years) was significantly higher than all the other groups. The flat rate in the group 1 (15-25 years) (12.6%) was significantly lower than in the group 3 (36-45 years) (22.9%) and group 4 (46-55 years) (26.1%). The oval rate in the group 1 (15-25 years) (70.7%) was significantly higher than all the other age groups. The oval rate in the group 3 (36-45 years) (47.1%) was significantly lower than other groups (Table 4).

Table 4. Evaluation of the right condyle by age

	15-25 (Group 1)	26-35 (Group 2)	36-45 (Group 3)	46-55 (Group 4)	
Right condyle	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**p**
Bifid	1 (0.5%)	3 (2%)	2 (1.2%)	2 (1.4%)	
Birdbeak	**3 (1.4%)**	**13 (8.8%)**	8 (4.7%)	**2 (1.4%)**	
Crooked finger	**16 (7.2%)**	9 (6.1%)	**14 (8.2%)**	**3 (2.1%)**	**0.001*** **
Diamond	**17 (7.7%)**	**10 (6.8%)**	**27 (15.9%)**	**12 (8.5%)**	
Flat	**28 (12.6%)**	25 (17%)	**39 (22.9%)**	**37 (26.1%)**	
Oval	**157 (70.7%)**	**87 (59.2%)**	**80 (47.1%)**	**86 (60.6%)**	

*Chi-square test *p<0.05 **p<0.01 ***p<0.001*
Bold letters mean statistically significant differences.

Table 5. Evaluation of the left condyle by age

	15-25 (Group 1)	26-35 (Group 2)	36-45 (Group 3)	46-55 (Group 4)	
Left condyle	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**p**
Bifid	1 (0.5%)	0 (0%)	2 (1.2%)	2 (1.4%)	
Birdbeak	12 (5.4%)	10 (6.8%)	12 (7.1%)	7 (4.9%)	
Crooked finger	24 (10.8%)	11 (7.5%)	13 (7.6%)	9 (6.3%)	0.070
Diamond	24 (10.8%)	15 (10.2%)	26 (15.3%)	10 (7%)	
Flat	32 (14.4%)	24 (16.3%)	41 (24.1%)	37 (26.1%)	
Oval	129 (58.1%)	87 (59.2%)	76 (44.7%)	77 (54.2%)	

*Chi-square test *p<0.05 **p<0.01 ***p<0.001*

DISCUSSION

The mandibular condyle is the part of the mandible that joins the TMJ (Solberg et al., 1985; Scapino, 1997). It has an oval and biconvex top surface, and a rounded head and located in the glenoid fossa, articulates with the articular disc to allow the condyle to move both translatorily and rotatorily (Blasberg & Greenberg, 2003). Depending on the amount of functional loading it is exposed to, the condyle varies significantly with age. Degenerative disorders of the condyle and the other parts of the temporomandibular joint can result from persistent, forceful stress. Examples of degenerative joint illnesses include osteophytes at the head of the condyle, flattening of the condyle surface, and internal disturbance of the articular disc resulting in disc perforation (Crow et al., 2005).

The shape of the condyle was studied using a variety of radiological techniques, which can help to determine how the condition is progressing. Transcranial, transorbital, and transpharyngeal views are a few examples of frequent conventional procedures.

Orthopantomography is an important diagnostic tool used in radiographic examination in dentistry to diagnose teeth and arches also it is cost-efficient and has a low radiation impact dosage (Kikuchi et al., 2003). Because of its benefits, OPGs are utilized in the present study (Dahlström & Lindvall. 1996, Crow et al., 2005).

There are no previous studies in the literature that classify condyle shapes as we do in our study, but these shapes have been used in different previous studies. In our study, we compiled these studies and included all condyle types used.

In this study, oval shape was determined to be the most prevalent shape in the sample, regardless of gender or whether it was the right or left side. Since the condyle shape is oval under normal conditions, it was already expected that the proportion of oval-shaped condyles to be higher in the current study. This finding was also similar in previous studies (Singh & Chakrabarty, 2015; Sonal et al., 2016; Anisuzzaman et al., 2019; Jawahar & Maragathavalli, 2019; Khanal & Pranaya, 2020, Shaikh et al., 2022).

The second most common condyle shape was found to be flattened in this study (19.3%) which was similar to the study by Gupta et al. (Gupta et al., 2022) (8.76%). While some other studies reported flattened shaped condyles in quite lower ratio (Singh & Chakrabarty, 2015; Nagaraj et al., 2017), some of them did not address this shape at all in their investigations (Sonal et al., 2016; Anisuzzaman et al., 2019; Khanal & Pranaya, 2020; Shaikh et al., 2022).

The third most prevalent shape observed in our analysis was diamond shaped (10.35%), which was also observed priorly in the studies of Sonal et al. (9%) (Sonal et al., 2016), Singh et al. (3.2%) (Singh et al., 2020), Anisuzzaman et al. (9%) (Anisuzzaman et al., 2019) and Gupta et al. (4.7%) (Gupta et al., 2022). However, in their studies, Nagaraj et al. (Nagaraj et al., 2017) and Singh and

Chakrabarty (Singh & Chakrabarty, 2015) did not discuss diamond shape.

The crooked finger shape of the condyle (7.3%) followed the previous morphologies in the present study. On the contrary, crooked finger shape condyles were reported to be the least common in research conducted by Anisuzzaman et al. (1%) (Anisuzzaman et al., 2019), Gupta et al. (1.2%) (Gupta et al., 2022), and Khanal et al.(4.2%) (Khanal & Pranaya, 2020).

Bifid shape was the least common shape seen in this study. The majority of the other studies did not mention bifid condyle. The bifid mandibular condyle is an uncommon abnormality whose source is unknown. The evidence implies that this abnormality is either traumatic or developmental in nature (Alpaslan et al., 2004). Therefore, it is an expected result that the likelihood of bifid condyles between patient groups is low.

In current study, patients were divided into 4 age groups. It was seen that as the age increases, the number of patients falling to the oval shaped category was seen to decrease, however in group 4 (46-55 years), oval shaped condyles (57.3%) were higher than group 3 (36-45 years) (45.9%) for both left and the right condyles. The oval condyle rate was significantly lower in the group 3 (36-45 years). As the number of patients with an oval-shaped condyle decreased with age, the number of patients with other shapes increased. According to our results flat shaped and birdbeak shaped condyles increased with age significantly. The condyle's cumulative increase in functional loading with age could be the reason for this situation. In the literature, it was also reported that the wear of the condylar head which leads to osteophyte growth can cause a change in the morphology of the condyle in older age groups (Tanimoto et al., 1990; Pereira Jr et al., 1994; Blasberg & Greenberg, 2003; Crow et al., 2005; Hegde et al., 2013).

When examined by gender, flat shaped condyle was found significantly higher in male patients (25%) than females (15.3%). On the contrary, crooked finger shaped condyle was found significantly higher in female patients (9.65%) than males (3.9%). In their study Gupta et al. also found flat shaped condyles are higher in male patients (Gupta et al., 2022).

Most of the previous studies identified 4 types of condyles in their research whereas in the current study 6 types were identified. The variations in the results might be due to the fact that the current research population was completely different from previous studies which had smaller sample sizes. Since the present study was carried out following the other studies, it was attempted to find as many forms as feasible, as it was stated in the previous studies.

There is no consistently recognised categorization for condyle shapes universally, and none of the previous research proposed a categorization with six various types of condylar forms except Gupta et al. (Gupta et al., 2022). The sample size of the current study was quite higher than the others, for this reason this range of condylar shape variations should be considered normal. This categorization will also serve as a benchmark for future research. It is recommended conducting a nationwide study to gather more precise information about the frequency of different condyle forms in the population. Additionally, this investigation was carried out using a panoramic radiograph, while three-dimensional imaging might have provided more precise results.

CONCLUSION

Based on the findings, it can be inferred that oval was the most observed morphology of the mandibular condyle regardless of gender and age. Bifid condyle shape was the least common shape in the study group. The youngest group (group 1) has the lowest rate of flat and bifid condyle shape; therefore, the oldest group (group 4) had the highest rate of flat and bifid shaped condyles. As expected in the current study, other condyle shapes were seen more frequently than oval condyle shape in patients due to increasing occlusal forces with age.

Conflicts of interest

None to declared.

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