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Clinical Paper
TMJ Disorders

An arthroscopic technique for closure of perforations in temporomandibular joint retrodiscal tissues

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Abstract. The objective of this retrospective study was to introduce and evaluate an arthroscopic discopexy for closure of retrodiscal tissue perforations. A total of 112 patients (135 joints) receiving an arthroscopic discopexy for management of retrodiscal tissue perforations between January 2016 and September 2019 were included. Pre- and postoperative visual analogue scale (VAS) pain scores and maximum inter-incisal opening (MIO), as well as magnetic resonance imaging (MRI) data, were collected and analysed. Success was recorded when the disc position was >11 o'clock, VAS pain score <3, and MIO>25 mm. For patients with a condyle deformity, postoperative bone remodelling was also recorded. The VAS pain score decreased from 3.04 ± 2.66 preoperatively to 0.88 ± 1.13 at 12 months postoperatively ($P < 0.001$) and MIO increased from 33.90 ± 7.39 mm to 35.19 ± 6.14 mm ($P = 0.029$). MRI evaluation revealed that 133 discs were successfully repositioned back on top of the condyle. Among these, 11 joints were associated with either VAS pain score ≥3 or MIO ≤25 mm. Therefore, a success rate of 90.4% (122/135) was achieved at 12 months postoperative. Bone remodelling was detected in 72 joints. Arthroscopic discopexy is a minimally invasive and effective treatment for retrodiscal tissue perforations that achieves the purpose of simultaneously restoring the intra-articular structures and relieving clinical symptoms.

Key words: temporomandibular joint; arthroscopy; Temporomandibular joint disc; Joint dislocation; Outcomes.

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Associated with internal derangement of the temporomandibular joint (TMJ), perforations are mainly observed in the late stages (Wilkes stage V) of anterior disc displacement (ADD), resulting in pain, sound phenomena, restricted jaw movement, osteoarthritis, and even jaw deformity[1–4].

Traditionally, perforations are managed by TMJ surgery such as discectomy or discectomy with replacement (e.g., using auricular cartilage)[5,6]. However, open surgeries might pose numerous risks including escalated degenerative changes, onset of ankylosis, and even facial nerve injury. Besides, for small perforations, such treatment modalities might tend to represent overtreatment[1,5,7].

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Meanwhile, certain TMJ arthroscopic management strategies including lavage of the joint, lysis of adhesions, and shaving of perforation margins have also been reported to reduce pain and restore joint mobility for ADD patients with perforations. According to Quinn and Stover[7], positive clinical results were achieved after shaving the perforation margins by arthroscopic lysis and lavage in the upper joint compartment. Nevertheless, all of these procedures focus mainly on washing out the inflammatory mediators and eliminating the adhesions, but do not provide any manipulation of the intra-articular derangement[5,7].

Since the 1990s when McCain et al. and Ohnishi et al. reported procedures of disc repositioning, the minimally invasive arthroscopic discopexy has gradually been recognized as an effective therapy in treating ADDs[8–10]. Later, Yang et al.[11] and Liu et al.[12] modified the disc repositioning and suturing technique and reported satisfactory results in 95% of cases based on magnetic resonance imaging (MRI) evaluation in a 24-month follow-up[13]. However, on reviewing all published studies, it was found that all treatments for disc repositioning under arthroscopy have been reported mainly for the management of ADD patients with Wilkes stages III and IV (the majority in stage III). It appears that a technique of arthroscopic discopexy for those ADD patients with perforations (Wilkes stage V) is lacking.

Accordingly, this study was performed to introduce the indications and techniques of arthroscopic discopexy for ADD with retrodiscal tissue perforation (RTP), and also to evaluate the effectiveness of such techniques based on both TMJ-MRI and clinical examination.

Materials and methods

Patient data

The study was conducted from January 2016 to September 2019 and included all patients treated by arthroscopic discopexy for ADD with RTP at the Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine (Shanghai, China). The study was designed in accordance with the Declaration of Helsinki for research, and the protocol was approved by the Ethics Committee of Shanghai Jiao Tong University School of Medicine.

The inclusion criteria were (1) Wilkes stage V with chronic pain or dysfunction[3] that has failed to respond to conventional non-invasive therapy for at least 6 months[14], or with progressive condyle resorption and facial asymmetry; (2) perforation size less than half of the condylar surface confirmed by direct arthroscopic visualization; and (3) fulfilling the following MRI inclusion criteria: (i) the deformed disc is still long enough to cover the condyle surface; (ii) the displacement distance is such that the anterior end of the disc is still reachable by the arthroscope introduced through the fossa puncture; (iii) the retrodiscal tissue is not thick; (iv) the condyle holds an average range of movement; (v) the eminence is not steep.

Patients with systemic disease, those with other TMJ diseases such as arthritis and synovial chondromatosis, patients with large perforations more than half the condylar surface, those with previously operated joints, and those without complete preoperative and postoperative (at least 12 months) clinical and TMJ-MRI examination data were excluded.

For all patients, the initial (provisional) diagnosis of ADD with RTP was based on the preoperative TMJ-MRI examination[15] : in sagittal images, the posterior point of the posterior band is located in front of the top point of the condyle; the condyle surface is irregular with osteophyte formation, protruding into the joint cavity and appears to connect with the cortical bone of the glenoid fossa in more than two successive scans. The final confirmation was accomplished with direct visualization under TMJ arthroscopy.

The primary predictor variable was the arthroscopic discopexy for disc displacement with RTP (pre- versus postoperative). The outcome variables were (1) clinical measurements including pain recorded with a visual analogue scale (VAS; 0–10, with 10 being maximum pain) and maximum inter-incisal opening (MIO); and (2) TMJ-MRI evaluation of disc position and bone remodelling (pretreatment versus 12 months post-treatment).The procedure was considered successful if the disc position was >11 o'clock, VAS pain score <3, and MIO >25 mm at 12 months postoperative.

Surgical technique

All procedures of arthroscopic discopexy for ADD with RTP were performed by the same surgeon (C.Y.) with more than 38 years of experience in TMJ surgery.

Armamentarium

A 2.7-mm, 0° angle arthroscopy set (Stryker, San Jose, CA, USA) was used, including a 3.2-mm outer protective cannula, a video surveillance system, and an image printer[12]. The suture equipment included a pair of in-hou;1;se designed suture grippers (lasso-type and hook-type) (Shanghai RuiJisi Industrial Co. Ltd, Shanghai, China), and a specially made surgical suture was also prepared (medical woven polyester with an inner core)[11,12].

Anaesthesia

In accordance with the previously reported techniques for ADD[11,12], treatment was usually performed under local anaesthesia, unless the patient asked for general anaesthesia.

First portal—fossa puncture

For ADD patients with perforation, the aim of the first puncture is a diagnostic arthroscopy to evaluate the disc and RTP. To locate this puncture site, the condyle was palpated at the pre-auricular cutaneous depression by asking the patient to open and close the mouth repeatedly. In the open mouth position, the back of the condyle was marked with the thumb nail of one hand, while the lower border of the zygomatic arch was marked using the thumb nail of the other hand. Following the intersection point (surface projection) of both thumb nail marks, usually 1–2 mm backwards, 2–3 ml of 2% lidocaine was first injected for anaesthesia and to inflate the upper joint space. Then, a 3-mm vertical incision was made on the skin, through which a sharp trocar protected by the outer cannula was inserted[11,12].

Once the capsule was penetrated by the sharp trocar, the arthroscopic cannula was then inserted in a forward and upward direction (15–45°) into the superior joint space. After that, a continuous lavage with lactated Ringer solution was maintained using a 50-ml syringe connected to an irrigation line[8,10].

Under direct arthroscopic visualization, a diagnostic sweep from the posterior synovial pouch, passing through the intermediate space to the anterior synovial pouch, was performed. At this stage, the arthroscopist could directly visualize the perforation and correlate the perforation size to the overall condylar surface. If the perforation size was less than half the surface of the condyle, then the procedure could proceed; however, larger perforations more than half the condylar surface are not optimal candidates for repair. Accordingly, by the first puncture it could be decided whether to continue the suturing procedure or merely stop the operation at that point, without further progression of

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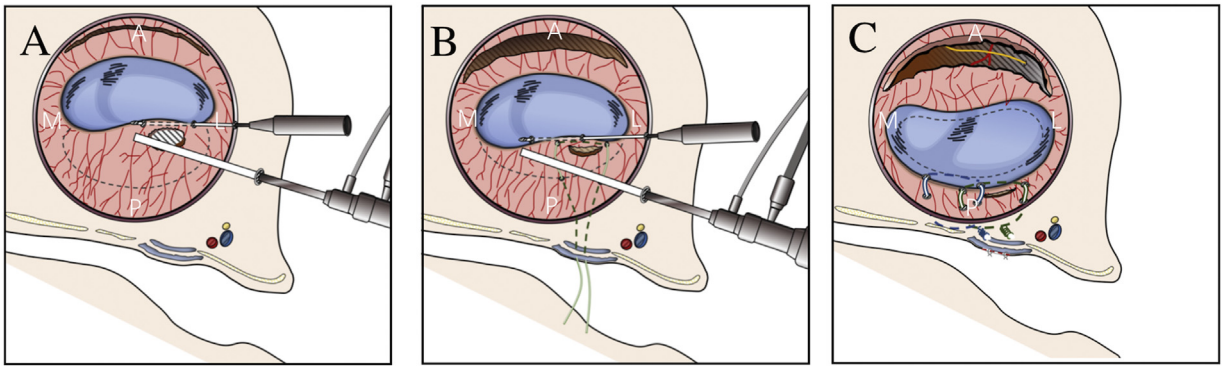

Fig. 1. Illustrated diagram showing the arthroscopic discopexy for anterior disc displacement with retrodiscal tissue perforation (RTP) located in the central 1/3 part of posterior part: (A) the suture needle for RTP compensation; (B) following completion of the first suture and posterior pull of the thread; (C) following the second suture for complete disc reduction and perforation pull back.

the procedure, unless there was an associated osteophyte formation. In such cases, the osteophyte was then shaved, followed by joint lavage.

This subjective evaluation of perforations was confirmed objectively by quantitative measurements following the second (eminence) puncture using the tapered end of the suture needle (Supplementary Material Fig. S1).

Following confirmation of the RTP diagnosis, two main factors should be addressed: first, based on the size of the perforation, the decision has to be made either to perform the discopexy or not; second, it is also crucial to define the exact location of the perforation, as the suturing technique and orientation differs according to the site of the perforation.

Second portal—eminence puncture

Under direct arthroscopic vision, the second puncture for anterior release (surface projection) was made at the intersection point of the anterior slope of the eminence and the line parallel to the arthroscopic cannula (which went into the anterior recess, and was located in the outermost part of the lateral cavity). The sharp trocar was inserted under vision into the anterior recess, with consideration to the triangulation concept[10]. Through the second cannula, an additional local anaesthetic was injected to prevent pain, decrease bleeding, and avoid masseteric nerve injury. Referring to the triangulation concept, a coblation probe was inserted in the working cannula and an incision was made ahead of the anterior band of the disc (attachment of the disc with the anterior synovium). When compared to the original technique for ADD (2–3 mm anterior to the anterior band), the line of anterior release for ADD with perforation is far more anterior in order to gain more tissue to cover the condyle after disc repositioning. After that, a sharp trocar was used for further tissue separation and to ensure free disc push back. Moving back to the intermediate space, the arthroscope can now clearly visualize the perforation boundaries. Moreover, any osteophyte formation can be shaved using either micromotor or endoscopic bone cutting forceps whenever discovered; shaving was performed in small and large perforations, as shown in Supplementary Material Fig. S2.

Third portal—suturing puncture

At this time, the arthroscopic cannula was pulled back from the anterior crypt and moved into the narrowest part of the intermediary cavity.

In this step, the size of the perforation was measured by means of the tapered tip of the suture needle (which is equal to 2 mm) as a standard for measurement from medial to lateral direction. So, the suture needle was used to measure the size of the perforation in millimetres for recording purposes, as shown in Supplementary Material Fig. S1.

A specially made suture needle was introduced midway between the first and second portals (diagnostic arthroscopy and anterior working portals), usually 10–15 mm ahead of the first diagnostic puncture. Once seen inside the upper joint space, the suture needle was then inserted 1–2 mm ahead of the anterior edge of the perforation, coming in and out from lateral to medial.

At this point, according to the type of disc displacement and location of the perforation, the location and orientation of the third puncture were determined as outlined below.

(1) For a RTP located in the central 1/3 part of the bilaminar zone in the case of a pure anterior displaced disc (Fig. 1), two sutures were usually recommended. In the superior joint space, the first suture needle (aiming for RTP compensation) was in a horizontal direction and was inserted anterior to the perforation. To achieve a complete disc reduction, the second suture, which was usually 5 mm posterior to the first one (surface projection), was inserted relatively medial to the RTP. It entered in between the visible parts of the first suture and came out distal to the distal part of the first suture.

(2) When the RTP was located in the lateral 1/3 part in the case of anteromedial disc displacement (Fig. 2), the first suture needle was inserted in a backward and downward direction and still in front of the RTP (if the perforation was smaller than 5 mm, the tip could go through it, while if the perforation was 5–10 mm, then the tip could go ahead of the perforation). After that, the second suture needle was directed horizontally and relatively medial to the perforation to achieve a complete disc reduction. Sometimes one suture was enough if the perforation was a relatively large size, to avoid over-reduction of the disc with subsequent uncovering of the condyle surface.

(3) As for RTPs located in the medial 1/3 part, in the case of anterolateral disc displacement (Fig. 3), the first needle was inserted in a forward and upward direction. Then the disc was pulled backwards in order to fulfil the disc reduction, as well as perforation exposure. After repositioning of the disc (the perforation was also partially reduced), a second suture could be inserted anterior to the edge of the RTP for a complete compensation. Again, in some cases, one suture could be enough if

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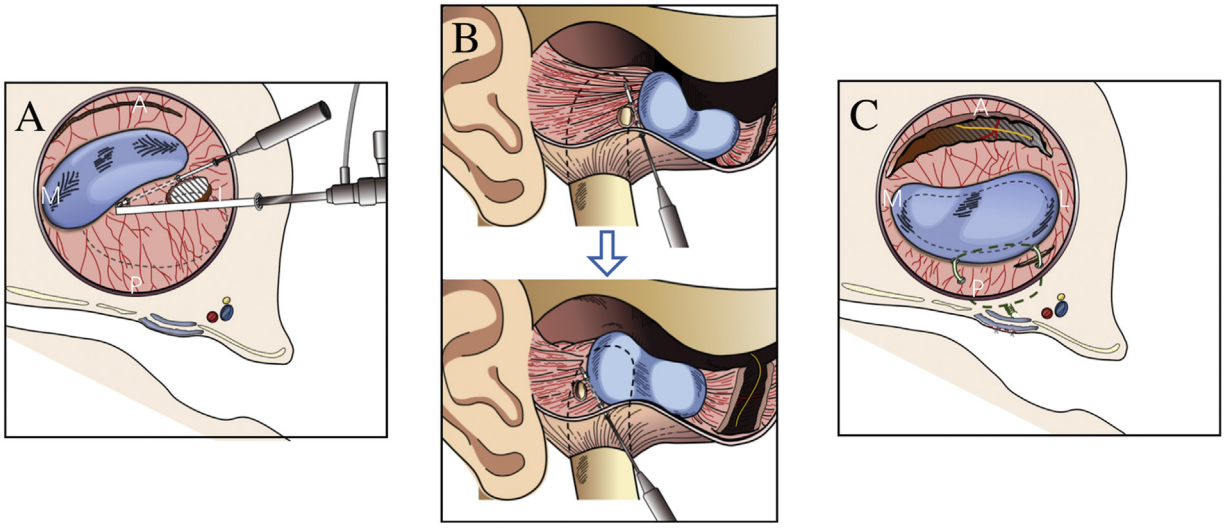

Fig. 2. Illustrated diagram showing the arthroscopic discopexy for anteromedial disc displacement with retrodiscal tissue perforation (RTP) located in the lateral 1/3 part: (A) the suture needle for RTP compensation with a backward and inward direction of the needle; (B) sagittal view showing the backward and inward direction of the suture needle ahead of the perforation; (C) reposition of the displaced disc and perforation.

the perforation was too much medial, in case of an excessive correction.

Fourth portal—transmeatal puncture

Meanwhile, as part of disc suturing, other two punctures were performed at the anterior wall of the external auditory canal. This time, two customized suture grippers (lasso-type and hook-type) were passed through the transmeatal puncture in sequence to catch the surgical suture from the suture needle out of the ear (Fig. 4A–E).

After that, the sutures were pulled backwards to reposition the displaced disc as well as to eliminate the RTP from the field (pulling the threads posteriorly directs the RTP backwards and excludes the RTP from the coverage over the condyle). In the meantime, the arthroscope was again moved from posterior to anterior for the final check. The coblation probe and trocars were again used for a complete anterior release.

Finally, the sutures were tied with knots positioned underneath the tragus cartilage and the skin incisions were closed[12].

A detailed algorithm for the management of patients with ADD and RTP is summarized in an illustrative diagram in Supplementary Material Fig. S3.

Statistical analysis

All data were analysed using IBM SPSS Statistics version 21.0 (IBM Corp., Armonk, NY, USA). A parametric paired *t*-test was used for the analysis of variables, and a probability value less than 0.05 ($P < 0.05$) was considered as statistically significant.

Results

From January 2016 to September 2019, a total of 216 patients who were potential candidates for the technique were identified. After careful evaluation, 104 patients

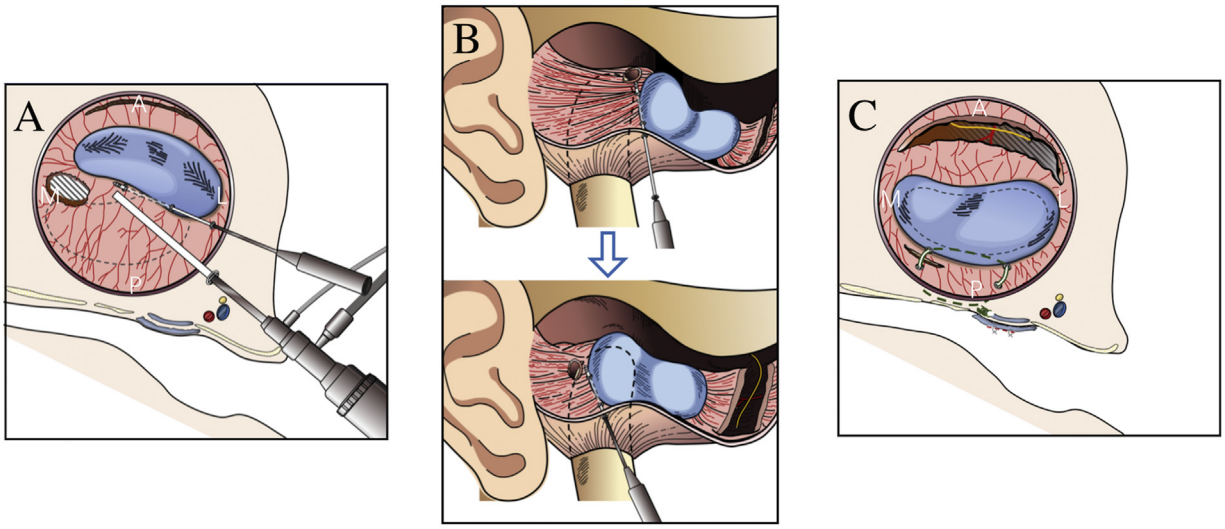

Fig. 3. Illustrated diagram showing the arthroscopic discopexy for anterolateral disc displacement with retrodiscal tissue perforation (RTP) located in the medial 1/3 part: (A) the suture needle for RTP compensation with a forward and inward direction of the needle; (B) sagittal view showing the forward and inward direction of the suture needle ahead of the perforation; (C) reposition of the displaced disc and perforation.

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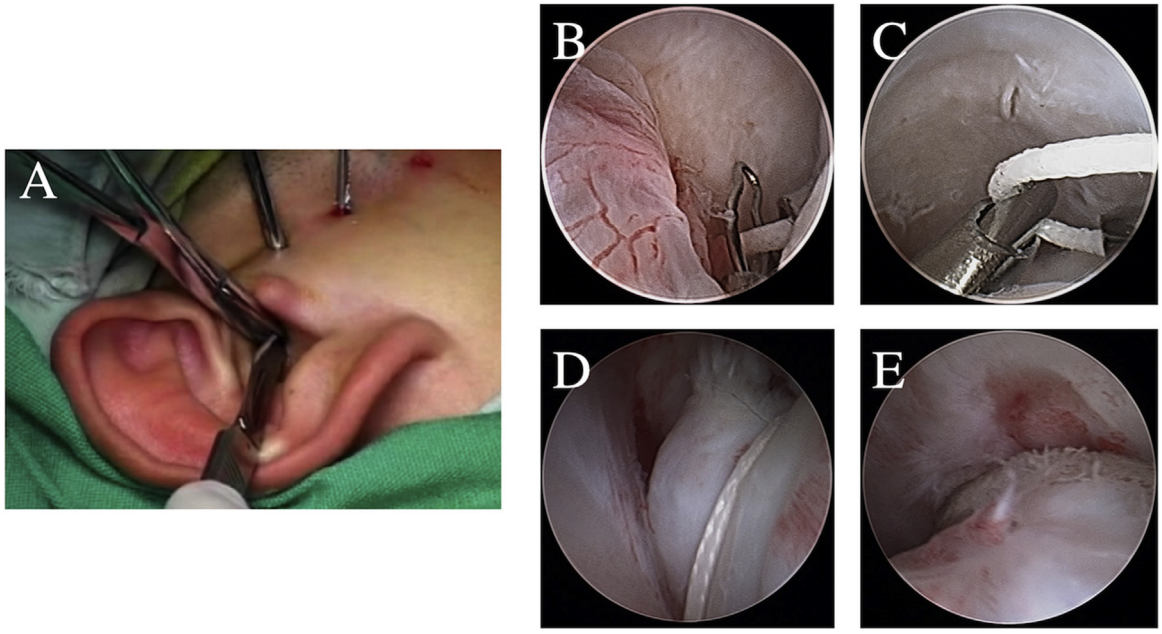

Fig. 4. The transmeatal puncture through which the specially designed suture grippers are introduced: (A) vertical incision behind the tragus for the transmeatal puncture; (B) arthroscopic view showing the lasso-type suture gripper with the suture materials; (C) arthroscopic view showing the hook-type suture gripper with the suture material; (D) pulling the suture thread backwards resulting in closure of the perforation; (E) arthroscopic view at the end of the procedure, showing the anterior edge of the released disc at the intermediate space, demonstrating successful disc repositioning and suturing.

Table 1. Basic clinical and demographic data of the included patients with disc displacement with perforations.

Characteristic	*n* (%) or mean ± SD
Sex	
Female	105 (93.8)
Male	7 (6.2)
Age (years)	21.00 ± 5.69
Side	
Unilateral	89 (79.5)
Bilateral	23 (20.5)

SD, standard deviation.

Table 2. Locations of retrodiscal tissue perforations.

Location of the retrodiscal tissue perforation	*n* (%)
Central 1/3	12 (8.9)
Medial 1/3	61 (45.2)
Lateral 1/3	62 (45.9)

were excluded according to the proposed exclusion criteria: two patients with other additional TMJ diseases; four patients with large perforations more than half the condylar surface; one patient with previously operated joints; and 97 patients with incomplete data. Finally, 112 patients with 135 affected joints met the inclusion criteria and were included in the study (Table 1). There were 105 female patients and seven male patients, with an average age of 21.00 ± 5.69 years (range 12–46 years). Of the 112 patients, 89 presented with unilateral joint involvement, while 23 presented with bilateral disease. Based on diagnostic arthroscopy, all perforations were located in the bilaminar zone, with 62 perforations on the lateral 1/3 part, 61 on the medial 1/3 part, and 12 on the central 1/3 part, as shown in Table 2.

In this study, all included joints with ADD and RTP were treated by the arthroscopic discopexy technique. Forty-four joints were operated with one suture and 91 joints with two sutures. As shown in Table 3, the mean VAS pain score decreased from 3.04 ± 2.66 before surgery to 0.88 ± 1.13 at 12 months postoperative ($P < 0.001$). An improvement of 1.29 mm in MIO was detected: 33.90 ± 7.39 mm preoperatively and 35.19 ± 6.14 mm postoperatively ($P = 0.029$).

Regarding the TMJ-MRI evaluation, 133 discs were repositioned back to cover the top of the condyle (Fig. 5). Among these, 11 joints were associated with either a VAS pain score ≥3 or MIO ≤25 mm. Accordingly, a success rate of 90.4% (122/135) was achieved at 12 months postoperative (success: disc position >11 o'clock, MIO >25 mm, VAS pain score <3). Bone remodelling was detected in 72 joints at an average of 3.9 months after arthroscopic discopexy (Fig. 5).

Discussion

Perforations of the TMJ, often associated with internal derangement and degenerative joint disease, have been reported with an incidence of 5% to 15% in disc displacements[1,3,4].

For patients with ADD, the ligaments of the retrodiscal tissue which are excessively extended, gradually lose their elasticity and become deformed. Meanwhile, the force of the condyle against the altered retrodiscal tissue leads to increased intra-articular pressure and friction between the tissues, which may eventually result in the perforation[1]. It has been reported that TMJ perforations frequently occur in the bila-

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Table 3. Changes in the mean VAS pain scores and MIO from preoperative to 12 months postoperative in patients undergoing arthroscopy treatment; mean ± standard deviation values.

Time point	VAS pain score	*P*-value[a]	MIO[b] (mm)	*P*-value[a]
Preoperative	3.04 ± 2.66	<0.001	33.90 ± 7.39	0.029
Postoperative (12 months)	0.88 ± 1.13		35.19 ± 6.14	

VAS, visual analogue scale (0–10, with a higher score indicating more severe pain); MIO, maximum inter-incisal opening.
[a] *P*-values calculated by *t*-test for continuous variables.
[b] MIO was measured to evaluate the movement of the TMJ.

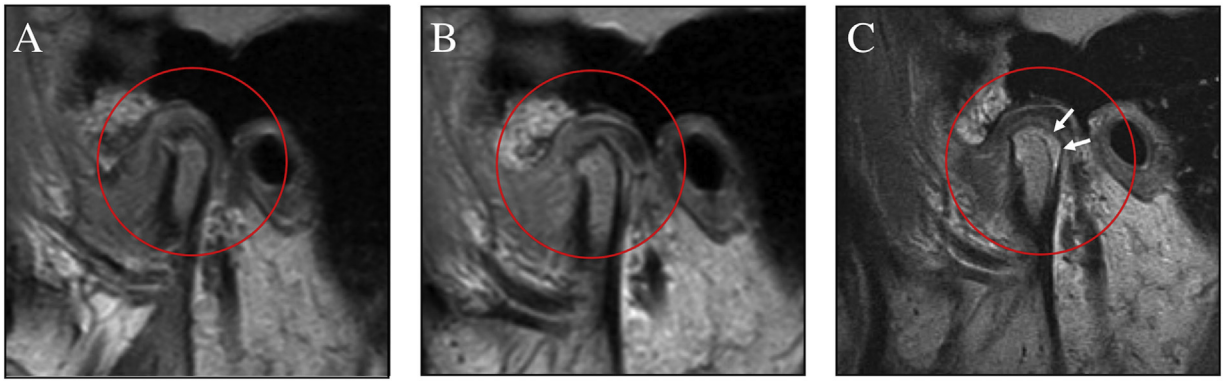

Fig. 5. TMJ-MRI of disc displacement with perforation: (A) before arthroscopic discopexy; (B) 3 months after arthroscopic discopexy; the disc was repositioned back on the top of the condyle; (C) 12 months after arthroscopic discopexy; the disc remained stable, covering the top of the condyle (white arrows show the new bone formation).

minar zone of the articular disc, usually slightly posterolateral in location[16]. Regarding a disc presenting with rotational (anterolateral or anteromedial) displacement, this tends to have a more medial or lateral perforation. A mechanism for this is that when the rotational disc displacement occurred, the contralateral part of the retrodiscal tissue was then located at the central articulating surface, therefore this has to endure high pressures during chewing.

Previous reports have recommended MRI, which has been used widely in TMJ-related diagnosis, as the initial step for all patients in order to detect ADD and perforations[2,15]. However, there remain some limitations of MRI in measuring the location and size of perforations. In particular, when the RTP is hidden at the extreme medial part of the disc, it might not be easily detected. Accordingly, diagnostic arthroscopy (the first puncture) is still considered as the gold standard for the diagnosis of RTP.

In this study, a diagnostic sweep from the posterior to anterior synovial pouches was performed under complete arthroscopic visualization in order to check both the TMJ disc and perforation. The size of the RTP was measured and recorded by consensus between the surgeon and assistant, and only small-sized perforations were repaired by the arthroscopic procedure and included in this study. The reason for this inclusion criterion is that if the perforation is too large, then the repositioned disc might still fail to cover the whole surface of the head of the condyle. In this case, closure of the perforation would no longer be continued, with no further disc repositioning or suturing procedures. In other words, the arthroscopic interventional procedure simply stops at this point and only the arthroscopic lavage would be performed.

In the current study, the subjective approximation of the size of the perforation was adequate to determine the feasibility of closing the perforation since this is not an exact criterion, and this obviates the need for a second portal if the perforation is untreatable. Nevertheless, the second portal is still performed even in untreatable cases, as such conditions (Wilkes stage V) are often associated with adhesions or bony osteophytes that require a second portal. The size of the perforation was then measured quantitatively using the suture needle for recording purposes; however, the final decision regarding whether to proceed or not was merely based on the subjective assessment. Postoperative conservative measures are the main treatment regimen for such untreatable cases; however, refractory patients are managed with costochondral grafts (CCG) or total alloplastic TMJ replacement (Supplementary Material Fig. S3). According to the proposed indications, four patients with oversized perforations were excluded from this study after the diagnostic arthroscopy. These patients received medical therapy (chondroitin sulphate) instead. Furthermore, following a period of no response to conventional treatment, two patients complained of serious clinical symptoms and therefore opted for joint replacement.

When compared to simply ADDs without perforations[11,12], suturing techniques are more complex and challenging for those cases of ADD with RTP. In such cases, both disc repositioning and perforation closure should be taken into consideration simultaneously. The suture needle should be inserted in front of the border between the rigid disc tissue and the bilaminar zone and at the same time also be in front of the anterior boundary of the perforation[11,12]. Then the perforation can be displaced backwards and be excluded from the coverage over the condyle when pulling the threads posteriorly.

According to Yang et al.[11], one to three sutures were required (two sutures were suitable for most patients), based on the severity of disc displacement. In the current study, 44 joints were treated with one suture, while 91 joints took two sutures. For an anteromedial disc displacement when perforations were located at the

lateral part of the retrodiscal tissue, one suture was often enough to achieve both disc repositioning and perforation closure. This is because the repositioning suture for medial ADD was pulled and fastened in a backward and outward direction, which is in accordance with the compensation direction for perforation closure. In some conditions when the lateral perforation was smaller than 5 mm, the suture needle could even go through it. For discs with an anterolateral displacement, perforations might be difficult to detect if they are located in the extreme medial part of the disc. Even under arthroscopic visualization, the folded TMJ disc and limited space will obstruct the diagnostic arthroscopy from sweeping further inside to examine the medial compartment. Following the first suture, aimed at disc reduction, the twisted disc will unfold and be pulled back into position. In the present study, four out of 61 medial perforations were thus exposed only after the first suture. In addition, usually one suture would be recommended for some ADDs with relatively large perforations to pull the disc back at 12 to 1 o'clock, covering the head of the condyle. In such cases, two sutures might lead to an excessive correction because there might not be enough disc tissue left after the first suture.

In the current study, stringent evaluation criteria were set by combining the clinical examination (VAS pain score and MIO) with the imaging assessment (TMJ-MRI), and a success rate of 90.4% at 12 months of follow-up was observed, with success reported only for those who simultaneously showed a disc position >11 o'clock, VAS pain score <3, and MIO >25 mm. Based on post-treatment MRI evaluation, 133 discs were repositioned back to cover the top of the condyle. The results of pain assessment showed that the VAS pain score improved significantly at 12 months follow-up interval, which could be explained as follows: (1) TMJ arthroscopy washed out the inflammatory mediators, therefore relieving joint pain; (2) Intra-articular adhesions were released either by the irrigation used during the arthroscopic procedure or by removal using arthroscopic forceps; (3) Shaving of the osteophytes and disc repositioning backwards prevented the bony contact between the condyle and the fossa, therefore eliminating mechanical friction and associated pain. When compared to patients with only ADD without perforations, patients with RTPs seemed to have an initially increased MIO before treatment. This could be because RTPs usually occur in the late stages of disc displacement. Following ADD, an over-stretching in the posterior region together with the long-term high pressure and repeated friction, might result in loss of ligament elasticity. Once there is a lack of tension in the posterior disc tissues, patients might no longer present with symptoms such as limited mouth opening.

Bone regeneration was observed in 72 joints after the arthroscopic discopexy, with potential improvements in the facial/occlusal deviation (unilateral) and mandibular retraction (bilateral) secondary to ADD with perforations[17–19]. The phenomenon of new bone formation could be explained by the procedure of disc repositioning often resulting in forward and downward movement of the condyle, with an increase in the posterior and superior joint spaces therefore decreasing the intra-articular pressure favouring bone remodelling. Interestingly, it was found that the postoperative new bone formation might be related to factors such as age at onset, course of the disease, condyle quality, etc. That is, the younger the age, the shorter the course, the better the bone quality, and the higher the probability of new bone formation after discopexy. This is probably because the intrinsic properties of the mesenchymal stem cells (MSCs) which compromise bone remodelling are age-related[20]. During the aging process, osteogenic/adipogenic differentiation and osteoclastogenesis activity are changed significantly among older patients[21]. Furthermore, reports have shown that homocysteine, which might lead to a decline in bone mineral density, also increases with age[22]. However, due to the limited number of patients in this study, it was not possible to analyse the discrepancy in the postoperative bone regeneration considering these variables. Therefore, further multicentre and randomized studies are essential.

Meanwhile, the approach of arthroscopic discopexy (repositioning and suturing) for ADD with RTP still has some limitations. First, the technique is only appropriate for the repair of disc displacement with small perforations, while larger perforations are still out of the scope of this technique. Therefore, for patients with a longstanding history of ADD and larger perforations, medical therapy or joint replacement might be an alternative. Second, the technique itself is complex and challenging, and the operator must have basic knowledge of open TMJ surgery and exceptional arthroscopic puncture and triangulation skills, in addition to excellent surgical skills. Third, the 12-month follow-up period is relatively short to precisely evaluate the outcomes of the technique, therefore the authors recommend further studies with longer follow-up.

In conclusion, this article introduces the indications and techniques of arthroscopic discopexy for ADD with retrodiscal tissue perforation. Based on the evaluation of both TMJ-MRI and clinical measurements (MIO and VAS pain score), satisfactory outcomes in the management of TMJ disc displacement and perforation repair were reported at 12 months of follow- up. These predictable and stable results indicate the technique to be an effective and reliable procedure for the treatment of ADD patients with retrodiscal tissue perforation.

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Competing interests

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

Ethical approval

This retrospective study was designed in accordance with all tenets of the Declaration of Helsinki for research with a protocol approved by the Ethics Committee of Shanghai Jiao Tong University, School of Medicine (Shanghai, China). All participants were informed of the research procedure and signed the participation consent agreement.

Patient consent

Not required.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijom.2021.08.002.

References

1. Munoz-Guerra MF, Rodriguez-Campo FJ, Escorial Hernandez V, Sanchez-Acedo C,

Gil-Diez Usandizaga JL. Temporomandibular joint disc perforation: long-term results after operative arthroscopy. *J Oral Maxillofac Surg* 2013;**71**:667–76.
2. Kim JY, Jeon KJ, Kim MG, Park KH, Huh JK. A nomogram for classification of temporomandibular joint disk perforation based on magnetic resonance imaging. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2018;**125**:682–92.
3. Wilkes CH. Internal derangements of the temporomandibular joint. Pathological variations. *Northwest Dent* 1990;**69**:25–32.
4. Cholitgul W, Petersson A, Rohlin M, Akerman S. Clinical and radiological findings in temporomandibular joints with disc perforation. *Int J Oral Maxillofac Surg* 1990;**19**:220–5.
5. Machon V, Levorova J, Hirjak D, Drahos M, Foltan R. Temporomandibular joint disc perforation: a retrospective study. *Int J Oral Maxillofac Surg* 2017;**46**:1411–6.
6. Dolwick MF. The role of temporomandibular joint surgery in the treatment of patients with internal derangement. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1997;**83**:150–5.
7. Quinn JH, Stover JD. Arthroscopic management of temporomandibular joint disc perforations and associated advanced chondromalacia by discoplasty and abrasion arthroplasty: a supplemental report. *J Oral Maxillofac Surg* 1998;**56**:1237–9. discussion 1239–1240.
8. McCain JP, Podrasky AE, Zabiegalski NA. Arthroscopic disc repositioning and suturing: a preliminary report. *J Oral Maxillofac Surg* 1992;**50**:568–79. discussion 579–580.
9. Ohnishi M. Arthroscopic laser surgery and suturing for temporomandibular joint disorders: technique and clinical results. *Arthroscopy* 1991;**7**:212–20.
10. McCain JP, de la Rua H, LeBlanc WG. Puncture technique and portals of entry for diagnostic and operative arthroscopy of the temporomandibular joint. *Arthroscopy* 1991;**7**:221–32.
11. Yang C, Cai XY, Chen MJ, Zhang SY. New arthroscopic disc repositioning and suturing technique for treating an anteriorly displaced disc of the temporomandibular joint: part I—technique introduction. *Int J Oral Maxillofac Surg* 2012;**41**:1058–63.
12. Liu X, Zheng J, Cai X, Abdelrehem A, Yang C. Techniques of Yang's arthroscopic discopexy for temporomandibular joint rotational anterior disc displacement. *Int J Oral Maxillofac Surg* 2019;**48**:769–78.
13. Zhang SY, Liu XM, Yang C, Cai XY, Chen MJ, Haddad MS, Yun B, Chen ZZ. New arthroscopic disc repositioning and suturing technique for treating internal derangement of the temporomandibular joint: part II—magnetic resonance imaging evaluation. *J Oral Maxillofac Surg* 2010;**68**:1813–7.
14. American Society of Temporomandibular Joint Surgeons. Guidelines for diagnosis and management of disorders involving the temporomandibular joint and related musculoskeletal structures. *Cranio* 2003;**21**:68–76.
15. Shen P, Huo L, Zhang SY, Yang C, Cai XY, Liu XM. Magnetic resonance imaging applied to the diagnosis of perforation of the temporomandibular joint. *J Craniomaxillofac Surg* 2014;**42**:874–8.
16. Liu XM, Zhang SY, Yang C, Chen MJ, Cai XY, Haddad MS, Yun B, Chen ZZ. Correlation between disc displacements and locations of disc perforation in the temporomandibular joint. *Dentomaxillofac Radiol* 2010;**39**:149–56.
17. Hall HD. Intra-articular disc displacement part II: its significant role in temporomandibular joint pathology. *J Oral Maxillofac Surg* 1995;**53**:1073–9.
18. Xie Q, Yang C, He D, Cai XY, Ma ZG, Shen YQ, Abdelrehem A. Will unilateral temporomandibular joint anterior disc displacement in teenagers lead to asymmetry of condyle and mandible? A longitudinal study. *J Craniomaxillofac Surg* 2016;**44**:590–6.
19. Liu X, Shen P, Wang X, Zhang S, Zheng J, Yang C. A prognostic nomogram for postoperative bone remodeling in patients with ADDWoR. *Sci Rep* 2018;**8**:4361.
20. Zhou P, Wu G, Zhang P, Xu RY, Ge J, Fu Y, Zhang YC, Du YF, Ye JH, Cheng J, Jiang HB. SATB2-Nanog axis links age-related intrinsic changes of mesenchymal stem cells from craniofacial bone. *Aging (Albany NY)* 2016;**8**:2006–11.
21. Goncalves JR, Wolford LM, Cassano DS, da Porciuncula G, Paniagua B, Cevidanes LH. Temporomandibular joint condylar changes following maxillomandibular advancement and articular disc repositioning. *J Oral Maxillofac Surg* 2013;**71**. 1759.e1–5.
22. Kim JI, Moon JH, Chung HW, Kong MH, Kim HJ. Association between homocysteine and bone mineral density according to age and sex in healthy adults. *J Bone Metab* 2016;**23**:129–34.

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