

Clinical Efficacy and Imaging Evaluation of Stabilization Splints in The Treatment of Adolescents with Temporomandibular Joint Osteoarthritis: A Retrospective Case Series

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Abstract

Background

Temporomandibular joint osteoarthritis (TMJ-OA) is a degenerative joint disorder characterized by condylar resorption that may impair mandibular growth and development in adolescents. Stabilization splints are widely used, but their effects on bone repair, growth, and disc position remain unclear. This study aimed to evaluate the clinical and imaging outcomes of stabilization splint therapy in adolescents with TMJ-OA.

Methods

This retrospective study included 48 adolescents (12 males, 36 females; mean age, 15.8 ± 1.8 years) with TMJ-OA treated with stabilization splints between January 2020 and December 2025. Clinical outcomes were assessed at baseline and after 1, 3, 6, and 12 months. Cone-beam computed tomography (CBCT) was performed at baseline and 6 months in all patients (80 affected condyles), and magnetic resonance imaging (MRI) was performed at baseline and 1 month in a subset of 15 patients (20 affected condyles). Main outcome measures included clinical symptoms, condylar morphology, and disc position. Paired t-test and McNemar test were employed to evaluate longitudinal changes in clinical symptoms.

Results

Significant improvements were observed for maximum mouth opening at T3 and T4, joint noises at T2 and T3, and spontaneous pain at T3 (all $p < 0.0125$). CBCT demonstrated cortical bone repair in 43.75% of affected condyles, with significant increases in anteroposterior, mediolateral, and height dimensions in repaired condyles. MRI showed no significant changes in disc displacement distance, disc length, or disc angle.

Conclusions

Stabilization splint therapy improved clinical symptoms and promoted condylar cortical bone repair in adolescents with TMJ-OA. However, its effects on disc repositioning and condylar growth were limited.

1. Introduction

Temporomandibular disorders (TMD) are a group of multifactorial conditions affecting the temporomandibular joint (TMJ), masticatory muscles, and associated structures [1, 2]. Among them, anterior disc displacement without reduction (ADDwoR) is a common and clinically significant subtype, manifesting with joint noises, pain, and restricted mandibular movement [2–6]. Generally, the anterior

displacement of the joint disc will alter the biomechanical environment within the joint, causing abnormal local stress on the condylar surface. Prolonged overloading may trigger adaptive remodeling, which can lead to condylar morphological changes and, in some cases, TMJ osteoarthritis (TMJ-OA) [6–8]. In adolescents, condylar bone resorption has been reported in up to 40.7% of cases [6, 9], and they often present with more severe erosion but milder pain than adults, which contributes to underdiagnosis and delayed treatment [10]. Given that adolescents are in a critical stage of growth and development, such destructive changes in bone tissue are particularly worthy of attention.

Treatment options for TMJ-OA include physical therapy, medicine intervention, occlusal splint therapy, and surgical procedures. Although surgical treatment has been shown to achieve better outcomes in adolescents by repositioning the disc and potentially preserving mandibular growth, conservative treatment often becomes the preferred choice for patients and their families due to fear of surgery. Among conservative modalities, occlusal splint therapy is one of the most widely used methods. Splints vary in material, thickness, and design, with individualized selection based on etiology and osteoarthritis classification. It achieves the purpose of relieving masticatory muscle spasm, reducing intra-articular pressure, and restoring the relationship between the articular disc and condyle by changing the position of the mandible and providing a stabilization contact point [11, 12]. It has been reported that in cases of myogenic temporomandibular disorders, occlusal splints can improve pain and function by 60% to 80% [13]. However, there is currently insufficient imaging evidence to confirm whether the alleviation of clinical symptoms is truly accompanied by actual improvement in the bony structure of the condyle. CBCT can clearly show degenerative changes such as bone spurs, sclerosis, and erosion of the condyle, while MRI is the gold standard for evaluating the position, shape of the articular disc, and joint effusion [14, 15]. Currently, most studies focus on the adult population, and there are few reports on the imaging comparison before and after stabilization splint therapy for adolescent TMJ-OA patients. There is a lack of systematic research that uses CBCT and MRI in combination to evaluate the outcome of condylar morphology and disc-mandible relationship.

This descriptive study reports the clinical efficacy of stabilization splints in treating TMJ-OA in adolescents. It also presents CBCT and MRI findings on morphological changes of the condyle and alterations in the articular disc-condyle relationship before and after treatment, and describes the observed role of stabilization splints in condylar adaptive remodeling, with the aim of providing descriptive imaging data for conservative management of adolescent TMJ-OA.

2. Materials and methods

2.1 Participants and treatment

This retrospective case series included adolescents aged 10–19 years who were diagnosed with TMJ-OA at the Department of Temporomandibular Joint [10], Affiliated Stomatological Hospital of Guangzhou Medical University, between January 2020 and December 2025 (Ethic number: LCYJ20250616006). TMJ-OA was diagnosed according to the Diagnostic Criteria for Temporomandibular Disorders and confirmed

by CBCT based on established imaging criteria [16, 17]. Patients were eligible if they had completed at least 3 months of follow-up after stabilization splint therapy. Patients with congenital craniofacial anomalies, previous maxillofacial trauma, prior TMJ surgery, or incomplete clinical or imaging records were excluded. During follow-up, no additional pharmacological, physiotherapeutic, orthodontic, or intra-articular treatments were administered. Clinical assessments were performed at baseline and at 1, 3, 6, and 12 months. CBCT examinations were obtained at baseline and 6 months, whereas MRI examinations were performed at baseline and 1 month in a subset of patients. Treatment compliance was assessed during follow-up visits. The treatment and follow-up procedures were based on the clinical protocol previously described by our group [6]. Given the retrospective, single-arm design, this study represents a case series aimed at describing outcomes and generating hypotheses, rather than establishing causal efficacy.

2.2 Clinical data collection

Demographic and clinical information was retrieved from the electronic medical records. The assessed clinical variables included joint noises, intermittent closed lock, spontaneous pain, joint tenderness, push-back mandibular test, mandibular opening pattern, maximum mouth opening (MMO), and masticatory muscle pain. Clinical assessments were performed using standardized clinical procedures described previously [6].

2.3 CBCT imaging analysis

CBCT scans were acquired using a standardized protocol (NewTom, Italy; 110 kV, automatic tube current modulation, 3.6 s exposure). Image analysis was performed using Greenlander software. Condylar morphology was quantified using the following parameters: anteroposterior (AP) and mediolateral (ML) diameters, condylar head height (CH), and condylar height (CL). Joint space was assessed by measuring the anterior, superior, and posterior clearances (**Supplementary Fig. 1**). Condylar position within the glenoid fossa was calculated using Pullinger's formula [18, 19]. The severity and spatial distribution of condylar cortical lesions were evaluated using the imaging scoring system of Ahmad et al. [20, 21] (**Supplementary Fig. 2**).

2.4 MRI imaging analysis

MRI examinations of the bilateral TMJs were performed in closed- and open-mouth positions using a 1.5-T scanner. T1-weighted, T2-weighted, and proton-density-weighted images were acquired using standardized TMJ imaging protocols. Disc status was evaluated according to disc position, morphology, displacement distance, and disc length. Joint effusion was graded on T2-weighted images according to the extent of high-signal fluid within the joint space. The MRI assessment protocol was based on previously published methods [22] and our group's established imaging procedures [23] (Fig. 1).

2.5 Statistical analysis

All statistical analyses were performed using SPSS version 28.0 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean $\pm$ standard deviation (SD). Shapiro-Wilk test was used to determine data distribution. For longitudinal clinical outcomes measured repeatedly at multiple time points, the patient was defined as the statistical unit of analysis ($n = 48$). Bilateral condylar cortical scores were aggregated to calculate a total condylar burden score for each participant, representing the cumulative osteoarthritic disease load at the patient numbers. This approach acknowledges that bilateral involvement constitutes a greater total pathological burden than unilateral involvement, and ensures that the degrees of freedom accurately reflect the number of subjects. For CBCT parameters, each affected condyle was treated as an independent unit ($n = 80$), classified by treatment response. For MRI parameters, analyses were similarly conducted at the condylar sides ($n = 20$). For comparisons of pre- and post-treatment data, continuous variables compared using paired t-tests. Categorical variables are reported as frequencies and percentages, and changes over time were assessed using the McNemar test. For clinical outcomes measured at multiple time points (baseline, T1, T2, T3, T4), a Bonferroni correction was applied to account for four pairwise comparisons versus baseline, and a two-tailed $p < 0.0125$ was considered statistically significant. For CBCT and MRI parameters, which were evaluated only before and after treatment (one comparison), the significance level was set at $p < 0.05$.

3. Results

3.1 Baseline

A total of 48 patients with adolescent TMJ-OA were included in this study, of which 12 (25.0%) were males and 36 (75.0%) were females. The age of participants ranged from 10 to 19 years, with a mean age of 15.840 ± 1.824 years. A clinical examination was conducted at the time of consultation, which revealed signs of TMD, including joint tenderness, noises, intermittent closed lock, or limited mouth opening in 87.5% of the patients (42/48). Baseline CBCT of the 80 affected condyles showed mean values of 17.433 ± 2.705 mm for anteroposterior diameter, 6.223 ± 1.361 mm for mediolateral diameter, 5.216 ± 1.598 mm for condylar head height, and 17.833 ± 3.327 mm for condylar height. MRI data from 15 patients (20 affected condyles) showed that disc morphology was predominantly type IV (60.0%, 12 sides), while types II and III each accounted for 20.0% (4 sides). Joint effusion was predominantly mild (75.0%, 15 sides), with no effusion in 10.0% (2 sides) and severe effusion in 15.0% (3 sides). The angle θ between the condylar vertex and the posterior band of the articular disc, mean disc length and displacement distance were $106.781^\circ \pm 14.507^\circ$, 6.930 ± 1.400 mm and 8.860 ± 2.008 mm, respectively (Fig. 2).

3.2 Analysis of clinical data (pre and post treatment)

Compared with baseline (44.396 ± 8.066 mm), stabilization splint treatment significantly increased MMO at T3 (46.703 ± 7.720 mm, $p = 0.001$) and T4 (48.963 ± 7.293 mm, $p < 0.001$), with no significant differences at T1 or T2. The incidence of joint noise decreased from 64.6% at baseline to 35.7% at T2 and 35.1% at T3, and the decreases were significant at T2 ($p = 0.001$) and T3 ($p = 0.002$) but not at T1 or

T4. For spontaneous pain, the incidence decreased from 31.3% at baseline to 8.1% at T3, with a significant reduction at T3 ($p = 0.004$), while no significant changes were found at T1, T2, or T4. No statistically significant changes were observed for intermittent closed lock (ICL), muscle tenderness, joint tenderness, or the push-back mandibular test at any time point (Table 1).

Table 1

Changes in clinical symptoms of adolescent TMJ-OA patients before and after different treatment cycles

Treatment cycle		T0 (n = 48)	T1 (1 months) (n = 32)	T2 (3 months) (n = 28)	T3 (6 months) (n = 37)	T4 (12 months) (n = 27)
Maximum Mouth Opening (mm)	Mean $\pm$ SD	44.396 $\pm$ 8.066	47.563 $\pm$ 7.782	45.500 $\pm$ 8.395	46.703 $\pm$ 7.720	48.963 $\pm$ 7.293
	t	/	-2.493	-1.657	-3.618	-4.528
	p	/	0.018	0.109	0.001*	< 0.001*
Joint noises	Positive	31	13	10	13	8
		64.6%	40.6%	35.7%	35.1%	29.6%
	p	/	0.039	0.001*	0.002*	0.065
Intermittent closed lock (ICL)	Positive	2	0	2	1	1
		4.2%	0.0%	7.1%	2.7%	3.7%
	p	/	1.000	1.000	1.000	1.000
Spontaneous pain	Positive	15	5	4	3	4
		31.3%	15.6%	14.3%	8.1%	14.8%
	p	/	0.375	0.039	0.004*	0.289
Muscle pain	Positive	4	2	2	0	0
		8.3%	6.3%	7.1%	0.0%	0.0%
	p	/	1.000	1.000	0.250	0.500
Joint tenderness	Positive	11	0	0	2	1
		22.9%	0.0%	0.0%	5.4%	3.7%
	p	/	0.031	0.031	0.016	0.070
Push-back mandibular test	Positive	6	1	0	0	1
		12.5%	3.1%	0.0%	0.0%	3.7%
	p	/	1.000	0.500	0.250	0.250

The Paired t-test and McNemar test were used to assess statistical differences between baseline (T0) and each subsequent time point. * Indicates $p < 0.0125$.

3.3 Attrition analysis

The attrition analysis revealed that completers ($n = 37$) and dropouts ($n = 11$) at T3 were comparable in T0 characteristics, including age, gender, and most clinical symptoms ($p > 0.05$). A significant difference was observed in the prevalence of MMO ($p = 0.016$), with a baseline value being higher in the withdrawal group. No other significant baseline differences were detected. (**Supplementary Table 1**).

3.4 Analysis of CBCT imaging

3.4.1 Bone regression of the condyle before and after treatment

Adolescent patients with TMJ-OA who received stabilization splint therapy were divided into three groups according to the change in condylar bone score from baseline to post-treatment: the improvement group (score decreased), the unchanged group (score unchanged), and the deterioration group (score increased). The affected condyles showed improvement in 43.75% (35 sides), stability in 28.75% (23 sides), and deterioration in 27.50% (22 sides) (Fig. 3a). The condylar position in the joint fossa was calculated using Pullinger's formula. In the improvement group, the condylar position changed significantly before and after treatment ($p = 0.046$), with a forward shift observed (Fig. 3b).

3.4.2 Condylar measurements of the affected side in different treatment time point

For the improvement group, the anteroposterior condylar diameter, the mediolateral condylar diameter, the condylar head height, and the condylar height of the affected side increased after treatment ($p < 0.05$); for the unchanged group, the anteroposterior condylar diameter and the condylar height of the affected side increased after treatment but the mediolateral condylar diameters and the condylar head height of the affected side decreased, but none were statistically significant ($p > 0.05$); for the deterioration group, there was a decrease in all indicators on the affected side after treatment ($p < 0.05$) (Table 2, Fig. 3c).

Table 2
Comparison of condylar measurements on the affected side before and after treatment in adolescent TMJ-OA patients of different groups

	Clusters	Anteroposterior condylar diameter	Mediolateral condylar diameter	Condylar head height	Condylar height
Improvement (n = 35)	Pre-treatment	17.598 ± 2.999	6.418 ± 1.255	5.251 ± 1.616	17.851 ± 4.491
	Post-treatment	17.843 ± 2.985	6.597 ± 1.306	5.605 ± 1.450	18.535 ± 4.278
	Δ	0.245 ± 0.449	0.179 ± 0.286	0.355 ± 0.590	0.684 ± 1.040
	<i>p</i>	0.003*	0.001*	0.001*	< 0.001*
No change (n = 23)	Pre-treatment	17.978 ± 2.514	6.596 ± 1.114	5.461 ± 1.674	18.826 ± 2.911
	Post-treatment	18.096 ± 2.766	6.586 ± 1.161	5.458 ± 1.463	19.119 ± 2.683
	Δ	0.118 ± 0.561	-0.010 ± 0.367	-0.003 ± 0.714	0.292 ± 1.020
	<i>p</i>	0.323	0.896	0.985	0.183
Deterioration (n = 22)	Pre-treatment	16.300 ± 2.596	6.002 ± 1.761	4.700 ± 1.290	16.665 ± 2.630
	Post-treatment	15.837 ± 2.594	5.812 ± 1.766	4.255 ± 1.535	16.097 ± 2.877
	Δ	-0.464 ± 0.643	-0.189 ± 0.372	-0.445 ± 0.534	-0.568 ± 1.162
	<i>p</i>	0.003*	0.026*	0.001*	0.032*

Paired t-test was used to assess statistical differences between baseline (T0) and the 6-month follow-up (T3) time point. * Indicates $p < 0.05$.

3.5 Analysis of MRI imaging

After treatment, 1 side (5.0%) with ADDwoR transformed into ADDwR, while the remaining 19 sides showed no significant change in displacement type. There were 2 sides (10.0%) changed from severe to moderate effusion (Fig. 4). No statistically significant differences were observed for any index before and after treatment ($p > 0.05$). Specifically, the angle θ between the condylar vertex and the posterior band of the articular disc increased by 1.662 ± 10.916 ($p = 0.504$); the average disc length decreased by 0.194 ± 0.596 ($p = 0.162$); and the average disc displacement distance increased by 0.311 ± 1.201 ($p = 0.264$) (Table 3).

Table 3
Comparison of MRI measurements of the affected condyle before and after treatment in adolescent TMJ-OA patients

Pre-treatment	θ	Disc length	Disc displacement distance
	106.781 ± 14.507	6.930 ± 1.400	8.860 ± 2.008
Post-treatment	108.443 ± 13.651	6.736 ± 1.629	9.170 ± 1.919
Δ	-1.662 ± 10.916	0.194 ± 0.596	-0.311 ± 1.201
t	-0.681	1.457	-1.151
p	0.504	0.162	0.264

A paired t-test was used to evaluate the statistical difference between the pre-treatment and post-treatment periods. * Indicates $p < 0.05$.

4. Discussion

This retrospective case series evaluated the clinical and imaging outcomes of stabilization splint therapy in adolescents with TMJ-OA using CBCT and MRI. The findings suggest that stabilization splint therapy was associated with improvements in clinical symptoms and condylar cortical bone repair, whereas its effects on condylar growth and the disc-condyle relationship appeared limited. As an observational study without a control group, these findings should be interpreted as descriptive evidence rather than proof of treatment efficacy.

4.1 Improvement of clinical symptoms by stabilization splints

The results of this study showed that stabilization splint treatment significantly improved the MMO of adolescent TMJ-OA patients, especially at 6 months (T3) and 12 months (T4), with a significant increase compared to the baseline ($p < 0.0125$), indicating sustained improvement in mandibular function. This result is consistent with previous studies, where the stabilization splint adjusts the occlusal relationship and reduces intra-articular pressure to improve the condylar-disc relationship and normalize the mandibular movement trajectory [24, 25].

In terms of joint noises and spontaneous pain, symptoms significantly improved at 6 months ($p < 0.0125$), suggesting reduced joint discomfort and improved patient-reported symptoms. Relevant studies have shown that occlusal splints can reduce joint noise and spontaneous pain by increasing the space for articular disc movement, restoring occlusal balance, and reducing joint load [26]. Zhang et al. [27] found that for patients with joint clicking, applying a stabilization splints for 6–8 months, the treatment effect was in nearly two-thirds of the patients, and the symptoms of patients disappeared or were relieved after treatment. However, for intermittent closed lock, muscle pain, joint tenderness, and

push-back mandibular test, this study did not observe statistically significant improvements ($p > 0.0125$), which may be related to the limited sample size, insufficient treatment time, or the limited intervention ability of the stabilization splint on myogenic symptoms. Some studies also pointed out that the treatment effect of simple occlusal splint therapy on muscle pain is limited, and physical therapy or drug intervention is needed to improve muscle pain symptoms [11, 28].

Most adolescents tolerate stabilization splints well [29]; however, prolonged use may result in irreversible occlusal changes such as anterior open bite. Therefore, splint therapy is generally limited to 3–6 months or followed by definitive occlusal adjustment, consistent with previous reports [24, 30, 31].

4.2 Effects of stabilization splints on condylar bone repair

In the present study, stabilization splint therapy was associated with improvement in the condylar cortical bone score in 43.75% of affected condyles, while 28.75% remained unchanged and 27.50% deteriorated. This indicates that splints may relieve biomechanical overload and promote limited bone repair, likely by reducing intra-articular pressure and optimizing occlusal force distribution [32–34].

Nevertheless, the overall rate of cortical repair remained modest. One possible explanation is that most patients presented with ADDwoR, in which persistent disc displacement continues to alter joint biomechanics and limits the biological environment required for complete bone regeneration. Because stabilization splints primarily reduce joint loading rather than restore the normal disc-condyle relationship, their capacity to promote extensive bone repair is likely to be inherently limited.

In contrast, Dong et al. [35] reported new bone formation in 70.3% of patients after arthroscopic disc repositioning, reaching 94.3% in those aged 10–15 years. These findings underscore that restoration of the disc-condyle relationship may provide greater regenerative potential than stabilization splint therapy alone.

4.3 Effects of stabilization splints on condylar growth and development

In the improvement group, the anteroposterior diameter, internal and external diameters, condylar head height, and condylar height of the condyle all significantly increased after treatment ($p < 0.05$), suggesting that stabilization splints may reduce abnormal joint loading and provide a favorable biomechanical environment for condylar remodeling. The position of the condyle in the joint fossa also showed a forward trend ($p < 0.05$), further supporting that the stabilization splint may help improve the distribution of joint load.

Although some morphological indicators of the condyle in the improvement group significantly increased, this study lacks sufficient evidence to show that the stabilization splints can directly promote the growth and development of the condyle. Because the participants were adolescents undergoing active craniofacial growth, part of the observed morphological changes may reflect physiological development rather than treatment alone. Previous studies have similarly suggested that stabilization

splints may facilitate condylar remodeling and cortical repair rather than directly stimulate condylar growth [36, 37].

In contrast, studies evaluating surgical disc repositioning have consistently reported substantially greater increases in condylar height, volume, and new bone formation than conservative splint therapy. Dong et al. [38] reported that in patients who underwent surgical treatment, condylar height and volume increased significantly more than in those receiving conservative occlusal splint therapy. Sun et al. [39] reported that after open suturing surgery, condylar height increased by 1.42–2.83 mm, markedly higher than the changes observed with conservative occlusal splint treatment in the present study. Similarly, another study found that 70.3% of patients developed new bone after arthroscopic surgery, with the highest rate (94.33%) in those aged 10–15 years [35]. Collectively, these findings suggest that restoration of the disc-condyle relationship may provide a stronger biological stimulus for condylar growth than stabilization splint therapy alone.

Therefore, stabilization splints should be regarded primarily as a conservative treatment that facilitates symptom relief and condylar remodeling rather than a therapy capable of promoting substantial condylar growth. For adolescents with severe condylar resorption or progressive deformity, treatment decisions should be individualized according to growth potential, disease severity, and the expected benefits of conservative versus surgical intervention.

4.4 The effect of stabilization splints on articular disc and disc-condyle relationship

MRI results showed that after treatment, the position, morphology, degree of joint effusion, and displacement distance of the articular disc did not significantly change ($p > 0.05$), suggesting that the stabilization splint has limited improvement effect on the soft tissue of the articular disc. Notably, one side with Type II ADDwoR (biconcave shape with mild posterior band thickening or slight folding) converted to ADDwR after treatment. Although this change did not reach statistical significance, we speculate that for discs with less severe folding, the splint may have facilitated this conversion by reducing condylar load and masticatory muscle spasm, thereby increasing joint space and relieving mechanical entrapment of the disc. For the remaining joints that did not improve, the lack of response may be attributed to the fact that most patients had already developed advanced structural changes such as disc folding and deformation (Type IV). Unlike anterior repositioning splints, stabilization splints primarily reduce joint loading rather than mechanically recapturing the displaced disc, which explains the limited MRI changes observed [40]. Therefore, while it may alleviate symptoms and create a favorable environment for bone repair, it cannot reverse established disc displacement, especially in cases with advanced disc deformation.

In contrast, more favorable structural outcomes have been reported with disc-repositioning interventions. In adult patients with ADDwoR, manual reduction combined with anterior repositioning splints achieved a structural repositioning rate of 77.1% on MRI after 6 months [41], suggesting that early disc recapture may be more effective than stabilization splint monotherapy in improving the disc-condyle

relationship. Furthermore, surgical disc repositioning has been shown to restore disc length and improve the disc-condyle relationship, whereas the combination of occlusal splint and arthrocentesis fails to prevent progressive disc degeneration [42]. Collectively, these findings suggest that invasive or disc-repositioning procedures may be more effective for patients with advanced disc deformation.

4.5 Attrition analysis and potential bias

In the attrition analysis, we observed that patients who dropped out by the T3 visit had a significantly higher baseline maximum mouth opening (MMO) compared to those who completed the 6-month follow-up (49.45 ± 7.81 mm vs. 42.89 ± 7.60 mm, $p = 0.016$). This difference may reflect that patients with milder mandibular hypofunction were more likely to discontinue treatment, possibly due to lower perceived need or greater satisfaction with early symptom relief. The higher baseline MMO among dropouts suggests a potential overestimation of treatment effect because these patients had less room for improvement. However, because the primary MMO analysis (**Supplementary Table 1**) included only completers at each time point, the observed significant improvements at T3 and T4 are based on patients who remained in the study and are unlikely to be biased by the dropout pattern. Nonetheless, the generalizability of the findings to patients with higher baseline MMO remains uncertain.

4.6 Limitations

This study has several limitations. First, its retrospective design and relatively small sample size limit the strength and generalizability of the findings. Second, MRI analyses were performed in only a subset of patients, reducing the statistical power to detect disc-related changes. Third, the absence of a control group makes it difficult to distinguish treatment-related effects from normal adolescent growth. Finally, longer-term prospective multicenter studies with larger cohorts are needed to validate these findings and determine the long-term effectiveness of stabilization splint therapy.

5. Conclusions

- 1) In this observational study, stabilization splint therapy was associated with improvements in the management of adolescent TMJ-OA symptoms. Significant improvements were observed in maximum mouth opening, joint noises and spontaneous pain, particularly after 6 months of treatment.
- 2) CBCT analysis showed a potential association between stabilization splint use and favorable changes in condylar cortical bone repair in a subset of patients, with significant increases in anteroposterior diameter, mediolateral diameter, and condylar height observed in the improvement group. However, there is insufficient evidence to suggest that stabilization splints directly promote condylar growth and development.
- 3) MRI did not show significant changes in disc position, disc length, or the angle θ between the condylar vertex and the posterior band of the articular disc, indicating that the stabilization splint had no significant effect on disc position.

Abbreviations

ADDwoR

Anterior Disc Displacement without Reduction

DC/TMD

Diagnostic Criteria for Temporomandibular Disorders

ICL

Intermittent Closed Lock

MMO

Maximum Mouth Opening

TMD

Temporomandibular Disorders

TMJ

Temporomandibular Joint

TMJ-OA

Temporomandibular Joint Osteoarthritis

CBCT

Cone-beam computed tomography

MRI

Magnetic resonance imaging

ML

Mediolateral condylar diameter

AP

Anteroposterior condylar diameter

CH

Condylar head height

CL

Condylar height

T1WI

T1 weighted images

T2WI

T2 weighted images

PDWI

Proton-density weighted images

FOV

Field-of-view

Thk

thickness

SD

standard deviation

Declarations

7.1 Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the Affiliated Stomatology Hospital of Guangzhou Medical University (Approval number: LCYJ20250616006). Due to the retrospective nature of the study, the requirement for written informed consent was waived by the Ethics Committee of the Affiliated Stomatology Hospital of Guangzhou Medical University.

7.2 Consent for publication

Not applicable.

7.3 Availability of data and materials

The corresponding author **D.DS. Dr. Y. Zhang** had full access to the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. The data and material that support the findings of this study are available from the corresponding author upon reasonable request.

7.4 Competing Interests

The authors declare that they have no competing interests.

7.5 Funding

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7.6 Authors' contributions

L. Huang: Data collection, Writing–original draft, Formal analysis, Validation, Visualization, Funding acquisition; **Y. Lin:** Data collection, Writing–original draft, Funding acquisition, Conceptualization, Methodology, Writing – review & editing; **Z. Liu:** Data collection, Methodology, Software support; **Z. Liu:** Data collection, Methodology; **R. Zhang:** Data collection, Methodology; **Q. Zhang:** Project administration, Supervision, Writing – review & editing; **Y. Zhang:** Conceptualization, Methodology, Writing – review & editing; **A. Wu:** Formal analysis, Software support, Conceptualization, Methodology, Writing – review & editing; **W. Cao:** Funding acquisition, Conceptualization, Project administration, Supervision, Writing – review & editing.

7.7 Acknowledgements

Not applicable.

7.8 Clinical trial number

This study is a retrospective analysis; therefore, a clinical trial registration number is not applicable.

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Figures

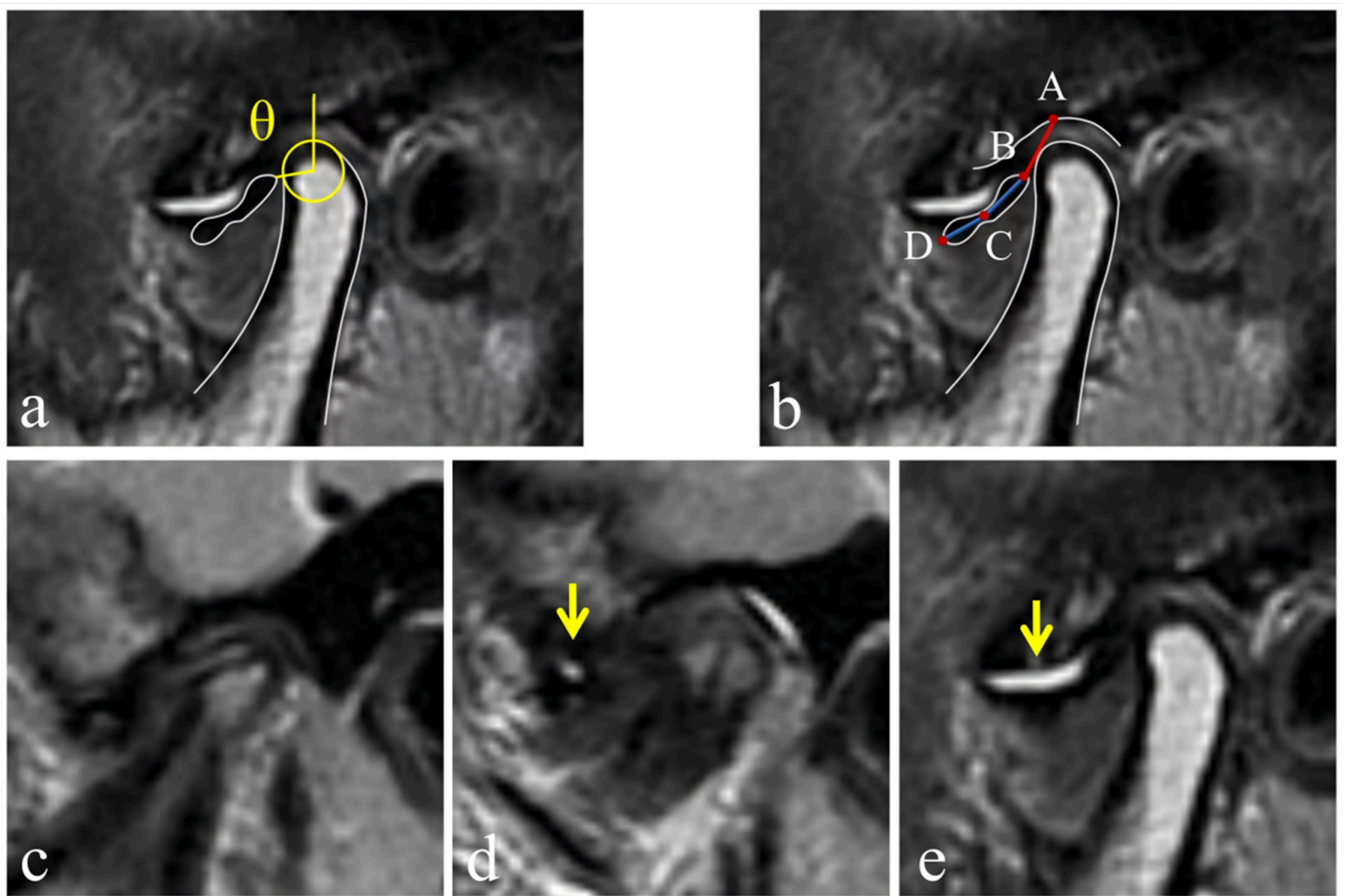


Figure 1

MRI measurements of temporomandibular joint disc and effusion. (a) Measurement of the angle θ between the condylar vertex and the posterior band of the articular disc. (b) Measurement of disc length and disc displacement distance. A: intersection of the condylar long axis with the condylar outline; B:

most posterior point of the disc; C: midpoint of the intermediate zone (if distinguishable); D: most anterior point of the disc. Displacement distance = AB. Disc length = BC + CD (or BD directly if zone C is indistinct). (c-e) Joint effusion in the upper joint space (arrows), with (c) no effusion, (d) mild effusion, and (e) severe effusion.

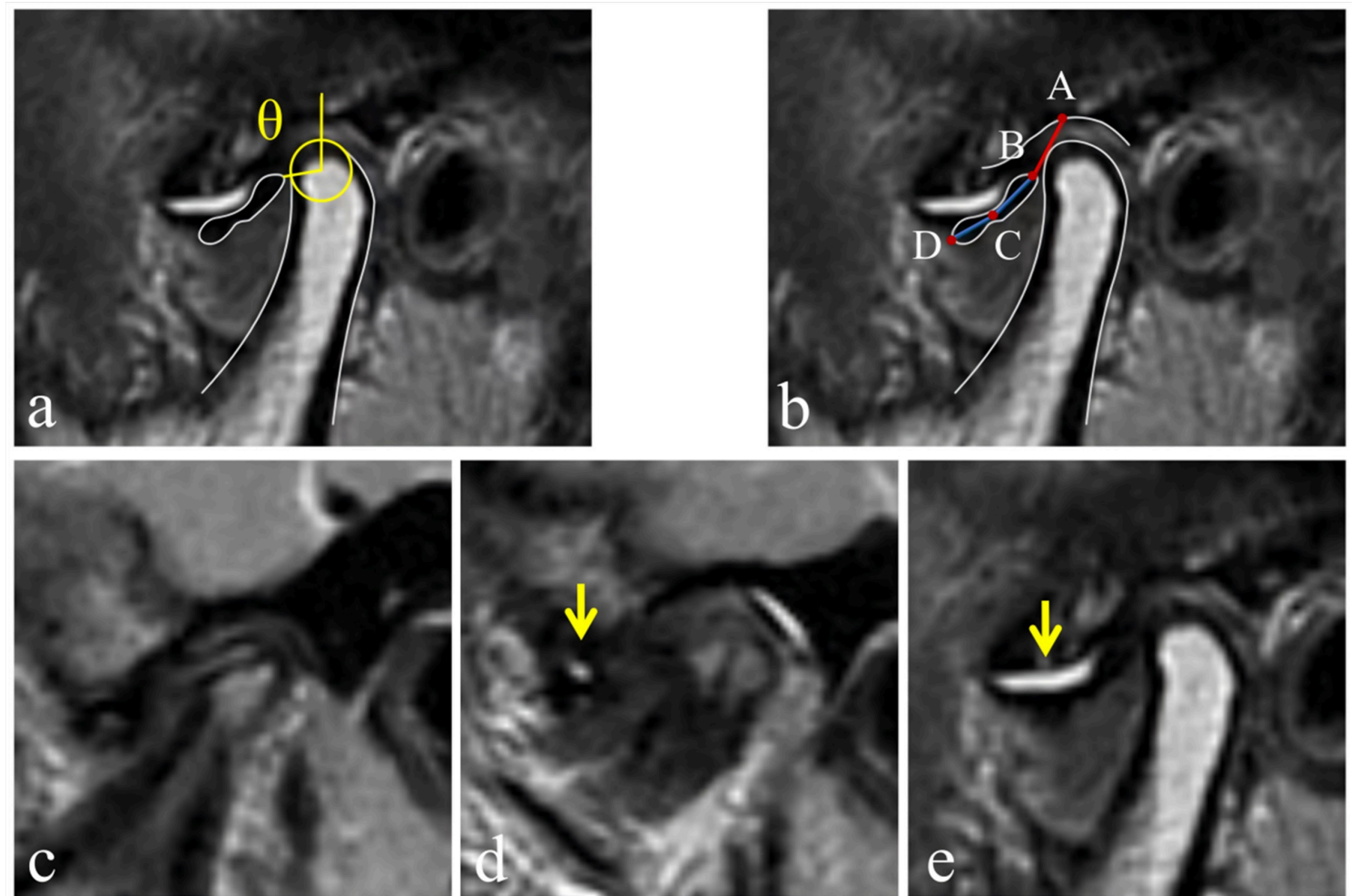


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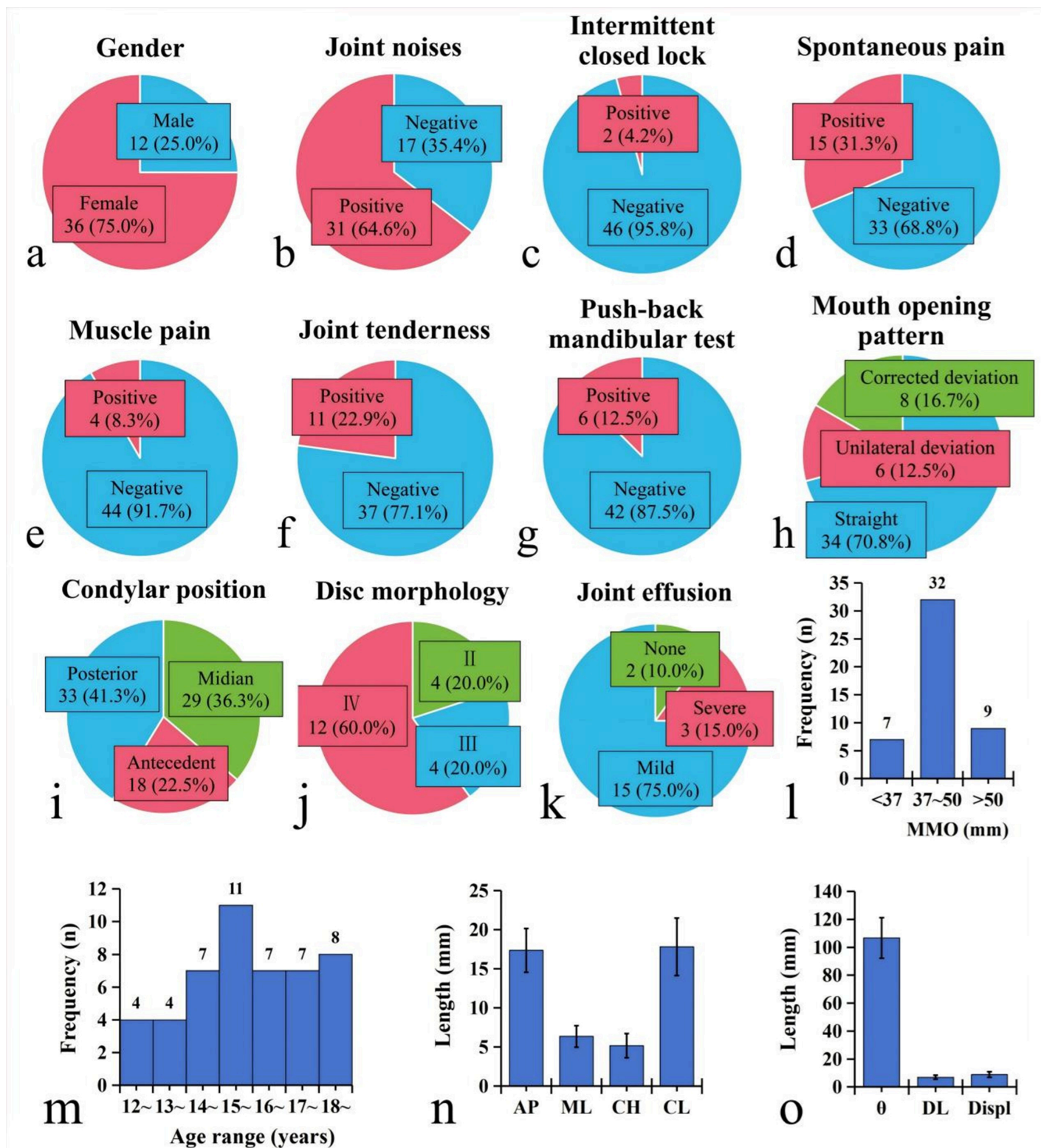


Figure 2

Distribution of demographic, clinical and imaging characteristics at baseline in adolescents with temporomandibular joint osteoarthritis (TMJ-OA) (n=48). (a) Gender; (b) Joint noises; (c) Intermittent closed lock; (d) Spontaneous pain; (e) Muscle pain; (f) Joint tenderness; (g) Push-back mandibular test; (h) Mouth opening pattern; (i) Condylar position (n=80); (j) Disc morphology (n=20); (k) Joint effusion (n=20); (l) Maximum mouth opening (MMO) distribution; (m) Age distribution; (n) Morphometric

parameters of the condyle (AP: Anteroposterior condylar diameter; ML: Mediolateral condylar diameter; CH: Condylar head height; CL: Condylar height) (n=80); (o) Joint disc-related measurement parameters (DL: Disc length; Displ: Disc displacement distance) (n=20).

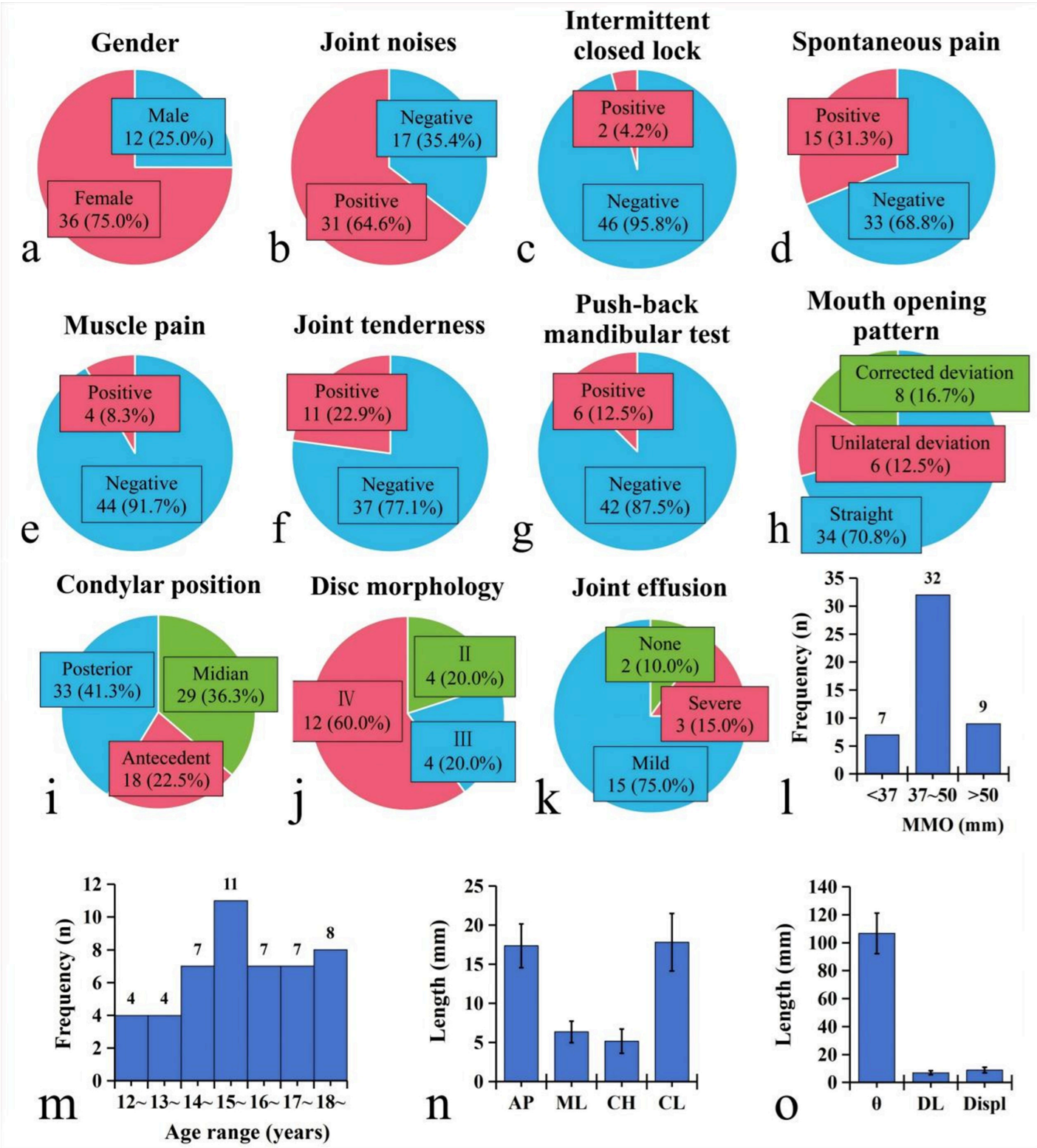


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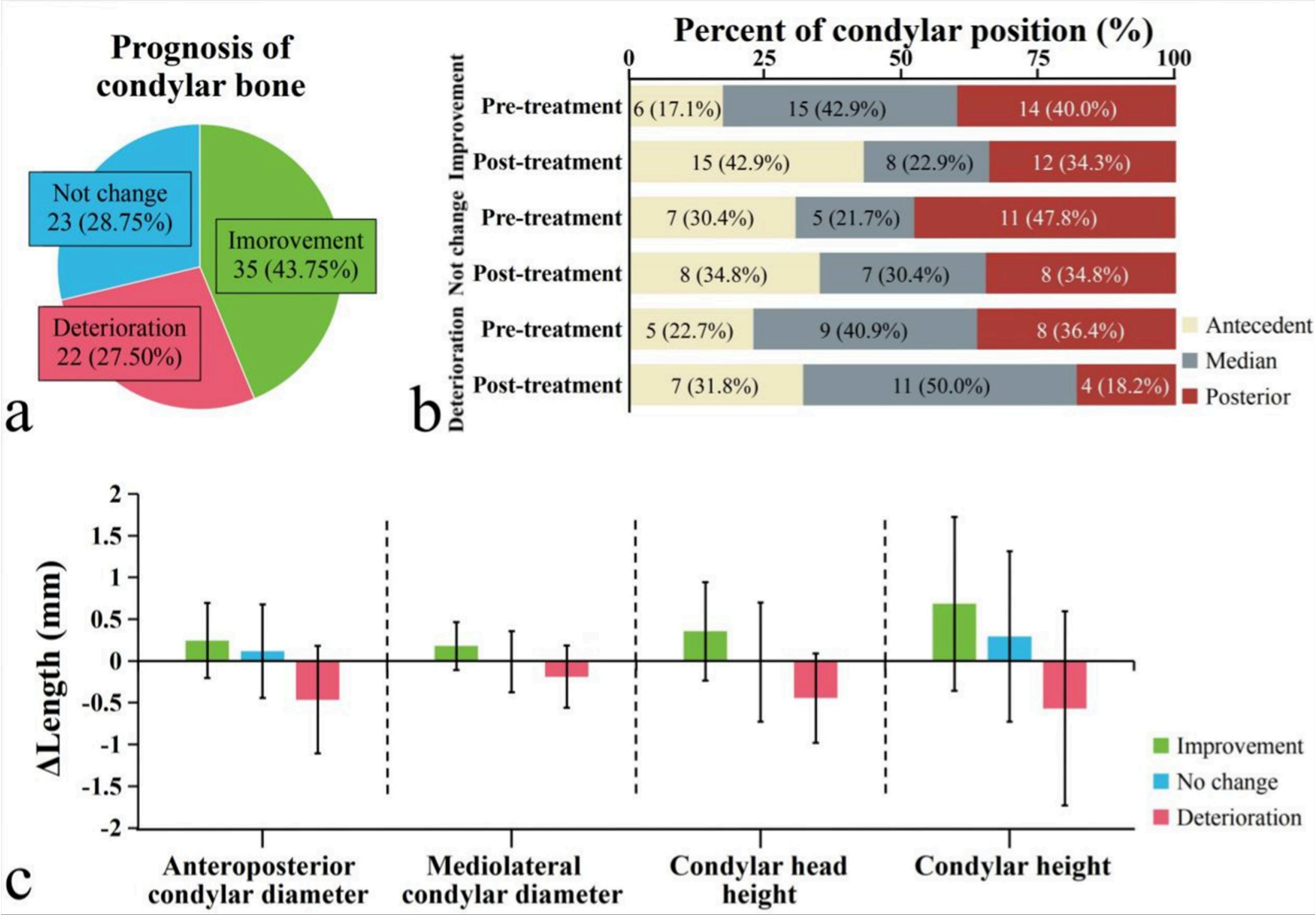


Figure 3

Condylar bone prognosis and condylar position changes after stabilization splint treatment. (a) Distribution of condylar bone prognosis groups (improvement, no change, deterioration) after stabilization splint treatment in adolescent temporomandibular joint osteoarthritis (TMJ-OA) patients (n = 80 affected condyles). (b) Comparison of condylar position within the articular fossa (anterior, central, posterior) before and after treatment, stratified by prognosis groups. (c) Changes in condylar morphometric measurements before and after treatment in different prognosis groups, including

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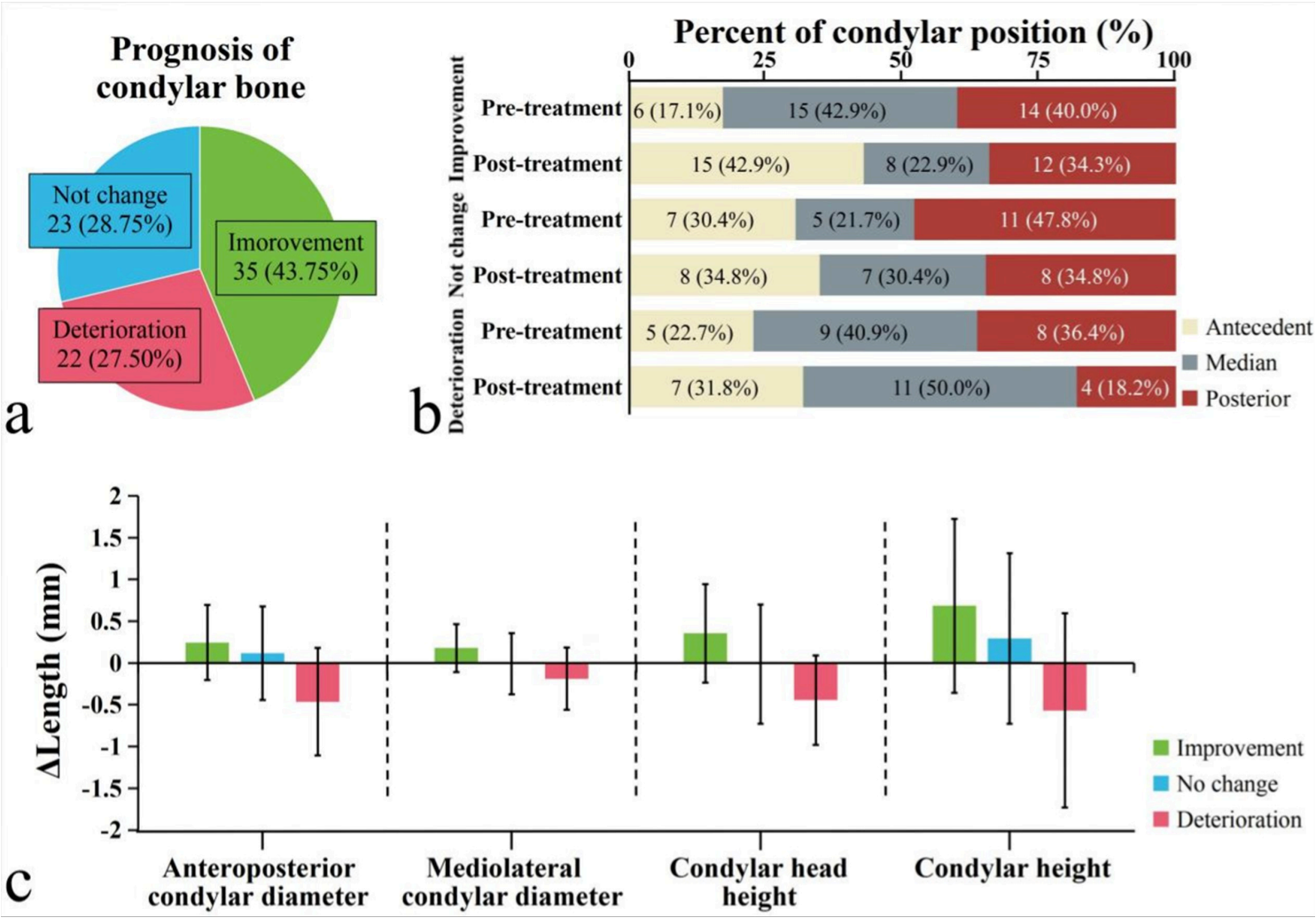


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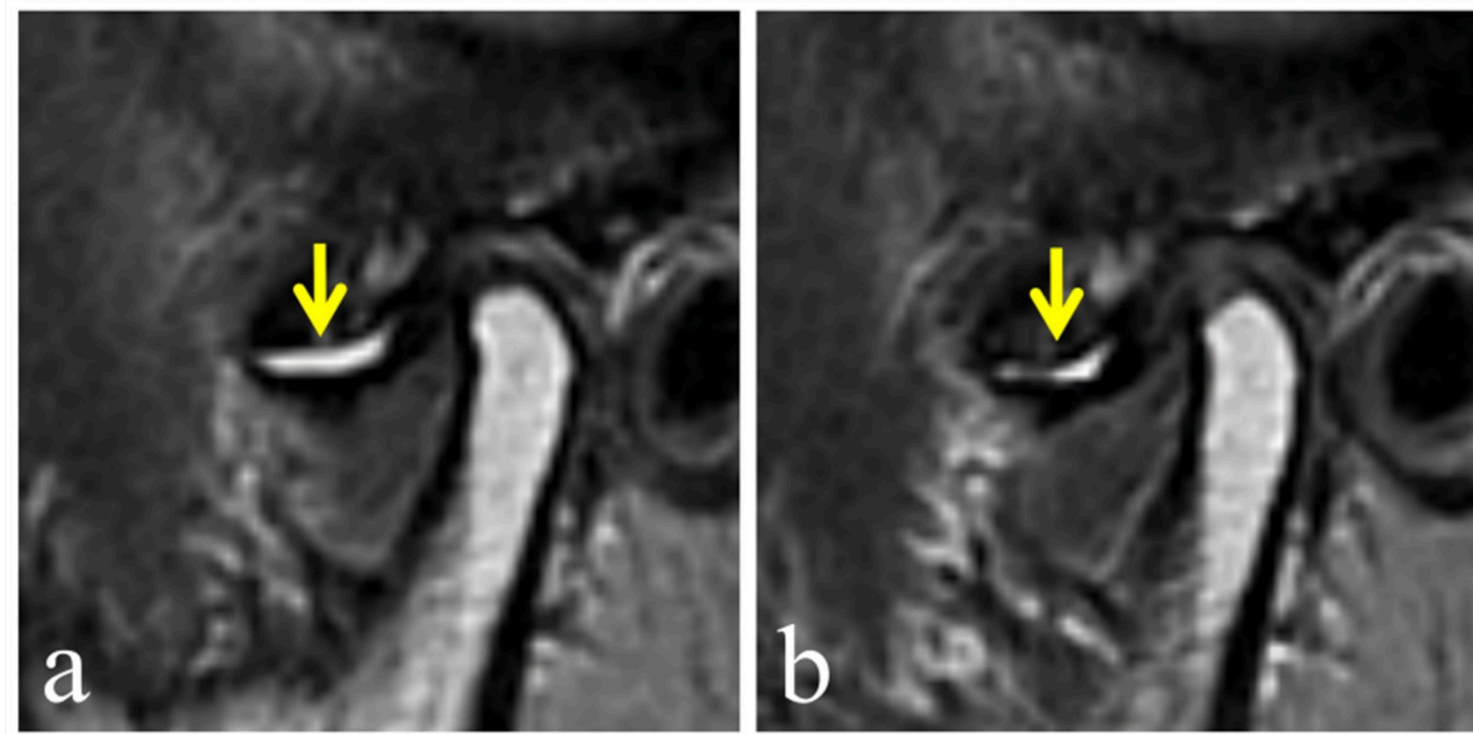


Figure 4

MRI images of joint effusion in the affected condyle before and after treatment in an adolescent patient with temporomandibular joint osteoarthritis (TMJ-OA). (a) Severe effusion before treatment (yellow arrow). (b) Moderate effusion after treatment (yellow arrow).

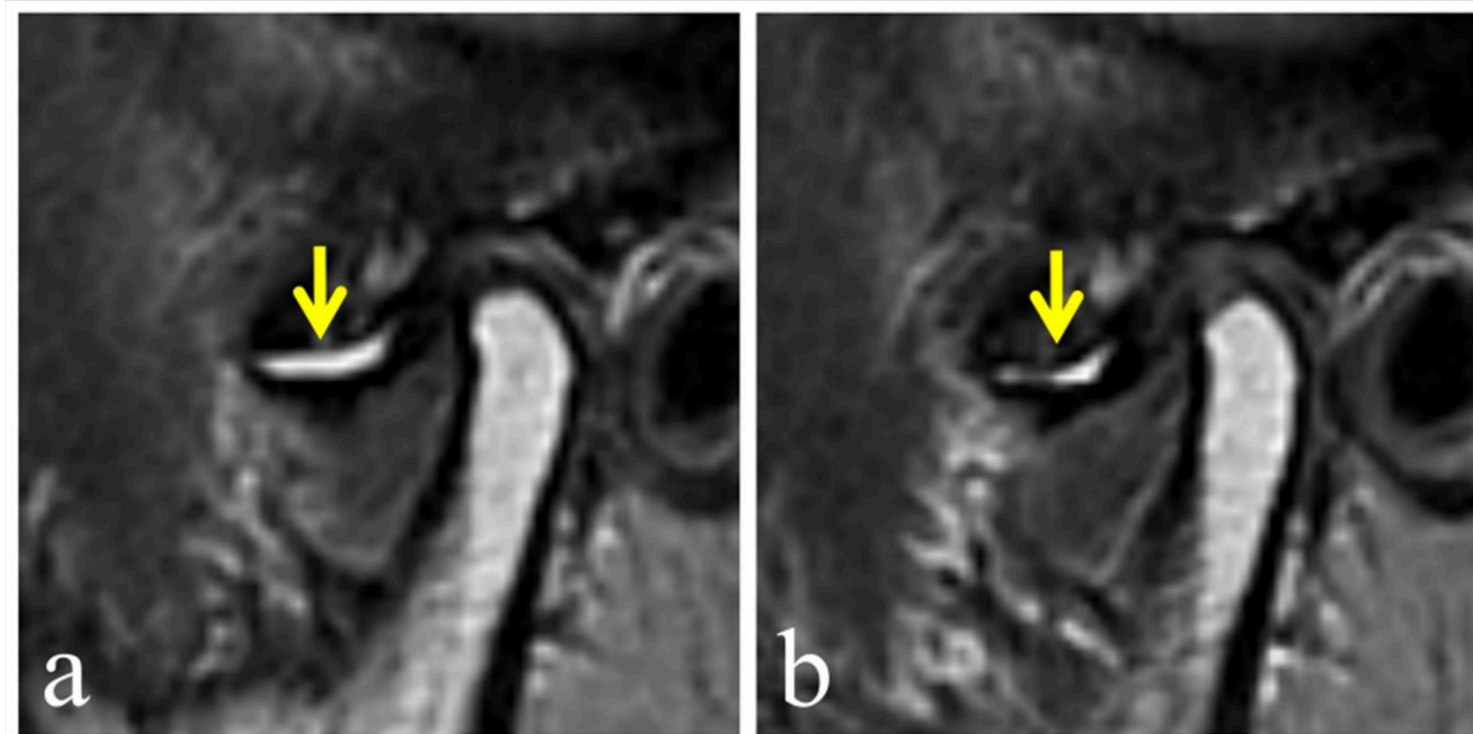


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