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Research Article

Evaluation of different types of mandibular condyle morphology in panoramic radiographs

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Abstract

Aim: We conducted this study to assess the morphology and symmetry of the mandibular condyle and to examine their associations with age, sex, and dental status—classified according to Eichner's system—using panoramic radiographic imaging.

Materials and Methods: In this cross-sectional study, 527 panoramic radiographs (1,054 condyles) were collected from individuals aged 19–58 years who were referred for routine evaluation. Two examiners—an oral and maxillofacial radiologist and a trained dental student—independently assessed all images. Condylar morphology was classified into four types: oval, diamond, bird beak, and crooked finger. The associations between condylar morphology and symmetry and participants' sex, age, and dental status, as defined by Eichner's classification, were analyzed using the chi-square test and analysis of variance (ANOVA).

Results: Of the 1,054 condyles examined, the oval type was the most prevalent morphology (58%), while the bird-beak type was the least common (13%). Regarding dental status according to Eichner's index, types A1 (47.0%) and A2 (30.7%) were more frequently observed in females than in males, who demonstrated proportions of 39.0% and 29.2%, respectively (p=0.047). Across all Eichner classes, the oval morphology remained the most common condylar form. No significant association was observed between Eichner classification and the morphology of either the right (p=0.191) or left (p=0.334) condyle. However, a significant relationship was found between mean age and Eichner classification (p=0.001).

Conclusion: Oval morphology and symmetrical presentation were the most prevalent condylar features among patients referred to the Department of Oral and Maxillofacial Radiology at Qazvin Faculty of Dentistry. According to Eichner's classification, type A1 was the most frequently observed dental status.

Keywords

panoramic radiography, temporomandibular joint, mandibular condyle

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Introduction

The temporomandibular joint (TMJ) is one of the most mobile joints of the skull and is of particular importance due to its complex structure and function.[1] As a principal component of the masticatory system, it contributes not only to mastication but also to swallowing and speech.[2] The mandibular condyle, a key structural element of the TMJ, may undergo morphological changes resulting from functional loading, aging, trauma, and various pathological conditions, including tumors and condylar hyperplasia.[3] Another factor that may influence condylar morphology is the number of tooth-supporting areas—classified according to Eichner's system based on occlusal contacts in the premolar and molar regions—which can affect condylar form.[4] Histological and morphological alterations of the condyle may disrupt facial symmetry—an important determinant of facial esthetics[5]— and contribute to joint dysfunction, leading to restricted mouth opening or joint sounds during mandibular movement.[3,6,7] The mandibular condyle demonstrates substantial variation in shape, size, and morphology[8], and these characteristics may differ among populations with distinct genetic backgrounds.[9] Additionally, condylar position may be influenced by temporomandibular disorders.[10] Therefore, accurate identification of normal condylar morphology and differentiation from pathological changes and TMJ abnormalities are essential.

Temporomandibular disorders (TMDs) represent a significant source of chronic pain in the oral, facial, cervical, and auricular regions and may also be associated with hearing impairment. Beyond functional disturbances, TMDs can adversely affect mental health and overall quality of life.[11-13] TMDs are the third most common group of conditions affecting the oral and maxillofacial area, following dental caries and periodontal diseases.[14] They predominantly affect individuals between 20 and 40 years of age and are more prevalent in women than in men.[15]

Clinical examinations, including palpation and auscultation, are fundamental for diagnosing temporomandibular disorders (TMDs). However, these assessments alone may not always yield a definitive diagnosis, thus necessitating the use of imaging modalities.[16,17] Among the available imaging techniques, panoramic radiography (PR) and cone-beam computed tomography (CBCT) are frequently utilized by dentists for temporomandibular joint (TMJ) evaluation.[18] PR offers advantages over CBCT in terms of accessibility, cost-effectiveness, and significantly lower effective radiation exposure to the patient. Nevertheless, PR has inherent limitations, including its two-dimensional representation and inconsistent magnification. Despite these drawbacks, condylar morphology is clearly visualized on panoramic radiographs, allowing for reliable differentiation between normal anatomical features and pathological condylar changes.[3,19-21] While PR is routinely employed to assess dental and skeletal status, limited attention has been dedicated to variations in mandibular condyle morphology on panoramic images[21], which can complicate the distinction between normal and pathological forms. This limitation may incur additional costs for patients and healthcare systems and could lead to unnecessary treatments.

Aim

Consequently, this study aimed to evaluate the morphological characteristics of the mandibular condyle on panoramic radiographs in relation to sex, age, and Eichner's index.

Materials and methods

This descriptive-analytical retrospective cross-sectional study received approval from the Ethics Committee of Qazvin University of Medical Sciences, Qazvin, Iran (ethics code: IR.QUMS.REC.1400.16). Based on a previously published study[1] reporting a 55% prevalence of a specific condylar morphology and setting a type I error at 0.05 (Z=1.96), the minimum sample size required to achieve the study's primary objective was calculated as n=380 using Cochran's formula for sample size calculation.[2]

Accordingly, a total of 527 individuals (332 women and 195 men) referred to the Department of Oral and Maxillofacial Radiology at the Faculty of Dentistry, Qazvin University of Medical Sciences, were enrolled in the study based on the predefined eligibility criteria.

Inclusion criteria were: absence of systemic or local diseases impacting bone quality/morphology; no history of TMJ pain or trauma, confirmed via medical record review; no radiographic evidence of condylar pathological lesions; dental status categorized as A1 to B2 according to Eichner's classification; and the presence of bilaterally visible condyles on panoramic radiographs with adequate contrast and image quality, free from radiographic technique errors that could obscure visualization of the mandibular condyle. Cases classified under Eichner class C were excluded due to the complete absence of posterior support and its known association with secondary condylar morphological alterations.

Routine standard panoramic radiography, previously prescribed for diagnostic purposes, was utilized in this study. All radiographs were acquired by a dentist, ensuring no additional radiation exposure to patients. The images were taken using a dental X-ray system (RAYSCAN α-SC; Ray Co., Ltd., Hwaseong-si, Korea) with standard exposure parameters (72 kV, 10 mA), adhering to the "as low as reasonably achievable" (ALARA) principle. A trained technician ensured proper patient positioning according to standard operating procedures.

Stored panoramic images were categorized by patient age and sex. Evaluation was performed independently by an oral and maxillofacial radiologist and a trained dental student. Disagreements were resolved through review by a third specialist in maxillofacial radiology to reach a consensus. The inter-observer agreement was found to be 97.3%, with a kappa coefficient of 0.92, signifying excellent reliability. Also,

the intra-class correlation coefficient (ICC) was estimated to be equal to 0.96, indicating intra-observer reliability.

Demographic variables, including age and sex, along with anatomical parameters such as condylar morphology and dental status (categorized according to Eichner's classification), were systematically recorded using predesigned data collection forms. All participant personal information was maintained under strict confidentiality, with only anonymized research findings reported and submitted to Qazvin University of Medical Sciences. Mandibular condyle morphology was classified into four types—oval (A), bird beak (B), diamond (C), and crooked finger (D)—following the classification system proposed by Chaudhary et al. **(Fig. 1)**.

A schematic illustration of mandibular condyle morphology according to Eichner's classification is presented in **Fig. 2**.[22]

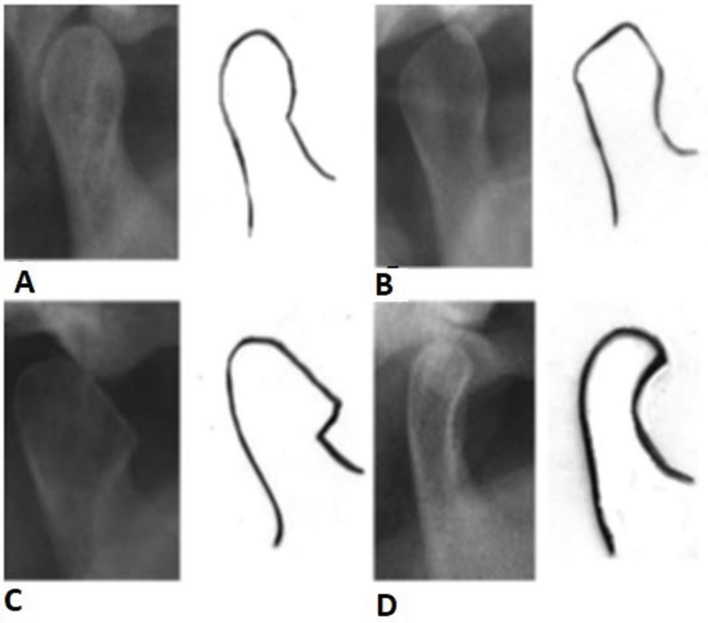

Figure 1. Different shapes of the mandibular condyle: **A**. Oval **B**. Bird beak **C**. Diamond **D**. Crooked finger

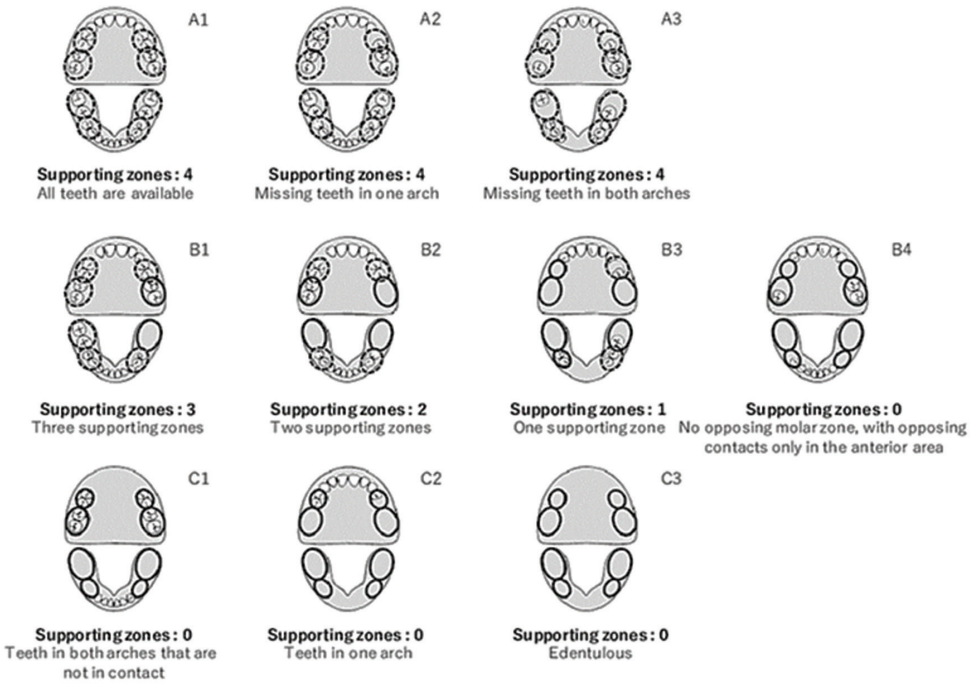

Figure 2. Categories of Eichner's classification: **A1**, complete dentition in both arches; **A2**, missing teeth in one arch; **A3**, missing teeth in both arches; **B1**, three supporting zones; **B2**, two supporting zones; **B3**, one supporting zone; **B4**, absence of opposing molar zones with contacts present only in the anterior region; **C1**, teeth present in both arches without occlusal contact; **C2**, teeth present in only one arch; **C3**, completely edentulous.

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Data analysis

Subsequent to data collection, statistical analyses were conducted utilizing SPSS software, version 25 (IBM Corp., Armonk, NY, USA). Quantitative variables were characterized by their mean and standard deviation, while categorical variables were reported as frequencies and percentages. The relationships between condylar morphology and symmetry and demographic variables (sex and age) were assessed via the chi-square test and one-way analysis of variance (ANOVA). A significance level of $p<0.05$ was established for all statistical tests. Prior to inferential analysis, the normality of quantitative variables was evaluated using Q-Q plots and histograms, and the homogeneity of variances was confirmed with the Levene's test.

Results

In this study, radiographic images from 527 patients (1,054 condyles) were evaluated, including 332 women (63%) and 195 men (37%). The participants' ages ranged from 19 to 58 years, with a mean age of 30.65±6.94 years.

Various types of mandibular condyle morphology

Fig. 3 displays the frequency distribution of various types of condyle morphology.

Various types of mandibular condyle morphology by sex

The study's findings revealed that the predominant condylar morphology, bilaterally, was type 1 (oval), evident in 610 out of 1,054 evaluated condyles (57.8%). This oval morphology was most frequently observed in women and on the left side (54.5%), with subsequent prevalence attributed to the crooked finger, bird-beak, and diamond types, in descending order. On the right side, the oval shape continued to be the most common morphology (57.2%), followed by the bird-beak, crooked finger, and diamond types.

In the male cohort, oval condylar morphology was the predominant type observed bilaterally, accounting for 60.0% on the left side and 62.6% on the right side. On the left side, the diamond type was the second most frequent morphology, while the bird-beak and crooked finger types were the least prevalent, each occurring with a frequency of 8.7%. For the right side, subsequent to the oval morphology, the diamond, bird-beak, and crooked finger types were ranked in descending order of frequency **(Table 1)**.

Among the 527 panoramic radiographs evaluated, condylar morphology was symmetrical in 393 cases (74.6%) and asymmetrical in 135 cases (25.4%). By sex, the condyles exhibited symmetrical morphology in 28.8% of men and 45.8% of women. Also, asymmetrical morphology was observed in 8.1% of men and 17.3% of women. However, based on the results of the chi-square test, the difference between the two groups was not statistically significant ($p=0.550$).

Among the symmetrical condyles, the oval morphology was the most prevalent, observed in 250 out of 527 instances. This was followed by the diamond type (n=54), the crooked finger type (n=52), and the bird-beak type (n=37). The study identified a statistically significant association ($p<0.001$) between condylar morphological type and sex, consistent across both the right and left sides.

Dental status based on Eichner's index and sex

According to Eichner's classification, the most prevalent dental status was type A1, accounting for 44% of cases, followed by type A2 (30.2%), type A3 (15.9%), type B1 (6.8%),

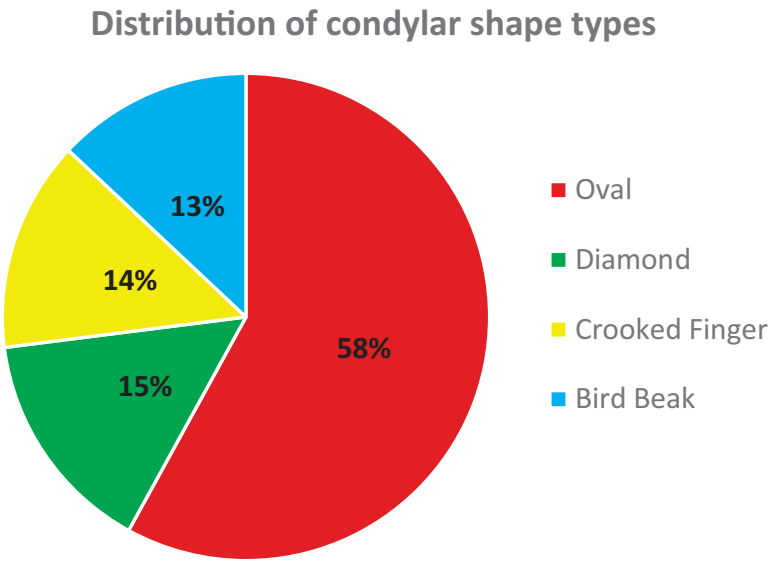

Figure 3. The frequency distribution of various types of condyle morphology.

Table 1. Different types of mandibular condyle morphology based on sex

			Morphology				*P*-value*
			Oval	Bird beak	Diamond	Crooked finger	
Left	Female	N (%)	181 (54.5)	47 (14.2)	44 (13.3)	60 (18.1)	0.001
	Male	N (%)	117 (60.0)	17 (8.7)	44 (22.6)	17 (8.7)	
Right	Female	N (%)	190 (57.2)	57 (17.2)	30 (9.0)	55 (16.6)	< 0.001
	Male	N (%)	122 (62.6)	17 (8.7)	40 (20.5)	16 (8.2)	

* By chi-square test. Data is presented as numbers (percentages).

and type B2 (3.0%). **Table 2** provides a detailed breakdown of these dental status categories stratified by sex. Both sexes exhibited type A1 as the most frequent category, observed in 47% of women and 39% of men. Women presented with the highest number of occlusal contacts in types A1 and A2 and also showed a higher prevalence of type B1 compared to men. Conversely, types A3 and B2, indicative of reduced occlusal support, were more prevalent in men, suggesting a significantly higher rate of edentulism among this group (p=0.047).

Association between age, Eichner's classification, and mandibular condyle morphology

The study revealed a significant association between Eichner's classification and age (p<0.001), as detailed in **Table 3**. A progressive increase in mean age was observed across the categories from A1 to B2, signifying an age-related trend in edentulism and a significant direct correlation between these variables. Post-hoc analysis using the Bonferroni correction indicated that while the differences between A2 and A3, and between B1 and B2, were not statistically significant (p>0.05), all other pairwise comparisons demonstrated statistically significant age differences (p<0.001).

No significant association was found between age and condylar morphology on either the left (p=0.569) or right (p=0.475) side, suggesting that mandibular condyle morphology is independent of age.

Various types of condylar morphology based on Eichner's criteria

The study found no statistically significant association between Eichner's classification and mandibular condyle

Table 2. Dental status based on Eichner's index and sex

			Eichner					Total	*p*-value*
			A1	A2	A3	B1	B2		
Sex	Female	N (%)	156 (47.0)	102 (30.7)	43 (13.0)	24 (7.2)	7 (2.1)	332 (100.0)	
	Male	N (%)	76 (39.0)	57 (29.2)	41 (21.0)	12 (6.2)	9 (4.6)	195 (100.0)	0.047
Total		N (%)	232 (44.0)	159 (30.2)	84 (15.9)	36 (6.8)	16 (3.0)	527 (100.0)	

* by chi-square; Data is presented as numbers (percentages).

Table 3. Association between age, Eichner's classification, and mandibular condyle morphology

		N	Mean (SD)	*p*-value*
Eichner	A1	232	27.75 (6.02)	0.001
	A2	159	31.58 (6.20)	
	A3	84	32.45 (6.71)	
	B1	36	37.28 (5.72)	
	B2	16	39.13 (7.95)	
Morphology Left	Oval	298	30.68 (6.86)	0.569
	Bird beak	64	31.61 (7.20)	
	Diamond	88	30.42 (7.43)	
	Crooked finger	77	29.99 (6.52)	
Morphology Right	Oval	312	30.82 (7.28)	0.475
	Bird beak	74	30.05 (6.54)	
	Diamond	70	29.80 (6.41)	
	Crooked finger	71	31.35 (6.35)	

* by One-way ANOVA; Data is presented as mean (standard deviation).

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morphology on either the left (p=0.334) or right (p=0.191) sides. Across all Eichner classes, the oval morphology was the most frequently observed **(Table 4)**. For all condylar morphologies except the bird-beak type, sample numbers decreased progressively from Eichner class A1 to B2. Consequently, A1 status, representing the maximum number of occlusal contacts, showed the highest frequency, followed sequentially by A2, A3, B1, and B2. This trend was notably absent for bird-beak condyles on both sides; for example, on the left side, the bird-beak morphology was more prevalent in the A2 class (n=26) than in the A1 class (n=22).

Discussion

In this study, the oval condylar morphology was the most prevalent, followed by diamond and crooked finger types, with the bird-beak type being the least frequent. This finding aligns with numerous prior studies, including those by Singh et al.[1], Al-Saedi et al.[2], Anisuzzaman et al.[3], Sonal et al.[21], Sahith et al.[20], and Sakya et al.[23], all of which also reported oval morphology as the most common. However, the distribution of other morphological types varied compared to our results. Several studies identified the bird-beak type as the second most common, followed by the diamond type, and the crooked finger as the rarest. In contrast, Karthikeyan et al.[19] found diamond, bird-beak, and crooked finger types to be the most frequent morphologies after oval. Furthermore, Sakya et al. included a flat condylar type, which was the least prevalent in their research. Potential explanations for these discrepancies include variations in sample size, geographic and ethnic diversity, and the adoption of different classification systems. For example, Sakya et al. utilized a five-group classification, unlike the four-type system employed in the current investigation.

Our study observed symmetrical condyles in 74.6% of patients, a finding consistent with previous research by Singh et al.[1], Al-Saedi et al.[2], Anisuzzaman et al.[3], Oliveira et al.[24], Sonal et al.[21], Sahithi et al.[20], Karthikeyan et al.[19], Sakya et al., and Fonseca et al.[9] Within the group of symmetrical condyles, the oval morphology was the most prevalent, followed by diamond and crooked finger types, with bird-beak morphology being the least common. Similar findings regarding the prevalence of these morphologies among symmetrical condyles were reported by Karthikeyan et al.[19] However, a difference was noted in the least prevalent type: whereas the crooked finger type demonstrated the lowest prevalence in their report, the bird-beak morphology was found to be the least common in our study. These discrepancies could potentially be attributed to ethnic and geographic variations, as well as differences in sample size across the studies.

In the current study, age did not show a significant association with condylar symmetry or the morphology of either the left or right condyles, mirroring the findings of Arif Dar et al.[25] However, a significant relationship was identified between condylar morphology on both sides and sex. This finding contradicts the results of several studies, including those by Arif Dar et al.[25], Bains et al.[26], Sakya et al.[23], Sahithi et al.[20], Ashwinirani et al.[6], and Nagaraj et al.[27] Conversely, it aligns with the observations made by Manjeet Singh et al.[1] The observed sex-related differences may be attributed to a higher prevalence of edentulism and reduced occlusal contacts among men. These factors could influence condylar morphology, thereby explaining the significant differences identified between males and females in both our study and that of Singh et al.

In the present study, Eichner's classification revealed type A1 as the most common dental status, accounting for 44% of cases, followed by A2 (30.2%), A3 (15.9%), B1 (6.8%), and B2 (3.0%). This distribution aligns with the findings re-

Table 4. Various types of condylar morphology based on Eichner's criteria

			Morphology Left				Total	p-value*
			Oval	Bird beak	Diamond	Crooked finger		
Eichner	A1	N (%)	129 (55.6)	22 (9.5)	39 (16.8)	42 (18.1)	232 (100.0)	0.334
	A2	N (%)	85 (53.5)	26 (16.4)	25 (15.7)	23 (14.5)	159 (100.0)	
	A3	N (%)	52 (61.9)	7 (8.3)	17 (20.2)	8 (9.5)	84 (100.0)	
	B1	N (%)	23 (63.9)	6 (16.7)	5 (13.9)	2 (5.6)	36 (100.0)	
	B2	N (%)	9 (56.3)	3 (18.8)	2 (12.5)	2 (12.5)	16 (100.0)	
			Morphology Right				Total	p-value*
			Oval	Bird beak	Diamond	Crooked finger		
Eichner	A1	N (%)	136 (58.6)	31 (13.4)	34 (14.7)	31 (13.4)	232 (100.0)	0.191
	A2	N (%)	85 (53.5)	32 (20.1)	18 (11.3)	24 (11.3)	159 (100.0)	
	A3	N (%)	53 (63.1)	8 (9.5)	12 (14.3)	11 (13.1)	84 (100.0)	
	B1	N (%)	29 (80.6)	1 (2.8)	4 (11.1)	2 (5.6)	36 (100.0)	
	B2	N (%)	9 (56.3)	2 (12.5)	2 (12.5)	3 (18.8)	16 (100.0)	

* by chi-square test. Data is presented as numbers (percentages).

ported by Singh et al.[1] Furthermore, a significant association was identified between dental status according to Eichner's classification and mean age. Specifically, a progressive shift from A1 towards B2 was observed with advancing age, characterized by an increase in edentulous areas and a decrease in the number of occlusal contacts.

Limitations and recommendations

Several limitations should be acknowledged. Firstly, the recruitment of all participants from a single center, coupled with the retrospective design relying on archived records, precluded direct clinical examination and may introduce selection bias. This, along with the clinic-based sampling, which may differ systematically from the general population, limits the generalizability of our findings. Moreover, sample selection and data extraction were performed solely based on panoramic radiographs and existing patient records, without specific clinical diagnostic criteria for temporomandibular joint disorders (TMD). Furthermore, the use of panoramic radiographs, providing only two-dimensional information, restricted a precise anatomical assessment of condylar morphology.

To address these limitations, future research should be conducted using multicenter designs that include diverse populations and prospective methodologies, thereby enabling direct clinical evaluation of patients when necessary. Incorporating three-dimensional imaging techniques, such as CBCT, would also improve the accuracy of morphological assessments.

Conclusion

Our study found that oval morphology was the most prevalent condylar type overall, consistently observed across all Eichner's classifications and among symmetrical condyles. The most common dental status was A1, and we found no statistically significant association between dental status and the morphology of either the right or left condyle. While a trend toward altered condylar morphology with increasing edentulism was suggested, it did not reach statistical significance. In contrast, a significant relationship was observed between mean age and dental status by Eichner's classification, with advancing age associated with fewer occlusal contacts and increased edentulism.

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Additional information

Ethical statement

- The authors declared that no clinical trials were used in the present study.
- The authors declared that no experiments on humans or human tissues were performed for the present study.
- Approval for this study was granted by the Ethics Committee of Qazvin University of Medical Sciences, Iran (ethics code: IR.QUMS.REC.1400.16). The requirement for informed consent was waived due to the anonymization of the data. Personal information was kept strictly confidential, with only anonymized research findings reported and submitted to Qazvin University of Medical Sciences.
- The authors declared that no experiments on animals were performed for the present study.
- The authors declared that no commercially available immortalised human and animal cell lines were used in the present study.

Conflict of interest

The authors have declared that no competing interests exist.

Artificial Intelligence (AI) use

The authors accept full responsibility for the content of the manuscript, including the disclosure of any use of AI. No AI tools were used in the preparation of this manuscript.

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Author contributions

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Data availability

All of the data that support the findings of this study are available in the main text.