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# RADIOGRAPHIC ASSESSMENT OF GENDER-RELATED CONDYLAR HEAD MORPHOLOGIC CHANGES USING A CONE BEAM COMPUTED TOMOGRAPHY. A RETROSPECTIVE STUDY

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## *ABSTRACT*

**Objective:** stratification of mandibular condylar head morphologic and dimensional variation in both genders.

**Materials and methods:** This is a retrospective study included 800 subject. Sample assignment into two groups with block randomization for gender and age using a computer software. The CBCT of the participants were interpreted for classification of the condylar head shape and condylar head dimensions in terms of height, antro-posterior length and mediolateral width.

**Results:** In regards to the condylar shape, there was no statistically significant difference between males and females at P-value >0.05. The condylar head height and width were found to be statistically significant between males and females at P-value <0.001. The highest mean value was found in males. Eventually, there was no statistically significant difference in anteroposterior parameter between males and females groups (p>0.05) on both sides.

**Conclusions:** Within the limitation of the present study sample, the radiographic analysis has shown that there is no difference in condylar head morphology between males and females. In regards to dimensional variation the condylar head was found to be significantly wider and higher in males.

**KEYWORDS:** Condylar morphology, Condylar head size, Gender difference, Radiographic interpretation, CBCT

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## INTRODUCTION

TMJ is a complex human body structure that serves a variety of activities, including eating, speaking, and swallowing, as well as maintaining the stability of the mandibular position, and preventing dislocation due to external or atypical forces. [1] The basic components of TMJ are the mandibular condyle, glenoid fossa, articular eminence, and articular disc positioned between the condyle and the glenoid fossa. [2] The mandibular condyle is an ellipsoid bony structure with a thin neck that connects to the ramus of the mandible. [3] The condylar process is a crucial anatomic element of the mandible that is responsible for vertical and sagittal mandibular bone development. [4] Anthropologists are interested in the condyle because the morphology, dimensions, and relationship between the component tissues of the TMJ can vary significantly. Such variation may play an essential role in diagnosing of temporomandibular joint disorder. [5] Condylar growth was symmetric in the age range below 20 years, according to Neto et al [6], with changes in frontal dimension occurring during development. The occlusal force, functional load, malocclusion type, and right and left sides all affect the mandibular condyle. It features limited differences in appearance that are bound to exist throughout normal development or adaptive condylar remodeling to accommodate developmental changes, trauma, malocclusion, developmental abnormalities, endocrine disorders, and radiotherapy. [7,8] The appearance of the mandibular condyle may vary from one person to another and between different age groups. To distinguish a normal variant from an abnormal condyle, a complete understanding of the structure, anatomy, and morphology is required. The condylar size in humans varies between 15 and 20 mm mediolaterally and 8–10 mm antero-posteriorly. [9]

Yale et al. [10] were the first to describe the various shapes of the mandibular condyle initially, he classified condylar heads into three types based on a superior view: concave, convex, and flat; however, Yale eventually simplified the classification into four types: convex, flattened, angled, and rounded. [10,11] Tadej et al. claimed that condylar size exhibited sexual dimorphism, with males having larger condyles than females, and that major increases in size occur in the mediolateral dimension than the antero-posterior dimension as a result of growth. [12] The TMJ of aged people shows the largest morphologic alterations due to joint degeneration. [13,14]

Advances in three-dimensional (3D) imaging have made the analysis of the TMJ far more accurate than ever. [15] Cone-beam computed tomography (CBCT) has less radiation exposure than conventional computed tomography (CT), and its high-resolution imaging can attain high levels of accuracy. [16] CBCT imaging of the TMJ complex, including the condyle, allows for more consistent and accurate detection of more subtle bone abnormalities in the TMJ, which simplifies subsequent clinical decisions. [17]

So, the objective of this study is to evaluate the variation in the mandibular condyle morphology and dimensions including condyle height, anteroposterior, and mediolateral dimensions in a sample of the Egyptian population using CBCT.

## SUBJECTS AND METHODS

Ethical approval has been obtained from the ethical committee of the faculty of dentistry of Cairo university with the approval number of (16-4-22).

*Study design:* This is a cross-sectional study.

*Sample size:* Sample size was calculated using OpenEpi, Version 3, open source calculator with the study power 80% and confidence limit 0.05. The estimated condylar height mean difference between males and females was 0.58 according to Chaurasia and Giri, 2017[18]. Based on this sample size test, the needed sample for each group was 120 subjects. However, the sample size was increased to be 400 in each study arm. A total sample size of 800 subjects enrolled in this study.

*Inclusion criteria*: In order to be enrolled in this study, the patients with scanned CBCT had to meet the following criteria:

- Age: > 20 years
- Un remarkable medical history

*Exclusion criteria:* For any individual, CBCT scans with an evident of radiographic abnormality suggestive of systemic disease predisposing to osteoporosis were excluded. The condylar areas intended for measurements with a large pathological lesion, deformity, bone asymmetry, fracture, surgical defect healing, mandibular reconstruction and severely resorbed condyle alveolar bone were also excluded from the study.

*Allocation of the subjects into the test groups:*

The enrolled subjects were randomly allocated using computer generated sequence with block randomization for both age and gender. The patients' data were kept un-revealed in opaque envelopes until all measurements were taken.

*Radiographic examination:* CBCT examination was performed using a CBCT machine (Scanora 3DX) (Soredex, Tuusula, Finland, high-resolution program, voxel size 0.2 mm, with exposure parameters of, 90 Kvp, 10 m.A, exposure time 10s), the field of view was adjusted to cover the condyles bilaterally according to the manufacturer's instructions.

All measurements are made using On-demand 3D™ software (Version 1.0.10.6388, CyberMed Inc, Seoul, South Korea), and viewed on a Dell monitor (22" Full HD 1920 × 1080 display) in dimmed lightroom.

Measurements were taken by two trained oral and maxillofacial radiologist observers of ten years clinical experience. Both assessors were blinded, they had no information regarding the gender or age of the examined subject. Eventual disagreements were discussed and data were reported after assessors' agreement was reached.

On the multiplanar (MPR) screen coronal, axial, and sagittal images were reoriented to display the widest condyle dimension in each plane. The coronal plane was oriented on the axial window to cross mediolaterally via the widest condyle dimension. (Fig. 1).

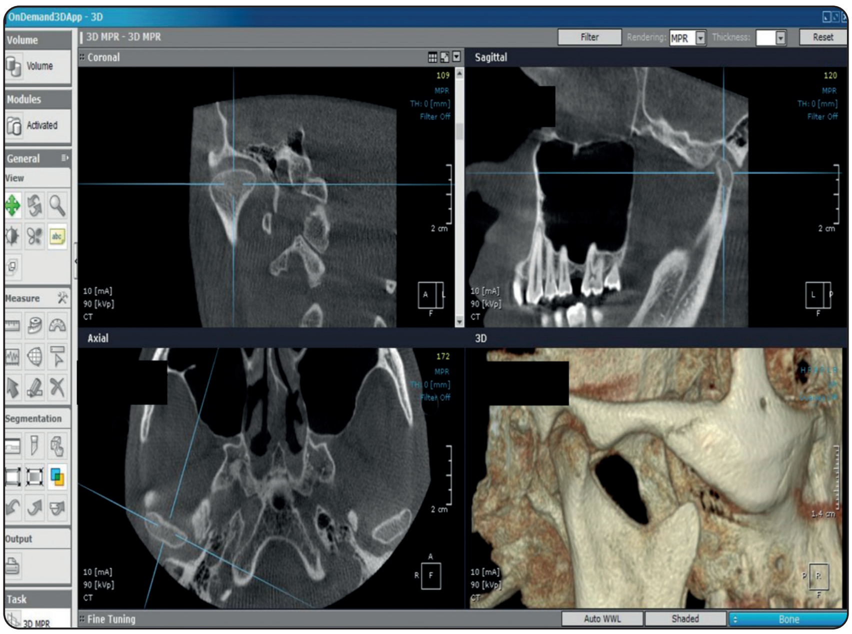


Fig. (1): Standardized orientation of the MPR views. The coronal plane was oriented on the axial window so that it passes through the widest condyle dimension mediolaterally. Sagittal plane was oriented on the axial window so that it runs perpendicular to the coronal plane

Condyle mediolateral width was measured on the corrected coronal view with the axial plane passing through the widest condyle dimension using the linear measurement tool on the software. Condyle height was measured on the corrected sagittal view using the linear measurement tool on the software. The Condyle anteroposterior dimension was measured on the corrected sagittal view on a line connecting the most prominent anterior (A) and posterior (P) points of the condylar head. (Fig. 2).

All parameters were assessed separately on right and left TMJs of both groups

### Radiographic Measures

- Condylar height in each gender (right and left)
- The condylar morphology was categorized in the coronal sections based on the classification given by (Yale et al) [12] as convex, round, flat, and angled.
- Condyle dimension anteroposterior (ap), mediolaterally (ml) in both sides' males and females.

### Measurements of Variables

R ap: Anterior-posterior width of condyle measured on the right side, L ap: Anterior-posterior width of condyle measured on the left side, R ml: Medio-lateral width of condyle measured on the right side, and L ml: Medio-lateral width of condyle measured on the left side.

## RESULTS

The mean and standard deviation values were calculated for each group in each test. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests, condyle height and width data showed parametric (normal) distribution, while condyle shape data showed non-parametric (not-normal) distribution.

To improve reliability of intra-and inter-observer agreement, random sample of the radiographs was reassessed after 2 weeks from first assessments in each group by each observer separately, intra- and inter-observer agreement was assessed using Intra-Class Correlation Coefficient (ICC) (is not accepted if Less than 0.73, 0.73 to 0.9 = Good,

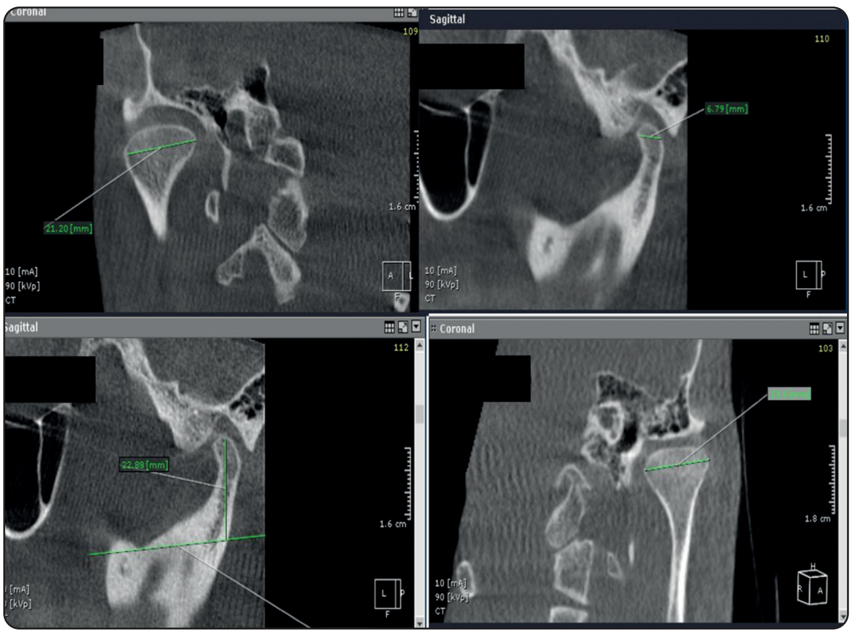


Fig. (2): Corrected coronal view showing measuring of the mediolateral condyle width along the axial plane passing through the condyle, corrected sagittal view showing measuring the antero-posterior condyle dimension, modified sagittal plane for measurement of condylar height and modified coronal plane showed flat shape of the condylar head

More than 0.94 is Excellent). Bland Altman plot (differences-vs-means plot) was used to show the agreement between two quantitative measurements by studying the mean difference and constructing limits of agreement [19].

For parametric data, independent sample t-test was used to compare between groups in non-related samples while for non-parametric data, Mann Whitney test was used to compare between groups in non-related samples

The significance level was set at P ≤ 0.05. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

### Condylar shape

**Right side:** There was no statistically significant difference between (Males) and (Females) groups where ($p$=0.760).

**Left side:** There was no statistically significant difference between (Males) and (Females) groups where ($p$=0.414). Table (1).

### Condyle dimensions

**Height on right side:** There was a statistically significant difference between (Males) and (Females) groups where ($p$<0.001). The highest mean value was found in (Males).

**Height on left side:** There was a statistically significant difference between (Males) and (Females) groups where ($p$<0.001). The highest mean value was found in (Males). Table (2).

**R ml:** There was a statistically significant difference between (Males) and (Females) groups where ($p$<0.001). The highest mean value was found in (Males).

**R ap:** There was no statistically significant difference between (Males) and (Females) groups where ($p$=0.130). The highest mean value was found in (Males). Table (2).

**L ml:** There was a statistically significant difference between (Males) and (Females) groups where ($p$<0.001). The highest mean value was found in (Males).

**L ap:** There was no statistically significant difference between (Males) and (Females) groups where ($p$=0.435). The highest mean value was found in (Males). Table (2)

TABLE (1): The mean, standard deviation (SD) of shape values in right and left groups.

| Variables | | Right | | Left | |
|---|---|---|---|---|---|
| | | Condyle shape | | Condyle shape | |
| | | N | % | N | % |
| Males | Convex | 310 | 77.5% | 310 | 77.5% |
| | Round | 36 | 9% | 28 | 7% |
| | Flat | 44 | 11% | 50 | 12.5% |
| | Angled | 10 | 2.5% | 12 | 3% |
| Females | Convex | 306 | 76.5% | 296 | 74% |
| | Round | 34 | 8.5 | 16 | 4% |
| | Flat | 52 | 13% | 78 | 19.5% |
| | Angled | 8 | 2% | 10 | 2.5% |
| p-value | | 0.760 ns | | 0.414 ns | |

***ns; non-significant (p>0.05)***

TABLE (2): The mean, standard deviation (SD) values of dimensions in right and left groups.

| Variables | Right | | | | | | Left | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Condyle height | | Condyle dimensions | | | | Condyle height | | Condyle dimensions | | | |
| | | | R ml | | R ap | | | | L ml | | L ap | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Males | 23.32 | 1.14 | 22.17 | 1.70 | 9.20 | 0.97 | 22.83 | 2.64 | 22.22 | 1.57 | 9.08 | 0.89 |
| Females | 16.16 | 0.73 | 16.74 | 0.85 | 7.35 | 1.09 | 16.29 | 1.17 | 17.03 | 0.84 | 7.24 | 0.81 |
| p-value | <0.001* | | <0.001* | | 0.130ns | | <0.001* | | <0.001* | | 0.435ns | |

***; significant (p<0.05)***

## DISCUSSION

The present study investigated the morphologic changes between males and females along with the morphologic characteristics in Egyptian population. All variables in this study were measured using CBCT software in sagittal, axial, coronal, and 3D reconstruction perspectives. CBCT provides excellent images of maxillofacial structures while using less radiation dose compared to other techniques. [20] The scanning technique generates multiplanar images of the condyle and surrounding structures, which are then rebuilt in three dimensions to study TMJ anatomy, location, and dynamics. [21,22]

Standardization of interpretation errors was not possible. However, to minimize the effect of this unavoidable error, the interpretation of the images was done by two blinded radiographic assessors. This was followed by inter-assessor consensus to report the agreed-on measures in order to standardize the results as possible.

It is important to mention that disparities between the present study and other studies on morphological variation of the condylar head may occur due to genetic, acquired, functional factors, age groups, and racial differences. Other affecting factors involve sample size and study design. It is also important to denote that condyle's morphology produces an initial environment, which is constantly adjusted throughout life based on the individual's mastication style. [23] Masticatory systems are based on the shape of the condyle; for example, a forceful bite is connected with flat, and angled condyles. [24,25]

In order to obtain equal distribution between the test groups, the subjects included in this study were allocated using block randomization for both age and gender.

The results of the present study have shown that the anteroposterior length of the condylar head was found to be higher in males with a mean of 9.20 mm and 9.08 mm on the right and left side, respectively while in females a mean length of 7.35 mm and 7.24 mm was found on the right and left side, respectively with no statistically significant difference between males and females (*p*=0.435). These findings matched those of Matsumoto & Bolognese's [26] study on the Brazilian population. The study included 30 dry skulls with mandible. They found that males had higher anteroposterior length values of the mandibular condyle than females, with mean lengths of 8.42 mm and 8.25 mm, respectively. Another study by Ishwarkumar et al [27] on a Black KwaZulu-Natal population. The study used 54 dry mandibles from the bone bank, they did not state clearly the male female ratio. However, they stated that males had higher values in ap length of mandibular condyles with mean length of 9.23 mm and 9.57 mm on the right and left sides, respectively, while females' mean length was

8.73 mm and 8.66 mm on the right and left sides, respectively.

Furthermore, due to this study showed also no significant, the ap condylar length had no statistically significant difference between males and females in data gathered by Alam et al [28] in a Saudi Arabia population. The study used 800 CBCT with 405 males and 395 females. The ap condylar length was 9.02 ± 0.96 mm and 8.74 ± 0.86 mm in males and 9.01 ±1.92 mm and 8.69 ± 1.77 mm in females, respectively. The same findings were reported by Chaurasia, & Giri's [18] study on the Indian population. They studied the condylar morphology using CBCT of 150 subjects with males representing 59.3% of the studied population. The study reported that the ap length of the male mandibular condyle is 7.37 mm and 7.32 mm on the right and left side, respectively while in females a mean length of 7.25 mm and 7.19 mm on the right and the left side are recorded respectively

The present study results have shown that the mediolateral width measurements of the mandibular condyle were higher in males with a mean of 22.17 mm and 22.22 mm on the right and left sides respectively, while in females the mean width was 16.74 mm and 17.03 mm on the right and left sides respectively with a significant difference ($p<0.001$). Our results are in line with those of the study by Chaurasia, & Giri [18]. They found that the ml width measurements of the mandibular condyle were higher for males 19.49 and 19.57 on the right and left side, respectively. However, in females, the mean was 17.97and 17.76 for right and left side of the condyle with a significant difference ($p=0.001$).

On the other hand, data collected by Alam et al [28] has shown that the ml condylar width on the right and left sides was 17.40 and 16.95 mm in males and 17.14 and 16.93 mm in females with no statistically significant difference. Also, the study of Ishwarkumar et al [27] reported that the ml width on the right side was found to be 18.10 mm in males and 17.66 mm in females, while on the left side the mediolateral width was recorded 18.11 mm and 17.81 mm in males and females respectively with no statistically significant difference.

Comparing the condylar height with gender, the results of this study revealed that the mean height of the condyle in males is 23.32 mm and 22.83 mm on the right and left side, while in females a mean height is 16.16 mm and 16.29 mm on the right and left side respectively with a statistically significant difference ($p<0.001$). our results agreed with that of Chaurasia, & Giri's [18] stated that the condylar height of males is slightly higher than females with a significant ($p<0.05$) difference in the condylar height between male and female in both right and left side.

In regard to the condylar morphology, the results of this study revealed that in the coronal section the convex morphology was more commonly observed followed by flat in males and females with no statistically significant difference between both groups on the right and left sides. The findings of this study agree with those of Ejima et al [29] who found these rates in CBCT images in European patients are convex in 72 %, flattened in 12 %, round in 11 %, and angled in 1 % in a scanned sample of (77) must be considered. Furthermore, Tassoker et al [30] found that the shape of the mandibular condyles was convex in 42.6 %, flat in 20.8 %, angular in 19.4 %, round in 10.6 %, and concave in 6.5 % in a sample of (108) Turkish patients.

The morphologic variations present between different studies on different populations suggest that each ethnic group might have unique features of condylar head morphology. All variations need to be addressed and accurately defined. This may have a positive impact on diagnosis of different pathological conditions affecting the TMJ.

## CONCLUSION

Condylar morphologies and sizes may be associated with gender in an Egyptian population. The collected data can be used as anthropological markers to assess different races. An accurate visualization of the condylar morphology and size is required to provide an early diagnosis of TMJ dysfunction. The use of CBCT can be a preferred 3D imaging technique for detecting morphological changes on the mandibular bone and allow clinicians to perform an accurate TMJ examination and visualize TMJ abnormalities Further research with larger sample size is recommended to investigate the effect of various factors such as age, tooth loss, and masticatory forces on the condyles in Egyptian populations.

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**Declaration of competing interest**

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