Int. J. Oral Maxillofac. Surg. 2019; 48: 769–778
https://doi.org/10.1016/j.ijom.2018.12.003, available online at https://www.sciencedirect.com

International Journal of
Oral & Maxillofacial Surgery

Clinical Paper
TMJ Disorders

Techniques of Yang's arthroscopic discopexy for temporomandibular joint rotational anterior disc displacement

X. Liu[1], J. Zheng[1], X. Cai[1], A. Abdelrehem[2], C. Yang[1]

[1]Department of Oral Surgery, Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine; Shanghai Key Laboratory of Stomatology & Shanghai Research Institute of Stomatology; National Clinical Research Center of Stomatology, Shanghai, China; [2]Department of Craniomaxillofacial and Plastic Surgery, Faculty of Dentistry, Alexandria University, Alexandria, Egypt

X. Liu, J. Zheng, X. Cai, A. Abdelrehem, C. Yang: Techniques of Yang's arthroscopic discopexy for temporomandibular joint rotational anterior disc displacement. Int. J. Oral Maxillofac. Surg. 2019; 48: 769–778.

Abstract. Disc displacement is a common disorder affecting the temporomandibular joint. According to previous publications, the displaced disc can be categorized into pure anterior displacement and rotational displacement (anteromedial and anterolateral). However, the technique of arthroscopy treatment has only been reported for patients with pure anterior disc displacement. In this study, an arthroscopic discopexy for rotational anterior disc displacement was developed and its effectiveness evaluated over 24 months of follow-up. A total of 532 patients (749 joints) with rotational anterior disc displacement, admitted to Shanghai Ninth People's Hospital between January 2011 and December 2015, were included. The success rate was based on clinical parameters (visual analogue scale (VAS) for pain, maximum inter-incisal opening (MIO), and complications) and radiographic data. The clinical and radiographic data were collected preoperatively and at 1, 6, 12, and 24 months postoperative. The VAS score decreased to 0.73 ± 1.43 following surgery ($P < 0.001$). A significant improvement in MIO (34.73 ± 6.28 mm) was also detected ($P < 0.001$). Magnetic resonance imaging showed discs repositioned in both sagittal and coronal images for 714 of the 749 joints, giving a success rate of 95.3%. This study reports an effective and predictable technique of arthroscopic discopexy for rotational anterior disc displacement.

Key words: temporomandibular joint; rotational anterior disc displacement; anterolateral disc displacement; anteromedial disc displacement; arthroscopic discopexy.

Accepted for publication 6 December 2018
Available online 26 December 2018

Disc displacement (DD) is a common disorder of the temporomandibular joint (TMJ) that often results in progressive joint dysfunction, including clicking, arthralgia, functional limitations, osteoarthritis, and even condylar resorption[1,2]. An estimated 36% of the general population has concerns about DD. According to the guidelines approved by the American

Society of Temporomandibular Joint Surgeons and the American Society of Maxillofacial Surgeons, interventional methods including arthroscopy and open surgeries are recommended for patients who have chronic pain or dysfunction and who have failed to respond to conservative treatments[3].

In 1887, Annandale first described surgical disc repositioning of the displaced disc[4]. Since then, many alternative new and modified TMJ disc repositioning techniques with various success rates have been advocated[5]. Mehra and Wolford[6] inserted one Mitek anchor into the condyle and fixed the disc with a special suture, achieving good results. Nevertheless, the outcomes were only evaluated clinically, without an imaging assessment. Zhang et al.[7] and He et al.[8] introduced a method to reposition the displaced disc using Yang mini-anchors fixed on the back of the condyle, and immediate postoperative magnetic resonance imaging (MRI) confirmed that over 96.3% of the joints had successful disc repositioning. McCain et al.[1] reported an arthroscopic technique for TMJ disc repositioning that was used on 11 joints with pure anterior DD. The success rate reached up to 81.8%, but the long-term stability remained unknown. Later, Yang et al.[2] introduced a modified arthroscopic technique of disc repositioning and suturing for anterior DD with a higher success rate of 95.42% on postoperative MRI.

With regard to the location of the displaced disc, anterior DD of the TMJ can be categorized into pure anterior displacement and rotational displacement (anterolateral displacement and anteromedial displacement), and these require different repositioning techniques[9,10]. With the advancements made in TMJ arthroscopy and increased knowledge of the arthroscopic anatomy of the TMJ[11], various techniques have been proposed to treat TMJ DD. Previous studies have reported arthroscopy treatment only for pure anterior DD, and it appears that no article has presented arthroscopic techniques to treat rotational DD[1,2]. Therefore, the purpose of this study was to introduce new techniques of arthroscopic discopexy for rotational anterior DD and to evaluate their effectiveness over 24 months of follow-up.

Materials and methods

Patient data

A retrospective study was conducted on patients with rotational anterior DD, admitted to the Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine between January 2011 and December 2015. 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. Informed consent was obtained from all participants.

The following inclusion criteria were applied[3,12,13]: (1) patient diagnosed with rotational anterior DD (anterolateral or anteromedial) on MRI; (2) Wilkes stages II, III, or IV, with no response to prior conservative treatments; (3) the patient had undergone arthroscopy treatment (patients who had undergone open discopexy were excluded). Exclusion criteria were (1) septic arthritis or synovial chondromatosis, (2) disc perforation, (3) lack of pre- and/or postoperative MRI, and (4) previously operated joints.

The diagnosis of DD was based on the preoperative MRI examination. Patients included were classified as having anterolateral or anteromedial DD according to the criteria of Foucart et al.[9]: (1) the DD was defined as anterolateral if the posterior part of the posterior band was located in front of the superior-most head of the condyle in the sagittal image, and the lateral point of the disc (Fig. 1A, point D) was located below the lateral pole of the condyle (Fig. 1A, point C) in the coronal image[9,10]; (2) the DD was defined as anteromedial if the posterior part of the posterior band was located in front of the superior-most head of the condyle in the sagittal image, and the medial point of the disc (Fig. 1B, point D) was located below the medial pole of the condyle (Fig. 1B, point C) in the coronal Image[9,10].

Surgical technique

A 2.7-mm 0° arthroscope set (Stryker, San Jose, CA, USA) with a 3.2-mm outer protective cannula, a video surveillance system, and an image printer were used. In addition, customized suture equipment (Shanghai ShenDing Industrial Co. Ltd, Shanghai, China) including a 12-gauge suture needle, a pair of self-designed grippers (a lasso-type and a hook-type), and a surgical suture (medical woven polyester with an inner core) were also used[2].

For all patients, the surgical procedures were performed by the same surgeon (C. Y.) with 28 years of experience in TMJ arthroscopic surgery.

In accordance with the protocol for pure anterior DD, the surgical procedures for

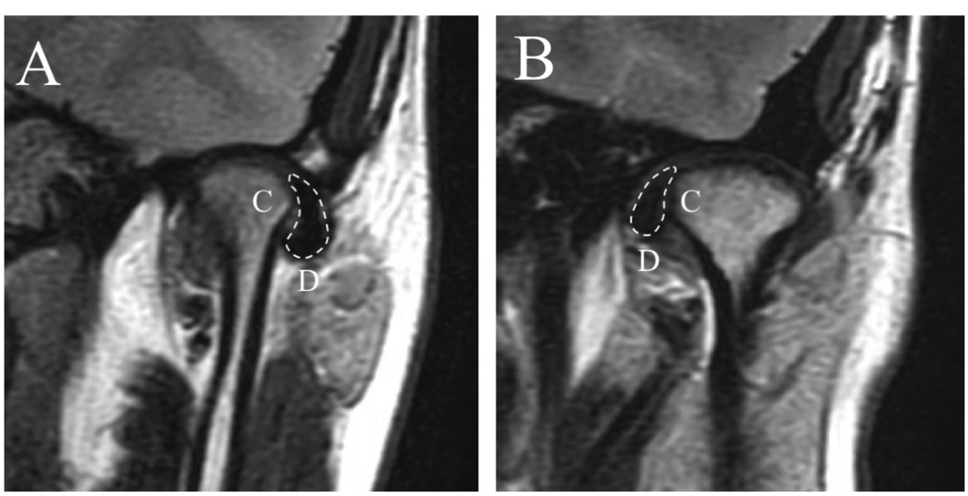

Fig. 1. Classification of disc displacement under MRI examination: (A) coronal image showing anterolateral disc displacement, in which the lateral point of the disc (point D) is located below the lateral pole of the condyle (point C); (B) coronal image showing anteromedial disc displacement, in which the medial point of the disc (point D) is located below the medial pole of the condyle (point C).

rotational anterior DD comprised a combination of anterior release, disc reduction, and disc suture, which were performed through five to six punctures (Fig. 2), under local anaesthesia (2% lidocaine) to avoid pain and to decrease bleeding[1,2].

Main and key points of rotational anterior DD

The first puncture, located on the concavity of the glenoid fossa, aimed at diagnostic arthroscopy. To access this puncture site, the patient was asked to adopt an open-mouth position. The surgeon then used a thumb to mark the posterior slope of the articular eminence and the condylar process. The point at the intersection of the two lines was determined, and the first puncture site was located 1–2 mm backwards from this point (Fig. 3). At this site, an arthroscopic cannula was inserted in a forward and upward direction (15–45°) into the superior joint space.

After a thorough arthroscopic exploration, the second puncture for anterior release was made; this was done in the closed-mouth position. The line of the anterior slope of the eminence was marked with the thumb. Next, a second cannula was placed on the body surface parallel to the arthroscopic cannula, which went into the anterior recess, and was located in the outer-most part of the lateral cavity (Fig. 4). The point of intersection of the two lines was identified. For anterolateral DD, the second puncture point was 1–2 mm behind the intersection point and in a forward direction (the tip was turned 15° clockwise to the horizontal line) (Fig. 5A, B). For anteromedial DD, however, the puncture point was 1–2 mm more forward. Accordingly, the direction of this puncture was designed backwards (the tip turned 15° anticlockwise to the horizontal line) (Fig. 5C, D). Under arthroscopic visualization, a coblation probe was then inserted into the working cannula[14]. The incision line was made 2–3 mm anterior to the anterior band from medial to lateral. Following this, trocars were used for further tissue separation and to push the disc backwards.

For disc reduction, the third puncture point (also named the body projection) was made between the first and the second puncture sites, usually 10–15 mm ahead of the first one. This time, the arthroscopic cannula was pulled back from the anterior crypt towards the lateral ridge of the articular tubercle, the narrowest part of the intermediary cavity. A 12-gauge suture needle was then inserted into the border between the bilaminar zone and the posterior band in a forward and upward orientation for anterolateral DD. For anteromedial DD, the puncture point was moved 1–2 mm forwards, and a backward and downward direction was used. The tip of the needle came in and out from lateral to medial, but was directed more laterally (Figs 6 and 7).

Accordingly, the fourth and fifth punctures were performed through the anterior wall of the external auditory canal, usually 5–10 mm away from the tip of the tragus. Through these punctures, two customized suture grippers were used to catch the surgical suture from the 12-gauge suture needle[2] (Fig. 8).

In order to maintain the stability of the disc, a second suture is commonly recommended. The point of this puncture (sixth) was usually 5 mm posterior to the third puncture. And then again followed by lasso type (fourth) and hook type (fifth) suture gripper insertion.

After suturing, the coblation probe and trocars were again used at the second site for a complete anterior release.

To reposition the anterolateral displaced disc, the sutures were pulled backwards and inwards, whereas to re-

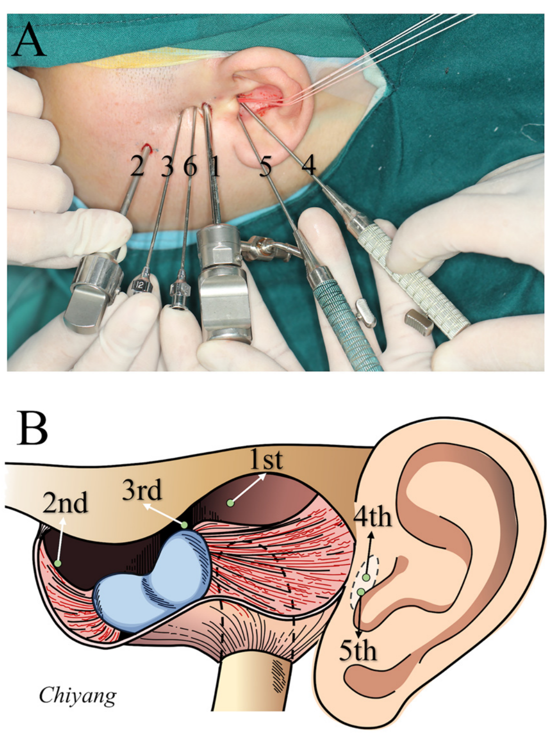

Fig. 2. (A) Clinical photo showing all six arthroscopic cannulae in place: (1) first (fossa) puncture cannula, (2) second (eminence) cannula, (3) 12-gauge needle insertion, (4) lasso type suture gripper insertion through transmeatal puncture, (5) hook type suture gripper insertion through transmeatal puncture, (6) 12-gauge needle insertion for the second suture, then again followed by lasso type and hook type suture gripper insertion (B) Schematic diagram showing the locations of the five cannulae (the first suture).

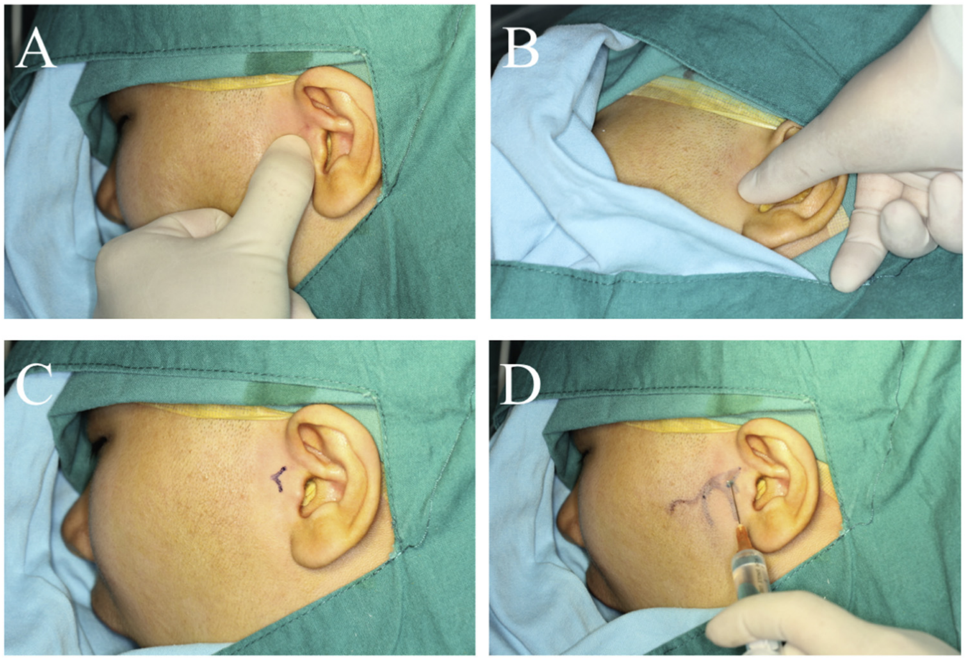

Fig. 3. The first arthroscopic puncture located on the concavity of the glenoid fossa. In the open-mouth position, the surgeon used a thumb to mark the posterior slope of the articular eminence (A) and the condylar process (B); the point at the intersection of the two lines was determined (C), and the first puncture site was located 1–2 mm backwards from this point (D).

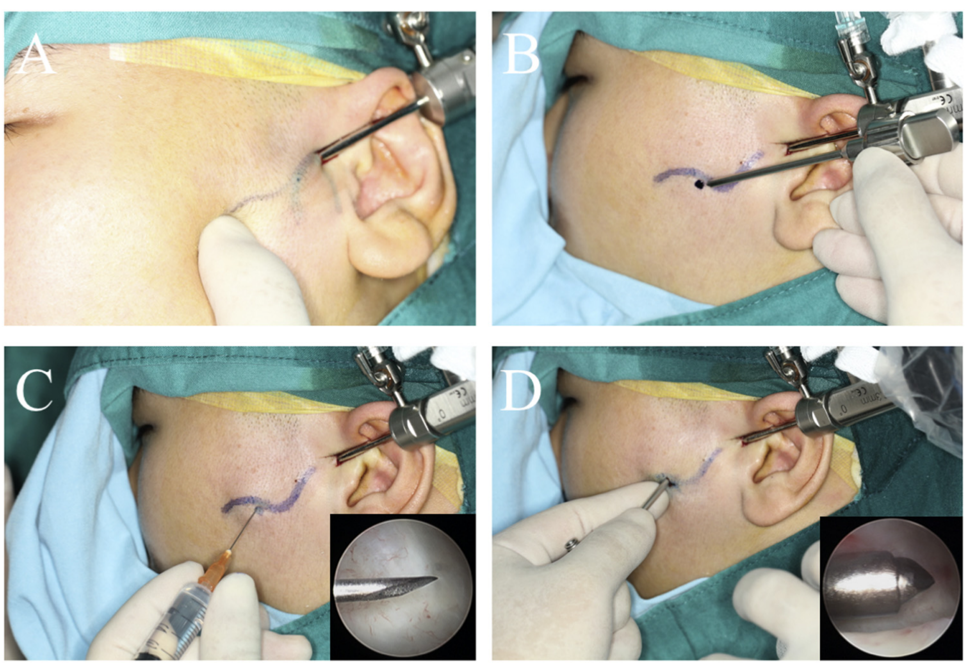

Fig. 4. In the closed-mouth position, the surgeon's thumb was used to mark the line of the anterior slope of the articular eminence (A). Then, a second cannula was placed on the body surface parallel to the arthroscopic cannula (B), in order to locate the second puncture site (C and D).

position the anteromedial displaced disc, the direction was changed to backwards and outwards (Fig. 9). After the final arthroscopic evaluation, the sutures were tied at the fourth and sixth punctures, with the knots positioned underneath the tragus cartilage.

Antibiotics and non-steroidal anti-inflammatory drugs were routinely prescribed and the patients were instructed to follow a soft diet for 3 days postoperative[2]. Mouth opening exercises were then started 1 week after the operation. For patients with a transient postoperative malocclusion, a functional appliance was recommended[15,16].

Postoperative evaluation

Patients were followed up regularly at 1, 6, 12, and 24 months postoperative. At

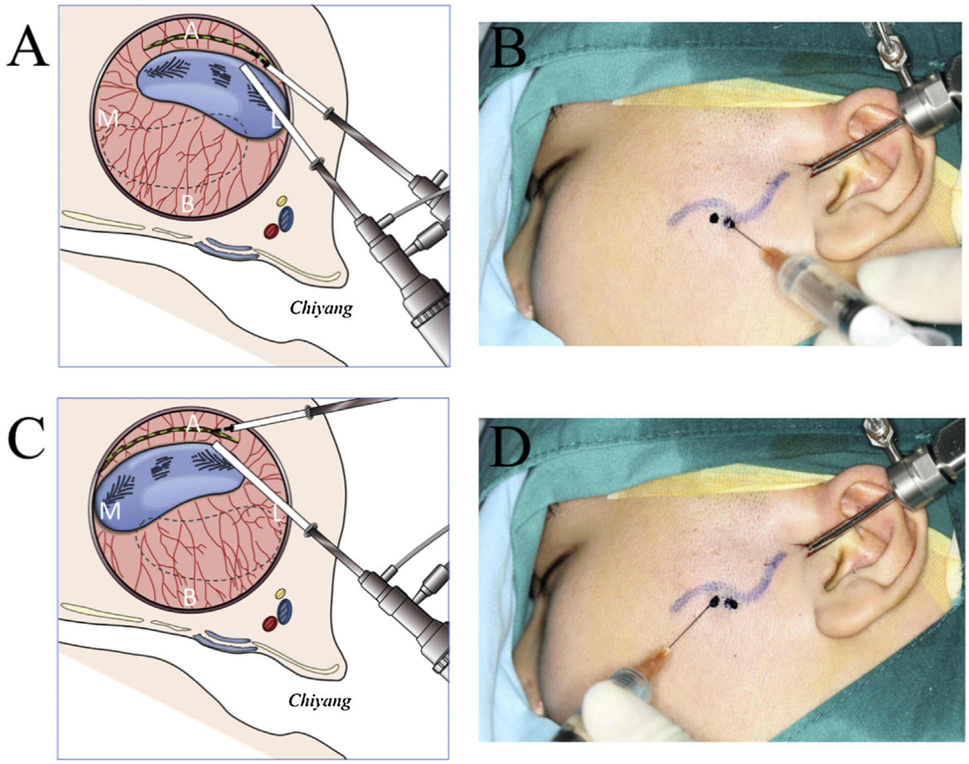

Fig. 5. Schematic diagrams and clinical photos demonstrating the insertion of the second puncture in a forward direction in the case of anterolateral disc displacement (A, B) and backward direction for anteromedial disc displacement (C, D).

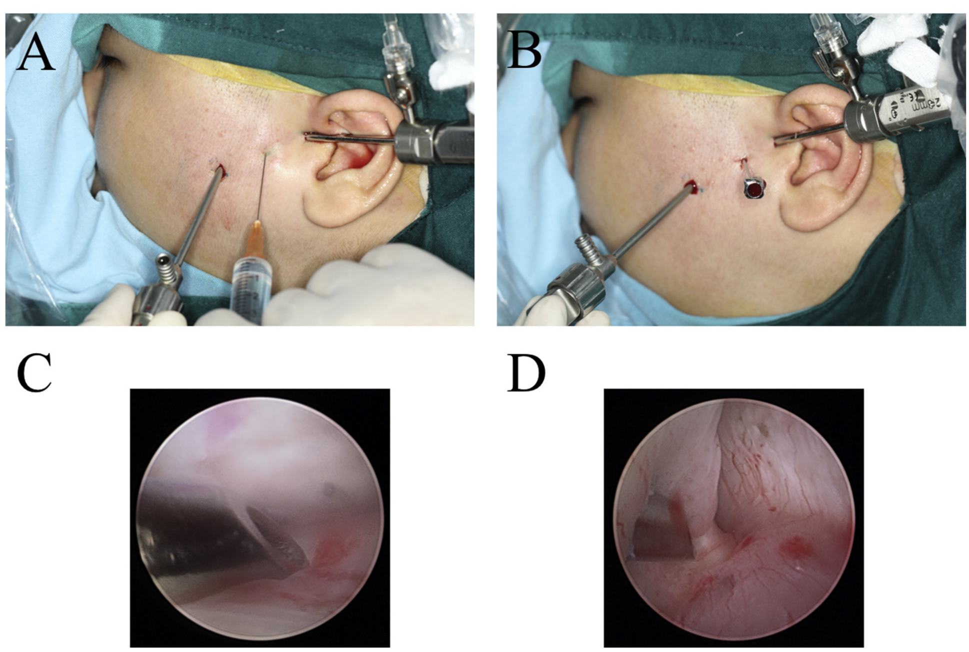

Fig. 6. (A) 5-gauge needle (2%lidocaine) was inserted to avoid pain as well as to work as a guidance for the third puncture. (B) 12-gauge suturing needle was then inserted in (following the mark of anesthesia needle). (C) under the arthroscopy, the tip of suturing needle went through the lateral point into the border of the bilaminar zone and the posterior band. (D) and then came out from the medial point.

these follow-up appointments, pain was evaluated using a visual analogue scale (VAS; with a score of 0 to 10, higher scores indicating more severe pain) and the maximum inter-incisal opening (MIO) was measured[17,18]. Successful repositioning of the disc was determined on MRI evaluation at 24 months postoperative (the disc was assessed in both sagittal and coronal images). The success rate was based on both the clinical and MRI evaluation.

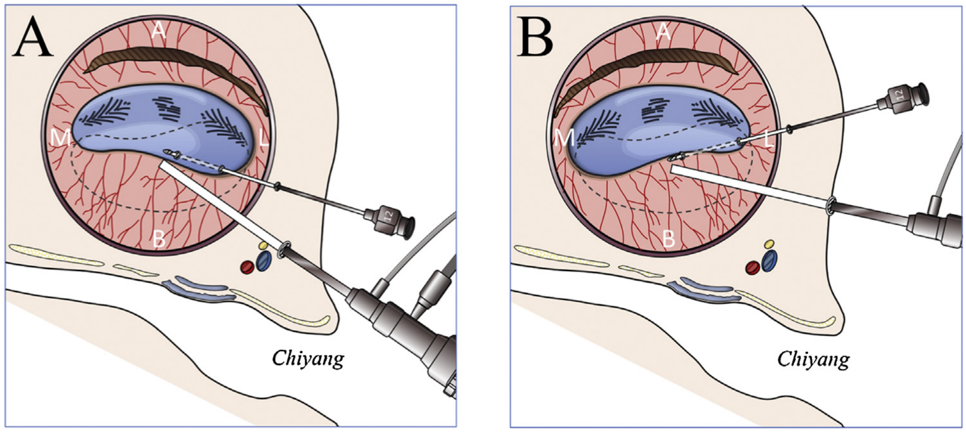

Fig. 7. A 12-gauge suture needle was then inserted into the border of the bilaminar zone and the posterior band, in a forward and upward orientation for anterolateral disc displacement (A), and in a backward and downward direction for anteromedial disc displacement (B).

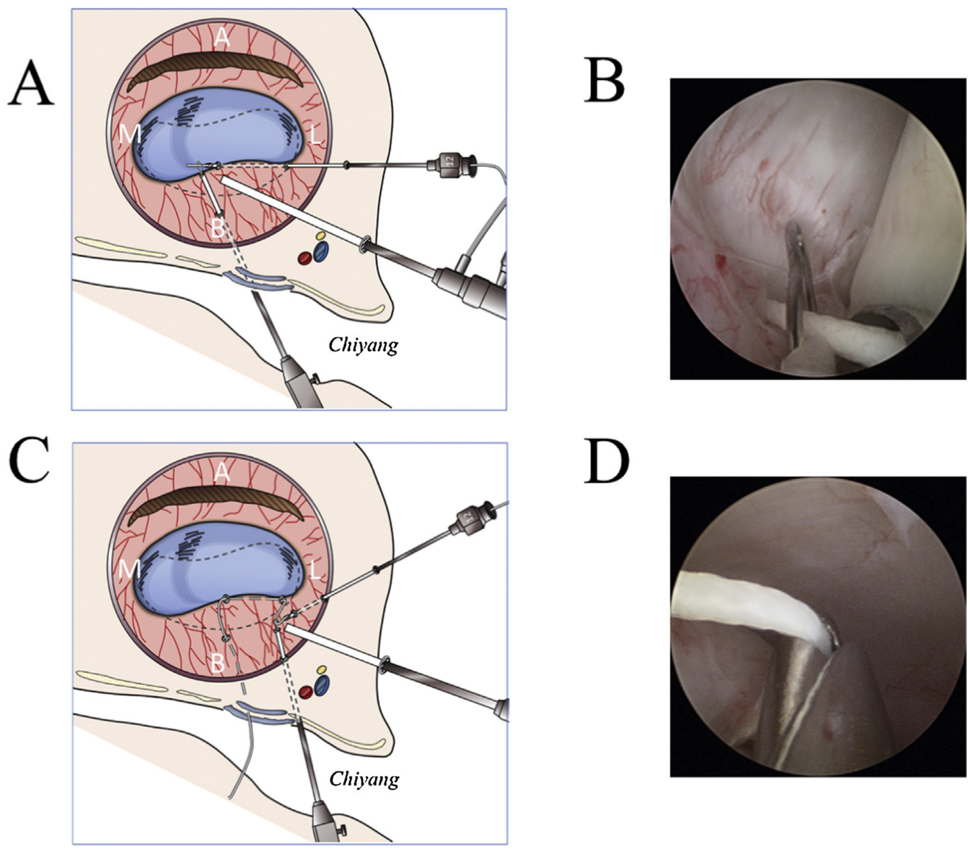

Fig. 8. Schematic diagrams and arthroscopic photos showing the customized suture grippers (lasso type) that were used to catch the surgical suture (A, B), and the customized suture grippers (hook type) (C, D).

Statistical analysis

Data including descriptive statistics and categorical variables were obtained. The data analysis was performed using IBM SPSS Statistics version 21.0 (IBM Corp., Armonk, NY, USA). The parametric paired *t*-test was used for continuous variables and the χ^2 test for categorical variables. A probability value under 0.05 ($P < 0.05$) was considered as statistically significant.

Results

A total of 1570 joints in 1193 patients were assessed for eligibility for inclusion in the study. Of these, 821 joints were not eligible (530 for pure anterior DD, five for septic arthritis, 34 for synovial chondromatosis, 87 for disc perforation, and 165 due to patients who were not compliant or who had MRI done at other hospitals), resulting in a total of 749 joints reviewed in this study. The age of the patients ranged from 13 to 63 years (mean

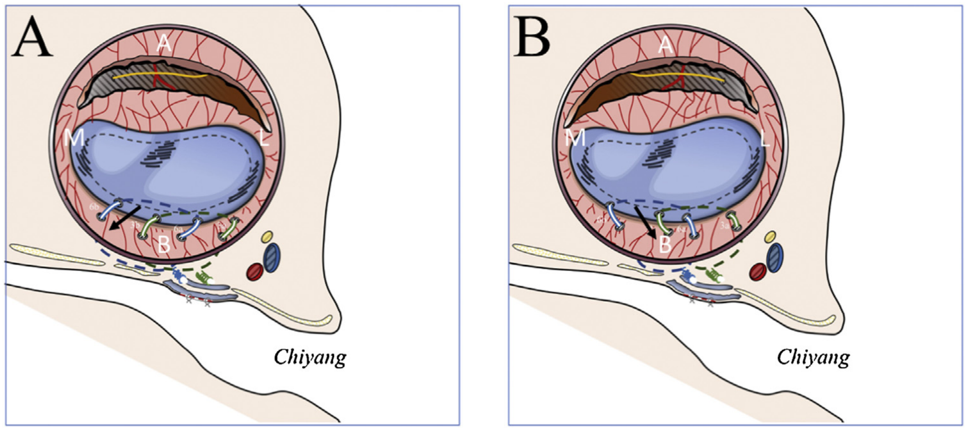

Fig. 9. To reposition the anterolateral displaced disc, sutures were pulled backwards and inwards (A), and to reposition the anteromedial displaced disc, the direction was changed to backwards and outwards (B).

21.23 ± 3.53 years). In this study, 408 joints with anterolateral DD and 341 joints with anteromedial DD underwent arthroscopy treatment (Table 1).

The mean VAS score for pain was 2.06 ± 2.13 before surgery and decreased to 0.96 ± 1.56 at 6 months, 0.79 ± 1.24 at 12 months, and 0.73 ± 1.43 at 24 months postoperative, with almost no episodes of pain reported at the subsequent follow-up visits ($P < 0.001$) (Table 2).

The mean preoperative MIO was 26.65 ± 7.87 mm. A significant improvement of up to 6 mm was detected at the 6-month follow-up. The mean postoperative values were 32.68 ± 6.37 mm at 6 months, 34.02 ± 6.12 mm at 12 months, and 34.73 ± 6.28 mm at 24 months postoperative ($P < 0.001$).

A success rate of 95.3% (714 joints) was calculated based on MRI evaluation at 24 months postoperative: the disc was found to be repositioned in both sagittal and coronal images, and new bone formation was identified on the apex of the condyle (Fig. 10).

Postoperative complications were encountered in 13 joints, which included severe bleeding requiring percutaneous suture ($n = 3$), masseteric nerve injury ($n = 8$), and suture rejection reactions ($n = 2$).

Table 1. Baseline characteristics of the patients.

Characteristic	
Sex, *n* (%)	
Male	147 (27.6)
Female	385 (72.4)
Age (years), mean ± SD	21.23 ± 3.53
Side, *n* (%)	
Unilateral	315 (59.2)
Bilateral	217 (40.8)
Pain VAS score[a], mean ± SD	2.06 ± 2.13
MIO[b] (mm), mean ± SD	26.65 ± 7.87
Classification, *n* (%)	
Anterolateral disc displacement	408[c] (54.5)
Anteromedial disc displacement	341[c] (45.5)

SD, standard deviation.
[a] The visual analogue scale (VAS) score for pain is a score from 0 to 10, in which a higher score indicates more severe pain.
[b] Maximum inter-incisal opening (MIO) evaluates the movement of the TMJ.
[c] The numbers of joints.

Table 2. Pain VAS scores, MIO, and complications over time following arthroscopy treatment[a].

Follow-up	Pain VAS	*P*-value[b]	MIO, mm	*P*-value[b]	Complications (*n*)
1 month	2.08 ± 2.27	–	26.91 ± 7.02	–	Severe bleeding (3)
6 months	0.96 ± 1.56	<0.001	32.68 ± 6.37	<0.001	Nerve injury (8)
12 months	0.79 ± 1.24	<0.001	34.02 ± 6.12	<0.001	Rejection reaction (2)
24 months	0.73 ± 1.43	<0.001	34.73 ± 6.28	<0.001	

MIO, maximum inter-incisal opening; VAS, visual analogue scale.
[a] Results are presented as the mean ± standard deviation values.
[b] *P*-values were calculated by *t*-test for continuous variables and by χ^2 test for categorical variables.

Discussion

DD is a common disorder of the TMJ and often results in clicking, pain, limited mandibular movements, and even masticatory difficulties[1,2]. According to previous studies, it affects one-third of the general population, with a higher prevalence in women[19]. Based on MRI of the TMJ, which is considered an accurate technique for the diagnosis of internal derangement, anterior DD may occur alone or in combination with medial or lateral shifts[20,21]. Foucart et al.[9] reported a rotational DD rate of 40.2% in 171 joints with anterior DD and considered this an important aspect of internal derangement. In the present study, 749 joints with rotational anterior DD fulfilled the inclusion criteria, in which lateral displacement predominated, with a lateral-to-medial ratio of 1.2:1.

In the 1990s, McCain et al.[1] introduced an arthroscopic technique for the management of anterior DD. Subsequently, Yang et al.[2] modified the arthroscopic repositioning and suturing technique for pure anterior DD and reported its use in 2167 patients, with a success rate of 95.42%. However, these studies focused on pure anterior DD without presenting any alternative method for other types of DD. Thus this article introduces a new technique of arthroscopic

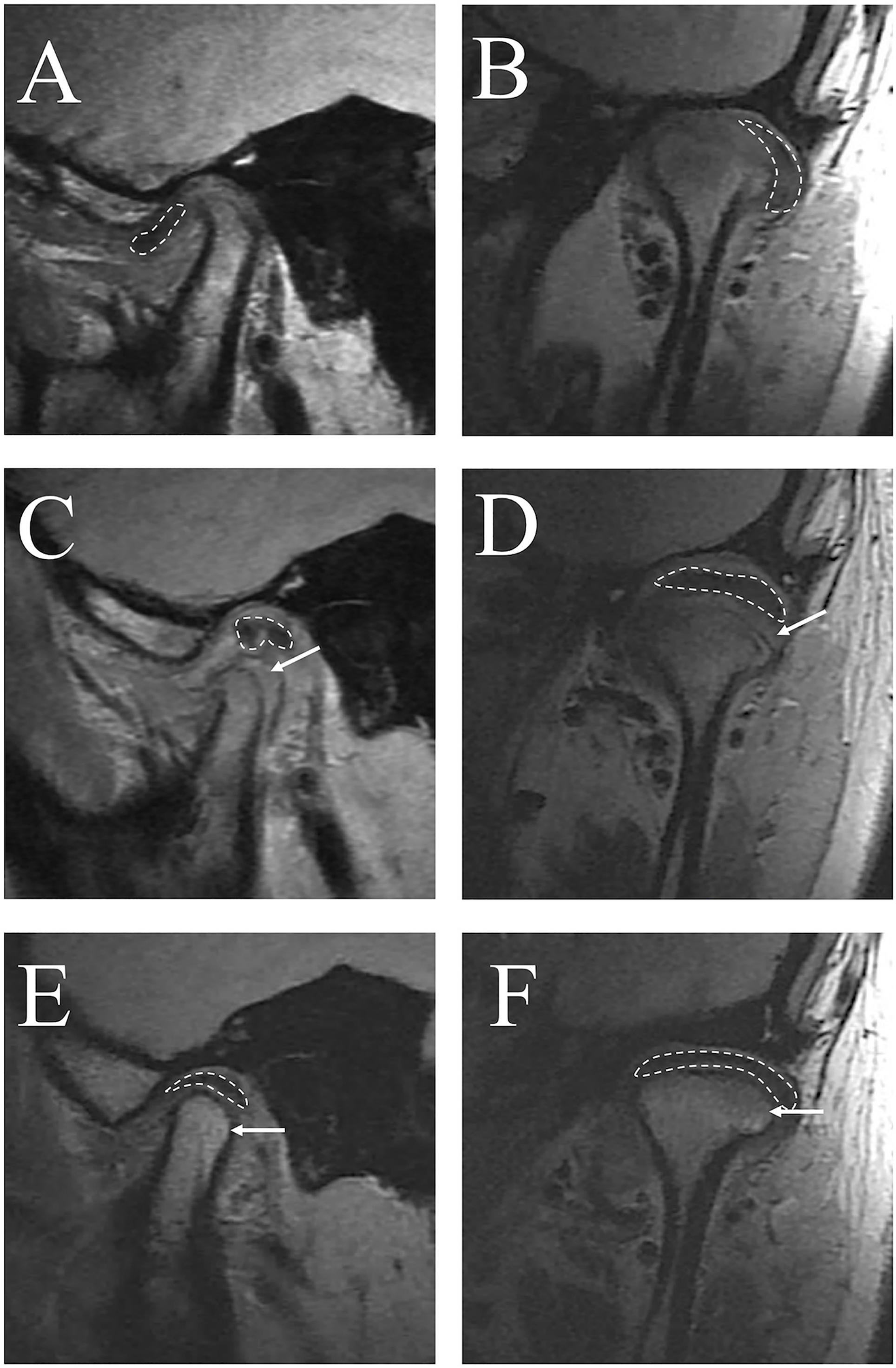

Fig. 10. MRI of the TMJ before surgery (A: coronal view; B: sagittal view), 6 months after surgery (C: coronal view; D: sagittal view), and at 24 months after surgery (E: coronal view; F: sagittal view) in the same patient, showing successful disc recapture and new bone formation of condylar remodelling. The white dotted line defines the TMJ disc; the white arrows mark the new bone formation.

disc repositioning and suturing for rotational anterior displacement including anterolateral and anteromedial DD.

Compared to pure anterior DD[2,22,23], the surgical procedure for rotational anterior DD is more difficult and complicated, as the disc requires repositioning in both the sagittal and coronal direction. Therefore, the puncture technique and direction of suture are the main and key points for success.

In this study, the first puncture point was 1–2 mm backwards from the intersection point of the posterior slope of the eminence and the condylar process. According to McCain et al.[1], this can effectively avoid damage to the blood vessel bundles, thus reducing bleeding during the puncture process. Through this puncture, the arthroscopy, which started from the posterior recess, went through the intermediary space and lateral groove and then into the anterior recess. This not only provides a clear view of the whole upper cavity, but also leaves enough space for further surgical procedures.

According to Yang et al.[2,14], complete release of the anterior attachment from medial to lateral with only 2 mm depth plays an important role in achieving a complete disc repositioning. However, for anterolateral DD, the strong lateral ligament makes it difficult to perform the release of the lateral part of the anterior attachment. Regarding anteromedial DD, the anatomical weakness of the condylar medial sulcus potentially obstructs the anterior release of the medial attachment to be conducted under direct arthroscopic visualization. Therefore, the second puncture was designed differently from that used in pure anterior DD. Comparatively, the puncture site for anterolateral DD was moved more backwards from the anterior surface of the eminence in order to cut the lateral part of the disc, and for anteromedial DD it was moved more forwards to cut the medial part of the disc. Moreover, in order to obtain complete release, a trocar with a sharp blade was often used afterwards to separate the ligaments while avoiding neurovascular bundle injury.

For disc reduction, the ideal puncture point (third) is usually 10–15 mm ahead of the first one. For rotational DD, this puncture was moved more backwards (anterolateral) or forwards (anteromedial) to ensure that the 12-gauge suture needle was nearly parallel to the horizontal axis of the disc. According to a previous study, if the direction of traction is inconsistent with the anteroposterior axis of the disc, it may be unable to resist the strength of the lateral pterygoid muscle, which may interfere with postoperative stability[2]. Furthermore, the third puncture site was required to be made above the lowest point of the eminence in order to avoid the challenge following disc suturing.

The suture technique used for rotational anterior DD was also different from that used in pure anterior DD. The latter can be reduced by a posterior pull suture. For rotational anterior DD, the suture was fastened in a backwards and inwards direction for anterolateral displacement, or a backwards and outwards direction for anteromedial displacement. Only in this way can the disc acquire the anterior/posterior (sagittal) and the inner/outer (coronal) reposition simultaneously.

In this study, the rotationally displaced disc was repositioned with a success rate of 95.3% according to the follow-up MRIs at 24 months postoperative. In most studies reported in the literature, a significant decrease in VAS pain score was achieved postoperatively. In the present study, the mean VAS score decreased from 2.06 preoperative to 0.73 during the follow-up period. Furthermore, the statistical analysis also showed an obvious improvement in MIO (8.98 mm) in patients treated by TMJ arthroscopic disc repositioning and suturing.

In the study by Yang et al., a total of two sutures contributed to a temporary overcorrection (the anterior band with vessels could be seen in the intermediary space under arthroscopic evaluation; the border between the bilaminar zone and posterior band was located at 1–2 o'clock on the condylar process on postoperative MRI), which helped avoid relapse of the DD[2]. In this study, a second suture was performed in 733 joints to hold enough tissue for disc reduction of the rotation cases.

The postoperative complications seen in seven of the patients with rotational DD in this study are in accordance with those reported for pure anterior DD. Zhang et al.[24] reported complications including haemorrhage of the lateral pterygoid muscle, masseteric muscle nerve injuries, and rejection reaction. In a large retrospective study, the reported complications included external auditory canal lacerations, auriculotemporal nerve injury, facial nerve paresis, and alteration of the ipsilateral visual accuracy[25].

Previous research on patients with anterior DD who received no treatment showed that the TMJ disc became more anteriorly displaced and shortened after 10.7 months of follow-up of the natural course[26]. Furthermore, the disc can only be successfully repositioned when the form and length of the disc are normal or close to normal. Otherwise, it would be very difficult to perform disc recapture if the disc was very short or deformed. Accordingly, reliable disc repositioning is best performed only prior to disc deformation and shortening.

There are two techniques of TMJ disc repositioning for the management of TMJ DD: arthroscopic surgery and open discopexy[17]. With the arthroscopic technique[2], the disc is repositioned by anterior release and is sutured to the external auditory meatus. This represents an effective technique for early internal derangement, but is often inadequate for longstanding cases of DD, as the posterior band is quite thick making arthroscopic repositioning challenging and often unstable. In these patients, open discopexy with mini-anchor fixation is the treatment of choice[6–8]. Regarding stability, the authors believe that disc fixation to the condyle using a Yang mini-anchor screw is more stable than arthroscopic suturing of the disc to the soft tissues anterior to the external ear. However, arthroscopic discopexy shows superior joint biomechanics.

This technique still has some limitations. It is inadequate for some patients with a longstanding history of DD or who are in the late stages of DD, and the technical requirement is relatively high. As the technique is complex and challenging, regular training is required to help the surgeon through the learning curve. The operator must have knowledge of open TMJ surgery and exceptional arthroscopic puncture and triangulation skills, in addition to excellent surgical skills. Therefore, the authors believe that this technique will be adopted among surgeons who are sincere in learning and practice.

In conclusion, this article describes an arthroscopic discopexy for the management of rotational anterior DD of the TMJ. In this study, significant improvements in MIO and VAS score for pain were reported during 24 months of follow-up after arthroscopic discopexy based on Yang's technique. However, patients with DD with disc perforation were not included, which represents a shortcoming. According to Liu et al.[27], perforation, which usually occurs in the lateral part of the articular disc, is also a special type of DD; hence, there is the need to present further techniques for such cases in future studies. The long-term results, including the relapse rate and condylar remodelling, will be investigated in future studies.

Funding

This study was supported by the Program of National Natural Sciencew Foundation of China (81870785), the Shanghai Municipal Science Research Project (SHDC12017101) and Shanghai Summit and Plateau Disciplines. The funding sources had no role in the study design, collection, analysis, and interpretation of the data, or in the writing of the report.

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, and the protocol was 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.

References

1. McCain JP, Podrasky AE, Zabiegalski NA. Arthroscopic disc repositioning and suturing: a preliminary report. *J Oral Maxillofac Surg* 1992;**579**:568–79. discussion 579-580.
2. 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.
3. 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.
4. Annandale T. On displacement of the inter-articular cartilage of the lower jaw and its treatment by operation. *Lancet* 1887;**1**:411–2.
5. Dolwick MF, Nitzan DW. The role of disc-repositioning surgery for internal derangements of the temporomandibular joint. *Oral Maxillofac Surg North Am* 1994;**6**:271–5.
6. Mehra P, Wolford LM. The Mitek mini anchor for TMJ disc repositioning: surgical technique and results. *Int J Oral Maxillofac Surg* 2001;**30**:497–503.
7. Zhang S, Liu X, Yang X, Yang C, Chen M, Haddad MS, Chen Z. Temporomandibular joint disc repositioning using bone anchors: an immediate post surgical evaluation by magnetic resonance imaging. *BMC Musculoskelet Disord* 2010;**11**:262.
8. He D, Yang C, Zhang S, Cai X, Wilson JJ. Modified temporomandibular joint disc repositioning with mini screw anchor: part I—surgical technique. *J Oral Maxillofac Surg* 2015;**73**:47. e1–9.
9. Foucart JM, Carpentier P, Pajoni D, Marguelles-Bonnet R, Pharaboz C. MR of 732 TMJs: anterior, rotational, partial and sideways disc displacements. *Eur J Radiol* 1998;**28**:86–94.
10. Matsuda S, Yoshimura Y, Lin Y. Magnetic resonance imaging assessment of the temporomandibular joint in disk displacement. *Int J Oral Maxillofac Surg* 1994;**23**:266–70.
11. González-García R, Gil-Díez Usandizaga JL, Rodríguez-Campo FJ. Arthroscopic anatomy and lysis and lavage of the temporomandibular joint. *Atlas Oral Maxillofac Surg Clin North Am* 2011;**19**:131–44.
12. Meyers RA, Schellhas KP, Hall HD, Indresano AT, Wilkes CH. Guidelines for diagnosis and management of disorders involving the temporomandibular joint and related musculoskeletal structures. American Society of Temporomandibular Joint Surgeons. *Northwest Dent* 1992;**71**:21–7.
13. Wilkes CH. Internal derangements of the temporomandibular joint. Pathological variations. *Northwest Dent* 1990;**69**:25–32.
14. Chen MJ, Yang C, Zhang SY, Cai XY. Use of coblation in arthroscopic surgery of the temporomandibular joint. *J Oral Maxillofac Surg* 2010;**68**:2085–91.
15. Costa YM, Porporatti AL, Stuginski-Barbosa J, Bonjardim LR, Conti PC. Additional effect of occlusal splints on the improvement of psychological aspects in temporomandibular disorder subjects: a randomized controlled trial. *Arch Oral Biol* 2015;**60**:738–44.
16. Wang BL, Yang C, Cai XY, Chen MJ, Zhang SY, Fang B, Yun B. Malocclusion as a common occurrence in temporomandibular joint arthroscopic disc repositioning: outcomes at 49 days after surgery. *J Oral Maxillofac Surg* 2011;**69**:1587–93.
17. Al-Moraissi EA. Open versus arthroscopic surgery for the management of internal derangement of the temporomandibular joint: a meta-analysis of the literature. *Int J Oral Maxillofac Surg* 2015;**44**:763–70.
18. Ishiyama H, Inukai S, Nishiyama A, Hideshima M, Nakamura S, Tamaoka M, Miyazaki Y, Fueki K, Wakabayashi N. Effect of jaw-opening exercise on prevention of temporomandibular disorders pain associated with oral appliance therapy in obstructive sleep apnea patients: a randomized, double-blind, placebo-controlled trial. *J Prosthodont Res* 2017;**61**:259–67.
19. Boering G. Temporomandibular joint arthrosis and facial deformity. *Trans Int Conf Oral Surg* 1967;**25**:258–60.
20. Larheim TA. Role of magnetic resonance imaging in the clinical diagnosis of the temporomandibular joint. *Cells Tissues Organs* 2005;**180**:6–21.
21. 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.
22. Murakami K, Moriya Y, Goto K, Segami N. Four-year follow-up study of temporomandibular joint arthroscopic surgery for advanced stage internal derangements. *J Oral Maxillofac Surg* 1996;**54**:285–90. discussion 291.
23. Ohnishi M. Arthroscopic laser surgery and suturing for temporomandibular joint disorders: technique and clinical results. *Arthroscopy* 1991;**7**:212–20.
24. Zhang S, Yang C, Cai X, Liu X, Huang D, Xie Q, Haddad MS, Chen Z. Prevention and treatment for the rare complications of arthroscopic surgery in the temporomandibular joint. *J Oral Maxillofac Surg* 2011;**69**:e347–53.
25. González-García R, Rodríguez-Campo FJ, Escorial-Hernández V, Muñoz-Guerra MF, Sastre-Pérez J, Naval-Gías L, Gil-Díez Usandizaga JL. Complications of temporomandibular joint arthroscopy. A retrospective study of 670 arthroscopic procedures. *J Oral Maxillofac Surg* 2006;**64**:1587–91.
26. Cai XY, Jin JM, Yang C. Changes in disc position, disc length, and condylar height in the temporomandibular joint with anterior disc displacement: a longitudinal retrospective magnetic resonance imaging study. *J Oral Maxillofac Surg* 2011;**69**:e340–6.
27. 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.

Address:
Chi Yang
Department of Oral Surgery
Shanghai Ninth People's Hospital
Shanghai Jiao Tong University School of Medicine
639 Zhizaoju Road
Shanghai
200011
China
E-mail: yangchi63@hotmail.com