Acute Intra-Articular Soft Tissue Injury as Seen on Magnetic Resonance Imaging and Its Association With Condylar Fracture Dislocation in Children

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Purpose: An intra-articular injury in growing patients should be well understood because it can interfere with normal temporomandibular joint (TMJ) function and even mandibular growth. The present study evaluated TMJ soft tissue injury after acute nondislocated and dislocated intracapsular condylar fractures (ICFs) in children.

Patients and Methods: In the present cross-sectional study, we enrolled a sample of children younger than 12 years old with acute ICFs. The predictor variable was the position of the ICF in relationship to the articular fossa, grouped as nondislocated and dislocated. The primary outcome variable was the injury type, including anterior displacement and deformity of the disc, joint effusion, and retrodiscal attachment tear. The second outcome variable was the injury score classified according to the injury type. Other study variables included age, gender, laterality, and the presence of concomitant fractures. The data were analyzed using the χ^2 test and logistic regression analysis. P values < .05 were considered to indicate statistical significance.

Results: A total of 44 children with 63 ICFs were included, of which 28 and 35 were nondislocated and dislocated fractures, respectively. Of the 63 ICFs, 56 (88.9%) had anterior disc displacement, 2 (3.2%) had disc deformity, 59 (93.7%) had joint effusion, and 11 (17.5%) had a retrodiscal attachment tear. According to the injury type, 4 joints were given a score of as 0, 3 a score of 1, 45 a score of 2, and 11 a score of 3. The injury type and score were significantly associated with fracture dislocation ($P < .05$).

Conclusions: In children with ICF, the presence of a retrodiscal attachment tear and disc deformity were less frequent. The type and severity of the soft tissue injury were associated with fracture dislocation. Additional studies are warranted to evaluate how soft tissue injuries affect TMJ function and fracture healing.

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The intracapsular condylar fracture (ICF) is common in children younger than 12 years old.[1] If inappropriately addressed, condylar fracture in growing patients can lead to ankylosis, functional disturbance, and even facial growth disturbances.[1,2] As a part of the temporomandibular joint (TMJ), once the condyle has fractured, both the bony and soft tissue structures of the TMJ will be greatly disturbed. In addition to the bony damage, the soft tissue injuries can also affect the prognosis.[3] Our recent study reported that sustained anterior disc displacement after condylar fracture will be associated with poor condylar remodeling in children.[4] According to previous studies, TMJ soft tissue injuries include disc displacement, joint effusion, and retrodiscal tissue tear, with disc displacement closely related to the development of complications.[3,5-10] However, these studies either had small samples or did not study children separately. Therefore, TMJ soft tissue injury occurring with condylar fractures in children remains poorly understood.

The purpose of the present study was to investigate the intra-articular soft tissue injury in children with acute ICFs. We hypothesized that the pattern and severity of the injury would be associated with dislocation of the fractured condyle. The specific aims were to categorize the intra-articular soft tissue injury as disc displacement and deformity, joint effusion, and retrodiscal attachment tear and to evaluate its relationship to the presence of ICFs with dislocation.

Patients and Methods

The independent ethics committee of the Peking University School of Stomatology approved the present study. The study population included all patients who had presented with ICF to our department for closed treatment from September 2014 to June 2018.

The inclusion criteria were as follows: *1)* age younger than 12 years; *2)* unilateral or bilateral ICF confirmed by radiography; and *3)* the availability of bilateral magnetic resonance imaging (MRI) scans of the TMJ within 2 weeks of the injury. Patients with a history of any systemic inflammatory disease (eg, idiopathic arthritis) or TMJ disorders according to the records were excluded.

Fractures were categorized as nondislocated or dislocated according to the relative position of the ICF and articular fossa on sagittal MRI studies in accordance with the report by Lindahl[11] (Fig 1) as the predictor variable. The other variables, including age, gender, fracture sides, and the existence of concomitant fractures, were recorded.

The outcome variable was the type of soft tissue injury. Disc position was classified as no displacement, partial displacement, and total displacement depending on the position of the posterior band in relation to the functional surface of the articular fossa according to Ikeda and Kawamura.[12] Disc deformity

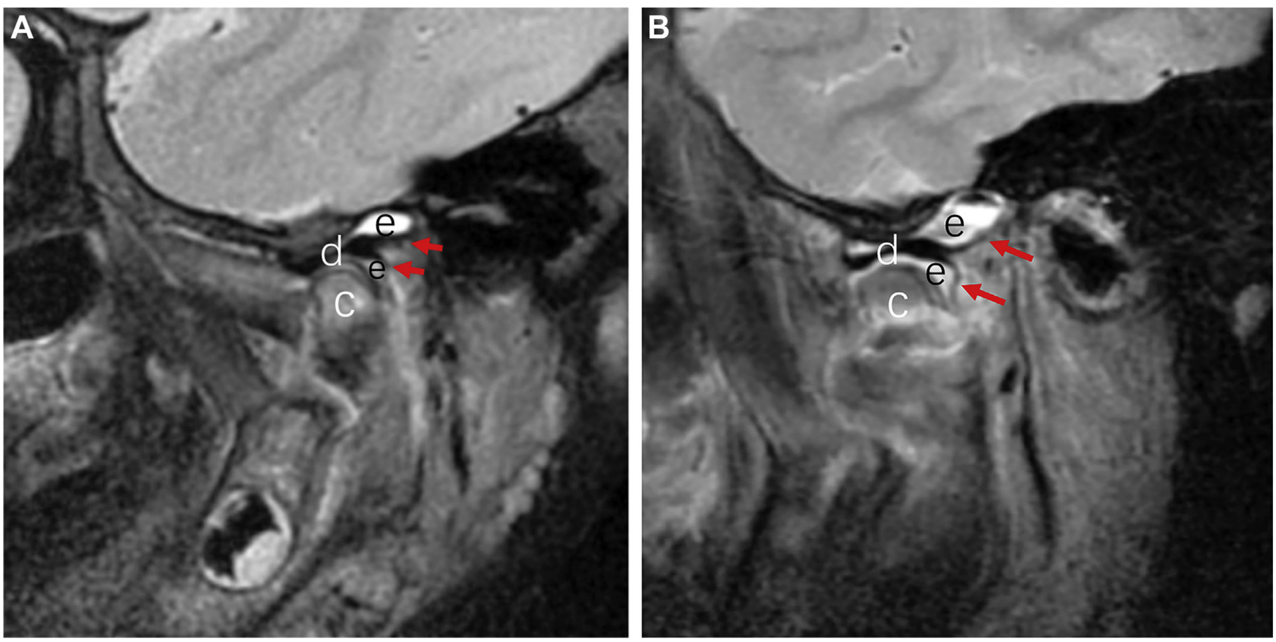

FIGURE 1. T2-weighted sagittal magnetic resonance images (MRIs) of nondislocated and dislocated fractures. *A,* MRI of a 2-year-old girl 5 days after her injury. The main part of the fractured condyle (*c*) was located within the fossa, the disc was partially displaced (*d*) and joint effusion was present in the superior and inferior cavities both (*e*). The retrodiscal attachments were intact (*arrows*). *B,* MRI of an 11-year-old girl 5 days after her injury. The fractured condyle (*c*) was dislocated from the fossa, the disc was totally displaced (*d*), and joint effusion (*e*) was present in the superior and inferior joint spaces, showing as a "double-tenpins sign." The superior and inferior retrodiscal attachments were intact (*arrows*).

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was depicted as the absence of a biconcave shape of the disc on at least 2 consecutive MRI sections.[7] Joint effusion was identified as an area of high signal intensity in the region of the superior or inferior joint space in at least 2 consecutive sagittal T2-weighted sections. A tear was defined as the splitting of the retrodiscal tissue or the presence of a dotted high signal area when the counter of the attachment was ill-defined.[6]

From the MRI findings, the articular soft tissue injury was scored as follows[3]: 0, no noticeable derangement; 1, joint effusion only; 2, joint effusion and disc displacement/deformity; and 3, joint effusion, disc displacement/deformity, and tear of the retrodiscal attachment.

MRI was performed with the teeth in habitual occlusion using a dual coil 1.5-Tesla scanner (Signa; General Electric, Milwaukee, WI). The oblique sagittal and T2-weighted MRI scans (repetition time, 3600 to 3900 ms; echo time, 82-92 ms; field of view, 12 cm × 12 cm; matrix 254 × 192) were used for the evaluation. The section thickness was 2 mm.

The MRI scans were independently inspected by 2 of us (Y.H. and J.L.) who were unaware of the study groups, and weighted kappa was used to test the agreements. Patient age between the 2 groups was compared using an unpaired *t* test. The other variables of gender, laterality, injury type, and the presence of concomitant fractures were counted by sides, described using percentages, and compared using the Pearson χ^2 test or the Fisher exact test when the expected count was less than 5. The correlations between the predictors and outcomes were evaluated using logistic regression analysis. Statistical analyses were conducted using Stata software, version 14.0 (StataCorp, College Station, TX). *P* values < .05 were considered to indicate statistical significance.

Results

Our study included 44 patients (19 girls and 25 boys; 22 unilateral and 22 bilateral cases, including 3 condylar neck fractures). Their age range was 2 to 12 years (mean age, 7.9 ± 0.4 years). The patients had 63 ICFs. The interval from the injury to the MRI examination ranged from 1 to 14 days (mean, 6.9 ± 0.6 days). Of the 63 ICFs, 28 (44.4%) were nondislocated fractures and 35 (55.6%) were dislocated fractures. The intraobserver agreement was good to excellent (kappa, 0.656 to 0.934).

The possible variables associated with the injury were analyzed. No variable, including age, gender, laterality, or the existence of a concomitant fracture, was associated with fracture dislocation ($P > .05$; Table 1) or the soft tissue injury type ($P > .05$; Table 2). Of the 63 joints, 56 (88.9%) had anterior disc displacement, 2 (3.2%) had disc deformity, 59 (93.7%) had joint effusion, and 11 (17.5%) had a retrodiscal attachment tear. Because of the low number of cases with disc deformity, disc deformity was excluded from the statistical analysis. The soft tissue injury types were compared between the nondislocated and dislocated groups. The results showed that disc displacement, joint effusion, and a retrodiscal attachment tear are more likely to occur in ICFs with dislocation ($P < .05$; Table 3).

Using the MRI findings, the severity of the injury was scored as 0, 1, 2, or 3. Of the 63 fractures, 4 had a score of 0, 3 a score of 1, 44 a score of 3, and 12 a score of 3 (Fig 2). The regression results showed that the disc displacement, retrodiscal attachment tear, and the injury score were associated with the fracture dislocation ($P < .05$; Table 4). Moreover, the severity of soft tissue injury was related to patient age ($P = .044$; Table 5).

Table 1. POSSIBLE VARIABLES ASSOCIATED WITH FRACTURE DISLOCATION

Variable	Nondislocated (n = 28)	Dislocated (n = 35)	*t* Test or χ^2 Test	*P* Value
Age (yr)	6.64 ± 0.74	6.69 ± 0.60	−0.045	.964
Gender			0.080	.777
Female	13 (46.43)	15 (42.86)		
Male	15 (53.57)	20 (57.14)		
Concomitant fracture				
No	18 (64.29)	27 (77.14)	1.260	.262
Yes	10 (35.71)	8 (22.86)		
Laterality				
Unilateral	9 (32.14)	13 (37.14)	0.171	.679
Bilateral	19 (67.86)	22 (62.86)		

Data presented as mean ± standard error of the mean or n (%).

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Table 2. POSSIBLE VARIABLES IN ASSOCIATION WITH TMJ SOFT TISSUE INJURY

Variable	Joint Effusion			Disc Displacement				Retrodiscal Attachment Tear		
	No (n = 4)	Yes (n = 59)	*P* Value	No (n = 7)	Partial (n = 17)	Total (n = 39)	*P* Value	No (n = 52)	Yes (n = 11)	*P* Value
Age (yr)	6.75 ± 1.44	6.57 ± 0.47	.964	5.14 ± 1.64	6.00 ± 1.50	7.23 ± 1.06	.288	6.29 ± 0.51	8.45 ± 1.01	.081
Gender			1.000				.417			.741
Female	2 (50.00)	26 (44.07)		3 (42.86)	10 (58.82)	15 (38.46)		24 (46.15)	4 (36.36)	
Male	2 (50.00)	33 (55.93)		4 (57.14)	7 (41.18)	24 (61.54)		28 (53.85)	7 (63.64)	
Concomitant fracture			1.000				.226			.714
No	3 (75.00)	42 (71.19)		3 (42.86)	12 (70.59)	30 (76.92)		38 (73.08)	7 (63.64)	
Yes	1 (25.00)	17 (28.81)		4 (57.14)	5 (29.41)	9 (23.08)		14 (26.92)	4 (36.36)	
Laterality			.288				.116			.494
Unilateral	0 (0.00)	22 (37.29)		0 (0.00)	7 (41.18)	15 (38.46)		17 (32.69)	5 (45.45)	
Bilateral	4 (100.00)	37 (62.71)		7 (100.00)	10 (58.82)	24 (61.54)		35 (67.31)	6 (54.55)	

Abbreviation: TMJ, temporomandibular joint.
Data presented as mean ± standard error of the mean or n (%).

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In all, 11 joints had a retrodiscal attachment tear, including 1 superior attachment tear and 10 inferior attachment tears. Of these joints, 1 was in the nondislocated group and 10 were in dislocated group. In the 10 joints with an inferior attachment tear, the morphology of the inferior cavity could not be detected (Fig 3A2). In 13 joints without evidence of a retrodiscal attachment tear, elongation of the retrodiscal attachments was noted, and the inferior joint cavity could not be detected (Fig 3B2). In 35 joints with intact retrodiscal attachments and joint cavities, the high signal of the superior and inferior joint cavities showed as a "double-tenpins sign" (Figs 1A,B, and 3C2).

Discussion

The present study observed the acute soft tissue injuries in children with ICFs and evaluated the types, frequency, and severity of the injury in association with fracture dislocation. In addition, we have proposed a new aspect for identifying a tear of the retrodiscal attachments by observing the morphology of the joint cavities.

DISC DISPLACEMENT AND DEFORMITY

Our study found that in children with ICFs, discs were anteriorly displaced with the fractured condyle, and the disc deformity happened less frequently. According to previous studies, the disc abnormities will include displacement, deformity, and perforation.[6,7,10] Sullivan et al[13] and Takaku et al[6] reported that all the discs were displaced, along with the fractured condyle. This was confirmed by our study and some previous studies.[7,10] The condylar fragments and discs were anteriorly displaced because of the contraction of the lateral pterygoid muscles. Wang et al[7] reported that 11 of 118 fractured TMJs (9.3%) had a disc deformity. The number in our study was lower (2 of 63; 3.2%). The morphological changes in the disc were thought to have resulted from traction of the lateral pterygoid muscles and compression between the condylar fragment and eminence. In some reported data, the disc perforation was defined by the high-signal intensity in the middle of the disc or by no visualization of the temporal posterior attachment. The incidence rate was 5.8 to 20%.[7,10] However, their results seem unreliable owing to the lower spatial resolution of MRI. We did not detect such changes in the present study.

JOINT EFFUSION

Joint effusion was the most common change after ICFs in children. Several studies have demonstrated MRI-based evidence of joint effusion of 70 to 100% after condylar fractures.[6,7,13-16] Takaku et al[6] observed

Table 3. TMJ SOFT TISSUE INJURY IN ASSOCIATION WITH FRACTURE DISPLACEMENT

Variable	Nondislocated (n = 28)	Dislocated (n = 35)	*P* Value
Disc displacement			.000*
No	7 (25.00)	0 (0.00)	
Partial	15 (53.57)	3 (8.6)	
Total	6 (21.43)	32 (91.4)	
Joint effusion			.000*
No	6 (21.43)	0 (0.00)	
Yes	22 (78.57)	35 (100.00)	
Retrodiscal attachment tear			.016†
No	27 (92.86)	25 (74.29)	
Yes	1 (7.14%)	10 (25.71)	

Data presented as n (%).
Abbreviation: TMJ, temporomandibular joint.
* $P < .001$.
† $P < .05$.

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an increased signal for all 12 joints and found hemarthrosis in 6 joints during surgery. Emshoff et al[16] found that effusion in the superior joint cavity was seen more often than in the inferior space, which was proved by Yu et al[8] and Kim et al.[5] Takahashi et al[15] found that 5 of 7 TMJs with dislocated fractures had both upper and lower joint effusion and suggested it might serve as a marker for the detection of severe intra-articular damage to the TMJ after condylar fractures, which was supported by our findings. However, Wang et al[7] found no statistically significant differences between the dislocated and nondislocated groups in the incidence of joint effusion. Our study also found that superior joint effusion was more frequent. We thought it might be because the inferior retrodiscal attachment will tear more easily compared with the superior attachment and, thus, the inferior effusion leaked out.

TEAR OF RETRODISCAL ATTACHMENT

We found that tearing of the retrodiscal attachment was less frequent in children. We supposed it might be of great advantage for the recovery of the displaced disc and restoration of the TMJ function, which was supported by our previous study.[4] This can be explained by the greater resilience of the tissue, which is less likely to tear, in younger patients. In the present study, the average age of the patients with a retrodiscal tissue tear was older than that of those without tears. However, the difference was not statistically significant (P = .081; Table 2). Previous studies have re-

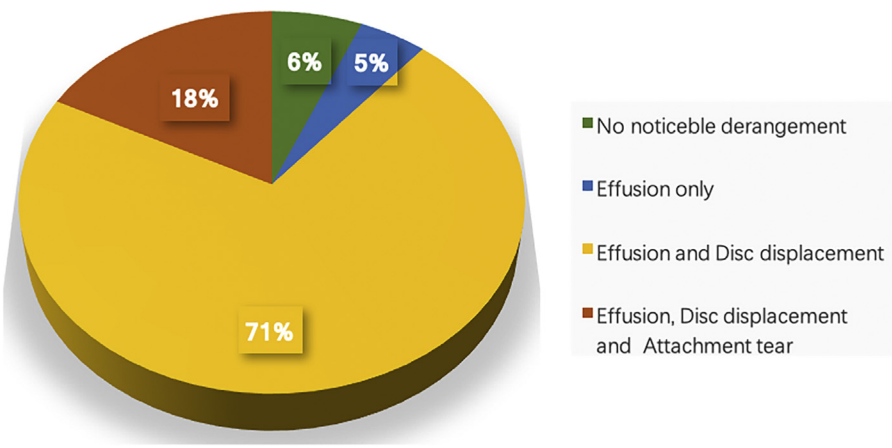

FIGURE 2. Severity of soft tissue injury as seen on magnetic resonance imaging studies.

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Table 4. REGRESSION MODEL OF TMJ SOFT TISSUE INJURY ASSOCIATED WITH FRACTURE DISLOCATION AND AGE

Variable	OR	95% CI	*Z*	*P* Value
Joint effusion				
Fracture dislocation				
No	Reference	NA	NA	NA
Yes	1.00	NA	NA	NA
Age	0.75	0.48-1.19	−1.23	.220
Disc displacement				
Fracture dislocation				
No	Reference	NA	NA	NA
Yes	52.03	9.24-293.03	4.48	.000*
Age	1.15	0.95-1.39	1.48	.140
Retrodiscal attachment tear				
Fracture dislocation				
No	Reference	NA	NA	NA
Yes	19.55	1.88-203.51	2.49	.013†
Age	1.23	0.99-1.53	1.88	.061

Abbreviations: CI, confidence interval; OR, odds ratio; NA, not applicable; TMJ, temporomandibular joint.
* $P < .001$.
† $P < .05$.

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ported that retrodiscal tissue tears are common (range, 39 to 84%) in patients with condylar injuries.[6,8,13,17] Additionally, consistent with our findings, the inferior attachment seemed more prone to tearing than did the superior attachment, possibly because the former is closer to the fracture than the latter. The incidence has varied among the reports because different criteria were used to diagnose such injuries. The traditional method to diagnose a tear is by finding the split, which can be easily missed because of the low spatial resolution of MRI. Several studies have reported that a dotted high-signal area on T2-weighted MRI scans represents a tear.[15] However, the identification will be influenced by edema and/or injury-induced inflammation. Our study has recommended a new aspect for diagnosing retrodiscal attachment tears by observing the morphology of the joint cavity. Because joint effusion is common and easily detected on T2-weighted MRI scans because fluids will display an intense signal. Where a tear is present, the fluids will leak out and the morphology of the cavity will become irregular or will have disappeared completely (Fig 3A2). Thus, the presence of a “double-tenpins sign” will suggest intact superior and inferior joint cavities, without any tear of the attachments.

Table 5. SEVERITY OF TMJ SOFT TISSUE INJURY ASSOCIATED WITH FRACTURE DISLOCATION AND AGE

Fracture Dislocation	OR	95% CI	*Z*	*P* Value
No	Reference	NA	NA	NA
Yes	26.38942	3.10-224.76	2.99	.003*
Age	1.196668	1.01-1.42	2.02	.044†

Abbreviations: CI, confidence interval; OR, odds ratio; NA, not applicable; TMJ, temporomandibular joint.
* $P < .001$.
† $P < .05$.

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Moreover, we found that the retrodiscal tissue tear was related to the presence of fracture dislocation, which was also confirmed by Wang et al.[7] According to Dwivedi et al,[10] higher condylar fractures will tend to cause greater injury to the retrodiscal tissue. We believe that the inferior retrodiscal attachment undergoes direct damage if the fracture is close to it. If the fracture is above the attachment point or near the top of condylar head, the retrodiscal attachments will be more likely to rupture or become elongated (Fig 3A,B). However, when the fracture occurs below the inferior attachment or near the condylar neck, the inferior attachment will tend to be displaced with the fractured condyle (Fig 3C).

We believed that younger patents might experience less tissue tear or milder disc displacement. The mean age of the patients with disc displacement or retrodiscal attachment tear was older (Table 2). However, the difference was not statistically

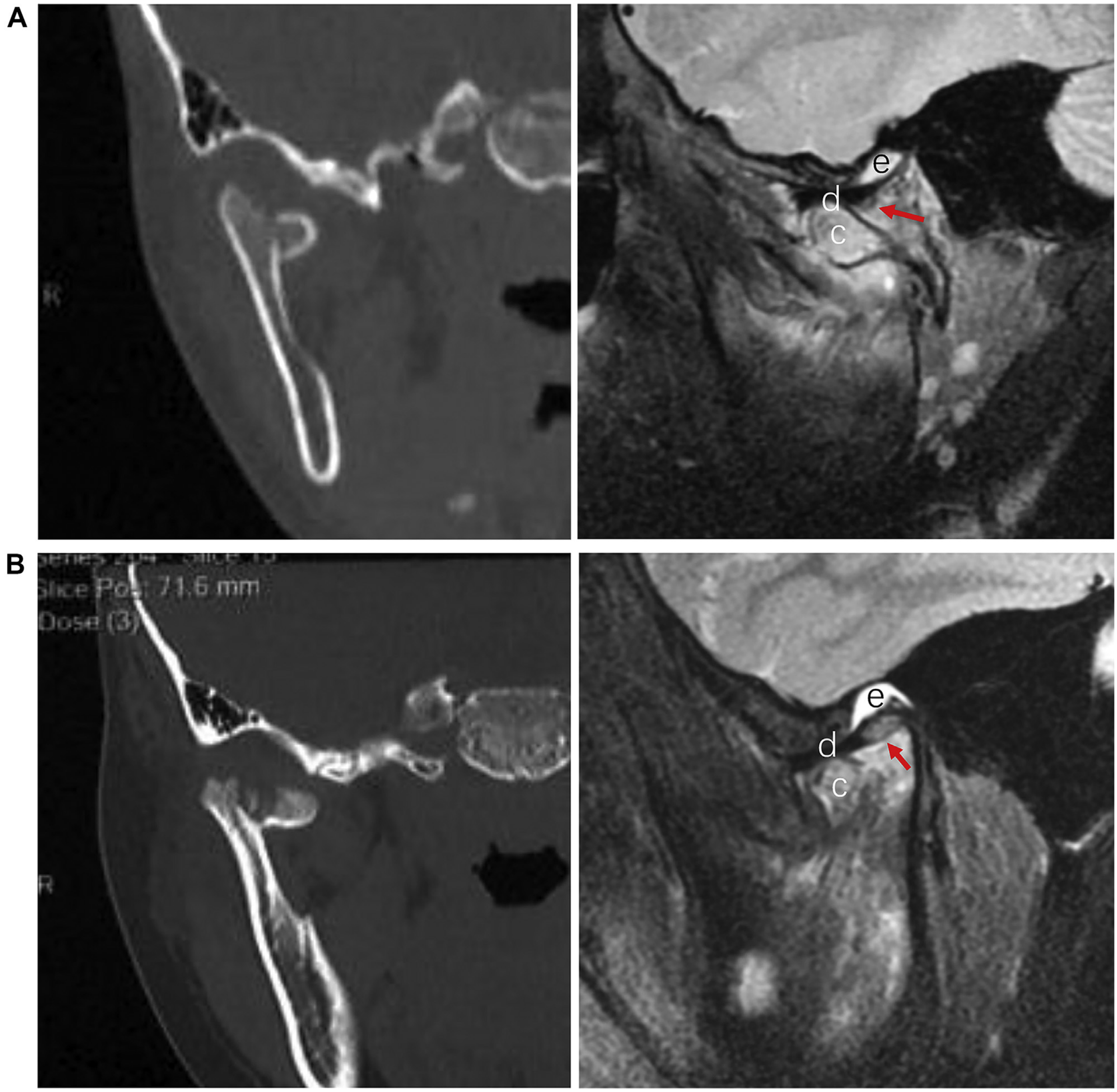

FIGURE 3. *A,* The fracture was near the top of the condyle (*A1*); splitting (a tear) in the inferior retrodiscal attachment was present (*A2, arrows*) with increased signal. The morphology of the inferior joint cavity was difficult to depict. *B,* The fracture was near the top of the condyle (*B1*); the inferior retrodiscal attachment was continuous but elongated (*B2, arrow*). The morphology of the inferior joint cavity was not detectable. **(Fig 3 continued on next page.)**

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significant ($P > .05$; Table 4). However, the severity of the soft tissue injury seemed to be age-related ($P = .044$; Table 5), supporting that older patients might experience greater severe soft tissue injury compared with younger patients.

Our study had some limitations. First, we could not confirm that the disc displacement or joint effusion had not been present before the fracture. Although TMJ symptoms were queried about before treatment and recorded if the patients had any problems with mouth opening or bruxism, the possibility of operator errors exists, which could have influenced our results. We evaluated the sides without fractures. No disc displacement or attachment tear was observed, and 2 TMJs had minimal joint effusion. Second, because of the nature of the retrospective study, the standardized and the MRI procedure could not be controlled, which might have affected the accuracy of our results. Moreover, the MRI scans were only assessed in the sagittal plane. Coronal evaluations are warranted to

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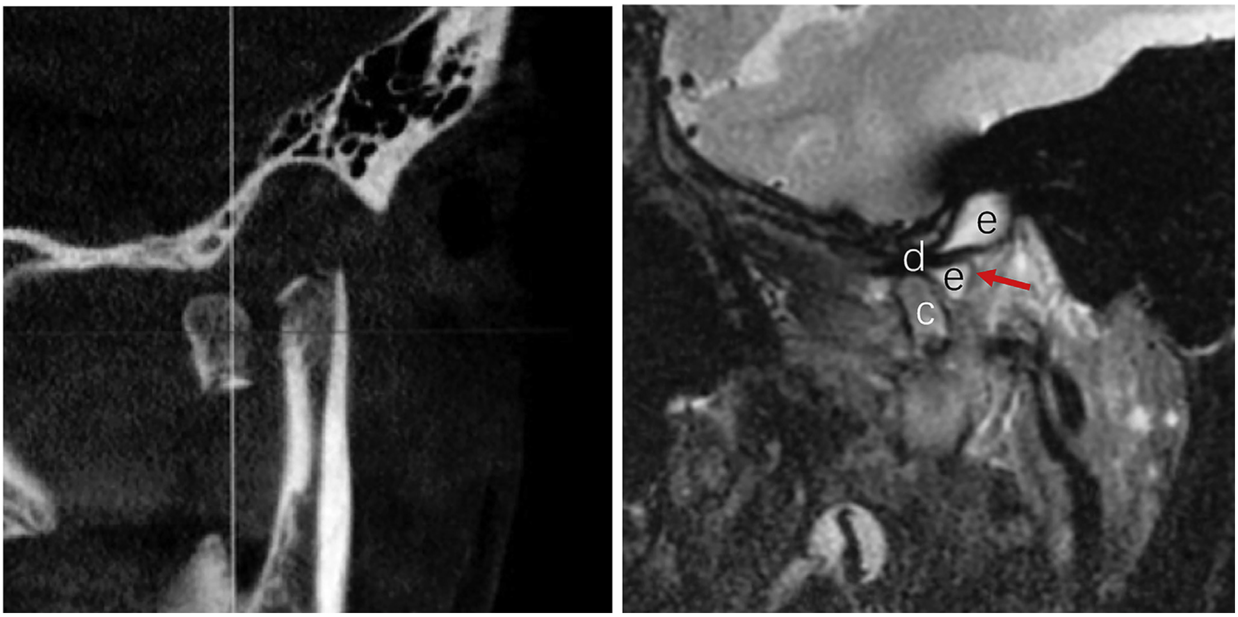

FIGURE 3 (cont'd). *C,* The fracture was near the condylar neck (*C1*); disc deformity was noted (*d*); the inferior attachment was intact (*C2, arrow*). Joint effusion was present in the superior and inferior joint, showing as a "double-tenpins sign" (*C2, e*).

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achieve a better understanding of the TMJ soft tissue injuries.

The procedure of performing MRI on children is concerning owing to the need for sedation to keep the patient from moving. In our experience, children older than 6 years can be successfully taught to keep still, with 1 parent allowed to accompany them during the examination. However, for patients younger than 6 years of age, we have usually waited until they were asleep, failing which, chloral hydrate was prescribed by the pediatrician and administered with parental consent. The treatment procedure included splinting and functional exercise in accordance with the report by Zhao et al.[18] The follow-up examinations and functional exercise might be required for a longer duration if total disc displacement were seen on MRI. A follow-up examination was recommended at 6 months after closed treatment.

In conclusion, the results of our study have shown that in children with ICFs, intra-articular soft tissue injury was associated with fracture dislocation. A tear of the retrodiscal tissue occurred less frequently; thus, visualization of the "double-tenpins sign" was common. Further studies are warranted to evaluate how the soft tissue injury will affect TMJ function and fracture healing.

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