Research Paper

Relationship Between Sex and the Measures of the Condylar Process of the Mandible in the CT Scan and Dry Bone

Parvindokht Bayat[1*], Amir Rezaie[2], Amin Haji Seid Husieni[2]

1. Department of Anatomy, School of Medicine, Arak University of Medical Sciences, Arak, Iran.
2. Student Research Committee, School of Medicine, Arak University of Medical Sciences, Arak, Iran.

Use your device to scan and read the article online

Citation Bayat P, Rezaie A, Haji Seid Husieni A. Relationship Between Sex and the Measures of the Condylar Process of the Mandible in the CT Scan and Dry Bone. Anatomical Sciences. 2024; 21(2):91-98.

Article info:
Received: 29 Feb 2024
Accepted: 16 Apr 2024
Available Online: 01 Jul 2024

Keywords:
Mandible, Condyle, Computed tomography (CT) scan, Dry bone

ABSTRACT

Introduction: One of the most active joints is the temporomandibular joint (TMJ), constituting the main part of the masticatory apparatus, contributing to essential functions such as mastication, speech, and deglutition. The mandibular condyle, an integral structural element of the TMJ, exhibits morphological adaptations throughout life in response to functional loading. This study aimed to investigate the morphometric characteristics of the mandibular condyle, including variations in size and contour, and assess possible sex-related age differences. To achieve this objective, condylar dimensions were evaluated in a representative sample drawn from the central Iranian population.

Methods: In the present study, morphometric assessments were performed on 70 mandibular specimens derived from 35 dry human skulls. Bilateral condylar dimensions were evaluated, with condylar length (LC) defined as the linear distance between the most anterior and posterior points of the condylar process, and condylar width (WC) determined as the maximum mediolateral distance in the coronal plane. All measurements were performed using digital calipers to ensure precision. Statistical analyses were conducted using SPSS software (version 20.0), with a significance threshold set at $P<0.05$. Descriptive statistics were applied to summarize the morphometric parameters, while an independent samples t-test was used to compare measurements between the right and left condyles. Additionally, Pearson's correlation coefficient and Tukey's post hoc test were employed to assess associations and intergroup variations, respectively.

Results: The mean LC was 17.83±3.08 mm (range: 11.50–23.00 mm), while the mean WC was 6.60±1.65 mm (range: 6.00–13.30 mm). The mean greatest condylar width (GWC) was 7.65±1.63 mm (range: 5.00–13.70 mm). Bilateral comparisons revealed mean LC values of 18.12±3.21 mm on the right side and 17.56±2.98 mm on the left side. Corresponding WC measurements were 6.55±1.12 mm (right) and 6.63±1.99 mm (left), with GWC values of 7.57±1.25 mm (right) and 7.72±1.92 mm (left). LC consistently exceeded WC across measurements. Correlation analysis identified a moderate negative association between age and LC (r=−0.347*) with no significant correlations observed between age and other parameters.

*** Corresponding Author:**
Parvindakht Bayat, PhD.
Address: *Department of Anatomy, School of Medicine, Arak University of Medical Sciences, Arak, Iran.*
Tel: *+98 (86) 3140307*
E-mail: *dr.bayat@Arakmu.ac.ir*

Copyright © 2024 The Author(s);
This is an open access article distributed under the terms of the Creative Commons Attribution License (CC-By-NC: https://creativecommons.org/licenses/by-nc/4.0/legalcode.en), which permits use, distribution, and reproduction in any medium, provided the original work is properly cited and is not used for commercial purposes.

A strong positive correlation was observed between the GWC and WC (r=0.845**). The predominant condylar morphologies were flat and convex shapes, each comprising 27% of cases.

Conclusion: Radiologically, TMJ evaluation is difficult due to the anatomical position. Research findings on TMJ disorders remain inconsistent, largely because of the multifactorial etiology of these conditions and methodological differences among studies. Variability in results may also stem from investigations focusing exclusively on single etiological factors or isolated clinical manifestations.

Introduction

The temporomandibular joint (TMJ) is among the most dynamic articulations and constitutes a key element of the masticatory system, facilitating essential functions, such as mastication, speech, and deglutition. Anatomically, the TMJ comprises the condylar process, glenoid fossa, articular disc - interposed between these two structures- and the articular eminence or tubercle [1]. The mandibular condyle serves as the pivotal center for rotational movements of the mandible within the craniofacial complex. It represents the most critical anatomical component of the mandible, playing a fundamental role in mandibular growth and development along both the vertical and sagittal planes [2]. In forensic investigations, the identification of human skeletal remains represents a fundamental initial procedure and serves as a foundation for subsequent analytical processes [3]. The mandible, characterized by a dense layer of compact bone, demonstrates greater durability and preservation than many other craniofacial bones. Sexual dimorphism in the mandible is notably expressed through variations in its shape and dimensional characteristics [3]. Consequently, the mandible is frequently used for sex determination in forensic science and anthropology. As a structural component of the TMJ, the mandibular condyle may exhibit morphological alterations over the course of life as an adaptive response to functional loading. Such morphological variations can result from a range of pathological or developmental conditions, including infections, trauma, neoplastic processes, condylar hyperplasia, and ankylosis [4]. This study aimed to assess the morphometric characteristics of the mandibular condyle, including variations in size, shape, and potential age- and sex-related differences in Iran. In this regard, condylar dimensions were measured in a representative sample from Arak City, Iran, marking the first investigation of its kind in this region. The obtained parameters were compared with the findings of previous studies, and various morphological types of condylar shapes were identified and classified.

Materials and Methods

Morphometric measurements were obtained using a digital caliper with an accuracy of 0.01 mm (Mitutoyo 0–6 inch, model 500-321; Mitutoyo America Corp., Aurora, IL, USA). All anatomical assessments were conducted in the Anatomy Mollag Hall of Arak University of Medical Sciences (Iran). To minimize measurement bias, a single investigator performed all measurements using the same instrument. Each parameter was measured twice, and the mean value was recorded for analysis. Specimens exhibiting morphological alterations in the coracoid process resulting from surgical intervention or shoulder trauma were excluded from the study. The specific measurements illustrated in Figure 1 were subsequently analyzed.

Bilateral condylar measurements were performed to evaluate condylar size and morphology. The assessment method was based on identifying anatomical landmarks and measuring linear distances between specific reference points. Condylar length (LC) was defined as the distance between the most anterior and posterior points of the condylar process, measured approximately 4 mm inferior to the highest point of the condyle. Condylar width (WC) was determined as the mediolateral distance between the innermost and outermost points of the condyle at the same 4 mm level. All measurements, including length, width, and maximal transverse dimension, were obtained by a single investigator using digital calipers to ensure accuracy and consistency (Figure 1).

Statistical analyses were performed using SPSS software, version 20.0 (IBM Corp., Armonk, NY, USA), with statistical significance set at $P<0.05$. Descriptive statistics were calculated for all parameters, while paired t-tests were employed to compare right and left condyles. Independent-samples t-tests were used to assess sex-based differences. Pearson's correlation coefficient and Tukey's post hoc tests were also applied where appropriate. The study protocol was approved by the Ethics Committee of Arak University of Medical Sciences.

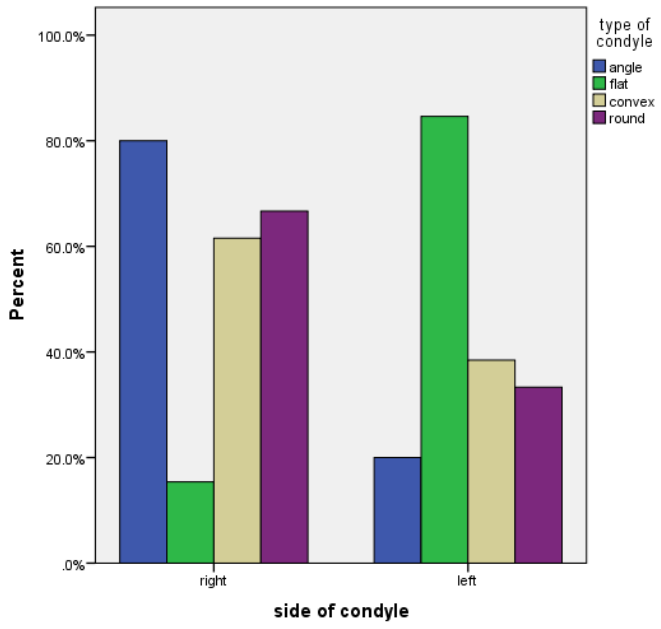


Figure 1. Types of mandibular condyle shape on the right and left sides

ANATOMICAL SCIENCES

Results

Of the 70 dry mandibles in the Mollags Museum of Arak Medical School, 47.1% were on the right side, and the rest were on the left side. The sample was 55.7% male, and the rest were female.

Table 1 presents descriptive statistics results (minimum, maximum, and Mean±SD).

Table 2 presents the mean, minimum, and maximum values of all measurements obtained from the mandibular condyle separately on the right and left, and the comparison of means for the right and left. As shown in Table 2, the mean length and the maximum width of the condyle were greater on the right side, and the mean width was greater on the left side. Also, comparison of means in right and left condylar parameters in Table 2 showed no statistically significant difference between them.

Table 3 presents mean, minimum, and maximum values obtained from mandibular condyles (MC) by gender. The mean length and width of the condyle were greater in males, and the mean maximum width was greater in females. Table 4 presents the relationship between gender and the size of mandibular condyle parameters. As shown in Table 5, a relationship was observed between age and CL (-0.347), and no correlation was found between age and other parameters; however, a significant relationship was observed between the greatest condylar width (GWC) and the WC (0.845) (Table 4).

Table 5 presents the types of mandibular condylar shapes. As shown in the table, the highest value was for the flat and convex type (38.2%), the lowest was for the round type (8.8%), and the highest was for the angle type (23.52%) of the condylar process.

Only in 8 skulls were the shapes of the right and left condyles similar (23.5%), and in the other skulls, they were different on both sides.

Table 1. Mean and mn/max values of mandibular parameters

Parameters	No.	Minimum (mm)	Maximum (mm)	Mean±SD (mm)
LC	66	11.50	23.00	17.83±3.08
WC	64	2.00	13.30	6.60±1.65
GWC	64	5.00	13.70	7.65±1.63

Abbreviations: LC: Condyle length; WC: Condyle width; GWC: Greatest condyle width.

ANATOMICAL SCIENCES

Table 2. Mean and min/max values of all measurements obtained from the mandibular condyle, and comparison of means between the right and left

Parameters	No.	Minimum	Maximum	Mean±SD	P
Right length condyle	32	12.00	23.00	18.12±3.21	0.065
Left length condyle	35	11.50	23.00	17.56±2.98	
Right width condyle	31	4.10	9.10	6.55±1.22	0.959
Left width condyle	34	2.00	13.30	6.63±1.99	
Right greatest width condyle	31	5.30	9.80	7.57±1.25	0.484
Left greatest width condyle	34	5.00	13.70	7.72±1.92	

ANATOMICAL SCIENCES

Note: LC=18.12±3.21 on the right side, 17.56±2.981 on the left side, and WC=6.55±1.12 on the right side, and 6.63±1.99 on the left side, and GWC=7.57±1.25 on the right side and 7.72±1.92 on the left side.

As shown in Figure 1, the highest value is for the flat type, and the lowest is for the angle type on the left and right sides. The highest value was for the angle type, and the lowest was for the flat type.

Discussion

This study aimed to investigate the size and shape of the mandibular condyle and analyze age-related variations and sex-related differences. The mandibular condyle is recognized as one of the principal sites of facial growth, with growth expressed predominantly in the upward and backward directions [5]. Condylar morphology exhibits substantial interindividual variability across different age groups and sexes. Normal variation in condylar form is influenced by multiple factors, as well as asymmetry between the right and left sides [6]. Consequently, condylar anatomy contributes significantly to individual differences in mandibular configuration and overall facial shape. Under physiological conditions, additional determinants of condylar shape include craniofacial pattern, magnitude and direction of masticatory forces, and the distribution of functional load. Minor discrepancies reported in previous studies may also reflect limitations in sample size or sampling balance [7]. When viewed from a superior aspect, the condyle is generally described as oval, and it is commonly assumed that a typical condylar head presents a predominantly convex articular contour with approximate symmetry between the two sides in the same individual. Numerous investigations assessing human condylar morphology have demonstrated that the shape of the mandibular condyle undergoes remodeling and alteration with advancing age, reflecting adaptive and degenerative changes over the lifespan [8]. Overall, the mandibular condyle is characterized by a rounded osseous projection with an upper biconvex oval articular surface.

Condylar growth is influenced not only by intrinsic genetic determinants but also by extrinsic functional and environmental factors. In the present study, the mean LC was 17.83±3.08 mm, the mean WC was 6.60±1.65 mm, and the mean GWC was 7.65±1.63 mm. Gindha et al. [9] reported that the mediolateral (mesiodistal) dimension of the mandibular condyle typically ranges from 15 mm to 20 mm, whereas the anteroposterior dimension ranges

Table 3. Mean and min/max values obtained from mandibular condyles by gender

Variables	Gender	No.	Mean±SD	Std. Error Mean
LC	1	37	18.31±3.12	0.52
	2	30	17.22±2.97	0.55
WC	1	35	6.60±1.45	0.24
	2	30	6.58±1.89	0.35
GWC	1	35	7.63±1.58	0.27
	2	30	7.66±1.70	0.31

Abbreviations: LC: Condyle length; WC: Condyle width; GWC: Greatest condyle width.

ANATOMICAL SCIENCES

Table 4. Relationship between gender and size of mandibular condyle

Variables	Sex	Length Condyle	Width Condyle	Greatest Width Condyle
Sex				
Length condyle	-0.347*			
Width condyle				0.845**
Greatest width condyle			0.845**	

*P<0.05; **P<0.01.

ANATOMICAL SCIENCES

from 8 mm to 10 mm, with the medial pole generally more prominent than the lateral pole. The mean values obtained in the current study are broadly comparable to those of the classical reference dimensions. However, the observed range of condylar sizes was wider in our sample, suggesting greater interindividual variation in this population.

In this study, the mean LC on the right side was 18.12±3.21 mm and 17.56±2.98 mm on the left side, whereas the mean WC measured 6.55±1.12 mm on the right and 6.63±1.99 mm on the left. The mean GWC was 7.57±1.25 mm on the right and 7.72±1.92 mm on the left (Tables 1 and 2). In comparison, mean LC was slightly greater on the right side, while mean width and greatest width were marginally greater on the left side; however, these side-specific differences were not statistically significant.

We also analyzed the influence of sex on condylar dimensions and compared measurements between males and females (Tables 3, 4 and 5). A correlation between LC and sex (r=−0.347) indicated that males tended to have larger LC and WC values than females, whereas GWC was approximately similar in both sexes; nonetheless, these sex-related differences did not reach statistical significance in our sample. Previous anthropometric studies, such as those by Giles [10], have reported that mandibular ramus height and breadth are highly dimorphic parameters and can achieve sex classification accuracies of approximately 85% in different populations of American Whites and Negroes [11], highlighting the forensic relevance of mandibular metrics.

The mandibular condyle exhibits pronounced sexual dimorphism that holds significant value in forensic identification from skeletal remains. Eun-Young et al. [12] analyzed condylar dimensions in patients across skeletal malocclusion classes I, II, and III and reported no significant sex-related differences in height, width, length, volume, or surface area of either the left or right condyles; however, subgroup analysis within Class I malocclusion revealed statistically significant sex differences across all measured parameters (P<0.05).

Sex determination from human skeletal remains represents a cornerstone of forensic medicine and biological anthropology, particularly in criminal investigations, identification of missing persons, and reconstruction of historical populations. When only fragmented mandibles or dentition are available, mandibular morphometrics become especially valuable. Pioneering studies by Morant and Adyanthaya [13], Martin and Oliver [14], and Paulinus et al. [15] established the mandible's utility for sex estimation, identifying ramus height as the most sexually dimorphic feature—surpassing differences observed in the mandibular body. Saini et al. [16] confirmed robust sexual dimorphism in the mandibular ramus of dry adult

Table 5. Types of condylar shapes of the mandibular

Type of Condyle		No. (%)
Valid	Angle	10(14.7)
	Flat	27(38.2)
	Convex	27(38.2)
	Round	6(8.8)
	Total	70(100.0)

North Indian mandibles. Complementing these findings, Giles [10] employed anthropometric analysis of known-sex mandibles and identified ramus height, maximum ramus breadth, and minimum ramus breadth as highly discriminatory metrics, achieving 85% classification accuracy across American White and Black populations.

The mandible is frequently recovered intact in skeletal remains and exhibits pronounced univariate sexual dimorphism, particularly in minimum ramus breadth, condylar height, and projective ramus height. Condylar morphology in this study was classified according to established criteria in both sagittal and coronal planes. We recommend that sex identification based on qualitative morphological features remains subjective and prone to error, whereas quantitative morphometric approaches provide greater accuracy and reliability for sex estimation from cranial remains [17]. The condylar process assumes an irregular cylindrical configuration owing to the inherent inclination of the mandibular neck. Its articular surface faces superomedially and anteriorly, accommodating variable joint dynamics. Bilateral mandibular movements are coordinated through these synovial articulations, resulting in adaptive remodeling of both the condyle and articular eminence, as documented by Alexiou et al. [18].

Research investigating temporomandibular disorders continues to yield heterogeneous findings attributable to the multifactorial etiology of these conditions, including biomechanical, psychosocial, and biological influences, or to methodological limitations, such as the exclusive focus on isolated etiological factors or singular clinical manifestations [19]. TMJ poses inherent challenges for radiographic assessment due to its intricate anatomy and superimposition of osseous structures; consequently, further studies are warranted to achieve more definitive insights. In the present investigation, condylar morphology was systematically classified into four distinct categories: Flat (38.2%), convex (38.2%), angled (14.7%), and round (8.8%).

Yale et al. [20] examined 3,008 mandibular condyles (MC) in coronal sections from 1,560 skulls, reporting prevalence rates of convex (58.3%), flat (25.2%), angled (11.6%), and round (3.0%) shapes. Although the overall distribution in our study diverges from Shyale et al.'s findings—with flat and convex forms predominating rather than convex alone—the angular category frequencies were comparatively similar (14.7% vs 11.6%). Such discrepancies may reflect population-specific racial or nutritional variations between the cohorts. Rajasekhara et al. [21] identified the round shape as most prevalent (71.9%) in sagittal cone-beam computed tomography images from 32 Indian subjects; by contrast, this morphology comprised only 8.8% in our Iranian sample, potentially attributable to ethnic differences, smaller sample sizes, or variations in imaging planes and study protocols.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

Authors' contributions

All authors contributed equally to the conception and design of the study, data collection and analysis, interpretation of the results, and drafting of the manuscript. Each author approved the final version of the manuscript for submission.

Conflict of interest

The authors declared no conflict of interest.

References

[1] Shear M, Speight PM.Cysts of the oral and maxillofacial regions UK: Blackwell price; 2007. [Link]

[2] Yavan M A , Isman E , Kocahan S. Evaluation of condylar structures on panoramic radiographs in adolescent patients with coeliac disease. Folia Morphologica. 2019; 78(1):191-4. [DOI:10.5603/FM.a2018.0051] [PMID]

[3] Kharoshah MA, Almadani O, Ghaleb SS, Zaki MK, Fattah YA. Sexual dimorphism of the mandible in a modern Egyptian population. Journal of Forensic and Legal Medicine. 2010; 17(4):213-5. [DOI:10.1016/j.jflm.2010.02.005] [PMID]

[4] Anisuzzaman MM, Khan SR, Khan MTI, Abdullah MK, Afrin A. Evaluation of Mandibular Condylar Morphology By Orthopantomogram In Bangladeshi Population. Update Dental College Journal. 2019; 9(1):29-31 [DOI:10.3329/updcj.v9i1.41203]

[5] Pramanik F, Firman RN, Sam B. Differences of temporomandibular joint condyle morphology with and without clicking using digital panoramic radiograph. Padjadjaran Journal of Dentistry. 2016; 28(3):159-64. [Link]

[6] Abdi AH, Kasaei S, Mehdizadeh M. Automatic segmentation of mandible in panoramic x-ray. Journal of Medical Imaging. 2015; 2(4):044003. [DOI:10.1117/1.JMI.2.4.044003] [PMID]

[7] Ferreira L, da Silva NK, Panelli C, Santos B, Luiz C, Junqueira J, et al. Prevalence of soft tissue calcifications in cone beam computed tomography images of the mandible. Revista Odonto Ciência. 2011; 26(4):297-303. [DOI:10.1590/S1980-65232011000400004]

[8] Chole RH, Patil RN, Balsaraf Chole S, Gondivkar S, Gadbail AR, Yuwanati MB. Association of Mandible Anatomy with Age, Gender, and Dental Status: A Radiographic Study. December 2013. ISRN Radiology. 2013; 2013:453763. [DOI:10.5402/2013/453763] [PMID]

[9] Gindha GS, Singh TP, Sood KS, Maharana SS. Amorphometric study of condyloid process of dry human mandible for sexing from its shape. MedCrave Online Journal of Anatomy & Physiology. 2017; 3(2):58–62. [DOI:10.15406/mojap.2017.03.00087]

[10] Giles E. Sex determination by discriminant function analysis of the mandible. American Journal of Physical Anthropology. 1964; 22(2):129-35. [DOI:10.1002/ajpa.1330220212] [PMID]

[11] Indira AP, Markande A, David MP. An indicator for sex determination - A digital radiographic study. American Whites and Negroes. 2012 ·Journal of Forensic Dental Sciences. 2012; 4(2):58-62. [DOI:10.4103/0975-1475.109885] [PMID]

[12] Eun-Young JE, Ro JA, Sang-Min LE, Jong-Tae PA. Tae PARK. Condylar size in malocclusion skeletal patterns: measurements of three dimensional models. Iranian Journal of Public Health. 2020; 49(3):595-7. [DOI:10.18502/ijph.v49i3.3159]

[13] Morant GM, Adyanthaya NK. A biometric study of the human mandible. Biometrika. 1936; 28(1-2):84–122. [DOI:10.1093/biomet/28.1-2.84]

[14] Martin T, Oliver WM. Mandible and dentition of Asfaltomylos patagonicus (Australosphenida, Mammalia) and the evolution of tribosphenic teeth. Journal of Vertebrate Paleontology. 2005; 25(2):414-25. [DOI:10.1671/0272-4634(2005)025[0414:MADOAP]2.0.CO;2]

[15] Paulinus SO, Mba EE, Ukpong EV, Archibong BE, Udoh BE, Egom AE, et al. Anthropometric study of the cranial parameters using computed tomography (CT) scan to establish cephalic index of a sampled population in Calabar, Nigeria. Global Journal of Pure and Applied Sciences. 2019; 25(2):153–9. [DOI:10.4314/gjpas.v25i2.4]

[16] Saini V, Srivastava R, Rai RK, Shamal SN, Singh TB, Tripathi SK. Mandibular ramus: an indicator for sex in fragmentary mandible. Journal of Forensic Sciences. 2011; 56(Suppl 1):S13–6. [DOI:10.1111/j.1556-4029.2010.01599.x]

[17] Osmani SR. The Demands of Inclusive Growth: Lessons from South Asia (The Mahbub Ul Haq Memorial Lecture). The Pakistan Development Review. 2008; 47(4):381-402. [DOI:10.30541/v47i4Ipp.381-402]

[18] Alexiou K, Stamatakis H, Tsiklakis K. Evaluation of the severity of temporomandibular joint osteoarthritic changes related to age using cone beam computed tomography. Dento Maxillo Facial Radiology. 2009; 38(3):141-7. [DOI:10.1259/dmfr/59263880] [PMID]

[19] Cortese A, Borri , Bergaminelli M. Bergaminelli F, Claudio PP. Condylar Neck and Sub-Condylar Fractures: Surgical Consideration and Evolution of the Technique with Short Follow-Up on Five Cases. Dentistry Journal. 2020; 8(4):125. [DOI:10.3390/dj8040125] [PMID]

[20] Yale SH, Ceballos M, Kresnoff CS, Hauptfuehrer JD. Some observations on the classification of mandibular condyle types. Oral Surgery, Oral Medicine, and Oral Pathology. 1963; 16:572-7. [DOI:10.1016/0030-4220(63)90146-4] [PMID]

[21] Rajasekhara S , Sharath S, Chandra,M, Parthasarathy LB. Cone beam computed tomography evaluation and endodontic management of permanent mandibular second molar with four roots: A rare case report and literature review. Journal of Conservative Dentistry . 2014; 17(4):385-8. [DOI:10.4103/0972-0707.136518] [PMID]

This Page Intentionally Left Blank