

MRI Parameter Analysis of Condylar Position, Morphology in Different Subgroups of Temporomandibular Disorders

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Research Article

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Abstract

Objective

This study aimed to analyze the differences in MRI parameters (including condylar position, morphology, long axis, short axis) among different subtypes of temporomandibular disorder (TMD).

Methods

Imaging and clinical data of 151 patients clinically diagnosed with TMD between September 2019 and March 2025 in our hospital were retrospectively collected. Given that bilateral TMD lesions are often asymmetric, this study used a single temporomandibular joint (TMJ) as the unit of analysis. A total of 302 TMJs from 151 patients were divided into three groups according to the type of disc displacement: no disc displacement group (ND) (130 joints), disc displacement with reduction group (DDWD) (63 joints), and disc displacement without reduction group (DDWOR) (109 joints). Intergroup differences in conventional MRI parameters (including condylar position, morphology, long axis, short axis) were analyzed.

Results

1. The mean age of the included patients was 25.6 years, with a male-to-female ratio of approximately 1:3.4. 2. The condylar long axis in the no disc displacement group was significantly larger than that in the disc displacement with reduction group and the disc displacement without reduction group ($P < 0.05$). The condylar short axis in the no disc displacement group was significantly larger than that in the disc displacement without reduction group ($P < 0.05$). Effect size analysis showed that the association strengths for condylar long axis ($\eta^2 = 0.146$) and short axis ($\eta^2 = 0.055$) were high and moderate, respectively. 3. Although condylar position (anterior, central, posterior) and morphology (oval, flat, beak-shaped) also showed statistically significant differences among the three groups ($P < 0.05$), indicating differences in condylar position and morphology among TMD subtypes, the correlations were weak (Cramer's $V < 0.2$).

Conclusion

Condylar long/short axes show statistically significant differences among different TMD subtypes, providing discriminative diagnostic value. Although condylar position and morphology also differ among subtypes, their association strengths are relatively weak.

Introduction

Temporomandibular disorder (TMD) is a group of common conditions involving the masticatory muscles, temporomandibular joints (TMJs), and related structures. Its main manifestations include joint pain, clicking, and limited mouth opening, which severely affect patients' quality of life^[1–3]. The etiology of TMD is complex and is currently recognized to involve multiple factors such as occlusal factors,

psychosocial stress, trauma, and parafunctional activities^[4, 5]. The pathological process often involves the articular disc, condyle, and peri-articular soft tissues^[6]. Magnetic resonance imaging (MRI) with its excellent soft-tissue contrast resolution, multiplanar imaging capability, and lack of ionizing radiation, has become the preferred imaging modality for TMD^[7]. MRI can clearly depict the position, morphology, and signal intensity of the articular disc, as well as osseous changes of the condyle, providing an important basis for TMD diagnosis, classification, and treatment planning. Based on the relative positional relationship between the articular disc and the condyle, TMD is often clinically subclassified into no disc displacement, disc displacement with reduction, and disc displacement without reduction. The pathological mechanisms, clinical presentations, and treatment strategies differ among these subtypes^[8].

Previous studies have shown that MRI parameters such as condylar position (anterior, central, posterior), condylar morphology (oval, flat, beak-shaped), condylar long and short axes may vary with disease subtype^[9–14]. However, most existing studies have focused on a single parameter or limited comparisons between two subtypes, lacking a systematic, quantitative analysis of multiple MRI parameters across different TMD subtypes. Notably, bilateral TMJ lesions in TMD patients are often asymmetric; therefore, using a single TMJ as the unit of analysis may better reflect the true disease characteristics, but few large-sample studies in the literature have adopted this analytical strategy.

Against this background, this study retrospectively collected MRI data from 151 TMD patients (302 TMJs). Using a single TMJ as the unit of analysis, we compared differences in condylar position, morphology, long axis, short axis among three disc displacement groups (no displacement, displacement with reduction, and displacement without reduction). The aim was to explore the distribution characteristics of MRI parameters across different TMD subtypes and to provide imaging evidence for clinical classification, disease assessment, and individualized treatment.

Materials and Methods

As a retrospective analysis, all data involved were de-identified clinical information. The Ethics Committee waived the requirement for informed consent from the subjects, and the study strictly complied with ethical standards.

1. Patient Selection

The sample was selected from patients who visited the First Affiliated Hospital of the University of Science and Technology of China (Anhui Provincial Hospital) between December 2019 and March 2025 and met the diagnostic criteria. To ensure data objectivity, a double-blind selection process was adopted: two clinicians with more than 5 years of experience in oral and maxillofacial practice independently reviewed the medical records and imaging data. Case selection was based on the internationally recognized Diagnostic Criteria for Temporomandibular Disorders (DC/TMD), a globally accepted

dual-axis diagnostic system for TMD classification^[15]. The inclusion criteria were as follows: (1) a definite diagnosis of TMD according to the DC/TMD criteria; (2) no previous TMJ-related therapeutic intervention before the MRI examination; and (3) complete clinical data and MRI images with sufficient quality for subsequent analysis. Exclusion criteria included: (1) presence of non-structural joint diseases such as tumors or rheumatoid arthritis; and (2) a history of trauma in the temporomandibular region. Through the above screening process, 151 eligible patients were finally included in this study. To maximize the authenticity and diversity of the clinical data, no restriction was placed on the MRI scanner model at the time of inclusion. The demographic characteristics (sex, age) and conventional imaging parameters (including condylar position, morphology, long axis, short axis, and articular disc morphology) of all 151 patients were analyzed; these parameters have good reproducibility and stability across different MRI devices.

2. MRI Protocol

2. MRI Protocol

The 151 included patients underwent MRI scanning using a Siemens MAGNETOM Vida and a GE DISCOVERY 750w 3.0T superconducting MR scanner. 64-channel head-neck coil was used. The sequences included axial T1-weighted imaging, open and closed-mouth oblique sagittal PDWI-FS, and open-mouth oblique sagittal T2WI-FS.

The scans were performed using fast spin-echo sequences. The parameters included repetition time (TR), echo time (TE), slice thickness, field of view (FOV), matrix, and number of averages (Aves). The specific parameter values are shown in Table 1. All MRI examinations were performed by experienced radiology technologists following a standardized protocol. Before scanning, patients received standardized mouth-opening training, which included measuring their maximum pain-free mouth opening and instructing them to perform adaptive biting exercises using an MRI-compatible mouth opener. This ensured that patients could maintain a stable position at their maximum tolerable mouth opening to facilitate the acquisition of the open-mouth imaging sequences.

Table 1
MRI Scanner Parameters.

	GE 750w 3.0T			Siemens Vida 3.0T		
	PDWI-FS	T2WI-FS	T1WI	PDWI-FS	T2WI-FS	T1WI
TR	4000 ms	6000 ms	150 ms	2400 ms	3000 ms	480 ms
TE	24 ms	87ms	2ms	32ms	67ms	9ms
Slice	2 mm	2 mm	3mm	2mm	2 mm	2mm
FOV/mm	140 ×140	140 ×140	240 ×240	140 ×140	140 ×140	170 ×210
Matrix	224×384	284×256	288×224	320×256	352×282	320×195
Avg	1	1.5	1	3	3	1

3. Definition of the TMJ Analysis Unit

In this study, a single temporomandibular joint (TMJ) was used as the unit of analysis. Although the TMJ is a paired organ, left and right sided lesions often exhibit significant asymmetry in clinical practice (e.g. one joint may have no disc displacement while the contralateral joint presents disc displacement). Moreover, clinical diagnosis, imaging evaluation, and treatment decisions are all made independently for each joint. Therefore, each TMJ was treated as an independent sample for grouping. Currently, this approach is commonly adopted in high-quality studies in the field. Accordingly, this study follows the standard practice in the field. Using the single joint as the unit of analysis not only aligns with the asymmetric clinical characteristics of the disease but also avoids masking important laterality-specific pathological information that could result from forced aggregation.

4. MRI evaluation of condylar position, morphology, and articular disc structure

- For the assessment of condylar position, based on the distance between the anterior and posterior slopes of the condyle and the corresponding slopes of the mandibular fossa, the positional relationship was classified into three types: anterior position [Figure 1a], posterior position [Figure 1b], and neutral position [Figure 1c]. For the classification of condylar morphology, it was categorized as oval [Figure 2a], flat [Figure 2b], or beak-shaped [Figure 2c]. On axial T2-weighted images in the closed-mouth position, the slice showing the maximum long axis of the condyle was identified for measurement. The maximum diameter parallel to the direction from the medial to the lateral pole of the condyle was recorded as the long axis [Figure 3], and the maximum diameter perpendicular to this long axis was recorded as the short axis [Figure 3]. For the assessment of articular disc morphology, based on TMD-related diagnostic criteria, it was classified into biconcave, elongated, folded, and posterior thickening types.

5. Statistical Analysis

- All statistical analyses were performed using IBM SPSS Statistics 26.0. A total of 302 temporomandibular joints (TMJs) from 151 subjects were analyzed. For continuous variables (including age, condylar long axis, and condylar short axis), normality was assessed using the Shapiro-Wilk test and homogeneity of variances using Levene's test prior to intergroup comparisons. When parametric test assumptions were met, one-way analysis of variance (ANOVA) followed by LSD-t test was used for multiple comparisons and post-hoc pairwise comparisons. Otherwise, the Kruskal-Wallis H test was applied. The strength of association between the continuous variables (condylar long axis and short axis) and the type of disc displacement was evaluated using η^2 (eta squared). For unordered categorical variables (including condylar position, condylar morphology, and articular disc morphology), intergroup differences were analyzed using the Pearson chi-square test. When more than 20% of cells in the contingency table had expected counts less than 5, Fisher's exact test was used instead to avoid statistical bias. All hypothesis tests were two-tailed, and a P-value < 0.05 was considered statistically significant. For variables that showed statistical significance in the chi-square test, Cramer's V coefficient was further calculated.

Results

A total of 302 temporomandibular joints (TMJs) (including both left and right sides) from 151 patients were included in this study. There were 117 female patients (77.5%) and 34 male patients (22.5%). The age ranged from 10 to 65 years, with a mean age of 25.64 ± 11.28 years. According to the type of disc displacement, the joints were divided into three groups: the no displacement group (130 sides), the disc displacement with reduction group (63 sides), and the disc displacement without reduction group (109 sides).

1. Condylar Long Axis Among the Three Groups

Descriptive statistical analysis showed that the mean condylar long axis differed among the three groups (no displacement, disc displacement with reduction, and disc displacement without reduction), with the no displacement group having the longest axis, followed by the disc displacement with reduction group, and the disc displacement without reduction group having the shortest. The mean condylar short axis also differed among the three groups, with the no displacement group showing a relatively longer axis, followed by the disc displacement with reduction group, and the disc displacement without reduction group the shortest. Data are presented as mean $\pm$ standard deviation, as shown in Table 2.

Table 2
Descriptive statistics of condylar long and short axes across
different disc displacement groups

Group	condylar long axes(mm)	condylar short axes(mm)
ND	17.95 ± 2.35	7.39 ± 1.54
DDWR	16.48 ± 2.56	6.93 ± 1.57
DDWOR	15.72 ± 2.50	6.57 ± 1.48

Before performing intergroup comparisons, we assessed the homogeneity of variances using Levene's test. The results showed that the variances for both the condylar long axis ($F(2,299) = 0.008$, $P = 0.992$) and the condylar short axis ($F(2,299) = 0.352$, $P = 0.703$) met the assumption of homogeneity ($P > 0.05$), allowing for subsequent parametric tests. One-way analysis of variance (ANOVA) was then used to further examine the differences among the three groups in the two core morphological parameters, namely the condylar long axis and short axis. By comparing the degree of mean differences among the groups, we precisely determined whether the differences reached a statistically significant level. The analysis revealed statistically significant differences among the three groups in both the condylar long axis ($F(2,299) = 25.561$, $P < 0.05$) and the condylar short axis ($F(2,299) = 8.698$, $P < 0.05$). Given that the ANOVA revealed significant statistical differences, Bonferroni's method was applied for post-hoc pairwise comparisons to precisely identify between which groups the differences existed. The results of the multiple comparisons are shown in Table 3. Although condylar position differed significantly among the three groups, the association was weak (Cramer's $V = 0.195$).

Table 3

Intergroup comparison of mean condylar long-axis and short-axis measurements among different disc displacement groups

dependent variable	(I)Disc displacement type	(J)Disc displacement type	Mean difference (I-J)	standard error	P value	95% CI	
						lower limit	upper limit
condylar long axes(mm)	ND	DDWR	1.475*	0.376	< 0.001	0.57	2.38
		DDWOR	2.234*	0.318	< 0.001	1.47	3.00
	DDWR	ND	-1.475*	0.376	< 0.001	-2.38	-0.57
		DDWOR	0.759	0.387	0.153	-0.17	1.69
	DDWOR	ND	-2.234*	0.318	< 0.001	-3.00	-1.47
		DDWR	-0.759	0.387	0.153	-1.69	0.17
condylar long axes(mm)	ND	DDWR	0.464	0.234	0.145	-0.10	1.03
		DDWOR	0.822*	0.198	< 0.001	0.35	1.30
	DDWR	ND	-0.464	0.234	0.145	-1.03	0.10
		DDWOR	0.358	0.241	0.417	-0.22	0.94
	DDWOR	ND	-0.822*	0.198	< 0.001	-1.30	-0.35
		DDWR	-0.358	0.241	0.417	-0.94	0.22

* The significance level for the mean differences was set at 0.05

2. Comparison of Condylar Position Across the Three Groups

The chi-square test results showed that there was a statistically significant difference in the distribution of condylar position (closed-mouth position) among the three groups ($\chi^2 = 22.854$, $P < 0.05$). The detailed distribution of condylar positions across different TMD subtypes is presented in Table 4.

Table 4
Distribution of condylar position in the closed-mouth position across different disc displacement groups

condylar position	ND	DDWR	DDWOR	Total
anterior	38(29.2%)	7(11.1%)	14(12.8%)	59(19.5%)
central	59(45.4%)	22(34.9%)	47(43.1%)	128(42.4%)
posterior	33(25.4%)	34(54.0%)	48(44.0%)	115(38.1%)
total	130	63	109	302

3. Analysis Results of Condylar Morphology Among the Three Groups

The Pearson chi-square test showed a statistically significant difference in the distribution of condylar morphology among the three groups ($\chi^2 = 23.344$, $P < 0.05$), with a Cramer's V coefficient of 0.197, indicating a weak association. This suggests that although condylar morphology differs statistically among different TMD subtypes, its value as a sole discriminant diagnostic indicator is limited. The detailed distribution is shown in Table 5. The DDWR group predominantly exhibited oval morphology, while the ND group and the DDWOR group were both dominated by flat morphology. Notably, the proportion of beak-shaped morphology in the DDWR group was markedly higher than that in the ND and the DDWOR group.

Table 5
Distribution of condylar morphology across different disc displacement groups

condylar morphology	ND	DDWR	DDWOR	Total
oval	39(30.0%)	31(49.2%)	20(18.3%)	90(29.8%)
flat	68(52.3%)	20(31.7%)	53(48.6%)	141(46.7%)
beak-shaped	23(17.7%)	12(19.0%)	36(33.0%)	71(23.5%)
total	130	63	109	302

Discussion

1. Differences in condylar long and short axes among TMD subtypes

- Our findings revealed significant differences in both condylar long and short axes across different TMD subtypes. The condylar long axis in the ND group (17.95 ± 2.35 mm) was significantly longer than that in the DDWR group (16.48 ± 2.56 mm) and DDWOR group (15.72 ± 2.50 mm). The condylar short axis showed a similar trend (ND: 7.39 ± 1.54 mm; DDWR: 6.93 ± 1.57 mm; DDWOR: 6.57 ± 1.48 mm). Effect size analysis demonstrated that the type of disc displacement explained a high

proportion of variance in condylar long axis ($\eta^2 = 0.146$) and a moderate proportion in condylar short axis ($\eta^2 = 0.055$), suggesting a close association between disc displacement status and reduced condylar osseous dimensions.

- Our findings are largely consistent with previous reports. Fan et al^[11] in a study of 137 TMD patients (274 TMJs), similarly found that the condylar long axis in the ND group (17.2 ± 2.4 mm) was significantly longer than that in the DDWR group (15.4 ± 2.0 mm) and the DDWoR group (14.7 ± 2.7 mm), with the short axis showing a comparable trend (ND: 7.3 ± 1.2 mm vs. DDWR: 6.5 ± 1.3 mm vs. DDWoR: 6.1 ± 1.4 mm) ($P < 0.05$). Guercio Monaco et al^[13] also found that the condylar head size in the DDWoR group was significantly smaller than that in the ND group, particularly in the mediolateral dimension ($P < 0.014$) and anteroposterior dimension ($P < 0.020$).
- Notably, in our study, significant differences were observed between the ND group and both displacement groups (ND vs. DDWR, ND vs. DDWoR), whereas no statistically significant differences were found between the DDWR and DDWoR groups (long axis $P = 0.153$; short axis $P = 0.417$). This finding is highly consistent with the results of Fan et al^[7] suggesting that changes in condylar dimensions associated with disc displacement may manifest primarily in the early stages of displacement. Once displacement is established, further progression may have a limited direct impact on condylar dimensions. Westesson et al^[12] using MRI and arthrography, found that the shorter side of the mandible often presented with a small condylar head and a short condylar neck, accompanied by disc displacement and degenerative joint disease, indirectly supporting the association between disc displacement and reduced condylar dimensions. The potential mechanisms underlying condylar dimensional reduction following disc displacement involve both biomechanical and biological factors. From a biomechanical perspective, disc displacement alters the stress distribution on the condyle within the fossa. Under normal conditions, the disc serves as a cushion that evenly distributes occlusal loads after displacement, the anterosuperior portion of the condyle directly bears abnormally increased compressive and shear stresses. Biologically, abnormal mechanical loading may activate osteoclastic activity in the subchondral bone, leading to bone resorption exceeding bone formation, manifesting as reduced condylar height and shortened long and short axes. Notably, Liao et al^[14] through semi-quantitative analysis, identified condylar bony changes (including resorption) as a factor associated with disc displacement without reduction. Mizuhashi et al. also confirmed that bone change types (erosion, flattening, osteophyte, atrophy) were significantly correlated with joint effusion ($P < 0.001$), TMJ pain ($P = 0.027$), and limited mouth opening ($P = 0.002$), suggesting that bony changes are not isolated imaging findings but are closely associated with clinical symptoms. Nevertheless, the absence of significant differences in condylar dimensions between the DDWR and DDWoR groups suggests that condylar dimensional reduction may occur primarily during the early stages of disc displacement; once displacement is established, further progression may have a limited impact on condylar dimensions. Several possible explanations may account for this phenomenon: (1) condylar adaptive remodeling may reach a "ceiling effect"—after a certain degree of dimensional reduction is achieved, further bone resorption may be biologically constrained; (2) reduced condylar dimensions may reflect individual anatomical

variation predisposing to disc displacement rather than being solely a secondary consequence of displacement, i.e., individuals with inherently smaller condyles may be more susceptible to disc displacement; and (3) during the progression from disc displacement with reduction to without reduction, condylar dimensional changes may occur predominantly in the early stages, with subsequent disease progression more characterized by degenerative changes in disc morphology rather than further osseous dimensional reduction.

2. Differences in condylar position among TMD subtypes

- Our results showed a statistically significant difference in the distribution of condylar position among the three groups ($\chi^2 = 22.854$, $P < 0.05$). In the ND group, the central position was predominant (45.4%), followed by the posterior position (25.4%). In the DDWR group, the posterior position was most common (54.0%), followed by the central position (34.9%). In the DDWoR group, the posterior (44.0%) and central (43.1%) positions were similarly distributed. However, the Cramer's V coefficient was only 0.195, indicating a weak association between condylar position and TMD subtypes, suggesting that condylar position alone has limited value in differential diagnosis.
- The relationship between condylar position and disc displacement remains controversial in the literature. Some studies have supported an association between condylar position and disc displacement. Chen et al^[16] in a large-sample study of 744 TMJs, found that the distribution of condylar positions was: central 43.7%, posterior 37.6%, and anterior 18.7%. They reported a statistically significant difference between disc position and condylar position ($P < 0.05$), but no linear correlation ($P = 0.159$). Their study also demonstrated a positive correlation between disc position and condylar morphology ($r = 0.413$, $P = 0.000$), and a negative correlation between condylar position and condylar morphology ($r = -0.152$, $P = 0.000$). Liao et al^[14] also identified central condylar position as one of the factors associated with the diagnosis of disc displacement without reduction. Additionally, some studies have suggested that in cases of mild disc displacement, the condyle tends to be in a posterior position; as displacement worsens (with more obvious anterior displacement), the condyle may return to a central position.
- However, other studies have presented differing viewpoints. Fan et al^[11] found no significant differences in condylar position among the no displacement, disc displacement with reduction, and disc displacement without reduction groups ($\chi^2 = 7.435$, $P = 0.115$). Another MRI-based study also reported considerable individual variability in condylar position, with approximately 50% of condyles in the central position and the remaining 50% distributed between anterior and posterior positions. These findings suggest that condylar position is influenced by multiple factors, and relying solely on condylar position to determine disc displacement status has inherent limitations.
- Several limitations should be acknowledged in this part of the study. First, the cross-sectional design precludes determination of the causal relationship between condylar dimensional reduction and disc displacement—whether reduced condylar dimensions increase the risk of disc displacement, or whether disc displacement leads to secondary condylar bone resorption—and

longitudinal studies are needed to clarify this. Second, we did not systematically evaluate degenerative bony changes of the condyle (such as erosion or osteophytes), which may be closely associated with the degree of disc displacement. Third, the assessment of condylar position relied on closed-mouth oblique sagittal MRI images, representing a static evaluation that cannot reflect dynamic positional changes during joint movement. Future studies could incorporate dynamic MRI or kinematic MRI techniques to explore positional changes of the condyle during functional movements and their relationship with TMD subtypes. Additionally, future research should combine longitudinal follow-up data to investigate the temporal trends of condylar dimensional changes and their association with the progression of clinical symptoms.

Conclusion

- These findings provide evidence-based imaging references for clinical assessment of TMD subtypes. MRI assessment of condylar long and short axes offers objective and reproducible parameters that can complement clinical examination in the evaluation of disc displacement. Future prospective longitudinal studies are warranted to elucidate the causal relationship between disc displacement and condylar bony remodeling, and to further validate the clinical utility of these imaging markers in guiding treatment decisions.

Declarations

Ethics approval and consent to participate

This retrospective study was conducted in accordance with the Declaration of Helsinki and approved by the First Affiliated Hospital of University of Science and Technology of China (IRB No: 2026-RE-295). The requirement for written informed consent was waived due to the retrospective nature of the study and the use of anonymised radiographic data.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request, subject to appropriate ethical approval and data sharing agreements.

Competing interests

The authors declare that they have no competing interests.

Funding

Authors' contributions

Ying Liu conceived the study design, supervised data analysis, and critically revised the manuscript. Mengqiu Liu collected and analyzed the imaging data, performed the statistical analysis, and drafted the manuscript. Pan Jiang contributed to clinical data acquisition and interpretation. All authors reviewed, revised, and approved the final manuscript.

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Figures

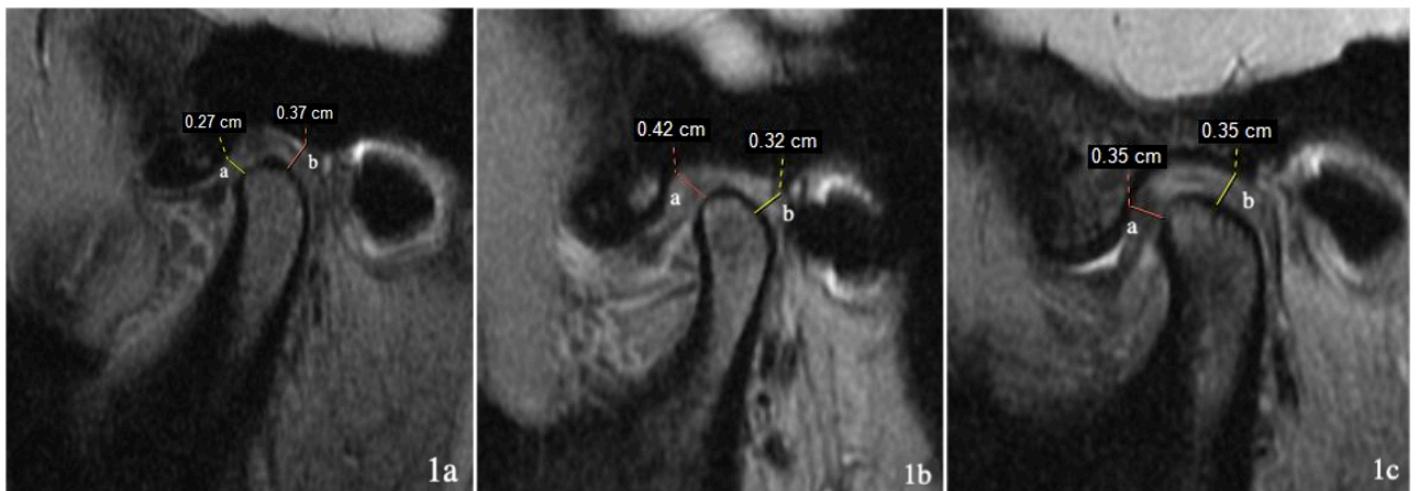


Figure 1

On the closed-mouth oblique sagittal view of the temporomandibular joint (TMJ), the condylar position can be determined based on the shortest distances between the anterior and posterior slopes of the condyle and the corresponding tangential lines of the articular fossa (denoted as a and b). The specific

measurements are illustrated in Figure 1a: 6a: anterior position ($a > b$); 1b: posterior position ($a < b$); 1c: neutral position ($a = b$).



Figure 2

The morphology of the condyle is classified into oval, flat, and beak-shaped types. The corresponding MRI findings are shown in Figure 2a (oval); 2b (flat); 2c (beak-shaped).

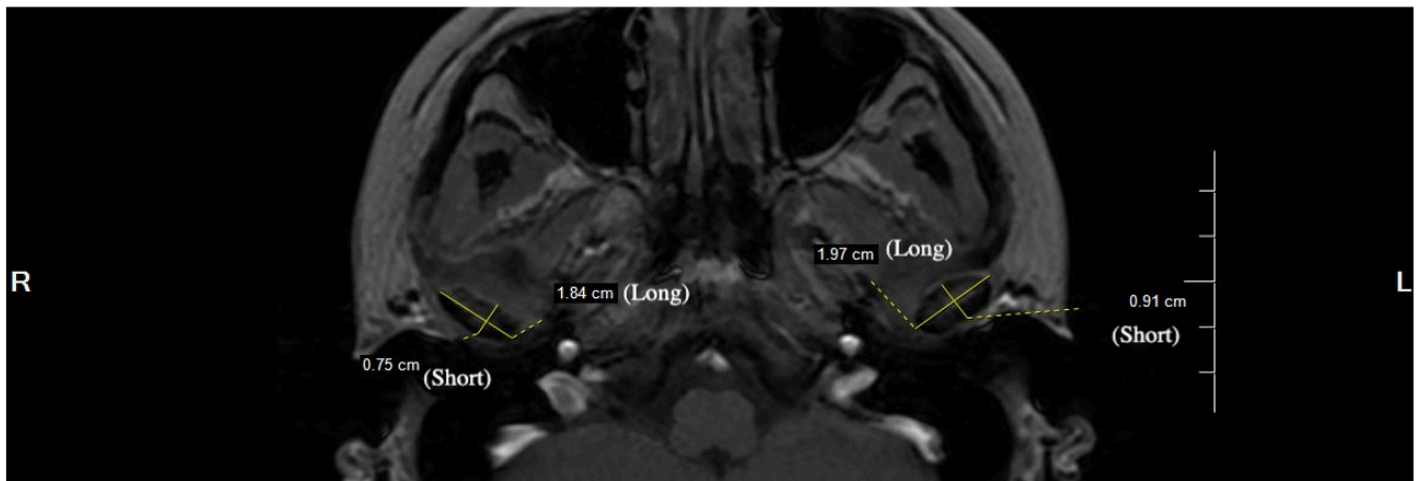


Figure 3

In the figure, “Long” refers to the long axis of the condyle; “Short” refers to the short axis of the condyle.