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Malocclusion Associated With Temporomandibular Joint Anterior Disc Displacement and Condylar Resorption in Adolescents: A Cross-Sectional Study

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Keywords: anterior disc displacement | condylar resorption | magnetic resonance imaging | malocclusion | temporomandibular disorders | temporomandibular joint

ABSTRACT

Background: Anterior disc displacement (ADD) is the most common type of temporomandibular joint (TMJ) internal derangement and may lead to condylar resorption (CR) during the adolescence period, but the specific malocclusion associated with ADD and CR remains unclear.

Objective: This study aimed to investigate the malocclusion associated with TMJ ADD and CR in adolescents.

Methods: This cross-sectional study included a clinical examination of adolescent patients aged 11–19 years. Magnetic resonance imaging (MRI) was used to diagnose both TMJ ADD and CR. Occlusal measurements were obtained and analysed using 3D scanning models.

Results: A total of 242 adolescent patients (53 males and 189 females) underwent TMJ MRI examination and dental occlusion scanning. The prevalence of anterior disc displacement without reduction (ADDwoR) was higher in females than that in males (OR > 1, $p < 0.05$). Deep overbite and posterior scissor bite were significantly associated with anterior disc displacement with reduction (ADDwR), while Angle Class II malocclusion, anterior open bite and posterior scissor bite were significantly associated with ADDwoR (OR > 1, $p < 0.05$). Adolescents with excessive overjet and anterior open bite were at a higher risk of CR (OR > 1, $p < 0.05$), whereas those with deep overbite and individual crossbite had a lower risk of CR (OR < 1, $p < 0.05$).

Conclusion: Our study offers valuable insights into the association between deep overbite, posterior scissor bite, Angle Class II malocclusion, anterior open bite, excessive overjet and the ADD and CR in adolescents. Orthodontic treatment for adolescent patients should prioritise the health of the TMJ, particularly for these types of malocclusion.

Guanlin Qu and Lingtong Bu contributed equally to this work.

1 | Introduction

Temporomandibular joint (TMJ) is the only bilateral linked joint in the human body that endures various pressures during daily oral activities [1]. Maintaining optimal loading is essential for preserving the health and function of TMJ [2–4]. Although the TMJ can temporarily adapt to abnormal loading, the adaptive capacity of condyle diminishes over time, potentially leading to the development of temporomandibular disorders (TMDs) including muscle disorders and internal derangement [5, 6]. Anterior disc displacement (ADD) is the most common type of TMJ internal derangement, which can impair mandibular movement, causing restricted mouth opening and reduced chewing ability [7, 8].

Occlusion is a complex system governed by neural signals from teeth, periodontal tissues and soft tissue receptors, with significant individual variability [9]. During the formation of adaptive occlusion, mechanical signals from peripheral receptors are transmitted to the central nervous system, which adjusts the position of mandible through intricate signalling pathways. This process results in changes in the relative position of the condyle and the glenoid fossa and alterations in stress distribution within the TMJ region, inducing condylar remodeling [9, 10].

The relationship between dental occlusion and TMD remains a topic of debate. Previous studies, which primarily focused on myogenic TMD patients, supported the multifactorial aetiology of TMD and suggested that occlusal factor was generally not significant [11]. However, in cases of TMJ internal derangement, Sato et al. [12] indicated that patients with ADD exhibited significantly lower occlusal contact area and occlusal force compared to the normal control group. Similarly, Taskaya et al. [13] found that non-working-side occlusion contact was statistically significant in ADD. Furthermore, malocclusion is widespread among adolescents and is recognised as a global public health concern [14]. During adolescence period, the progression of ADD may lead to condylar resorption (CR), which in turn may cause dentofacial deformities such as mandibular retrusion or deviation, severely impairing the oral-maxillofacial function and life quality of patients [15, 16]. Nonetheless, the specific malocclusion associated with ADD and CR remains unclear.

Accordingly, this study retrospectively analysed the malocclusion and TMJ MRI of 242 adolescent patients who experienced TMJ discomfort or had dentofacial deformities and a history of TMJ discomfort. The primary objective was to investigate the malocclusion associated with different stages of ADD with or without CR in adolescents. We wished to provide guidance for the prevention and treatment of ADD related to malocclusion and to reduce the impact on the oral-maxillofacial function and life quality of adolescents.

2 | Materials and Methods

2.1 | Ethics Approval and Consent to Participate

This study included adolescent patients aged between 11 and 19 years who sought care at the TMJ-Orthodontic Clinic of the Department of Oral Surgery at Shanghai Ninth People's Hospital from January 2021 to December 2023. The patients and their parents provided informed consent to participate in the study. The study received approval from the Human Research Ethics Committee of Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine (SH9H-2020-T7-1), and followed the principles outlined in the Declaration of Helsinki and the STROBE guidelines.

2.2 | Study Population

The inclusion criteria for this study were as follows: (1) chief complaint of TMJ discomfort or dentofacial deformities with previous TMJ discomfort, (2) aged between 11 and 19 years, and (3) permanent dentition.

The exclusion criteria were as follows: (1) contraindication to MRI, (2) history of TMJ surgery, (3) history of orthodontic, occlusal splint and prosthetic treatment, (4) history of craniofacial developmental disorders, craniofacial infection or traumatic injury, (5) systemic illness accompanied by cognitive or behavioural problem, (6) usage of medication such as antidepressant, muscle relaxant and nonsteroidal anti-inflammatory drug, and (7) refusal to participate in.

2.3 | Sample Size Calculation

To meet the recommended minimum of 10 occurrences per variable in multiple analysis, a sample size of at least 160 was required [17]. This study included 242 patients, providing a sufficient sample size.

2.4 | Clinical Examination

All patients underwent a routine examination at the TMJ-Orthodontic Clinic. During their first visit, patients provided a history of TMD or dentofacial deformities, and the doctor conducted an initial extraoral and intraoral examination. The examination items included maximum mouth opening, sounds during TMJ palpation when opening and closing the mouth (clicking or crepitus), and pain upon palpation of the muscles around the TMJ.

2.5 | Magnetic Resonance Imaging Examination and Evaluation

Previous studies showed that 30% of ADD patients did not exhibit TMJ symptoms [18]. Therefore, clinical symptoms alone are not sufficient for diagnosing ADD, and TMJ MRI is the gold standard for its diagnosis [19]. All participants in the study underwent TMJ MRI examination using a 3.0-T MRI scanner (Ingenia, Philips Healthcare Systems) and a six-channel dS Flex M surface coil receiver. Proton density-weighted imaging (PDWI) sequences were acquired in oblique sagittal planes with the mouth closed. T2-weighted images (T2WIs) were used in oblique coronal planes with closed mouth and oblique sagittal planes with the mouth open. The assessment followed the method developed by Ikeda [20, 21]. A

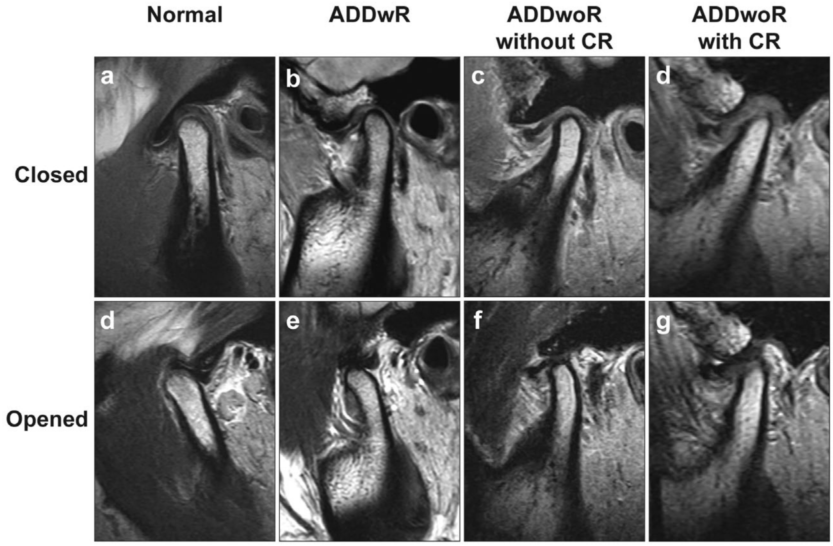

FIGURE 1 | Examples of patients based on MRIs. (a, e) Normal radiographic relationship between disc and condyle with the mouth closed and opened. (b, f) ADDwR with the mouth closed and opened. (c, g) ADDwoR without CR with the mouth closed and opened. (d, h) ADDwoR with CR with the mouth closed and opened.

normal disc position was determined when the posterior band was observed at the 12 o'clock position with the mouth closed (Figure 1a,e). If the posterior band was located at 10 o'clock or lower in the OSag images, it was classified as ADD. ADDwR was diagnosed when the disc was displaced anteriorly in relation to the posterior slope of the articular eminence and the condyle head, accompanied by disc reduction upon mouth opening (Figure 1b,f). ADDwoR was diagnosed when the disc was displaced anteriorly in relation to the posterior slope of the articular eminence and the condyle head, but without reduction of the disc upon mouth opening (Figure 1c,g). CR was assessed through the utilisation of MRI to observe the morphological characteristics of the condyle (Figure 1d,h). A TMJ specialist and a radiologist analysed each MRI image according to the above criteria. A third TMJ specialist reviewed the image if the two experts had different opinions.

2.6 | 3D Measurements of Occlusion

The dental occlusion and arches were digitally captured using a 3D scanner (3Shape, Copenhagen, Denmark), and measurements were subsequently conducted using the 3Shape software. This study evaluated malocclusion including Angle's classification, mandibular midline deviation, deep overbite, excessive overjet, anterior open bite, individual crossbite, edge-to-edge incisor, posterior scissor bite, posterior teeth absence and lingual tipping deep overbite.

The criteria for occlusion examination were based on molar sagittal relationship established by Angle's classification: Class I, Class II and Class III on both sides. The cases with the molars in one side being in Class II and on the other side in Class III relationship were excluded because of the difficult of classification. Mandibular midline deviation was determined when the midline of mandibular dentition deviated more than 2 mm from the facial midline. Deep overbite was recorded if the upper anterior teeth covered more than half of the length of the crowns of the lower anterior teeth (degrees II and III). Excessive overjet was recorded when the distance between the labial surface of upper incisor and the labial surface of lower incisor was more than 5 mm (degrees II and III). Anterior open bite was recorded if the anterior vertical overbite was negative and more than 3 mm (degrees II and III). Individual crossbite was recorded when one or more maxillary anterior teeth were located lingual to the mandibular anterior teeth. Edge-to-edge incisor was recorded if one or more incisal edges of maxillary incisors contact with incisal edges of lower anterior incisors. Posterior scissor bite was recorded when the buccal cusps of the lower teeth occlude lingual to the lingual cusps of the upper teeth. Posterior teeth absence was recorded when one or more posterior teeth were absent. Lingual tipping deep overbite was recorded if the anterior upper teeth covered more than one-third of the length of the crowns of the lower anterior teeth with one or more lingual tippings of maxillary incisors [11, 22, 23].

2.7 | Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics software version 19.0 (Chicago, IL, USA). Descriptive statistics, including frequencies, were employed to present data on categorical variables. The Student's *t*-test was used to compare normally distributed parameters between two groups. The chi-squared test identified significant differences between categorical variables, whereas the Fisher's exact test was applied for sample size smaller than five. Multivariable logistic regression analysis assessed the association between outcome variables (ADD and CR) and explanatory variables (gender and malocclusion) that were statistically significant in univariate analyses. Odds ratios (ORs) with corresponding 95% confidence intervals (CIs) were calculated. Angle Class I was used as a reference when the bilateral molar relationship was analysed as an explanatory variable. All statistical tests were two-tailed, with a significance level set at $p < 0.05$.

3 | Results

The World Health Organisation defines an adolescent with the age range of 10 to 19 years [24]. According to the inclusion criteria of this study, most 10-year-old adolescents are still in the mixed dentition phase and do not meet the inclusion criteria of permanent dentition, so they were excluded. This study included 242 adolescent patients, aged 11–19 years, who either presented with TMJ discomfort or had a history of TMJ discomfort along with dentofacial deformities. For patients with unilateral joint discomfort, the contralateral joint was also included, considering the TMJ functions as a bilateral linked joint. Accordingly, a total of 484 joints were analysed in this study.

3.1 | Participant Characteristics of Age, Gender and TMJ Clinical Manifestations

Among 242 adolescent patients, 53 were male with an average age of 14.19 ± 1.641 years and 189 were female with an average age of 14.01 ± 1.939 years. The Student's *t*-test showed no statistically significant difference in age between males and females. Regarding TMJ clinical manifestations, both males and females exhibited a high proportion of clicking and crepitus, with no statistical difference between the two groups. However, the proportion of females experiencing pain and limited mouth opening was significantly higher than that of males ($p < 0.05$) (Table 1).

TABLE 1 | Age, gender and TMJ clinical manifestations of participants (%).

Items	Gender		p
	Male ($n = 53$)	Female ($n = 189$)	
Age (mean ± SD)	14.19 ± 1.641	14.01 ± 1.939	0.153[a]
TMJ clinical manifestations			
Clicking	38 (20.1)	11 (20.8)	0.917[b]
Crepitus	10 (18.9)	44 (23.3)	0.495[b]
Pain	6 (11.3)	58 (30.7)	0.005[b]*
Limited mouth opening	13 (24.5)	86 (45.5)	0.006[b]*

[a]Results of Student's *t*-test.
[b]Results of Chi-squared test.
*$p < 0.05$.

3.2 | Association Between Disc Position for Each TMJ and Various Independent Variables

Table 2 shows the association between different stages of ADD progression and various independent variables. Based on TMJ MRI findings regarding disc displacement, the 484 joints were categorised into three groups: normal group, ADDwR group and ADDwoR group. In all three groups, the proportion of female patients was significantly higher than that of male patients ($p < 0.05$). Among ADDwoR and ADDwR patients, the proportion of Angle Class II was higher than that of Angle Class I, which was higher than that of Angle Class III ($p < 0.05$). The ADDwoR group showed higher proportion of anterior open bite ($p < 0.001$) and CR ($p < 0.05$). The ADDwR group had higher proportion of deep overbite, posterior scissor bite and lingual tipping deep overbite ($p < 0.05$). Conversely, the normal group had higher proportion of individual crossbite and edge-to-edge incisor ($p < 0.05$). The proportion of CR in the ADDwoR group (52.9%) was much higher than that of the ADDwR group (5.0%) and normal group (0.6%) ($p < 0.001$) (Table 2).

3.3 | Multivariate Logistic Regression Analysis of the ADDwR and ADDwoR Groups

Variables with $p < 0.05$ in the univariate analysis from Table 2 were included in the multivariate logistic regression analysis to explore the association between these variables and different degrees of ADD. The indicators from the normal group were used as the reference baseline. The results showed that the incidence of ADDwoR in females was 2.122 times than that in males ($p < 0.05$). In terms of dental occlusion, the ratio of deep overbite in the ADDwR group was 2.207 times that of the normal group, and the ratio of posterior scissor bite was 2.427 times that of the normal group. For patients in the ADDwoR group, the ratio of Angle Class II was 1.762 times that of Angle Class I, the ratio of anterior open bite was 4.177 times that of the normal group and the ratio of posterior scissor bite was 2.111 times that of the normal group ($p < 0.05$). Regarding condylar morphology, the incidence of CR in the ADDwR group was 11.043 times that of the condylar morphology no alteration group, whereas in the ADDwoR group, the incidence of CR was 221.381 times that of the condylar morphology no alteration group ($p < 0.001$) (Table 3).

3.4 | Association Between Condylar Morphology for Each TMJ and Various Independent Variables

Table 4 shows the association between CR and various independent variables. On the basis of the presence of condylar bone resorption observed in TMJ MRI, the 484 joints were divided into two groups: no alteration group and CR group. In both groups, the proportion of female patients was significantly higher than that of male patients ($p < 0.05$). Among CR patients, the proportion of Angle Class II was higher than that of Angle Class I, which was higher than that of Angle Class III ($p < 0.05$). In the CR group, the proportion of deep overbite and individual crossbite was lower ($p < 0.05$), whereas the proportion of excessive overjet and anterior open bite was higher ($p < 0.05$ and $p < 0.001$, respectively). The proportion of ADDwoR in the CR group (95.2%) was much higher than that of ADDwR (4.0%) and normal disc position (0.8%) ($p < 0.01$). There were no statistically significant differences between the two groups for mandibular midline deviation, edge-to-edge incisor, posterior scissor bite, posterior teeth absence and lingual tipping deep overbite ($p > 0.05$) (Table 4).

3.5 | Multivariate Logistic Regression Analysis of the CR Group

Variables with $p < 0.05$ in the univariate analysis from Table 4 were included in the multivariate logistic regression analysis

TABLE 2 | Association between disc position for each TMJ and various independent variables.

Items	Disc position			p
	Normal (n = 161)	ADDwR (n = 100)	ADDwoR (n = 223)	
Gender				
Male	49 (30.4)	23 (23.0)	34 (15.2)	0.002[a*]
Female	112 (69.6)	77 (77.0)	189 (84.8)	
Malocclusion				
Molar relationship				
Angle Class I	64 (39.8)	30 (30.0)	70 (31.4)	0.003[a*]
Angle Class II	63 (39.1)	58 (58.0)	127 (57.0)	
Angle Class III	34 (21.1)	12 (12.0)	26 (11.7)	
Mandibular Midline Deviation	83 (51.6)	50 (50.0)	99 (44.4)	0.344[a]
Deep overbite	38 (23.6)	51 (51.0)	57 (25.6)	< 0.001[a*]
Excessive overjet	45 (28.0)	37 (37.0)	84 (37.7)	0.115[a]
Anterior open bite	5 (3.1)	1 (1.0)	24 (10.8)	< 0.001[b*]
Individual crossbite	40 (24.8)	15 (15.0)	31 (13.9)	0.016[a*]
Edge-to-edge incisor	20 (12.4)	4 (4.0)	12 (5.4)	0.012[b*]
Posterior scissor bite	18 (11.2)	26 (26.0)	44 (19.7)	0.008[a*]
Posterior teeth absence	13 (8.1)	6 (6.0)	21 (9.4)	0.584[a]
Lingual tipping deep overbite	8 (5.0)	17 (17.0)	23 (10.3)	0.007[a*]
Condylar morphology				
No alteration	160 (99.4)	95 (95.0)	105 (47.1)	< 0.001[b*]
CR	1 (0.6)	5 (5.0)	118 (52.9)	

[a]Results of Chi-squared test.
[b]Results of Fisher's exact test.
*$p < 0.05$.

to explore the association between these variables and CR. Indicators from the condylar morphology no alteration group were used as the reference baseline. In terms of dental occlusion, the incidence of deep overbite in the CR group was 0.401 times that of the control group ($p < 0.001$), the incidence of excessive overjet was 2.479 times that of the control group ($p < 0.001$), the incidence of anterior open bite was 10.921 times that of the control group ($p < 0.001$) and the incidence of individual crossbite was 0.405 times that of the control group ($p < 0.05$). Regarding TMJ disc position, the incidence of ADDwR in the CR group was 9.108 times that of the normal disc position ($p < 0.05$), and the incidence of ADDwoR was 163.806 times that of the normal disc position ($p < 0.001$) (Table 5).

4 | Discussion

TMJ ADD is a common condition among adolescents and young adults [25]. ADDwoR is recognised as a progressive stage of ADDwR and may increase the risk of CR in adolescents [26, 27]. In this study, ADDwoR was observed in 46.1% of the evaluated TMJs, whereas CR was detected in 25.6% of the TMJs. Early diagnosis and treatment are critical for patients with progressive ADD, particularly in the presence of CR. This study is the first to analyse the associated malocclusion in adolescent patients with ADD or CR.

The age range of the population included in this study was 11–19-year-old adolescents with permanent dentition, and there was no significant difference between the age of males and females. Among them, the incidence of ADDwoR was 2.122 times higher in females than that in males. There was no significant difference in clicking and crepitus symptoms between males and females, but the incidence of pain and limited mouth opening was significantly higher in females than that in males. Articular disc plays a vital role in TMJ by contributing to smooth movement of condyle and reducing articular surface wear [28]. However, pathologic condition such as ADD can place undue stress on the condyle, which can trigger the degenerative process [28]. Displaced disc may disrupt normal TMJ contact surface and affect cartilage homeostasis [29]. Several studies have demonstrated that ADDwoR significantly increased the prevalence of CR [30]. Consistent with these findings, our study showed similar results that both ADDwR and ADDwoR exhibited a significant increase in the risk of CR.

TABLE 3 | Multivariate logistic regression analysis of the ADDwR and ADDwoR groups.

	ADDwR		ADDwoR	
Items	**OR (95% CI)**	***p***	**OR (95% CI)**	***p***
Gender				
Male	Reference		Reference	
Female	1.617 (0.875–2.989)	0.125	2.122 (1.257–3.579)	0.005*
Malocclusion				
Molar relationship				
Angle Class I	Reference		Reference	
Angle Class II	1.667 (0.920–3.019)	0.092	1.762 (1.090–2.849)	0.021*
Angle Class III	0.927 (0.407–2.115)	0.858	0.720 (0.376–1.379)	0.322
Deep overbite	2.207 (1.189–4.096)	0.012*	0.812 (0.464–1.424)	0.468
Anterior open bite	0.532 (0.060–4.746)	0.572	4.177 (1.493–11.684)	0.006*
Individual crossbite	0.860 (0.427–1.732)	0.673	0.676 (0.386–1.185)	0.172
Edge-to-edge incisor	0.469 (0.147–1.494)	0.200	0.480 (0.216–1.066)	0.071
Posterior scissor bite	2.427 (1.207–4.881)	0.013*	2.111 (1.131–3.939)	0.019*
Lingual tipping deep overbite	2.078 (0.783–5.517)	0.142	2.127 (0.838–5.400)	0.112
Condylar morphology				
No alteration	Reference		Reference	
CR	11.043 (1.213–100.559)	0.033*	221.381 (28.914–1695.034)	<0.001*

Note: Results of multivariate logistic regression analysis.
*$p < 0.05$.

A key finding of this study was that deep overbite and posterior scissor bite were significantly associated with ADDwR, whereas Angle Class II, anterior open bite and posterior scissor bite were significantly associated with ADDwoR. Restricted anterior and lateral mandibular movements in patients with deep overbite and posterior scissor bite may reduce the activity of the temporalis and masticatory muscles, which could be one of the contributing factors to the development of ADD [31, 32]. The relationship between Angle Classification and TMD has been debated in previous research. Thilander et al. [33] evaluated 4724 children and adolescents aged 5 to 17, and Bilgiç et al. [34] examined 923 children aged 7 to 12. Both studies reported significant association between Angle Class III malocclusion and TMD. However, other studies have not found evidence supporting this association. In our study, we did not observe a correlation between Angle Class III malocclusion and ADD. Demir et al. [35] investigated the relationship between occlusal factors and masticatory muscle sensitivity in a cohort aged 10 to 19, finding that excessive overjet increased the sensitivity of the occlusal and extra pterygoid muscles. Although excessive overjet may exert stress on the masticatory muscles, our study did not find a significant association between excessive overjet and ADD. Furthermore, in patients with deep overbite, anterior mandibular movement is restricted, causing the condyles to remain in the forced posterior position. In patients with posterior scissor bite, anterior lateral mandibular movement is restricted, potentially leading to unilateral chew and increased TMJ loading, which also could be one of the contributing factors to ADD.

Another important finding of this study was that excessive overjet and anterior open bite were significantly associated with CR. Multivariate logistic regression analysis revealed that adolescents with excessive overjet and anterior open bite were at a higher risk of CR, whereas those with deep overbite and individual crossbite had a lower risk. This may be attributed to the backward and downward rotations of the mandible in CR patients, which exacerbated excessive overjet and anterior open bite. Alsabban et al. [36] reported that the majority of CR patients had malocclusion, of which 93.8% were Angle class II malocclusion, and more than 65% had anterior open bite, which was in general agreement with our study.

Currently, the treatment of ADDwR primarily focuses on symptomatic management [30]. For adolescents with ADDwoR accompanied by CR, there is evidence that disc repositioning surgery can restore the damaged condylar head [37]. Postoperatively, the condyle shifts anteriorly and inferiorly, resulting in an increased joint space, which facilitates the regeneration of the condylar head [38]. Bilateral surgery generally results in the mandible moving forward and downward, whereas unilateral surgery causes the mandible to shift towards the opposite side, thereby improving mandibular retrusion and deviation to some extent. Therefore, it is crucial

TABLE 4 | Association between condylar morphology for each TMJ and various independent variables.

Items	Condylar morphology		
	No alteration ($n=360$)	CR ($n=124$)	p
Gender			
Male	85 (23.6)	21 (16.9)	0.121[a]
Female	275 (76.4)	103 (83.1)	
Malocclusion			
Molar relationship			
Angle Class I	128 (35.6)	36 (29.0)	0.011[a*]
Angle Class II	171 (47.5)	77 (62.1)	
Angle Class III	61 (16.9)	11 (8.9)	
Mandibular midline deviation	176 (48.9)	56 (45.2)	0.474[a]
Deep overbite	120 (33.3)	26 (21.0)	0.010[a*]
Excessive overjet	109 (30.3)	57 (46.0)	0.002[a*]
Anterior open bite	8 (2.2)	22 (17.7)	<0.001[a*]
Individual crossbite	74 (20.6)	12 (9.7)	0.006[a*]
Edge-to-edge incisor	27 (7.5)	9 (7.3)	0.929[a]
Posterior scissor bite	69 (19.2)	19 (15.3)	0.338[a]
Posterior teeth absence	25 (6.9)	15 (12.1)	0.072[a]
Lingual tipping deep overbite	32 (8.9)	16 (12.9)	0.197[a]
Disc position			
Normal	160 (44.4)	1 (0.8)	<0.001[b*]
ADDwR	95 (26.4)	5 (4.0)	
ADDwoR	105 (29.2)	118 (95.2)	

[a]Results of Chi-squared test.
[b]Results of Fisher's exact test.
*$p<0.05$.

to correct malocclusion such as deep overbite and posterior scissor bite that can affect mandibular anterior and lateral movement through orthodontic treatment prior to disc repositioning surgery, so that the risk of surgical recurrence due to occlusal factors can be reduced.

Our study provides valuable insights into the association between dental malocclusion and the ADD or CR. These malocclusion should be addressed during adolescence through orthodontic treatment. However, to establish a causal relationship, further longitudinal studies are necessary. Long-term follow-up research would improve our understanding of how malocclusion contributes to the development and progression of ADD and the impact of CR on occlusal changes. Additionally, exploring potential risk factors such as genetic predisposition, environmental influence and occlusal habits will deepen our understanding of the aetiology of ADD and facilitate the development of more effective treatment strategies [39–41].

TABLE 5 | Multivariate logistic regression analysis of the CR group.

Items	CR	
	OR (95% CI)	p
Malocclusion		
Molar relationship		
Angle Class I	Reference	
Angle Class II	1.602 (0.977–2.625)	0.062
Angle Class III	0.519 (0.224–1.200)	0.125
Deep overbite	0.401 (0.233–0.688)	<0.001*
Excessive overjet	2.479 (1.531–4.016)	<0.001*
Anterior open bite	10.921 (4.331–27.535)	<0.001*
Individual crossbite	0.405 (0.202–0.809)	0.010*
Disc position		
Normal	Reference	
ADDwR	9.108 (1.023–81.071)	0.048*
ADDwoR	163.806 (22.142–1211.812)	<0.001*

Note: Results of multivariate logistic regression analysis.
*$p<0.05$.

5 | Conclusion

In conclusion, our study highlights the significance of occlusal characteristics in relation to TMJ health. The study offers valuable insights into the association between deep overbite, posterior scissor bite, Angle Class II malocclusion, anterior open bite, excessive overjet, and the ADD and CR in adolescents. Orthodontic treatment for adolescent patients should prioritize the health of the TMJ, particularly for these types of malocclusion.

Author Contributions

Guanlin Qu contributed to the conception, design, data acquisition and statistical analysis, and drafted the manuscript. Lingtong Bu contributed to the data acquisition and statistical analysis. Qingling You and Yi Luo contributed to the data acquisition. Zhigui Ma contributed to conception, design, data acquisition and statistical analysis, and critically revised the manuscript. Chi Yang contributed to the conception, design, analysis, and interpretation, and critically revised the manuscript. All authors provided final approval and agreed to be accountable for all aspects of the work.

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Ethics Statement

The study was approved by the Human Research Ethics Committee of Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine (SH9H-2020-T7-1).

Consent

All study participants and their parents have provided informed consent to publish their identifiable images or information in the open access journal of this study. All methods were carried out in accordance with relevant guidelines and regulations of the declaration.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

We are willing to share all the data used for statistical analysis in this article, please contact the corresponding author to obtain the original data.

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