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Assessment of Mandibular Condylar Morphology in the Saudi Population of the Qassim Region. A Retrospective Cross-sectional Study

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ABSTRACT

Background: The mandibular condyle's shape varies according to genetic, environmental, and functional factors. To diagnose temporomandibular disorders and to plan orthodontic and prosthodontic therapies, it is imperative to evaluate these variances. One popular imaging technique for evaluating condylar morphology is panoramic radiography (orthopantomograms [OPGs]). **Objectives:** The study's objectives are to determine the prevalence of various condylar shapes and how they relate to age and gender by employing OPGs to retrospectively assess condylar morphology in a Saudi population. **Methods:** One thousand digital OPGs from patients who were at least 18 years old were the subject of a retrospective cross-sectional investigation. Oval, diamond, bird beak, and crooked finger forms were the four categories into which condylar morphology was divided. The OPGs were reviewed by an experienced oral and maxillofacial surgeon. Using SPSS software version 27.0, the data were examined to look for correlations between condylar morphology and demographic characteristics using chi-square tests and descriptive statistics. **Results:** The most common condylar morphology observed was the oval type (53.5% on the right and 52.3% on the left), followed by bird beak (22.4% right, 23.6% left), diamond (14.2% right, 13.9% left), and crooked finger (9.9% right, 10.2% left). Oval condyles were more prevalent in younger age groups, whereas degenerative changes (crooked finger morphology) were more common in older individuals. Gender-based variations revealed that males had a higher prevalence of oval condyles, while females exhibited a greater frequency of diamond and crooked finger morphologies. A statistically significant association was found between right condylar morphology and age groups. **Conclusion:** The study confirms the predominance of oval-shaped condyles across all age groups and genders, with degenerative changes becoming more prevalent with age. Gender-based variations in condylar morphology may be attributed to genetic, hormonal, and functional factors. OPG remains a reliable and accessible tool for assessing condylar morphology.

Keywords: Age-related changes, condylar morphology, gender differences, mandibular condyle, panoramic radiography, temporomandibular joint

Introduction

The temporomandibular joint (TMJ) plays a crucial role in the functional and structural integrity of the craniofacial system.[1] The morphology of the mandibular condyle is highly variable, influenced by genetic, environmental, and functional factors.[2] Understanding these variations is essential for diagnosing temporomandibular disorders (TMDs), planning orthodontic and prosthodontic treatments, and assessing the effects of aging and gender differences on the TMJ.[3]

Panoramic radiography (orthopantomography) is a commonly used investigation technique to assess condylar morphology due to its wide availability, low cost, and capacity to present an almost complete overview of maxillofacial structures.[4] Earlier studies described different morphological patterns of the condyle, with normal, flattened, convex, angled, and osteoarthritic changes; variations related to age-related remodeling and degenerative processes, as well as hormonal influences have been proposed.[5-7] However, the prevalence and distribution of these morphological types among different populations remain underexplored.[8]

In this study, we aimed to retrospectively assess condylar morphology using orthopantomograms (OPGs) in a Saudi population from the Qassim region. This region was selected due to its distinct demographic and lifestyle factors that may influence TMJ characteristics. The study compares condylar types across age groups and genders. The findings may help improve understanding of condylar changes with age, adaptive patterns, and potential risk factors for TMDs in this population.

Materials and Methods

Study design and setting

This retrospective cross-sectional study was conducted to evaluate the morphology of the mandibular condyle using OPGs in a Saudi population from the Qassim region. A total of 1,000 radiographs were consecutively selected from archived digital records of patients aged 18 years and above who visited the dental radiology department for diagnostic or treatment purposes between January 2021 to March 2025 in the dental radiology department. The study aimed to classify condylar types and analyze their distribution concerning age and gender. Ethical approval was obtained from the institutional review board with order number 25-31-02 before the study.

Study population

The study included digital OPGs of patients aged 18 years and above who visited the dental radiology department for diagnostic or treatment purposes. Only radiographs with high diagnostic quality, allowing clear visualization of both mandibular condyles, were included. Exclusion criteria were a history of trauma, TMJ surgery, congenital craniofacial abnormalities, or systemic conditions affecting bone metabolism, such as osteoporosis and rheumatoid arthritis, as these factors could alter condylar morphology. Radiographs with poor image quality – due to blurring, artifacts, or incorrect patient positioning – were also excluded to ensure accurate assessment.

Radiographic imaging and analysis

OPGs were obtained using a digital panoramic system (Soredex Cranex D panorex + ceph X-ray machine, Tuusula, Finland) under standardized exposure parameters kVp 70, mA 12, and time 12s. All radiographic images were taken with the same machine to maintain consistency. The images were analyzed, displayed on a high-resolution, calibrated monitor to ensure accurate interpretation. To assess observer reliability, two experienced oral radiologists independently evaluated the condylar morphology. A random subset of 100 radiographs was re-assessed after a 2-week interval to measure intra-observer agreement, while inter-observer agreement was evaluated by comparing results between the two observers using Cohen's kappa statistics. The study was approved by the institutional ethics committee and all radiographs were anonymized before analysis. As the data were retrospective and involved no direct patient interaction, the requirement for informed consent was waived.

Evaluation of condylar morphology

The morphology of the mandibular condyle was classified into four distinct shapes based on previous literature: Type I (Oval Shape), the most common, characterized by a smooth and rounded appearance; Type II (Diamond Shape), featuring a more angular form with sharper edges; Type III (Bird Beak Shape), exhibiting a pointed and protruding structure resembling a bird's beak; and Type IV (Crooked Finger Shape), presenting an irregularly contoured condyle, often linked to degenerative changes. The radiographic evaluation was conducted by an experienced oral and maxillofacial surgeon. In cases where discrepancies arose in classification, a consensus decision was reached through discussion with the oral radiologist to ensure accuracy and reliability in the morphological assessment.

Statistical analysis

Data were analyzed using SPSS software version 27.0. Descriptive statistics (means, standard deviations, and percentages) were used to summarize the distribution of condylar types. Chi-square tests were employed to assess the association between condylar morphology and categorical variables such as gender and age groups. A $P < 0.05$ was considered statistically significant. There were no missing data for the included variables, as only complete radiographic records with all necessary demographic information were selected for analysis.

Results

The morphology of both condyles (right and left) will be classified into four types, as identified by Chaudhary *et al*. These include: Type I – round or oval-shaped, Type II – diamond-shaped, Type III – bird beak-shaped, and Type IV – crooked finger-shaped, as shown in Figure 1.

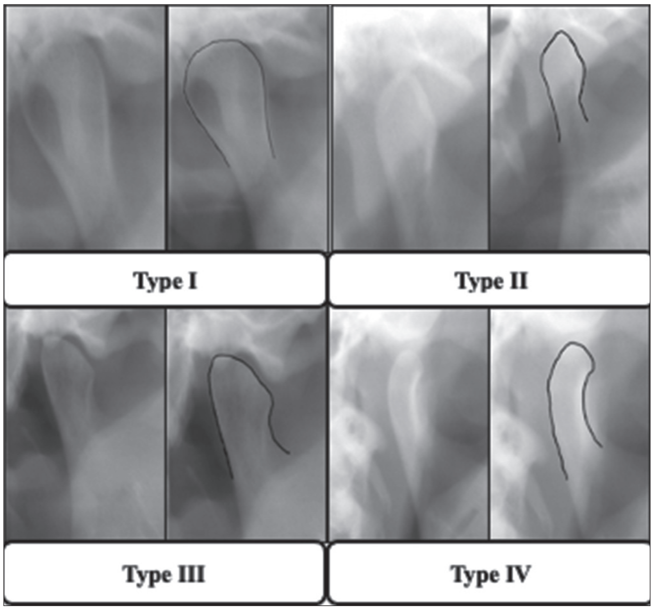

Figure 1: The four types of condylar shapes

The study included a total of 1000 participants, with a gender distribution of 44.0% females (n = 440) and 56.0% males (n = 560) [Figure 2]. Figure 3 shows that the most common type was the oval condyle (53.5%), followed by bird beak (22.4%), diamond (14.2%), and crooked finger (9.9%) in the right side. Similarly, the left condylar morphology also demonstrated a predominance of the oval shape (52.3%), followed by bird beak (23.6%), diamond (13.9%), and crooked finger (10.2%) [Figure 4]. The age distribution of participants indicated that the majority belonged to the 18–25 age group (35.2%), followed by 26–35 years (26.0%), 36–45 years (21.4%), 46–55 years (12.4%), and the least representation was in the 56–65 age group (5.0%) [Figure 5].

Table 1 shows the distribution of right condylar morphology across different age groups. The oval condyle was the most frequently observed type across all age groups, with the highest occurrence in the 18–25 age group (36.6%) and decreasing in prevalence with age, reaching 4.9% in the 56–65 age group. Bird beak morphology was also commonly seen, with its highest frequency in the 18–25 group (28.6%), followed by a gradual decline across older age groups. Diamond-shaped condyles were most prevalent in the 18–25 groups (44.4%) and showed a marked reduction in older individuals, with only 0.7% observed in the 56–65 age groups. The crooked finger morphology had the lowest overall prevalence, with its highest occurrence in the 18–25 group (29.3%) and lowest in the 56–65 group (8.1%). A $P = 0.02$, indicating a statistically significant association between right condylar morphology and age groups at the 5% significance level ($P < 0.05$).

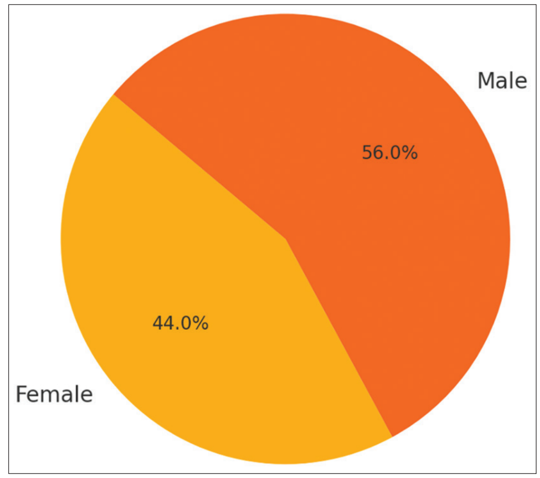

Figure 2: Gender distribution of study participants

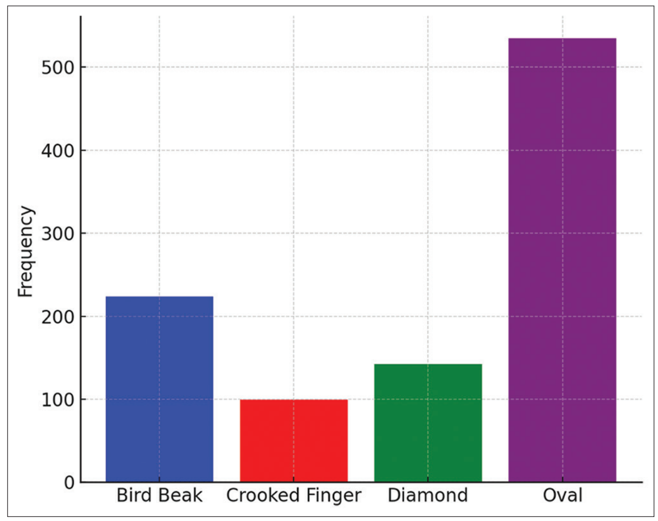

Figure 3: Distribution of types of condylar morphology in the right side

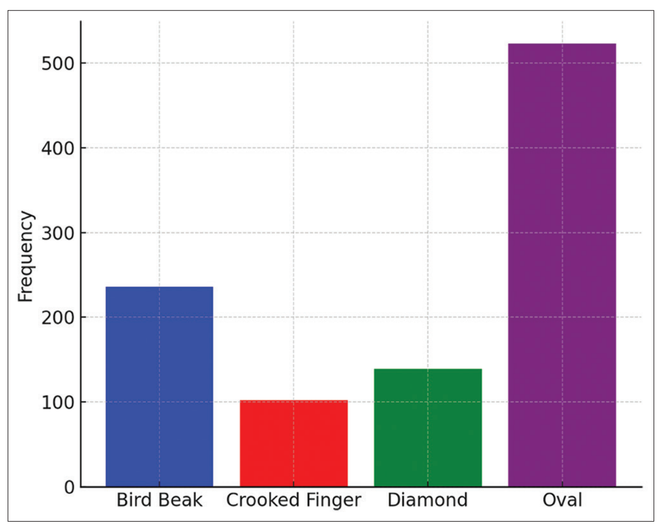

Figure 4: Distribution of types of condylar morphology in the left side

Table 2 shows the distribution of left condylar morphology across different age groups. The oval condyle was the most prevalent across all age groups, with its highest occurrence in the 18–25 age groups (37.7%), followed by a gradual decline in older age groups, reaching 3.8% in the 56–65 age group. The bird beak morphology was also common, with the highest frequency in the 18–25 group (30.5%), showing a decreasing trend with age. The diamond-shaped condyle had its highest prevalence in the 18–25 groups (36.7%), while its occurrence dropped significantly in the 56–65 group (1.4%). The crooked finger morphology was the least common overall, with its highest occurrence in the 18–25 group (31.4%) and lowest in the 56–65 group (7.8%). The $P = 0.10$, indicating that the association between left condylar morphology and age groups is not statistically significant at the 5% significance level ($P > 0.05$).

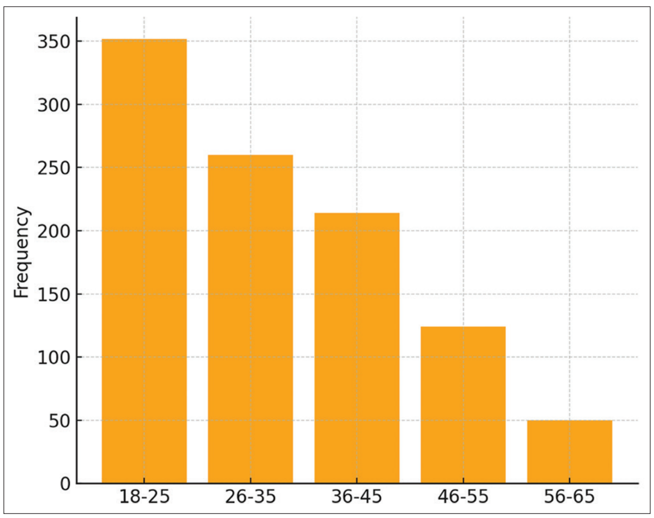

Figure 5: Distribution of age group among study participants

Table 3 shows left condylar morphology distribution by gender, which revealed that oval condyles were the most prevalent type in both males and females, with a higher occurrence in males (56.8%) compared to females (43.2%). The bird beak morphology was significantly more common in males (69.1%) than in females (30.9%). In contrast, the crooked finger morphology was more frequent in females (53.9%) than in males (46.1%), making it the only condylar type where female prevalence exceeded male prevalence. The diamond-shaped condyle was also more commonly found in females (61.9%) than in males (38.1%), suggesting gender-based morphological differences. The $P < 0.001$, indicating a highly significant association between left condylar morphology and gender at the 5% significance level ($P < 0.05$).

Similarly, in the right condylar morphology distribution by gender, the oval condyle remained the most dominant morphology, being more common in males (57.2%) compared to females (42.8%) [Table 4]. The bird beak morphology was more frequently observed in males (70.1%) than females (29.9%), while the crooked finger morphology was slightly higher in females (54.5%) than males (45.5%), similar to the left condylar findings. The diamond morphology was more prevalent in females (63.4%), whereas males had a lower occurrence (36.6%) [Table 5]. The $P < 0.001$, indicating a highly significant association between right condylar morphology and gender at the 5% significance level ($P < 0.05$).

Table 5 describes the symmetry and asymmetry of condylar morphology among the distribution. The most common symmetrical morphology was the oval condyle on both sides (Oval-Oval), observed in 52.3% of cases,

Table 1: Right condylar morphology distribution by age

Age group	Bird beak (%)	Crooked finger (%)	Diamond (%)	Oval (%)	Total (%)	*P*-value
18–25	64 (28.6)	29 (29.3)	63 (44.4)	196 (36.6)	352 (35.2)	0.02*
26–35	55 (24.6)	23 (23.2)	36 (25.4)	146 (27.3)	260 (26.0%)	
36–45	60 (26.8)	25 (25.3)	23 (16.2%)	106 (19.8)	214 (21.4)	
46–55	30 (13.4)	14 (14.1)	19 (13.4)	61 (11.4)	124 (12.4)	
56–65	15 (6.7)	8 (8.1)	1 (0.7)	26 (4.9)	50 (5.0)	
Total	224 (100)	99 (100)	142 (100)	535 (100)	1000 (100)	

P<0.05*

Table 2: Left condylar morphology distribution by age

Age group	Bird beak (%)	Crooked finger (%)	Diamond (%)	Oval (%)	Total (%)	*P*-value
18–25	72 (30.5)	32 (31.4)	51 (36.7)	197 (37.7)	352 (35.2)	0.10
26–35	59 (25.0)	25 (24.5)	43 (30.9)	133 (25.4)	260 (26.0)	
36–45	56 (23.7)	22 (21.6)	26 (18.7)	110 (21.0)	214 (21.4)	
46–55	29 (12.3)	15 (14.7)	17 (12.2)	63 (12.0)	124 (12.4)	
56–65	20 (8.5)	8 (7.8)	2 (1.4)	20 (3.8)	50 (5.0)	
Total	236 (100)	102 (100)	139 (100)	523 (100)	1000 (100)	

P<0.05*

Table 3: Left condylar morphology distribution by gender

Gender	Bird beak (%)	Crooked finger (%)	Diamond (%)	Oval (%)	Total (%)	*P*-value
Female (F)	73 (30.9)	55 (53.9)	86 (61.9)	226 (43.2)	440 (44.0)	<0.001*
Male (M)	163 (69.1)	47 (46.1)	53 (38.1)	297 (56.8)	560 (56.0)	
Total	236 (100)	102 (100)	139 (100)	523 (100)	1000 (100)	

P<0.05*

Table 4: Right condylar morphology distribution by gender

Gender	Bird beak (%)	Crooked finger (%)	Diamond (%)	Oval (%)	Total (%)	*P*-value
Female (F)	67 (29.9)	54 (54.5)	90 (63.4)	229 (42.8)	440 (44.0)	<0.001*
Male (M)	157 (70.1)	45 (45.5)	52 (36.6)	306 (57.2)	560 (56.0)	
Total	224 (100)	99 (100)	142 (100)	535 (100)	1000 (100)	

P<0.05*

Table 5: Symmetry and asymmetry in condylar morphology

Category	Morphology pattern	Frequency (n)	Percentage
Most common symmetrical	Oval - Oval	523	52.30
Rarest symmetrical	Crooked Finger - Crooked Finger	99	9.90
Most common asymmetrical	Oval - Bird Beak	236	23.60
Rarest asymmetrical	Oval - Crooked Finger	102	10.20

indicating that this shape is the predominant form in the population. Conversely, the rarest symmetrical morphology was the crooked finger condyle on both sides (Crooked Finger-Crooked Finger), seen in only 9.9% of cases, suggesting that degenerative condylar changes affecting both sides symmetrically are less frequent.

Regarding asymmetry, the most frequently observed asymmetrical pattern was an oval condyle on one side and a bird beak condyle on the other (Oval-Bird Beak), occurring in 23.6% of cases. This suggests that while oval morphology remains dominant, variations in functional or developmental factors contribute to asymmetric condylar remodeling, with bird beak shapes being the most common variant. On the other hand, the rarest asymmetrical pattern was an oval condyle on one side and a crooked finger condyle on the other (Oval-Crooked Finger), accounting for 10.2% of cases.

Figures 6-9 show symmetrical condylar morphology, where both the right and left condyles have the same shape. Figure 6 displays oval-oval (Type I-Type I) symmetry, the most common type. Figure 7 shows diamond-diamond (Type II-Type II) symmetry, while Figures 8 and 9 present bird beak-bird beak (Type III-Type III) and crooked finger-crooked finger (Type IV-Type IV) symmetry, respectively. These symmetrical patterns suggest that condylar shape is often the same on both sides, likely due to genetics and growth patterns.

Figures 10-13 highlight asymmetrical condylar morphology, where the right and left condyles have different shapes. Figure 10 shows a crooked finger (Type IV) on one side and a bird beak (Type III) on the other, which may indicate changes due to function or aging. Figure 11 presents a bird beak (Type III) on one

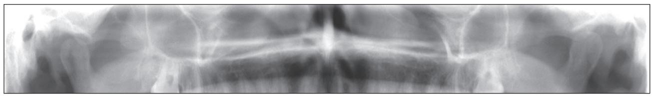

Figure 6: An orthopantomogram which shows symmetry on right and left condyles as oval (type I) - oval (type I)

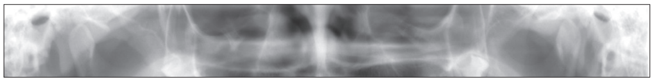

Figure 7: An orthopantomogram which shows symmetry on right and left condyles as diamond (type II) - diamond (type II)

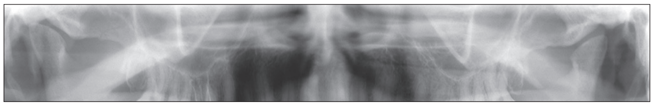

Figure 8: An orthopantomogram which shows symmetry on right and left condyles as bird beak (type III) - bird beak (type III)

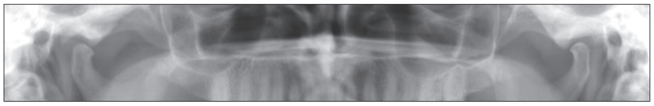

Figure 9: An orthopantomogram which shows symmetry on right and left condyles as crooked finger (type IV) - crooked finger (type IV)

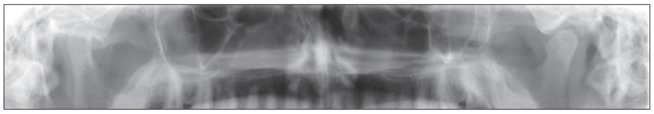

Figure 10: An orthopantomogram which shows asymmetry as crooked finger (type IV) - a bird beak (type III) for the right and left condyle

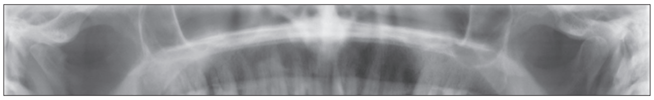

Figure 11: An orthopantomogram which shows asymmetry as a bird beak (type III) - oval (type I) for the right and left condyle

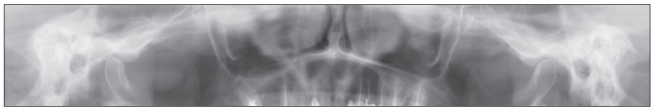

Figure 12: An orthopantomogram which shows asymmetry as crooked finger (type IV) - diamond (type II) for the right and left condyle

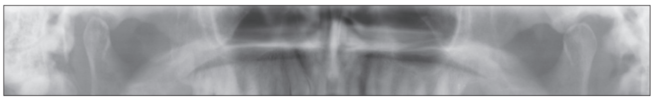

Figure 13: An orthopantomogram which shows asymmetry as a diamond (type II) - oval (type I) for the right and left condyles

side and an oval (Type I) on the other, while Figure 12 shows crooked finger (Type IV) and diamond (Type II) asymmetry. Figure 13 displays diamond (Type II) and oval (Type I) asymmetry, further suggesting that different factors, such as chewing habits or joint stress, may affect condylar shape over time.

Discussion

This study aimed to assess condylar shapes using OPGs in a Saudi population and to compare differences based on age, gender, and sides. The oval condyle was the most common shape seen across all age groups and both genders. This agrees with earlier studies, such as by Shaikh *et al*., who found oval condyles in 50% of cases, followed by bird beak shapes (40%).[9] Diamond and crooked finger shapes were the least common (4.8%). Shakya *et al*. also found oval condyles to be the most frequent on both sides, while diamond and flat types were rare.[10]

Age-related differences

In this study, oval condyles were less common in older individuals, while shapes like the crooked finger were more common with increasing age. This pattern was also reported by Singh *et al*., who found that tooth loss and changes in bite can affect condylar shape.[11] Arayapisit *et al*. found similar results, with round shapes being the most common, followed by pointed and flat types, and age likely affecting the changes.[12] Yalcin *et al*. used CBCT and showed that condylar shape changes were more noticeable in people without teeth, matching the trend seen here.[13] Kurusu *et al*. also found that people with weaker chewing force had smaller condyles, especially at the sides and back, showing that daily use can affect condylar shape.[14]

Gender differences

In this study, oval condyles were more common in males, while females had more diamond and crooked finger shapes. This trend was also seen by Shaikh *et al*., where oval shapes were most frequent in both genders and crooked finger types were least common.[9] Shakya *et al*. and Yalcin *et al*. both noted gender differences, possibly due to hormonal or functional factors.[10,13] These variations may be influenced by hormonal factors, such as estrogen, which affects bone metabolism and joint stability, potentially making females more susceptible to degenerative changes. In addition, differences in muscle strength and joint loading patterns between males and females may contribute to these morphological differences.

Symmetry

Most individuals in this study showed symmetrical condylar shapes on both sides, most commonly the oval type. This is consistent with findings by Singh *et al*., who reported bilateral symmetry in 81.4% of cases.[11] However, Bhasin *et al*. noted a higher frequency of asymmetry, particularly among individuals with TMJ disorders.[15] While this study did not focus on clinical symptoms, the presence of condylar asymmetry may indicate uneven joint loading or altered mandibular function, which can potentially contribute to TMJ dysfunction, joint pain, or mandibular deviation. Tan *et al*. observed a predominance of pointed condyles in the Malaysian Sarawak population, whereas Wangai *et al*. reported that condylar shapes varied by population, with Kenyan individuals more frequently showing curved lateral and anterior surfaces – highlighting the importance of considering ethnic and anatomical differences when interpreting condylar morphology.[16,17] Lower occlusal forces result in reduced mechanical loading on the mandibular condyle, which may lead to underdevelopment or altered remodeling of the condylar structure over time. Observed condylar asymmetry may reflect uneven joint function and has been linked to clinical conditions such as mandibular deviation, joint discomfort, and TMJ dysfunction in some individuals.

Other factors and limitations

Condylar fractures in childhood can affect how the condyle grows later. Wu *et al*. found that patients treated without surgery had more abnormal condylar shapes than those who had surgery.[18] This suggests early surgical care may help in better jaw growth and shape. A main limitation of this study is that panoramic X-rays show only a flat image and may miss some condylar details. Arayapisit *et al*. found that angled condyles are harder to see on OPGs and recommended CBCT for more accurate images.[12] Shubhasini *et al*. also supported the use of CBCT for better detection of changes that may not be clear on regular X-rays. Future studies using CBCT or MRI could give more detailed information on condylar shapes.[19] Long-term studies could also help track how these shapes change over time and how they relate to TMJ problems. Furthermore, as this study relied on 2D OPGs, certain morphological details may not have been fully captured. Further studies using 3D imaging techniques such as CBCT could provide more precise and comprehensive insights.[20]

Conclusion

This study highlights variations in condylar morphology across age groups and genders in a Saudi population, with oval condyles being the most common and crooked finger morphology the least. Age-related degenerative changes were evident, with an increased prevalence of crooked fingers and other irregular shapes observed in older individuals. Males more frequently exhibited oval condyles, while females showed a higher occurrence of diamond and crooked finger morphologies. A significant association was found between right condylar morphology and age, suggesting that degenerative changes may be more pronounced on the right side with increasing age, while no such link was observed on the left. Highly significant associations were also noted between condylar morphology and gender. These findings highlight the importance of recognizing morphological differences in the assessment, diagnosis, and treatment planning of TMJ disorders.

Authors' Contributions

Not applicable.

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Conflicts of Interest

The author has no potential conflict of interest related to the publication of this paper.

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