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Does condylar height decrease more in temporomandibular joint nonreducing disc displacement than reducing disc displacement?

A magnetic resonance imaging retrospective study

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Abstract

The aim of the study was to compare condylar height changes of anterior disc displacement with reduction (ADDwR) and anterior disc displacement without reduction (ADDwoR) in temporomandibular joint (TMJ) quantitatively, to get a better understanding of the changes in condylar height of patients with anterior disc displacement who had received no treatment, and to provide useful information for treatment protocol. This longitudinal retrospective study enrolled 206 joints in 156 patients, which were divided into ADDWR group and ADDwoR group based on magnetic resonance imaging examination. The joints were assessed quantitatively for condylar height at initial and follow-up visits. Also, both groups were further divided into 3 subgroups according to age: <15 years group, 15 to 21 years group, and 22 to 35 years group. Paired *t* test and independent *t* test were used to assess intra- and intergroup differences. The average age of the ADDwR group was 19.65 years with a mean of 9.47 months' follow-up. The follow-up interval of the patients with ADDwoR was 7.96 months, with a mean age of 18.51 years. Condylar height in ADDwoR tended to decrease more than those in ADDwR, especially during the pubertal growth spurt and with the presence of osteoarthrosis, meaning ADDwoR could cause a severe disturbance in mandibular development. Thus, an early disc repositioning was suggested to avoid decrease in condylar height.

Abbreviations: ADD = anterior disc displacement, ADDwoR = anterior disc displacement without reduction, ADDwR = anterior disc displacement with reduction, H_1 = condylar height at initial visit, H_2 = condylar height at follow-up visit, ICR = idiopathic condylar resorption, ID = internal derangement, MA = mandibular asymmetry, MRI = magnetic resonance imaging, OA = osteoarthrosis, TMJ = temporomandibular joint.

Keywords: Anterior disc displacement, Condylar height, MRI, Temporomandibular joint

1. Introduction

Of the temporomandibular joint (TMJ) internal derangements (IDs), anterior disc displacement (ADD) is one of the most frequently observed. Oğütcen-Toller et al[1] found that 81.25% of the TMJ IDs were pure ADDs, whereas 9.82% had anteromedial disc displacement and 7.14% with anterolateral disc displacement. It is recognized that ADD can result in degenerative changes of the condyle and may limit the mandibular growth if the disc becomes displaced during adolescence.[2,3] Previous studies have shown that the disc would likely become more anteriorly displaced and shortened, as well as a decrease in condylar height after >6-month follow-up, if ADD was left untreated.[4,5] The more severe ADD progresses, the shorter the ramus height becomes.[6,7] Of note, unilateral juvenile ADD patients could suffer from condylar height decrease of the affected side, which leads to the development of mandibular asymmetry (MA).[5,8] Although several imaging studies have revealed that regression of condylar size and height is likely to occur in ADD patients,[3,4,9] there were still some limitations in former studies, such as the following: the study groups were small or not well-matched, the differences in condylar height variations between ADD with reduction (ADDwR) and ADD without reduction (ADDwoR) remained unclear, and the condylar height changes in different ages needed further study. Moreover, condylar height has been measured in coronal plane of magnetic resonance imaging (MRI),[4,10] yet quantitative analysis on parasagittal MRI image was seldom.

Editor: Li Wu Zheng.

Author contributions: YKH participated in the study design, acquisition, and measurement of data, analysis and interpretation of data, and drafting and revising the manuscript for important intellectual content. CY conceptualized and designed the study, critically reviewed and revised the manuscript, and approved the final manuscript as submitted. XYC participated in the study design, and critically reviewed and revised the manuscript. QYX participated in data collection and measurement, and critically reviewed and revised the manuscript for important intellectual content. All authors approved the final manuscript as submitted and agreed to be accountable for all aspects of the work.

This study was supported by the Science and Technology Commission of Shanghai Municipality Science Research Project (14DZ2294300).

The authors have no conflicts of interest to disclose.

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Medicine (2016) 95:35(e4715)

Received: 8 June 2016 / Received in final form: 3 August 2016 / Accepted: 3 August 2016

http://dx.doi.org/10.1097/MD.0000000000004715

MRI is currently the gold standard for evaluating TMJ, for its unmatched advantage of a noninvasive, radiation-free technique with high tissue contrast and the ability to assess joint effusion.[11,12] In the Department of Oral Surgery of the Ninth People's Hospital, Shanghai Jiao Tong University, School of Medicine, MRI is a routine examination for the patients with TMJ diseases.[4,10]

The purposes of this study were to get a better understanding of condylar height change in natural course of ADD, as well as to provide useful information for treatment protocol, through the quantitative measurements of the condylar height in ADDwR and ADDwoR groups between the MRI records of initial and follow-up visits, and analysis of the possible relative factors affecting condylar height changes. The authors hypothesized that condylar height decreased more in ADDwoR than in ADDwR, and the severity of it might differ with age, osteoarthrosis (OA), and ID stage.

2. Materials and methods

2.1. Study design

A longitudinal retrospective study was designed and implemented, with approval of the institutional review board of the Ninth People's Hospital (Shanghai, China). The study followed the tenets of the Declaration of Helsinki[13] for research involving human subjects, and all participants signed an informed consent agreement. The methods were carried out in accordance with the approved guidelines of STROBE.

The patients included in this study were collected from a consecutive series of patients who had been referred to the TMJ division of the Department of Oral and Maxillofacial Surgery in Shanghai Ninth People's Hospital affiliated to Shanghai Jiao Tong University School of Medicine. Patients included in this study were <35 years old without sex restrictions who assisted the clinic from January 2013 to December 2015, had ADDwR or ADDwoR confirmed by MRI at first visit, had 2 MRI records with an interval >3 months, did not have idiopathic condylar resorption (ICR) at first visit, had no treatment before and during the follow-up period except for drugs, and had no history of infection, injuries to the jaws, or congenital and systematic disorders.

Patients excluded from this study had ADDwR progressing to ADDwoR after follow-up and had poor image quality of MRI that was unsuitable for quantitative measurement, owing to movement by the patient when undergoing MRI.

2.2. Study variables

The predictor variable was ADDwR versus ADDwoR. The outcome variables were changes in condylar height over time. Other variables consisted of age, sex, OA, and ID stage.

In this study, condylar height (H) was measured directly. Condylar height at initial visit (H_1) and condylar height at follow-up visit (H_2) were defined as condylar heights at initial and follow-up visits. Changes in condylar height (ΔH) was computed ($\Delta H = H_2 - H_1$), indicating the changes during the interval. Ages were categorized into 3 groups: <15 years old, 15 to 21 years old, and 22 to 35 years old.

2.3. MRI technique

MRI scans were obtained using a 1.5-Tesla imager (Signa, General Electric, Milwaukee, WI) with bilateral 3-inch TMJ surface coil receivers. A slice thickness of 1 mm with a skip of 0.3 mm, a 120-mm field of view, and a matrix of 512×256 pixels were used. With the help of localizers, sagittal and coronal oblique planes were obtained. T1-weighted images and T2-weighted images were acquired in occlusion and maximum mouth opening. T1-weighted images were used to assess disc position and condylar changes, whereas T2-weighted images were used to determine joint effusion.[14]

Disc position was considered normal in the parasagittal plane when the posterior band of the disc was over the topmost portion of the condyle between 11 and 12 o'clock.[15] ADDwR was diagnosed when the disc was anterior to the condyle at closed mouth position but back to the normal position during the mouth-opening movement. ADDwoR was considered when the disc remained anterior to the condyle and eminence during opening mouth.[16]

2.4. Evaluation of MRI

Quantitative measurements were performed by 2 oral and maxillofacial surgeons, and remeasured 20% of the total images at a 2-week interval. Intra- and interexaminer reliability was estimated. Furthermore, categorical variables were assessed by the same 2 surgeons. Consensus was reached by discussion when there was a disagreement.

The parasagittal slice with the largest cross-section of the condyle (usually the central slice) was chosen for tracing, on which some points and reference lines were drawn with the assistance of Adobe Photoshop CS5 (Adobe Systems, San Jose, CA). Next, linear measurements for condylar height were achieved using MB-Ruler measuring software (accurate to 0.01 mm) (Markus Bader, Berlin, Germany).

2.4.1. Osteoarthrosis. OA was recorded as present or absent, which was defined by the presence of condylar deformities associated with flattening, subchondral sclerosis, surface irregularities, erosion, and osteophytes were observed on MRI images.[17]

2.4.2. ID stage. The TMJ ID was classified into 5 stages based on Wilkes and Bronstein's classification criteria:[18] stage I, ADDwR without changes in disc morphology or OA; stage II, ADDwR with mild–moderate deformity of the disc and/or OA; stage III, ADDwoR with mild-to-moderate disc deformity and/or OA; stage IV, ADDwoR with sever disc deformity and OA; stage V, ADDwoR with sever disc deformity, associated with disc perforation and obvious disc deformation, as well as OA.

2.4.3. Condylar height. The long axis of the condyle was determined by 2 circles. O_1 was the largest circle internally tangent to the outline of the anterior, posterior, and superior surfaces of the condylar head, allowing separation of the condylar head from the neck region. O_2 was an internally tangent circle drawn at the most curved area between the condylar head and neck. A line joining those 2 circle centers defined the long axis of the condylar head (y'). Circle O_3 was drawn at the narrowest area of the condylar neck, and the long axis of the condylar neck (y) was determined by O_2 and O_3. A line perpendicular to y tangent to the lowest point of the mandibular notch was drawn as the horizontal axis (x'), and a line parallel to x' and tangent to the top of the condylar head was named x. The distance between x and x′ was recorded as H[4,8] (Fig. 1).

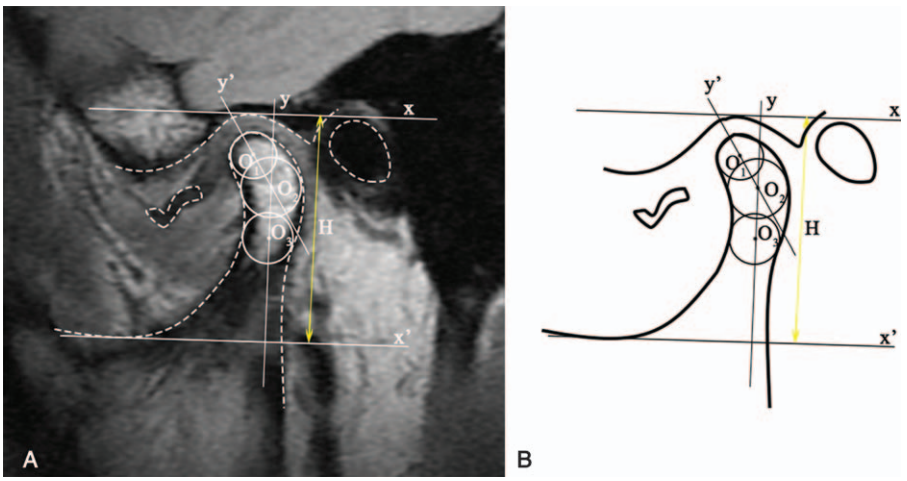

Figure 1. Measurement of condylar height on MRI. (A) In MRI image and (B) schematic diagram. MRI = magnetic resonance imaging.

2.5. Statistical analysis

The data were analyzed by standard statistical software packages (SPSS, version 17.0; IBM Corporation, Chicago, IL). A P value of <0.05 was determined as statistically significant.

Differences in H_1 and H_2 in the ADDwR and ADDwoR groups were compared using paired t test. Intra- and intergroup differences in ΔH were analyzed using independent t tests.

3. Results

3.1. Demographic descriptions

In total, 214 joints were matched the inclusion criteria, but 8 were excluded, so the final total was 206 joints in 156 patients (122 females and 34 males). On initial MRI examination, ADDwR was verified in 81 joints and ADDwoR in 125 joints. The average age of the ADDwR group was 19.65 years (13–35 years old), with a mean of 9.47 months' (3–25 months) follow-up interval. The average age of the ADDwoR group was 18.51 years (12–35 years old), and the follow-up interval was 7.96 months (3–47 months). There were no significant differences of age and follow-up interval between the 2 groups ($P > 0.05$, Table 1). The prevalence of OA was 3.7% in ADDwR and 31.2% in ADDwoR at first visit, whereas it rose to 11.1% and 67.2% at follow-up visit.

3.2. MRI evaluations

In the ADDwR group, the condylar was 0.17 mm higher after follow-up on average, whereas it was 0.29 mm lower in the ADDwoR group. Paired t test showed that no considerably increase was found in the ADDwR group, but the condylar height decreased significantly in the ADDwoR group ($P = 0.126$, 0.026, respectively). Details of the condylar height changes were demonstrated in Table 2. Intraclass correlation coefficients for interobserver agreement ranged between 0.84 and 0.88, and for intraobserver agreement between 0.93 and 0.96, showing excellent reliability.

3.3. Intragroup differences

In the ADDwR group, although H_2 was significantly higher than H_1 statistically in males ($P = 0.048$), the difference was not important in females ($P = 0.885$). However, H_2 was significantly lower than H_1 in females ($P = 0.020$).

As for different age groups, paired t test showed that condylar height of <15-year-old age subgroup increased significantly ($P = 0.034$) in the ADDwR group. Although in the 3 age subgroups of ADDwoR group, even though no significant differences were found, condylar height decreased in each subgroup, even in teenagers.

In ADDwoR group, OA could aggravate condylar resorption significantly ($P = 0.003$). However, condylar height increased significantly ($P = 0.012$) in patients with OA and ADDwR. H_2 of stage IV reduced significantly compared with H_1 (Table 2).

3.4. Intergroup differences

Condylar height reduced considerably more in ADDwoR (Fig. 2) than in ADDwR (Fig. 3) ($P = 0.013$). Significant differences were found between several subgroups of ADDwR and ADDwoR

Table 1

Basic data of the study population at first visit.

	ADDwR (joints) N (%)	ADDwoR (joints) N (%)
Sex		
Male	21 (25.9)	22 (17.6)
Female	60 (74.1)	103 (82.4)
Age group, y		
<15	21 (25.9)	53 (42.4)
15–21	30 (37.0)	44 (35.2)
22–35	30 (37.0)	28 (22.4)
OA		
Present	3 (3.7)	39 (31.2)
Absent	78 (96.3)	86 (68.8)
Wilkes stages		
Stage I	65 (80.2)	
Stage II	16 (19.8)	
Stage III		94 (75.2)
Stage IV		29 (23.2)
Stage V		2 (1.6)

ADDwoR = anterior disc displacement without reduction, ADDwR = anterior disc displacement with reduction, OA = osteoarthrosis.

Table 2

Intragroup differences of condylar height.

	ADDwR			ADDwoR		
	H_1 (mm)	H_2 (mm)	*P*	H_1 (mm)	H_2 (mm)	*P*
Sex						
Male	24.30 ± 2.12	24.91 ± 1.91	0.048*	26.49 ± 3.32	26.53 ± 3.37	0.796
Female	26.11 ± 3.20	26.13 ± 3.38	0.885	24.27 ± 3.33	23.91 ± 3.18	0.020*
Age group, y						
<15	24.30 ± 2.93	24.89 ± 3.25	0.034*	24.00 ± 3.02	23.68 ± 3.10	0.069
15–21	25.11 ± 2.14	25.17 ± 2.10	0.754	25.05 ± 3.48	24.77 ± 3.09	0.344
22–35	27.12 ± 3.36	27.10 ± 3.45	0.758	25.29 ± 3.93	25.05 ± 4.01	0.093
OA						
Present	23.93 ± 1.66	24.20 ± 1.61	0.012*	23.70 ± 3.34	23.11 ± 3.25	0.003*
Absent	25.71 ± 3.08	25.87 ± 3.14	0.150	25.10 ± 3.40	24.94 ± 3.25	0.362
Wilkes stages						
Stage I	25.76 ± 2.77	25.82 ± 2.98	0.588			
Stage II	25.17 ± 4.04	25.79 ± 3.67	0.079			
Stage III				24.96 ± 3.31	24.72 ± 3.24	0.143
Stage IV + V				23.76 ± 3.68	23.31 ± 3.51	0.019*
Total	25.64 ± 3.05	25.81 ± 3.11	0.126	24.66 ± 3.43	24.37 ± 3.35	0.026*

ADDwoR = anterior disc displacement without reduction, ADDwR = anterior disc displacement with reduction, H_1 = condylar height at initial visit, H_2 = condylar height at follow-up visit, OA = osteoarthrosis.
* $P < 0.05$, significant differences between initial and follow-up visits (paired *t* test).

groups, including female subgroup, <15-year-old subgroup, and the presence of OA subgroup (Table 3).

4. Discussion

Although several studies have reported that condylar height would be lowered if the disc was anteriorly displaced,[4,5,8] the differences in condylar height changes between ADDwR and ADDwoR were not reported. In our investigation, first the patients were divided into ADDwR and ADDwoR groups, to study the distinctions concerning condylar height, which was not reported before. Then unlike previous study, we enrolled patients from both teenagers and adults to explore the differences between teenagers and adults. Also, we compared the condylar height changes with regard to different sex, OA, and ID stages.

Our hypothesis was that pronounced shortage in condylar height would be found in ADDwoR compared with ADDwR, and the severity of condylar height reducing might differ with age, OA, and ID stages. The results supported our hypothesis. The condylar height decreased 0.29 mm on average in the ADDwoR group, whereas it increased 0.17 mm in the ADDwR group. Besides, teenagers with ADDwR showed apparent growth of the condyles, whereas condylar heights of teenagers in the ADDwoR group decreased a little instead of increasing. Stage IV demonstrated evident change in condylar height, which may be due to lesser number of cases in this subgroup, and high prevalence of OA. In the ADDwoR group, condylar height decreased considerably in patients with OA, revealing that OA accompanied with ADDwoR might aggravate condylar resorption. In the ADDwR group, condylar height increased no matter whether or not OA presented. On the one hand, this might be because there were only 3 cases of patients with OA in the ADDwR group, and they were all adolescents; on the other hand, it could be inferred that OA would have little impact on condylar growth for patients with ADDwR.

According to Nebbe et al's[19,20] circle-center method, sometimes it was difficult to separate the condylar head from the condylar neck owing to various shapes of the condylar head.

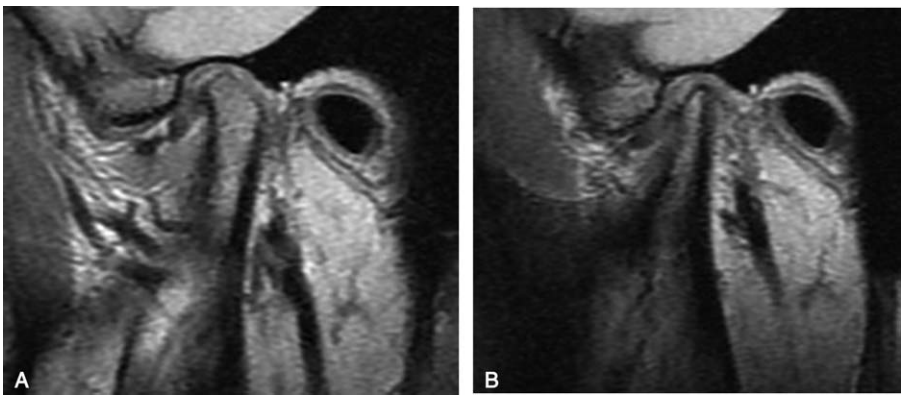

Figure 2. MRI scans of a 14-year-old female ADDwoR patient with the interval of 8 months, showing significant loss of condylar height and volume. (A) First visit and (B) follow-up visit. ADDwoR = anterior disc displacement without reduction, MRI = magnetic resonance imaging.

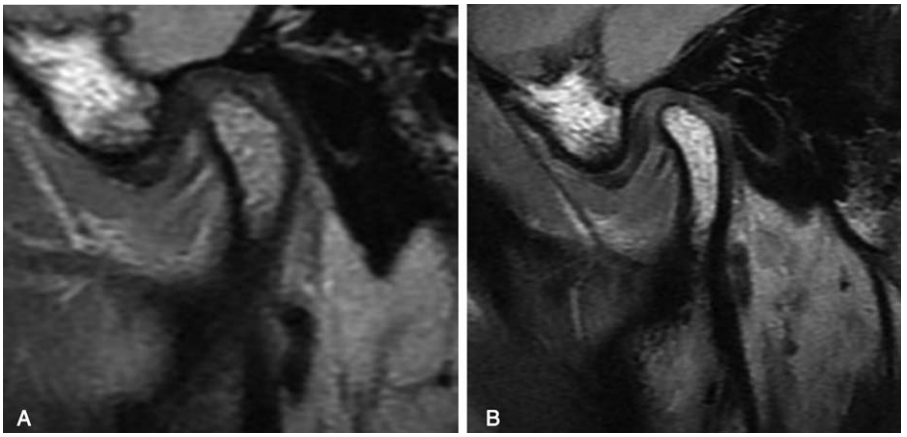

Figure 3. MRI scans of a 16-year-old female ADDwR patient with the interval of 21 months, showing condylar growth. (A) First visit and (B) Follow-up visit. ADDwR = anterior disc displacement with reduction, MRI = magnetic resonance imaging.

Thus, we adjusted the second and third circles according to the shape of the condyle, to provide a stable and accurate long axis of the condylar neck to measure the changes in condylar height.[21]

Notwithstanding clinical signs and symptoms of ADD tend to subside with time,[22–26] the disc continued to deteriorate and condylar height may be shortened, which may be a precursor of MA, especially in patients with ADDwoR. Cortical bone begins to form around the periphery of the condyle during 12 to 14 years of age, also known as pubertal growth spurt period, and by the age of 21 to 22, full development of the mandibular condyle is accomplished,[27] meaning loss of growth potential. Based on that, patients were divided in 3 age subgroups to discuss the condylar height changes. As bone quality would definitely differ between young adults and old people, we limited the age to 35 years old, to achieve more scientific results.

As Boering first called attention to the juvenile form of ID and pointed out the greater severity of the skeletal deformity, some researchers have concluded that ADD may contribute to the mandibular development deficiency by retarding growth as well as loss of condylar bone. Consequently, unilateral ADD may result in MA and bilateral ADD may induce mandibular retrusion.[2,5,8,21,28,29] Moreover, it was suggested that the relapse of dentofacial deformities in orthodontic and orthognathic treatments were caused by TMJ dysfunction.[30,31] Therefore, disc position is an important and crucial factor in the development of condylar height.

It was demonstrated that condylar height of the healthy side increased 0.75 mm in a retrospective cohort study involving unilateral ADD patients <20 years, and the condylar height of the affected side decreased.[5] Relatively, in our investigation, the condylar height of ADDwR patients increased significantly in <15-year-old subgroup, although the added value was a little bit <0.75 mm. Nevertheless, around the pubertal growth spurt period of ADDwoR patients, instead of obvious growth of the condylar, its height and volume was even reduced (Fig. 2). No significant difference was found between H_2 and H_1 in <15-year-old subgroup of ADDwoR group, which just perfectly illustrated that normal condylar growth was limited as a result of nonreducing disc displacement. So, the shortened condylar height in teenagers was caused by limited condylar growth and condyle degeneration. In the 15- to 21-year-old group, the growth peak has ended, which may explain why there was no distinct difference between ADDwR and ADDwoR. In addition,

Table 3

Intergroup differences of condylar height.

	ADDwR ΔH (mm) Mean ± SD	ADDwoR ΔH (mm) Mean ± SD	*P*
Sex			
Male	0.61 ± 1.32	0.04 ± 0.67	0.089
Female	0.01 ± 0.79	−0.36 ± 1.53	0.044*
Age group, y			
<15	0.59 ± 1.20	−0.32 ± 1.25	0.006*
15–21	0.06 ± 1.12	−0.27 ± 1.90	0.388
22–35	−0.03 ± 0.48	−0.25 ± 0.74	0.183
OA			
Present	0.27 ± 0.05	−0.59 ± 1.15	<0.001*
Absent	0.16 ± 1.00	−0.15 ± 1.52	0.125
Total	0.17 ± 0.98	−0.29 ± 1.43	0.013*

ΔH = changes in condylar height, ADDwoR = anterior disc displacement without reduction, ADDwR = anterior disc displacement with reduction, OA = osteoarthrosis.
* $P < 0.05$, significant differences between ADDWR and ADDwoR groups (independent *t* test).

adults have lost the potential of condylar growth, accompanied with OA, resulting in condylar height reduction.

OA is characterized by degeneration of the articular cartilage and bone, whose specific causes are unknown.[23] Helms et al[32] found that 17% of ADDwR joints also had degenerative joint disease, whereas 95% of joints with displaced nonreducing discs had degenerative changes. Our findings indicated that the occurrence of OA was 3.7% in ADDwR and 31.2% in ADDwoR at first visit and elevated to 11.1% and 67.2% at follow-up visit. This difference may result from different sample size and follow-up period. Whether disc displacement is a consequence or a cause of OA is not clear, and some researchers believed that ID could equally be the cause, the consequence, or a mere accompanying factor of OA.[2,33] Because an overload on normal articular cartilage or normal stresses on aberrant cartilage are considered to be risk factors for OA,[23] and the disc may distribute joint loads, it was reasonable to infer that the condylar resorption would be more severe in patients with ADDwoR and OA, which was confirmed by the results of our present study. A previous study showed normal disc position could prevent the gross degenerative changes of OA and promote growth of the mandible,[2] and our findings were in accordance with this previous study. In our study, the prevalence of OA in ADDwR was lower than in ADDwoR, and OA accompanied with ADDwR would not lead to significant condylar height reduction.

During our clinic work, we discovered that almost all of the ICR patients had displaced disc without reduction, and after disc repositioning, massive condylar bone regeneration could be manifested. Although the detailed mechanism of ICR remains unknown, we strongly believe that ADDwoR before the growth peak was a key factor in the pathogenesis of ICR. The best time to treat ID probably is early in the disease process before significant skeletal or occlusal changes occur, when an individual has optimal capacity for growth. Besides, the disc should be repositioned either by arthroscopic disc repositioning or by anchorage surgery, while the disc and condyle were still salvageable.

Raised levels of cytokines in the synovial fluid such as interleukin (IL)-6, tumour necrosis factor (TNF)-a, IL-1b, IL-8, and IFN-c have been associated with inflammation in patients with TMJ ID,[34] which may have something to do with pain and OA occurrence in TMJ. Certainly, clinical symptoms such as pain, locking, and limitation in mouth-opening are also important for the treatment of TMJ ID, which have not been investigated in this study and need further research. Besides, the follow-up period was relatively short when compared with other studies on the natural course of disc displacement. Thus, we do not know when and whether condylar resorption would cease. Also, there was a lack of normal control, because usually patients with normal joints do not need to take MRI examinations twice. So we could not determine that compared with normal disc–condyle relationship, ADDwR would not hinder condylar growth. Moreover, a larger sample size was needed to obtain more detailed age-stratified and follow-up-stratified outcomes, as well as a higher test power. Also, further study about the relationship between OA and ADD, as well as the natural course of OA in ADDwR and ADDwoR was needed.

In summary, the present study showed that condylar height of ADDwoR patients tended to decrease more than those of ADDwR patients, especially during the pubertal growth spurt and with the presence of OA, meaning ADDwoR could cause a severe disturbance in mandibular development. Orthodontists and TMJ and orthognathic surgeons should pay more attention to the possibility that ADDwoR can result in facial asymmetry and unstable treatment effect.

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