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Research Paper

Age related variations of the mandibular condyle in a sample of Saudi population

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Abstract. This research aimed to assess the structural and morphological variations in shape and size of the condylar head with age and gender in a sample of Saudi population. Radiographic evaluation of the bilateral condylar heads shape and size were measured on CBCT images and statistically analyzed using SPSS 22.0. There was a considerable variation in shape and size of the condyles among males and females with age. The shapes of the condyles varied between convex, round, flat and angled. The most predominant and statistically significant shape in both right and left condyles was convex ($P < 0.05$). Whereas, there was no significant difference according to shape between the right and left condyles among males and females with increased age. Using the student t-test; there was a statistically significant difference in the ML dimensions between the right ($P = 0.006$) and left condyle ($P = 0.040$) between males and females and with increased age ($P = 0.00$) but with no statistically significant difference between the AP dimensions of the right and left condyle with gender and age ($P > 0.05$). The morphology of the mandibular condyle was subject to significant linear age-related changes in shape and size with no significant gender differences. There was an obvious decrease in length and width with age in both genders. Condylar length was significantly greater among males and gradually decreased in size with age.

Keywords: Mandibular condyle, CBCT, shape, size, Anteroposterior (AP), Mediolateral (ML).

INTRODUCTION

The appearance of the mandibular condyle greatly varies among diverse individuals. Morphologic deviations may arise based on simple developmental alterations as well as remodeling of the condyle to accommodate developmental aberrations, malocclusion, trauma, endocrine disorders, radiation therapy and other conditions (Alomar *et al.*, 2007; Standring, 2005).

The condyle is unique because any manifestations of the mandibular development are led by the mandibular condyle (Ross and Johnston, 1994). Different genetic acquired and functional factors may also play a major role in the morphologic outcome of the condyle (Hegde *et al.*, 2013).

Several investigators stated that the mandibular condyle significantly differed in dimensions and form with age, sex, facial type, occlusal force, functional load, and type of occlusion and between the two sides (Hegde *et al.*, 2013; Neto *et al.*, 2010). Condylar size in men was reported to be greater than in women and midline deviations significantly led to an increase in the size of

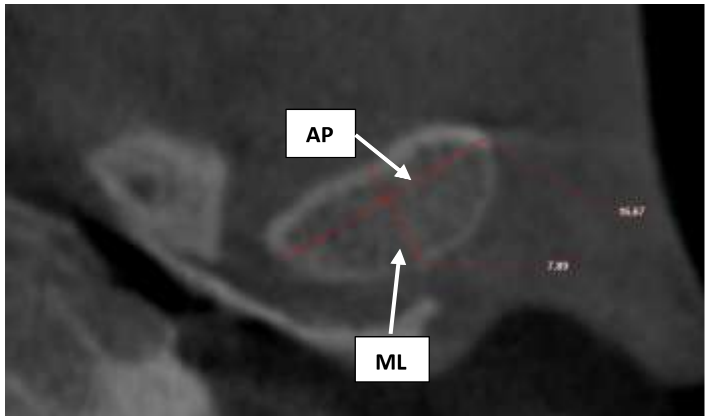

Figure 1. Anteroposterior (AP) and Mediolateral (ML) measurements.

the condylar head during growth on the affected side (Ueda *et al*., 2003).

Mandibular condyle has been widely studied on dry and post-mortem human skulls, histology, panoramic and cephalometric radiographs, magnetic resonance, computed tomography and Cone-Bean Computed Tomography (CBCT) (Neto *et al*., 2010; Yale *et al.*, 1966). Yale *et al.* (1961) were initially the prime investigators to study the different profiles of the mandibular condylar head and according to their observations, they classified them into three categories: concave, convex and flat. However, with further studies, they modified them into four categories namely; convex, flattened, angled and round (Yale *et al*., 1963, 1966).

Variations in the shape and size of the condyles are an imperative factor in identifying temporomandibular joint (TMJ) disorders. Differentiating structural discrepancies of the condylar head hold a diagnostic challenge for the radiologist and surgeons in various circumstances. An in-depth understanding of the structure and morphology of the condylar head is essential for distinguishing a normal condition from an abnormal aberration (Hegde *et al*., 2013).

Objectives

The current research was undertaken to assess the structural and morphological variations in shape and size of the condylar head with age and gender in a sample of Saudi population.

METHODOLOGY

The present investigation is a retrospective study where 253 male and female patients' radiographs were retrieved from the archives of the Oral Maxillofacial Radiology (OMFR) Department from the Dental University Hospital, King Saud University, Saudi Arabia following the approval of the Research Protocol by the IRB & CDRC. Radiographic evaluation of the shape and size of the right and left condylar heads were measured on Cone-Beam Computed Tomography (CBCT). The classification of Yale *et al.* (1966) was followed for the categorization of the morphology of the condylar heads. On CBCT images, the condylar head Anteroposterior (AP) width and Mediolateral (ML) length was measured on axial sections that showed the greatest size for each condylar head separately as shown in Figure 1. Two oral maxillofacial radiologists evaluated the CBCT images. Inter–examiner agreement was analyzed using kappa statistics, and a high degree of agreement (Kappa index: 89.7%) was found between the examiners.

Inclusion and exclusion criteria

- Male and female subjects whose ages were within the range of 18 – 60 years with normal TMJ were only included.
- Patients with history of developmental anomalies and syndromes, temporomandibular joint disorders, endocrinal diseases and facial asymmetry were excluded from the study.

Statistical analysis

The data was collected and analysed using Statistical Package for Social Sciences (SPSS®, Version 22.0; IBM Corp., New York, NY, USA), to calculate the power of sample size estimation performed at the 5% level of significance (α = 0.05) with a power of sample of 0.86. The sample size should not have been less than 250 to 300 radiographs from male and female subjects from the archives.

The collected data were statistically analyzed using descriptive statistics, frequency, percentages. Correlation between age, gender and condylar shape were analyzed

Table 1. Demographic data.

Variables		Frequency	%
Gender	Male	90	35.6
	Female	163	64.4
Age	18 – 40	157	62.1
	41 – 60	96	37. 9

Table 2. Right and left condylar variations according to gender.

Shape	Right Condyle				Left Condyle			
	Male		Female		Male		Female	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Convex	47	52.2	81	49.7	45	50	70	42.9
Round	15	16.7	27	16.6	14	15.6	27	16.6
Flat	13	14.4	32	19.6	11	12.2	28	17.2
Angled	12	13.3	14	8.6	12	13.3	9	5.5

Table 3. Right and left condylar variations according to age.

Shape	Right Condyle				Left Condyle			
	18 - 40		41 - 60		18 - 40		41 - 60	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Convex	82	52.2	46	47.9	69	43.9	46	47.9
Round	31	19.7	11	11.5	28	17.8	13	13.5
Flat	20	12.7	25	26	20	12.7	19	19.8
Angled	16	10.2	10	10.4	17	10.8	4	4.2

using Fisher test and Pearson's chi-square test for categorical variable data. The one-way and two-way analysis of variance (ANOVA) tests were used when comparing between age and gender variations of the condylar heads within and between each of the modalities used. Multivariate logistic regression was also used when needed. The level of statistically significant difference was set at $p \leq 0.05$.

RESULTS

The 253 CBCT images retrieved from the OMFR Department, Dental University Hospital of King Saud University, were classified according to gender and age, where 90 males and 163 females with age range 18 to 60 years were included as shown in Table 1.

There was a considerable variation in shape and size of the condyles among males and females with age (Tables 2 to 5). The shapes of the condyles varied between convex, round, flat and angled as shown in Figures 2a to d.

The most predominant and statistically significant shape in both right and left condyles was convex ($P < 0.05$). Whereas there was no significant difference according to shape between the right and left condyles among males and females ($P = 0.591$; Table 2) and with increased age ($P = 0.061$; Table 3). There seemed to be a gradual variation in shape with increased age where the convex, round and slightly the angled shapes started to decrease in frequency with age whereas the flattened shape seemed to increase with age but with a weak statistically significant difference among genders with age.

Using Pearson's correlation test; there was no strong correlation between the anteroposterior (AP) width of the right and left condyle ($r = +0.0358$; $P = 0.000$), and correspondingly between males and females ($r = +0.414$; $P = 0.000$). The correlation seemed to increase with age but was still not significantly strong ($r = +0.387$; $P = 0.000$).

There was a significantly strong positive correlation in the mediolateral (ML) length between the right and left condyle ($r = 0.889$; $P = 0.000$) and between males and females ($r = 0.918$; $P = 0.000$) and with increasing age ($r = 0.904$; $P = 0.000$).

Using the student t-test; there was a statistically significant difference in the ML dimensions between the

Table 4. Student t-test showing mean and standard deviation of the AP and ML dimensions of the mandibular condyle according to gender.

	Gender	N	Mean ± Std. Deviation	p-value
R_AP	Male	89	7.25 ± 2.416	.683
	Female	157	7.01 ± 2.192	
R_ML	Male	89	15.0274 ± 7.11837	.006*
	Female	157	14.4613 ± 5.58324	
L_AP	Male	82	6.95 ± 1.418	.517
	Female	134	7.17 ± 2.071	
L_ML	Male	82	15.2633 ± 7.25581	.040*
	Female	135	13.6444 ± 5.76198	

***** Statistically significant level P < 0.05 R=Right condyle; L=Left condyle; AP=Anteroposterior; ML=Mediolateral

Table 5. Student t-test showing mean and standard deviation of the AP and MD dimensions of the mandibular condyle according to age.

	Age	N	Mean ± Std. Deviation	p-value
R _AP	18-40	152	7.19 ± 2.422	.511
	41-60	94	6.95 ± 2.014	
R_ML	18-40	152	15.5100 ± 5.32299	.000*
	41-60	94	13.3015 ± 7.16805	
L_AP	18-40	133	7.03 ± 1.560	.078
	41-60	83	7.18 ± 2.246	
L_ML	18-40	133	15.5332 ± 5.47724	.000*
	41-60	84	12.2342 ± 7.21993	

***** Statistically significant level P < 0.05; R = Right condyle; L = Left condyle; AP = Anteroposterior; ML = Mediolateral

right (P = 0.006) and left condyle (P = 0.040), between males and females and with increased age (P = 0.00). While there was no statistically significant difference between the AP dimensions of the right and left condyle with gender and age (P > 0.05) as shown in Tables 4 and 5.

DISCUSSION

Evaluation of the condylar shape and size is one of the most commonly disputed topics to enhance knowledge about craniofacial development. The mandibular condyle appears to respond to functional demands, as its shape is progressively subjected to remodeling from childhood to adulthood, where its final shape and size could be related to age (Saccucci *et al.*, 2012). Consequently, the present research was undertaken to determine age-related variations in the shape and size of the mandibular condyle in a sample of Saudi population.

The recent initiation of 3-D technology including the Cone Beam Computed Tomography (CBCT) engineering has domineered the conventional CT scanners by providing diminished scanning periods of about 10-30 seconds and less exposure to radiation dosages of up to 15 times lesser than those of CT scans scan. They enabled a more comprehensive examination of the temporomandibular joint and mandibular condyle than previous methods (Neto *et al.*, 2010; White, 2008).

Assessments of the Condylar head were formerly carried out with 2-D images, where the axial sections were combined with the sagittal and coronal sections using diverse radiographic procedures for obtaining precise readings (Hussain *et al*., 2008). But the recent 3-D technology has overtaken the need of costly and complex use of different approaches and techniques. It replicates several images on the axial, coronal and sagittal planes, with the option of observing enhanced

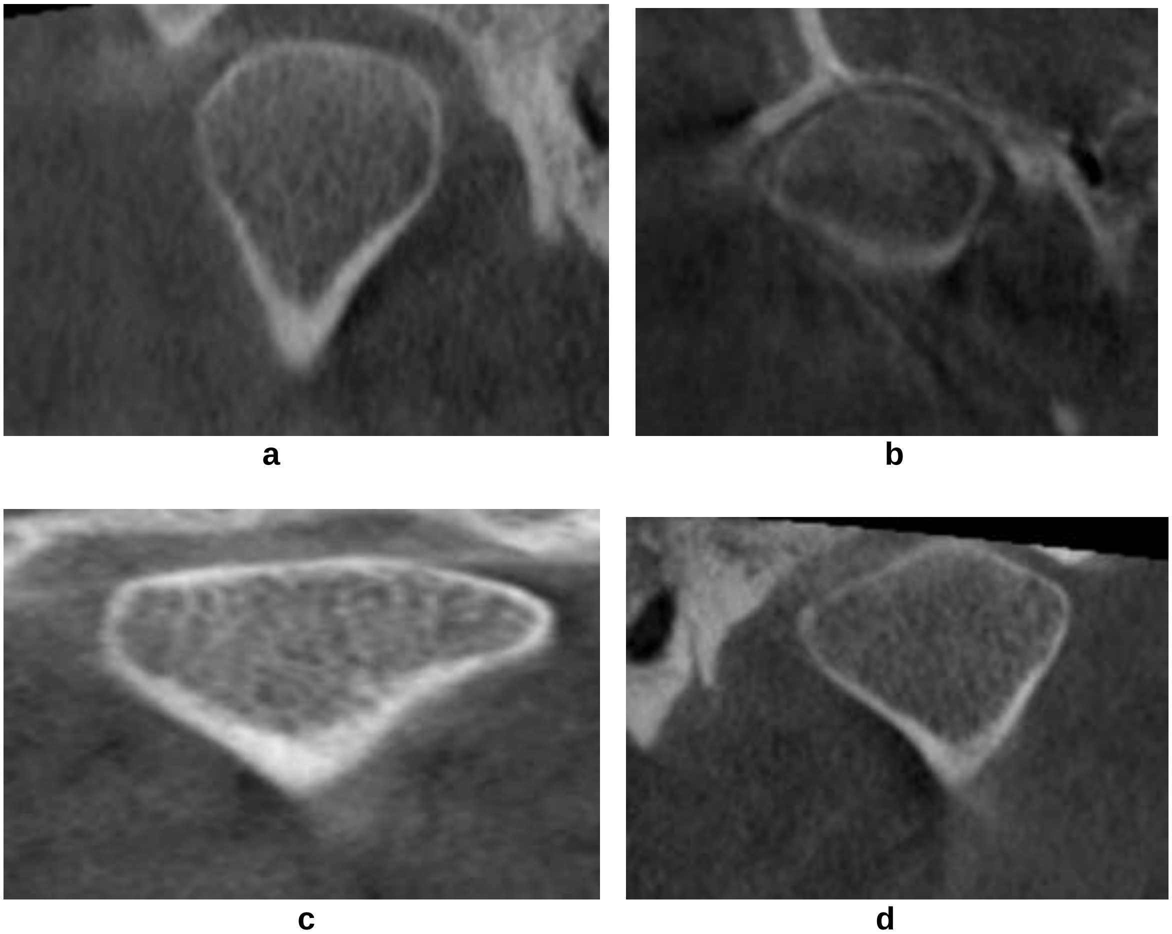

Figure 2. Various shapes of Mandibular Condyles. a. Convex shape; b. Round Shape; c. Flat Shape; d. Angled Shape.

and interactive images. Consequently, they facilitate the consistent and accurate description of the morphology and measurement of the condylar head dimensions thereby simplifying the capability to recognise the precise structure and the occurrence of pathologic changes for subsequent clinical decisions (Borahan *et al.*, 2016; Talaat *et al.*, 2016).

CBCT images being superior over other methodologies for identifying morphology of mandibular condyles, enabled the researchers to identify the condylar shape and more explicitly, to precisely assess and correlate the size of the right and left condylar anteroposterior (AP) and Mediolateral (ML) dimensions in males and females at different age groups (Honey *et al.*, 2007).

The appearance of the right and left mandibular condyles considerably varied both, in shape and size in various individuals with age. The condylar shapes varied from convex to round, flat and angled. The most predominant morphologic shape detected was the convex in both right and left condyles. They were almost equally distributed in males and females followed by the round, flat and angled shapes which were statistically significant ($P < 0.05$), and in contradistinction to that reported by Ueda *et al.* (2003), where they observed that the convex type was predominantly more in women whereas in men the concave type. There seemed to be a gradual decrease in frequency of the convex, round and angled shapes whereas there was a non-significant increase in the flat shape with age comparable to that described by Mathew *et al.* (2011) and Takayama *et al.* (2008). The current findings are in consistency with Hegde *et al.* (2013) who stated that the normal condylar head is most commonly convex in shape and proportion on both sides in the same person. Ross and Johnston (1994) have formerly reported that normal disparity of the condylar shape was found among males and females between the right and left condyles with increased age, confirming our present findings. Previous studies have revealed that condylar shape alterations were chiefly associated with inclined condylar heads (Katsavrias and Halazonetis, 2005).

Variations in the size of the mandibular condyle were evident in the present study among males and females with increasing age. The anteroposterior width exhibited little variations with age that did not display statistically significant differences between the right and left condyle among males and females (P = 0.683; 0.517 respectively), while the mediolateral length variations appeared greater, where a statistically significant difference was observed between the right and left condylar head among males and females (P = 0.006; 0.04 respectively), similar to previous findings (Juniper, 1994; Pullinger and White, 1995). Standring (2005) stated that when the condylar head is viewed from above, it looks unevenly ovoid in shape and measured approximately 15 to 20 mm mediolaterally and 8 to 10 mm anteroposteriorly that is in partial agreement with the present findings as it falls within the aforementioned range.

There was no apparent significant difference between gender and shape and size in regards the AP width but there was a statistically significant difference in MD length among males and females with age in accordance with Al-Koshab *et al.* (2015), as well as with Dalili *et al.* (2012) and Ikeda and Kawamura (2009). Honda *et al*. (2005) had stated that the size of the condyle in males is commonly greater than females, undoubtedly due to the overall architectural variances between males and females in general.

The diverse range of differences in shape and size suggests high variability among subjects. This may result from developmental disparities during condylar growth depending on the remodeling progression by preserving its width while enlarging in length over the years, in accordance with the earlier observations of Mathew *et al.* (2011) and Takayama *et al.* (2008). They mentioned that age is a factor that regulates the remodeling process, but found no direct linear correlation between age and radiographic morphological variations of the condyle, and they added that since the adaptive or degenerative alterations of the condyle take place over an extended period of time, thus it is comprehensible that condylar deviations may increase with advancing age. However, the present findings do not support the research of Crow *et al.* (2005) where their observations of the morphologic changes of the condyle was more prevalent in younger age groups on panoramic radiographs.

In conclusion, the basic morphology of the mandibular condyle is established early in life, and accordingly, modified due to functional load (Neto *et al*., 2010). Minor asymmetries in size and shape between the right and left condyles among males and females are anticipated during the process of normal condylar growth with age. CBCT is verified to be a useful means for the morphological evaluation and measurement of the condylar head.

CONCLUSION

- CBCT proved to be a useful tool to measure and evaluate the condylar morphology.
- The morphology of the mandibular condyle was subject to significant age-related changes in shape and size with no significant gender differences.
- There was a linear relationship between condylar shape with age.
- There was an obvious decrease in length and width with age in both genders.
- Condylar length was significantly greater among males and gradually decreased in size with age.

RECOMMENDATION

Further studies are needed with a larger sample size for the generation of even and repeatable data on the shape and size of the condyle in functionally normal temporomandibular joints that in turn would form the foundation for further investigations in the future where the detected variabilities of the mandibular condyles would be an important factor for diagnosing TMJ disorders.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

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