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Association between Temporomandibular Joint Condylar Morphology and Habitual Chewing Side.

Mohammed Al-Maqaleh[1] *, Al-Kasem Abbas[1], Taghreed Al-Kibsi[1] and Abdulbaset Mufadhal[2]

[1]**Department of Oral and maxillofacial surgery , Faculty of Dentistry, Sana'a University, Sana'a, Yemen.,**
[2]**Department of Conservative Dentistry and Endodontics, Faculty of Dentistry, Sana'a University, Sana'a, Yemen.**

*Corresponding author: dr.m.almaqaleh@gmail.com

Abstract

Background and Objectives: Condylar shape varies among individuals and may be influenced by developmental, occlusal, and pathological factors. Condylar shape can aid in the diagnosis of temporomandibular disorders (TMD) when evaluated alongside clinical findings. This study aimed to investigate whether the shape of the temporomandibular joint (TMJ) is associated with habitual chewing in a sample of the Yemeni population, using panoramic radiographs.

Materials and Methods: This retrospective, analytical, cross-sectional study included 200 participants (400 condyles) who attended dental clinics at the Faculty of Dentistry, Sana'a University, and private dental clinics. The habitual chewing side was determined using a self-report questionnaire included in the Case Record Form (CRF). Digital panoramic radiographs were analyzed, and the condyle was traced manually using the MicroDicom DICOM Viewer. Five condylar shape classifications were used: type 1 (round), type 2 (diamond), type 3 (bird beak), type 4 (crooked finger), and type 5 (bifid). Intra- and inter-examiner reliability were tested using Cohen's kappa. The chi-square test was used to compare the associations among the study variables. The Fisher's Exact Test was applied to a small sample of male participants. The data were analyzed using SPSS version 27.

Results: Among the 200 participants (180 females, 20 males; aged 18–49 years), 52.5% preferred chewing on the right side. The round condylar shape was the most prevalent overall (males: 50%; females: 50.6%), whereas the bifid shape was the least common in both sexes (males: 7.1%; females: 3.3%). No statistically significant association was observed between the preferred chewing side and condylar morphology in males ($p = 0.323$), females ($p = 0.148$), or the overall study population for the right ($p = 0.097$) and left condyles ($p = 0.388$).

Conclusion: Within the limitations of this study, it may be concluded that the round shape was the most common type among the selected group of Yemeni adults, regardless of sex or side. The least common type is bifid. Additionally, there was no significant association between the preferred chewing side and condylar shape.

Article Info

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1. INTRODUCTION

The temporomandibular joint (TMJ) is a complex and unique anatomical structure in humans. It forms a movable articulation between the mandibular condyle and squamous portion of the temporal bone [1]. TMJ health is crucial for daily life activities because it plays an essential role in the movement of the mandible during chewing, swallowing, and speech [2, 3]. The morphology of the mandibular condyle varies among age groups and individuals. These variations may be influenced by malocclusion, trauma, developmental abnormalities, and some diseases [4, 5]. Previous anatomical and radiographic studies have identified several condylar shapes, including oval, birdbeak, diamond, crooked finger, and bifid [6–8].

Radiographic assessment of condylar morphology is

commonly performed using panoramic radiographs due to their accessibility, low radiation dose, and acceptable diagnostic value [9, 10]. Variations in condylar shape have been associated with temporomandibular disorders (TMD), age, sex, occlusion, and functional loading patterns, indicating that the condyle is responsive to the mechanical demands imposed by the masticatory system [11].

Habitual chewing has been proposed as a factor influencing condylar shape. Some studies have reported that unilateral chewing may contribute to the remodeling of the condylar head [12–15]. Sritara et al. found that specific chewing patterns may affect condylar morphology, although side preference alone is not a strong predictor [16]. In contrast, prolonged unilateral chewing has been found to cause measurable changes in condylar morphology on CBCT [17]. Other studies have reported no significant side-to-side differences in condylar shape, suggesting that chewing habits may not produce structural variations in the shape of the condyle [18–20].

Findings from previous studies are inconsistent, and the association between the preferred chewing side and condylar morphology remains unclear. Therefore, this study aimed to assess whether the condylar shape is associated with habitual chewing in a sample of Yemeni adults.

2. MATERIALS AND METHODS

2.1. STUDY DESIGN

The present study is a retrospective analytical cross-sectional study that analyzed previously acquired panoramic radiographs to investigate the association between condylar morphology and habitual chewing side in a sample of Yemeni patients.

2.2. STUDY AREA

This study was conducted at the Faculty of Dentistry, Sana'a University, and selected private dental clinics in Sana'a City from June 2025 to August 2025.

2.3. SAMPLE SIZE CALCULATION

The sample size was calculated using a standard formula for estimating the population proportion:

$$sample\ \ size = \frac{z^2 \times p \times (1-p)}{d^2} \quad [21]$$

- Z = value corresponding to the desired confidence level (Z=1.96).
- p = estimated population proportion; in this study, p = 0.513 (51.3%) based on a previous study [22].
- d = absolute error; a value of 0.07 was considered.

A 0.07 margin of error was used to balance precision and feasibility, yielding an estimated sample size of approximately 196, rounded to 200.

2.4. STUDY POPULATION

A total of 200 participants (400 condyles), including those who visited the dental clinics at the Faculty of Dentistry, Sana'a University, for consultation and panoramic radiography, in addition to patients from private dental clinics, were included. All panoramic radiographs included in this study were obtained for routine diagnostic purposes. No additional radiographs were obtained, specifically for this study.

2.5. INCLUSION AND EXCLUSION CRITERIA

2.5.1. Inclusion Criteria

- Individuals aged ≥ 18 years.
- Individuals with ≥ 20 remaining teeth with a posterior occlusal stopper on both sides and normal skeletal relationship.

2.5.2. Exclusion Criteria

- History of TMJ trauma or surgery.
- History of orthodontic treatment.
- Serious craniofacial disease or previous craniofacial operations.
- Systemic musculoskeletal disorders.
- Use of medications affecting TMJ.
- Developmental or congenital craniofacial anomalies.
- Poor-quality or distorted panoramic radiographs.
- Missing posterior teeth or edentulism.
- Participants with no dominant chewing side.
- Participants who chew qat.

2.6. DATA COLLECTION

Data were collected using a structured case record form, including patient records, and a short questionnaire on habitual chewing. The questionnaire asked participants to self-report their habitual chewing side (right, left, or both) based on daily habits; those reporting equal use of both sides were classified as having no dominant side and were excluded from analyses. Condylar morphology was evaluated using panoramic radiographs. No additional radiographs were obtained to minimize unnecessary radiation exposure.

2.7. RADIOGRAPHIC EVALUATION

Digital panoramic radiographs were obtained using the same calibrated panoramic radiographic unit

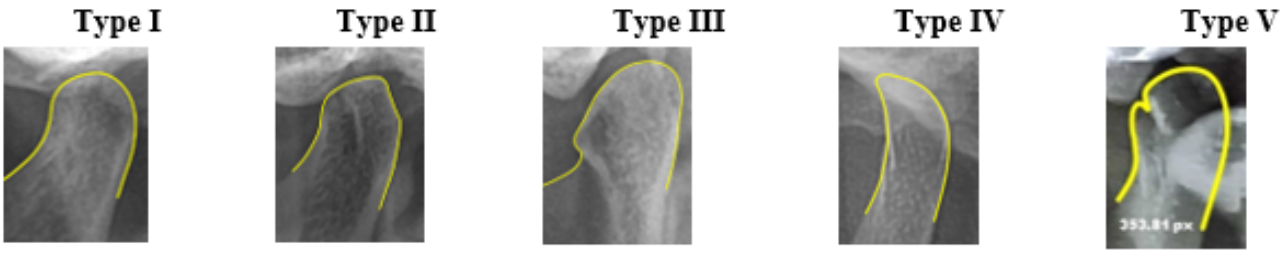

Figure 1. Condylar Shapes.

(Model: PAPAYA; GENORAY Co., Ltd., Seoul, South Korea), and all radiographs were taken by the same experienced X-ray technician with standardized patient positioning. Radiographs were manually analyzed using the MicroDicom DICOM Viewer (v.2025.3) to trace the mandibular condyle outline. The right and left condyles of each participant were evaluated separately.

Condylar morphology was evaluated using the most commonly used classification system comprising four types (Types I–IV) [23, 24]. During the evaluation, an additional fifth type (Type V: Bifid) was identified in the study population, which was also reported in another study [7].

2.8. RELIABILITY ASSESSMENT

Both intra- and inter-examiner reliability were assessed to ensure consistency and reliability of radiographic evaluations. For intra-examiner reliability, all panoramic radiographs were re-evaluated by the same examiner after a two-week interval. For inter-examiner reliability, a second examiner independently assessed the same subset of radiographs, using the same classification criteria.

2.9. DATA ANALYSIS

Qualitative data are presented as frequencies and percentages. Cohen's kappa (κ) was used to evaluate the examiner reliability. In addition, the chi-squared (χ^2) test was used to compare associations among the study variables. For the small sample of male participants, Fisher's Exact Test was used because it is more reliable than the chi-square test when the expected counts are low. Data analysis was performed using SPSS Statistics version 27.0 for Windows (IBM Corp., Armonk, NY, USA).

2.10. ETHICAL CONSIDERATIONS

Ethical approval was obtained from the Research Ethics Committee of the Faculty of Dentistry at Sana'a University. Informed consent was obtained from all the participants prior to their inclusion in the study.

3. RESULTS

Of the 200 participants, 180 were female (90%) and 20 were male (10%). The participants' ages ranged from 18 to 49 years old. Ninety-six females (53.3%) preferred eating on the right side, while 84 female participants (46.7%) preferred eating on the left side. In contrast, 9 males (45%) preferred eating on the right side and 11 (55%) preferred eating on the left side. Overall, the study population included 105 participants (52.5%) who preferred eating on the right side and 95 participants (47.5%) preferred eating on the left side. The intra-examiner reliability was κ = 0.935 and the inter-examiner reliability was κ = 0.852.

Among male participants (n = 20), the most common condylar shape was round. On the right condyle, the round shape accounted for 35.7% of right-side chewers and 64.3% of left-side chewers, followed by the bird beak and crooked finger shapes (Table1, Figure 2). There was no significant association between habitual eating and condylar shape in males (P = 0.323).

Among female participants (n = 180), round and diamond shapes were the most commonly observed. On the right condyle, a round shape was seen in 47.5% of right-side chewers and 52.5% of left-side chewers, whereas the diamond and bird beak forms appeared less frequently (Table2, Figure 2). Statistical analysis showed no significant association between the preferred chewing side and the condylar shape in females (p = 0.148).

For all participants, regardless of gender, among right condyles, a round shape was seen in 50.5% of right-side eaters and 65.3% of left-side eaters. Diamond shape was more frequent among right-side eaters (25.7%) than among left-side eaters (12.6%). The bird beak, crooked finger, and bifid types were more evenly distributed between the two groups. Statistical testing revealed no significant association (p = 0.097), although a non-significant trend suggested that left-sided eaters may have a slightly higher proportion of round condyles (Table3, Figure 3).

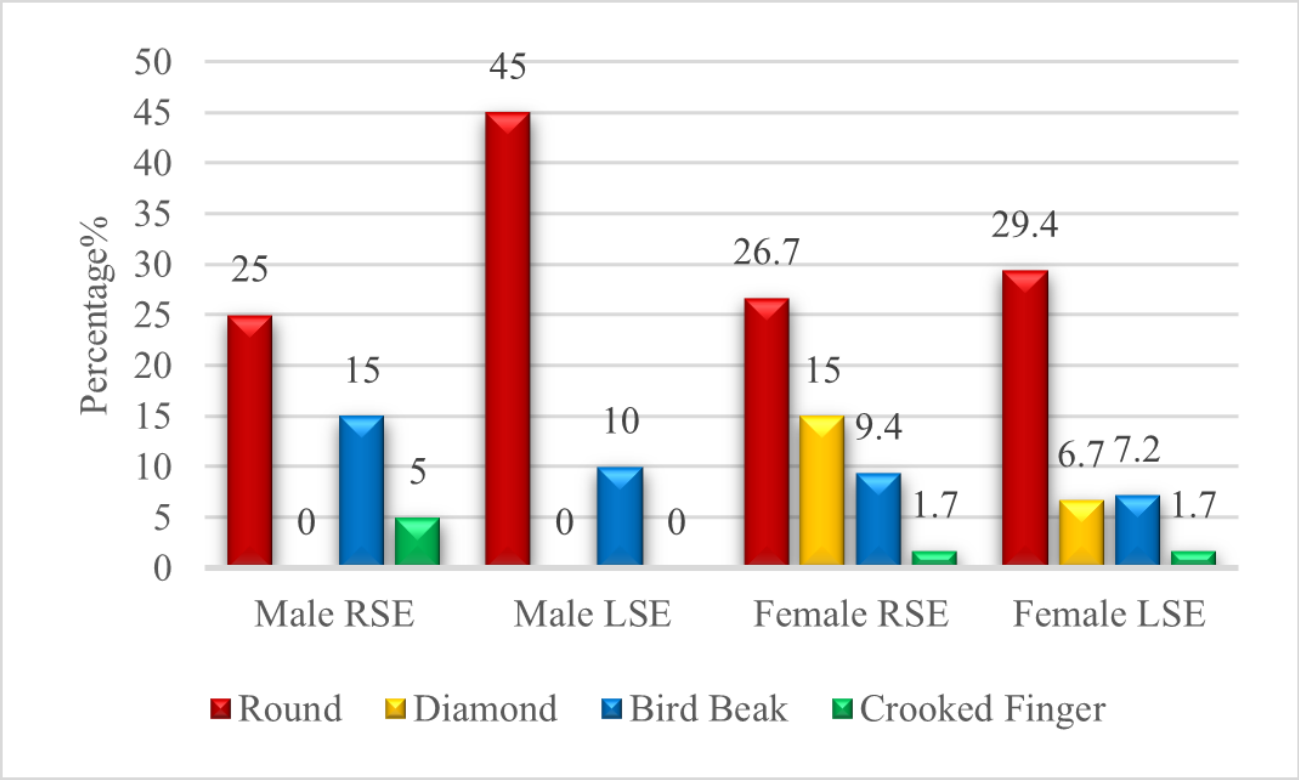

Figure 2. Distribution of condylar shapes according to preferred chewing side and gender. **RES:** Right eating side, **LES:** Left eating side

For the left condyles, a round shape was present in 48.6% of right-side eaters and 57.9% of left-side eaters, while a diamond shape was observed in 23.8% and 16.8%, respectively. The bird beak, crooked finger, and bifid shapes showed minor variations between the groups, as shown in Table3. The chi-squared test confirmed no significant association (P = 0.388).

4. DISCUSSION

In the present study, no significant association was observed between the preferred chewing side and condylar morphology, indicating that habitual chewing may not influence the condylar shape.

Several studies have emphasized the potential influence of occlusal forces on the shape of the condyle. These studies attributed the asymmetry between condylar shapes to unilateral chewing and temporalis muscle activity [13–15]. Likewise, Dogan and Boyacioglu mentioned eating habits and masticatory load as contributing factors that influence the morphology of the mandibular ramus and condylar region [25]. Consistent with the findings of the present study, Sritara et al. observed that while specific chewing patterns influenced condylar shape, side preference alone was not a strong determinant of morphological variation, which aligns with the nonsignificant association found in our study [16].

A previous CBCT study reported that prolonged unilateral chewing leads to remodeling of the condyle shape [17]. In contrast, our study, which examined the preferred chewing side for regular food, found no significant association with condylar shape. This difference may be due to the shorter chewing duration and lower sensitivity of panoramic radiographs than CBCT in detecting subtle changes.

Both males and females showed a near-even distribution of condylar shapes bilaterally. Although the number of rounds tended to be higher in left-side eaters and diamonds were higher in right-side eaters, statistical testing showed no significant association (p = 0.097 for right condyles; p = 0.388 for left condyles). Many studies in the literature showed symmetry between the right and left condylar shape, regardless of the preferred chewing side [8, 18, 26–28]. These findings are consistent with the results of the present study.

In contrast, several studies have indicated that occlusal load and functional demands may significantly influence condylar morphology. Variations in chewing side preference, masticatory force distribution, and habitual unilateral mastication have been associated with the adaptive remodeling of the condylar head. Chaulagain et al. reported a higher prevalence of angled condyles on the left side in females, potentially reflecting

Table[1]: Distribution of condylar shapes according to preferred chewing side in Males.

Gender	Eating Side	Condyle Shape	n (%)
Male ($p = 0.323$)	Right	Round	5 (25.0%)
		Diamond	0 (0.0%)
		Bird Beak	3 (15.0%)
		Crooked Finger	1 (5.0%)
		Total	9 (45.0%)
	Left	Round	9 (45.0%)
		Diamond	0 (0.0%)
		Bird Beak	2 (10.0%)
		Crooked Finger	0 (0.0%)
		Total	11 (55.0%)

Table[2]: Distribution of condylar shapes according to preferred chewing side in females

Gender	Eating Side	Condyle Shape	n (%)
Female ($p = 0.148$)	Right	Round	48 (26.7%)
		Diamond	27 (15.0%)
		Bird Beak	17 (9.4%)
		Crooked Finger	3 (1.7%)
		Total	96 (53.3%)
	Left	Round	53 (29.4%)
		Diamond	12 (6.7%)
		Bird Beak	13 (7.2%)
		Crooked Finger	3 (1.7%)
		Total	84 (46.7%)

$p < 0.05$, statistically significant

functional adaptation to preferred unilateral chewing [29]. In agreement with these findings, Kaur and Kaur observed that flat condyles were more common on the right side in males, a pattern consistent with the functional adaptation described by Chaulagain et al. [20].

Further evidence supporting the influence of functional loading on condylar morphology was provided by Fukagawa et al., who identified a significant association between unilateral chewing and mandibular asymmetry

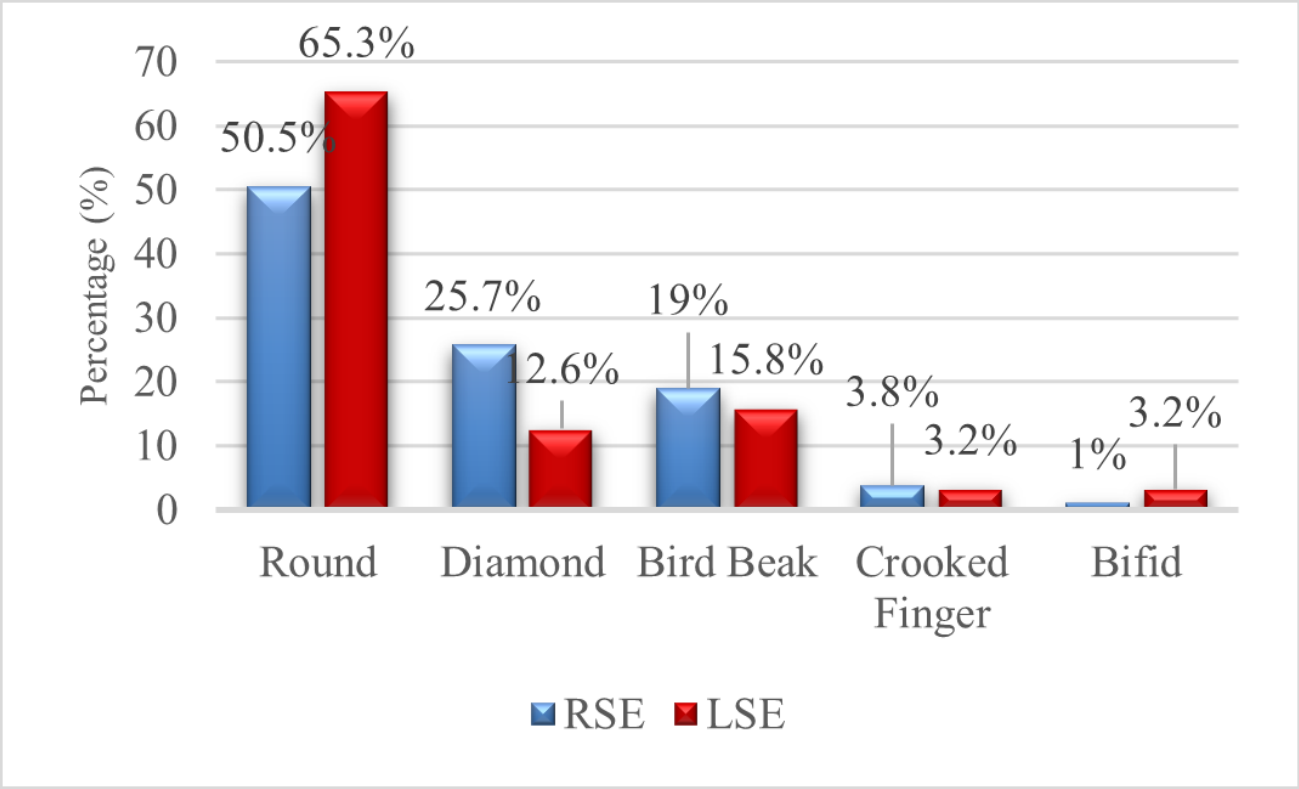

Figure 3. Distribution of condylar shapes according to preferred chewing side. **RES:** Right eating side, **LES:** Left eating side.

Table[3]: Distribution of condylar shapes according to preferred chewing side

Condyle	Shape	RSE	LSE	Total
Right Condyle (p=0.097)	Round	53 (50.5%)	62 (65.3%)	115 (57.5%)
	Diamond	27 (25.7%)	12 (12.6%)	39 (19.5%)
	Bird beak	20 (19.0%)	15 (15.8%)	35 (17.5%)
	Crooked Finger	4 (3.8%)	3 (3.2%)	7 (3.5%)
	Bifid	1 (1.0%)	3 (3.2%)	4 (2.0%)
Total		105 (100%)	95 (100%)	200 (100%)
Left Condyle (p=0.388)	Round	51 (48.6%)	55 (57.9%)	106 (53.0%)
	Diamond	25 (23.8%)	16 (16.8%)	41 (20.5%)
	Bird beak	18 (17.1%)	19 (20.0%)	37 (18.5%)
	Crooked Finger	8 (7.6%)	3 (3.2%)	11 (5.5%)
	Bifid	3 (2.9%)	2 (2.1%)	5 (2.5%)
Total		105 (100%)	95 (100%)	200 (100%)

RSE: Right eating side; **LSE:** Left eating side.
$p < 0.05$, statistically significant.

[30]. Another study reported that habitual unilateral mastication can create uneven loading within the temporomandibular joints, leading to alterations in joint space dimensions and subsequent condylar

remodeling [31]. Moreover, individuals who consistently chew on one side have been reported to exhibit structural adaptations, including reduced condylar height, positional displacement, and changes in condylar angulation [31, 32].

The limitations of this study include its cross-sectional design, which limits causal inference and partly limits subjective visual assessment. Additionally, the restriction of the sample to a single region in Yemen and the unequal sex distribution (90% female) limit the generalizability of the findings, particularly regarding male condylar morphology. Finally, the study did not consider other factors that could influence condylar morphology, such as age, occlusion type, and systemic conditions. Future studies should include larger, more diverse populations and employ advanced imaging modalities, such as CBCT, along with longitudinal designs, to assess changes in morphology over time.

5. CONCLUSION

Based on the findings of this study, and within its limitations, the round condylar shape was the most common among the selected group of Yemeni adults, regardless of sex or side, whereas the bifid shape was the least common. Furthermore, no significant association was observed between the preferred chewing side and the condylar morphology.

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CONFLICT OF INTEREST

None to declare.

ETHICAL COMMITTEE

The study protocol was reviewed and approved by the Research Ethics Committee of the College of Dentistry, Sana'a University, Sana'a, Yemen.

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