The Knee 26 (2019) 1125–1135

Contents lists available at ScienceDirect

The Knee

Novel techniques

Application of assisted portal under anterior horn of lateral meniscus for the treatment of discoid meniscus injury

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ARTICLE INFO

Article history:
Received 14 January 2019
Received in revised form 5 May 2019
Accepted 2 July 2019

Keywords:
Anterior horn
Arthroscopic
Assisted portal
Discoid meniscus.

ABSTRACT

Purpose: The assisted inferior anterolateral portal under anterior horn of the lateral meniscus (UAHLM portal) was applied to treat the lateral discoid meniscus injury conveniently and the clinical outcomes were evaluated.

Methods: A retrospective review was conducted on 60 patients who underwent arthroscopic surgery with a symptomatic discoid lateral meniscus. Normal anterolateral/anteromedial portals assisted with UAHLM portal (1-2 cm inferior to the anterolateral portal) were used. All patients were followed up for 24–48 months (median, 33 months) and evaluated by MRI images and clinical outcomes including clinical findings, Lysholm scores and IKDC scores.

Results: After meniscus plasty with or without repair, most of the upper layer of lateral meniscuses was retained. A total of 54 patients (16 males and 38 females, 42 ± 17.8 years old) showed satisfactory clinical results without requiring reoperation after a median follow-up time of 33 months. At final follow-up, a full range of motion was achieved in all patients. MRI indicated the thickness of anterior horn of lateral meniscus was (5.38 ± 1.09 mm) before the operation and (4.04 ± 0.71 mm) after the operation at the 2-year follow-up; clinical outcomes were improved significantly than the baseline: positive McMurray test (50 *vs.* 2, $P< 0.001$), Lysholm score (64.9 ± 9.0 *vs.* 94.7 ± 4.9, $P< 0.001$), and IKDC score (54.4 ± 7.7 *vs.* 92.6 ± 4.3, $P< 0.001$). No significant complication was observed during the follow-up.

Conclusion: Thus, this technique with assisted UAHLM portal was convenient for arthroscopic discoid meniscus plasty and meniscus repair and served as an effective method in patients with a symptomatic discoid lateral.

1. Introduction

A discoid meniscus is susceptible to injury due to its abnormal shape, tissue thickness, irregular collagen arrangement and poor vascularization [1,2]. The incidence of a discoid meniscus in Asian countries is 10–13%, which is higher than that in Western countries [3–5]. A horizontal tear is the most common pattern of discoid meniscus injury [6–8]; it can extend to all sides and

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https://doi.org/10.1016/j.knee.2019.07.003
0968-0160/

reach the edge of the capsule, thereby splitting the meniscus into two layers. The common treatment for symptomatic discoid meniscus injury is arthroscopic surgery; however, the conventional arthroscopic technique makes visualizing and excising the lower layers of an injured meniscus difficult. The lower layer of the anterior horn in a horizontal tear is especially challenging, even for an experienced arthroscopic surgeon [9,10].

The present study evaluated the clinical and radiographical outcomes of the application of assisted inferior anterolateral portal under anterior horn of the lateral meniscus (UAHLM portal) for the treatment of discoid meniscus injury. It aimed to explore an easy, rapid and safe way to manage a discoid meniscus injury with this technique.

2. Methods

2.1. Patients

A retrospective review was conducted on 60 patients who had suffered from a symptomatic lateral discoid meniscus injury and underwent arthroscopic meniscus plasty with a UAHLM portal from August 2012–September 2014 at the Department of Orthopedics, Changhai Hospital, Shanghai, China. All surgeries were performed by the same physician using a conventional portal and assisted UAHLM portal. The inclusion criterion was a single-side arthroscopic lateral meniscus plasty. The exclusion criteria were: a lateral meniscus injury combined with meniscus injury on bilateral knees, cartilage injury, ligament injury and medial meniscus injury. All patients were diagnosed by magnetic resonance imaging (MRI), clinical symptoms (pain, swelling, clicking, catching, or locking) and lateral joint line tenderness. A discoid meniscus tear diagnosed by MRI was the main diagnosis. Data were obtained from the hospital's electronic information system, and follow-up information was gathered at the outpatient department. Patients without complete data were excluded from the review.

2.2. Surgical technique

Patients were placed in a supine position with the ability to flex the knee (to ensure that the figure-four position could be achieved after spinal anesthesia). A tourniquet was applied to the proximal thigh and inflated during the operation. First, two routine portals were made: anterolateral and anteromedial portal. A higher anterolateral portal was located one to 1.5 cm above the joint line and at the lateral edge of the patellar tendon in a palpable soft spot. A common anteromedial portal was made by the same method through an arthroscopic view from the anterolateral portal. Injury type and area of the lateral meniscus were confirmed after a routine arthroscopic inspection with a four-millimeter 30° arthroscope angle (Smith & Nephew, USA) through the anterolateral portal. The specific meniscus tear site was difficult to find due to the lateral discoid meniscus impediment. The central third of the lateral discoid meniscus was excised and, thus, the specific range, depth of injury, and stability of the upper and lower layers of the meniscus were examined using a probe.

Under the view of a scope in the anteromedial portal, an inferior anterolateral portal under the anterior horn of the lateral meniscus was established. The surface anatomy of the UAHLM portal was at one to 1.5 cm lateral to the patellar tendon and

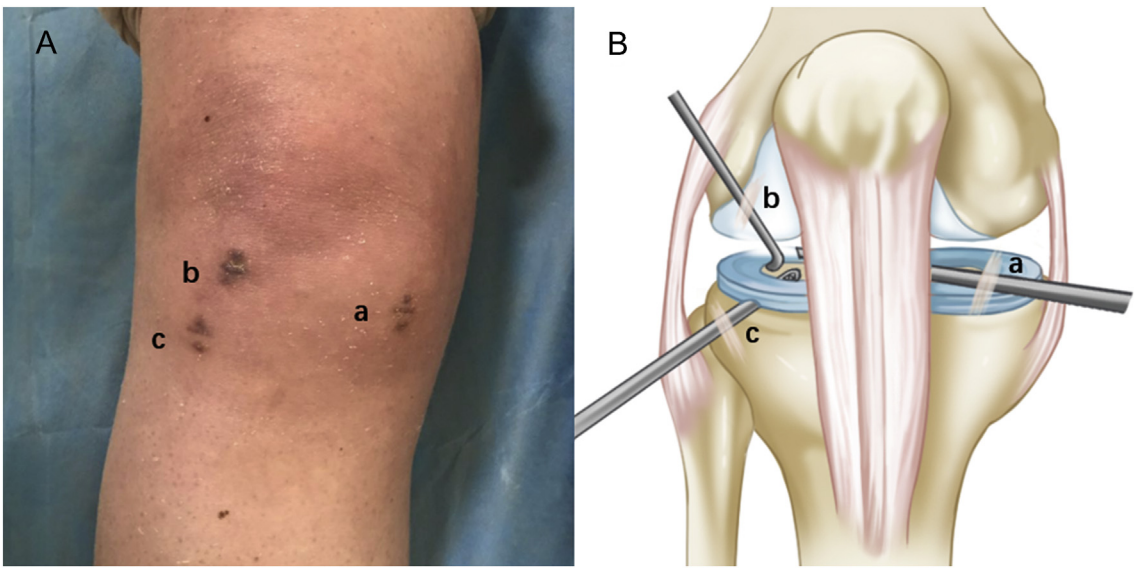

Figure 1. A. Surface symbols of the three portals used in this operation. (a) anteromedial portal: medial edge of the patellar tendon, 1 cm above the joint line; (b) higher anterolateral portal: lateral edge of the patellar tendon, 1–1.5 cm above the joint line; (c) assisted-inferior anterolateral portal, 1–1.5 cm lateral to the patellar tendon and 1–2 cm inferior to the anterolateral portal. B. Illustration of the three portals.

one to two centimeters inferior to the anterolateral portal (Figure 1A). An 18-G needle aiming for the posterior horn of the meniscus was inserted outside-in to localize the exact spot. If the periphery of the meniscus was sufficiently thick and separated into two layers, intra-articular entry was located through the lateral meniscus (inferior to the upper layer and superior to the lower layer). In other cases when the lateral meniscus was relatively thin, intra-articular entry was located inferior to the lower layer. A knife was inserted at the exact point of the needle and run parallel to the dermatoglyphic to make a 3–5 mm incision, and mosquito forceps were used to expand the portal to facilitate instrument passing.

The upper layer of the injured lateral meniscus was pulled back by a probe and the lower layer was exposed (Figure 2). Usually, the lower layer was thinner, more severely injured and needed to be excised. The lower layer could be excised through the gap in the two layers (Figure 3). If the periphery of the meniscus was thin, intra-articular entry was under the lower layer of the meniscus, followed by resection of the lower layer (Figure 4). All of the steps avoided tibial plateau cartilage damage. Saucerization was performed to all lateral discoid menisci to restore them to a normal crescent shape; however, a minimum of six to eight millimeters width of the meniscus was retained (Figure 5) [11]. After saucerization and meniscectomy of the lower layer of the horizontal tear, peripheral tears and some radial tears of the upper layer were routinely sutured. The criteria for a repair were a meniscus with good fixation and a reducible edge without degeneration and a rolled edge. The status of the upper layer and suture was checked with the arthroscope through the UAHLM portal. Finally, the overall status of the lateral meniscus was inspected with the arthroscope through the anteromedial portal (Figure 6).

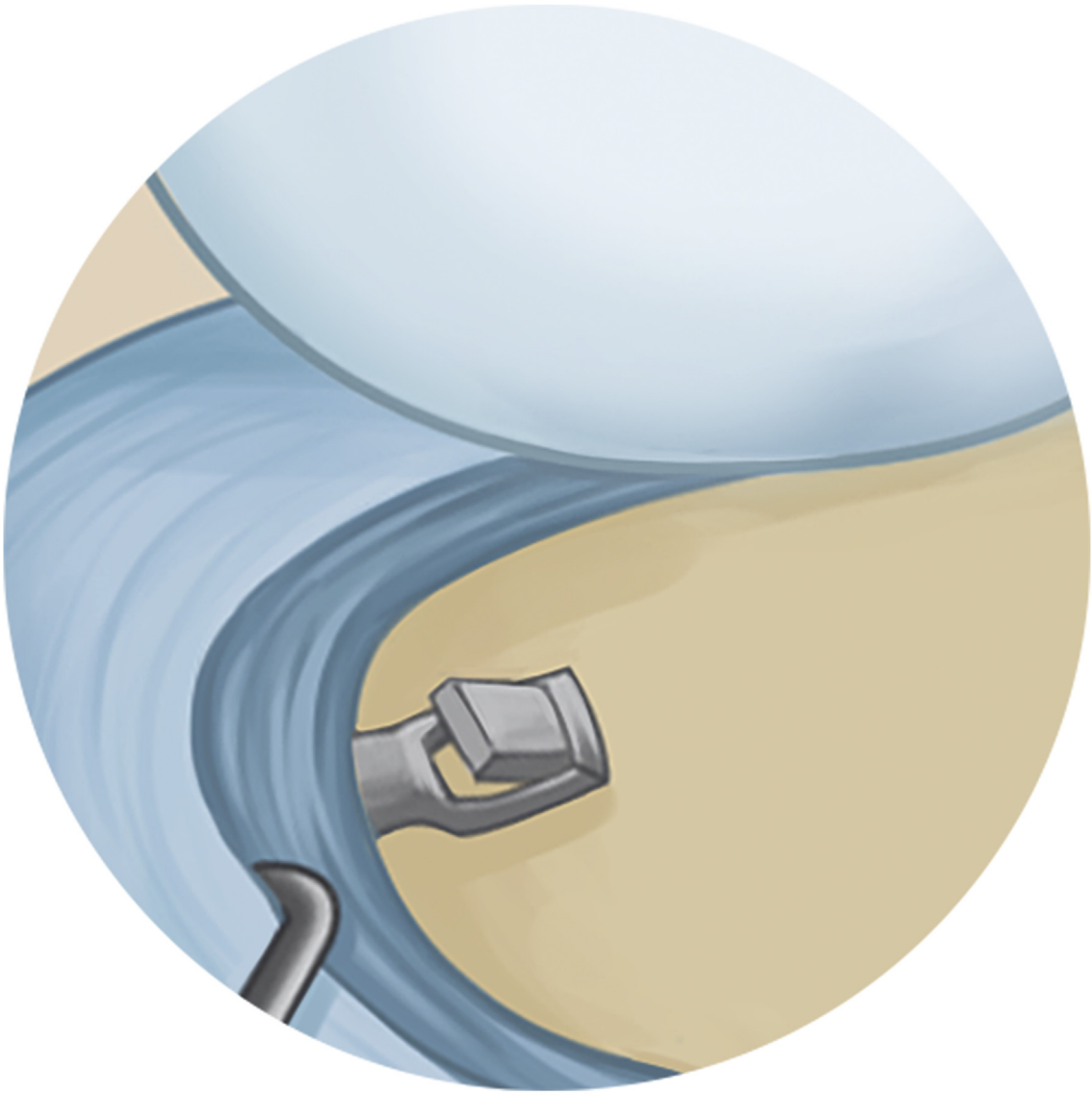

Figure 2. Under the view of a 30° arthroscope angle through the anteromedial portal, the needle was inserted from outside to inside, the upper layer of the meniscus separated, and the lower layer exposed. The lower layer of the anterior horn was excised with basket forceps.

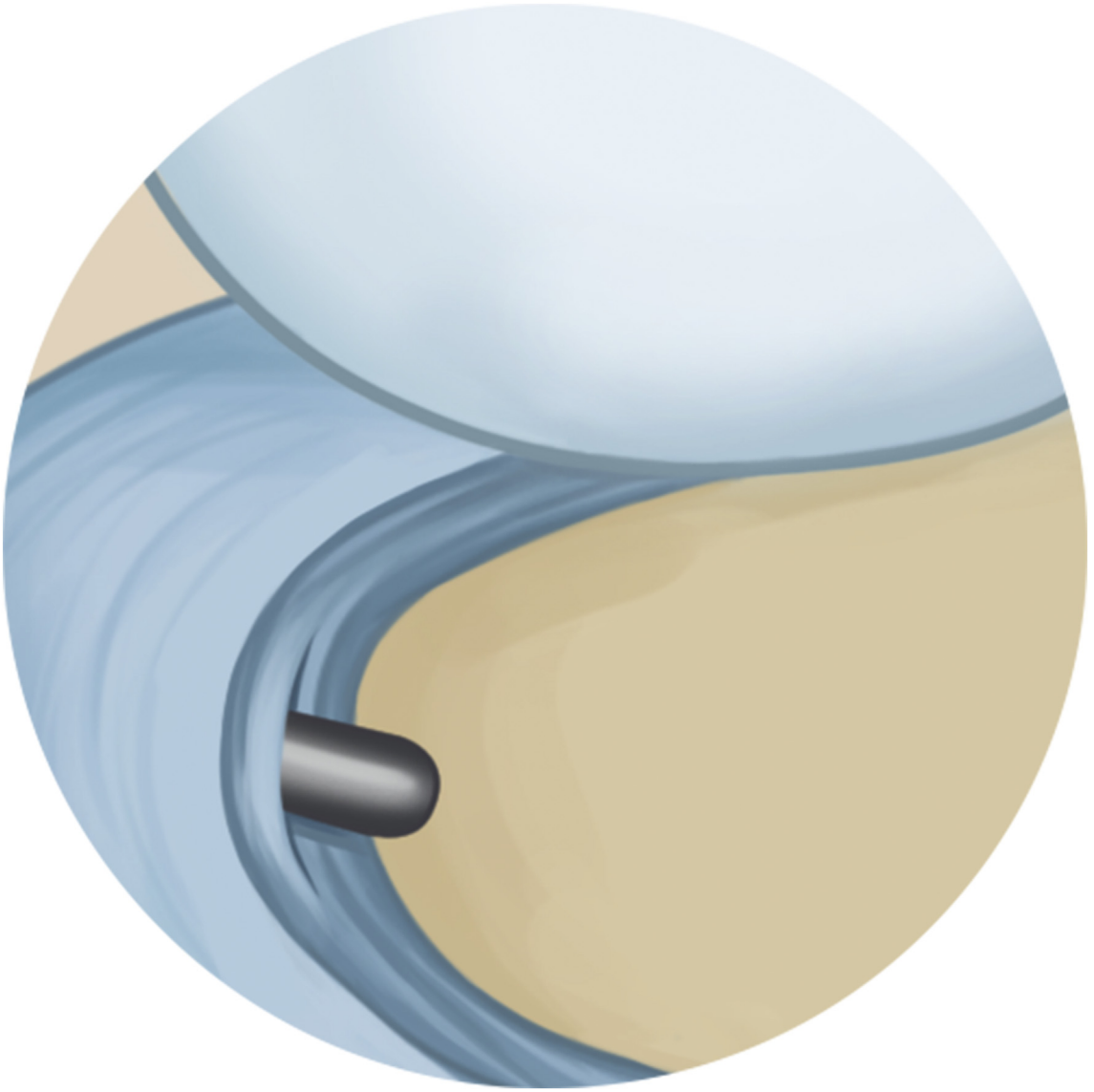

Figure 3. When the periphery of the meniscus is sufficiently thick and separates into two layers, the lower layer can be excised through the gap in the two layers.

2.3. Rehabilitation

For patients who underwent partial meniscectomy, knee range of motion (ROM) and strengthening exercises were started the day after surgery, and partial weightbearing as tolerated with crutches was allowed. Closed kinetic exercises and full weightbearing were started two weeks postoperatively. Passive knee ROM exercises should have reached 120° at two weeks postoperatively. For patients who had partial meniscectomy and meniscus repair, ROM was restricted to 0–90°, and touch weightbearing with crutches was allowed for six weeks postoperatively. Full squatting and closed kinetic exercises were started at three months postoperatively. The duration of rehabilitation was approximately six months. The strengthening and knee ROM exercise program was conducted by experienced therapists. All the rehabilitation programs were delivered to patients in video format before surgery and also checked at the outpatient department.

2.4. Evaluation methods

All patients were followed up by physical examination, subjective scale score and MRI at the outpatient clinic at six months, 12 months and 24 months. The operated knee ROM was recorded, and a McMurray test was conducted by the same surgeon. Lysholm and International Knee Documentation Committee (IKDC) scores were also used to evaluate clinical outcome [12–15].

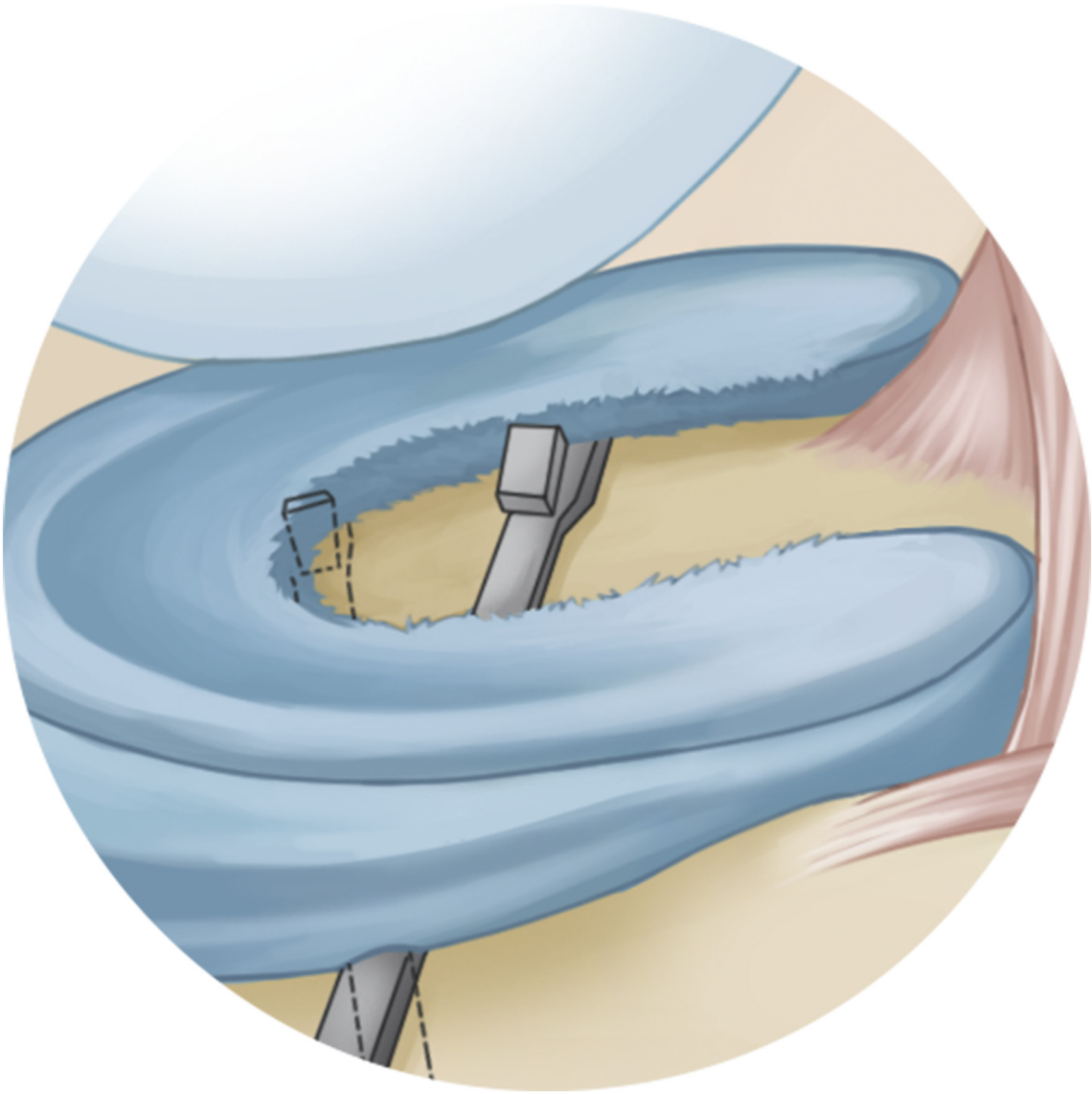

Figure 4. Resection of the lower layers of the central and posterior horn of the lateral meniscus was convenient and, hence, the periphery of the posterior horn was repaired.

2.5. Statistics

Data including operation records, MRI images and operation videos were analyzed using SPSS22.0 (IBM, USA). Measurement data were presented as the mean ± standard deviation. A paired *t*-test compared the differences before and after the operation. Significance was defined as a *P*-value <0.05.

3. Results

3.1. Population characteristics

Six patients were lost to follow-up: four refused to attend the follow-up visit and two lost contact. Of the remaining patients, 16 patients were men and the other 38 were women. Median age of the patients was 42.0 (range, seven to 69) years, and the median follow-up period was 33 (range, 24–48) months. All patients suffered from a symptomatic lateral meniscus injury, of which 33 had a complex tear and 18 had a horizontal tear. Fifty patients were positive for the McMurray test before surgery. Thirty-two patients had meniscus plasty only, and 22 had meniscus plasty and repair.

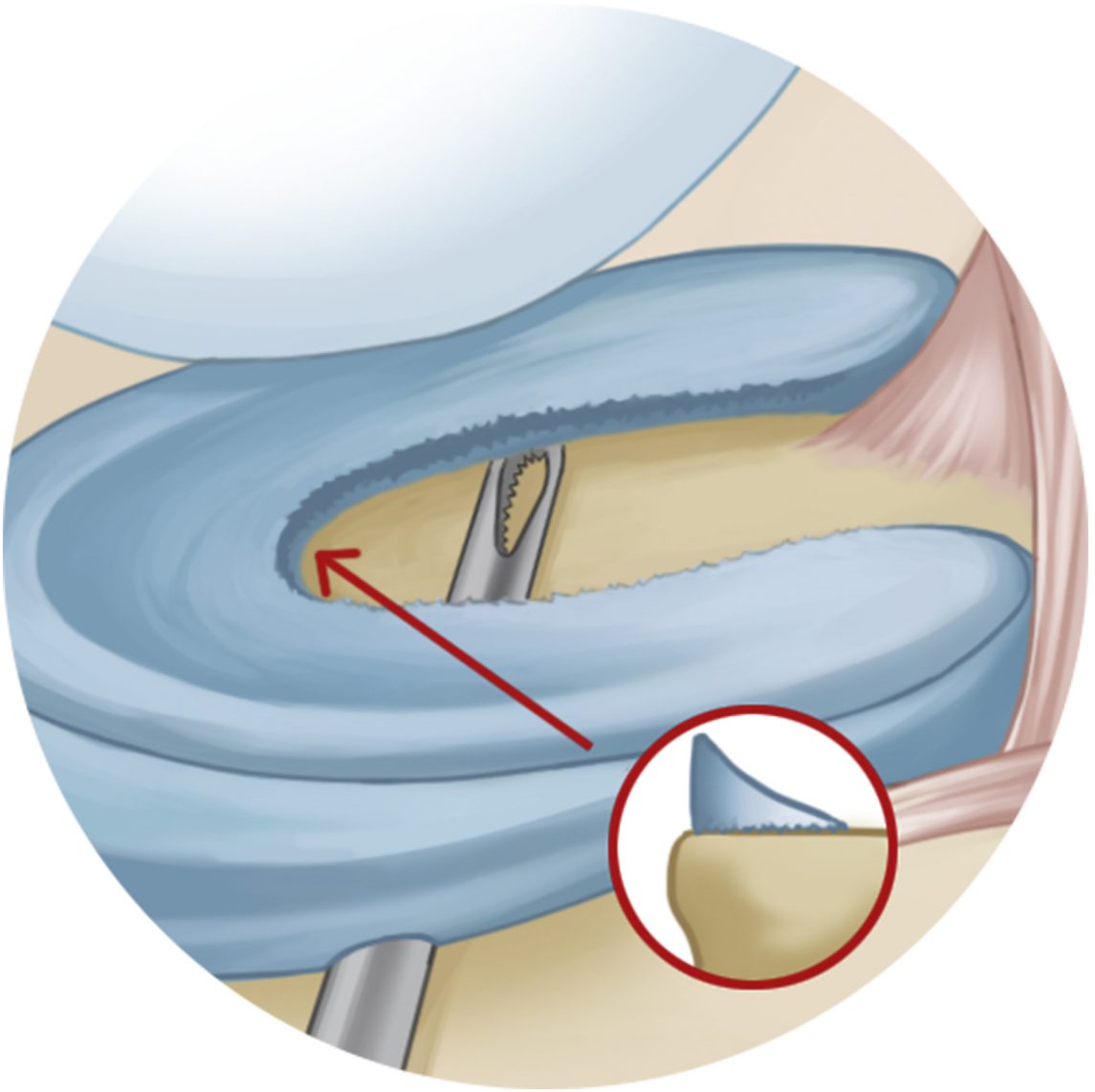

Figure 5. Punch, shave, and radiofrequency were used through an assisted inferior anterolateral portal reforming the lateral discoid meniscus to a normal crescent shape. The arrow showed the lower layer and the circle showed the final shape of lateral discoid meniscus after resection.

3.2. Objective and subjective evaluation

Clinical evaluation outcomes at final follow-up are shown in Table 1.

Lysholm score: pre-operative, 64.9 ± 9.0; postoperative, 94.7 ± 4.9. The difference was statistically significant ($P < 0.001$). A total of 95.4 ± 4.2 patients had meniscus plasty only and 93.4 ± 5.1 had meniscus plasty and repair; no difference was observed between the two groups ($P > 0.05$).

IKDC score: pre-operative, 54.4 ± 7.7; postoperative, 92.6 ± 4.3. The difference was statistically significant ($P < 0.001$). A total of 93.0 ± 4.0 patients had meniscus plasty only and 92.0 ± 4.9 had meniscus plasty and repair; no difference was noted between the two groups ($P > 0.05$).

Types of discoid meniscus, according to Watanabe classification, and types of meniscus tears are evaluated in Table 2. The Lysholm and IKDC scores between complete and incomplete types of discoid meniscus are shown in Table 3. Forty-one patients had a complete tear and 14 (34.1%) of them had a horizontal tear. Thirteen patients had an incomplete tear and four (30.1%) of them had a horizontal tear. The Lysholm score was 94.6 ± 5.2 in complete tears and 95.4 ± 3.8 in incomplete tears postoperatively ($P = 0.221$). The IKDC score was 93.0 ± 4.1 in complete tears and 91.4 ± 4.6 in incomplete tears postoperatively ($P = 0.591$). There were no significant between-group differences observed ($P > 0.05$).

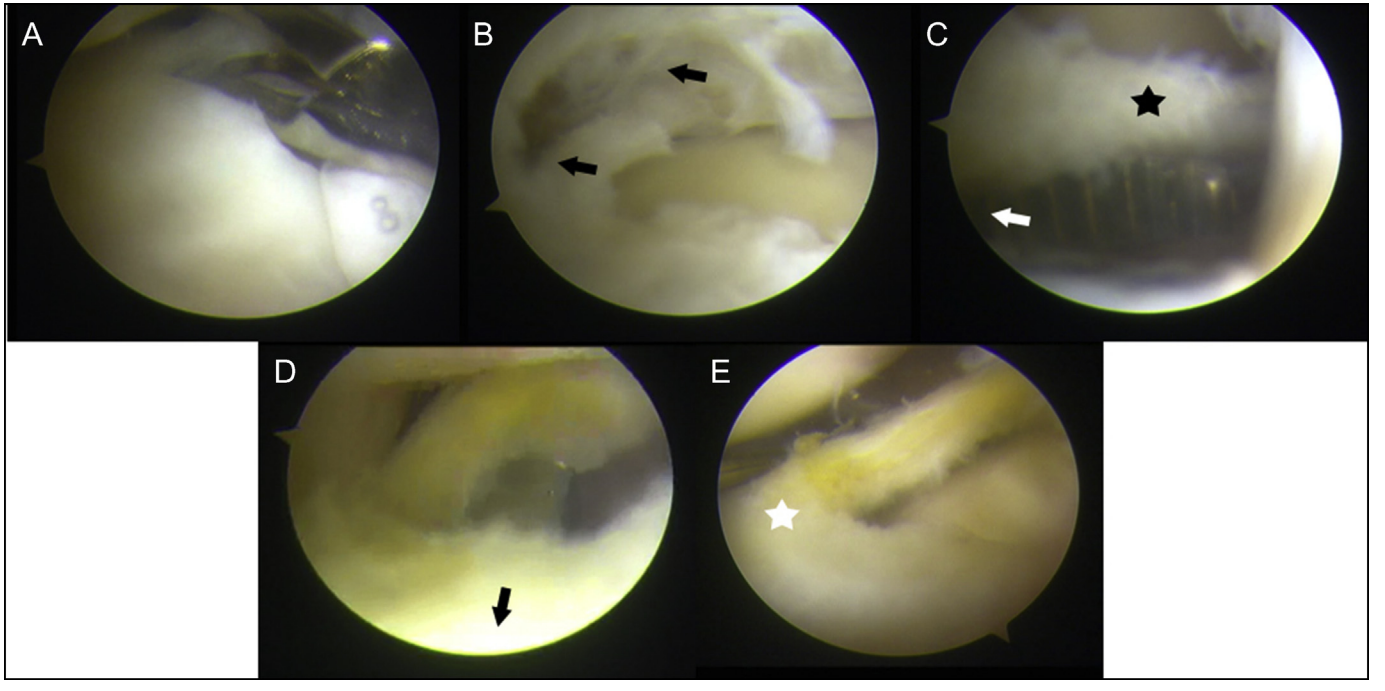

Figure 6. Arthroscopic saucerization was conducted using an assisted inferior anterolateral portal. (A) The arthroscope was inserted at an angle of 30° through the anterolateral portal, and a punch was inserted through the anteromedial portal to resect the median part of the discoid meniscus. (B) Horizontal and parrot-beak tears (black arrows) were observed through the anterolateral portal after the median part was resection. (C) An assisted inferior anterolateral portal (white arrow) under the upper layer of the lateral meniscus (black star) was established through the arthroscopic view at 30° from the anteromedial portal. (D) Reshaping the residual meniscus with a punch, shaver and radiofrequency through UAHLM portal (black arrow) and anteromedial portal. (E) The final shape of the lateral meniscus (white star) was viewed at the end of surgery through the anteromedial portal.

Table 1
Overall clinical evaluation outcomes (n = 54).

	Pre-operative	Postoperative[a]	*P*
Lysholm score	64.9 (9.0)	94.7 (4.9)	<0.001
IKDC score	54.4 (7.7)	92.6 (4.3)	<0.001
McMurray test, n	50.0 (89%)	2.0 (4%)	<0.001
Anterior horn of LM thickness, mm, n = 10	5.38 (1.09)	4.04 (0.71)	<0.001

Data are presented as mean (SD).
LM, lateral meniscus; IKDC, International Knee Documentation Committee.
[a] Postoperative status at 2-year follow-up.

Table 2
Injury classification of lateral discoid meniscus (n = 54).

Classification	Complete type	Incomplete type	Wrisberg type	Total
Longitudinal-vertical	4	2	0	6
Horizontal	14	4	0	18
Radial	3	2	0	5
Flap	2	0	0	2
Complex	18	5	0	23
Total	41	13	0	54

All patients gained full knee ROM and were able to return to their pre-injury functional level, as assessed at the last follow-up.

McMurray test: 50 (89%) patients were positive in the McMurray test pre-operatively and two (four percent) patients remained positive at the last follow-up. The difference was statistically significant (paired *t*-test, $P < 0.001$).

MRI: MRI images from 10 patients were gathered and analyzed. All of them showed a reshaped lateral meniscus; the thickness and width were resected close to normal status as much as possible (Figure 7). No lateral meniscus instability was found in the postoperative MRI. The anterior horn thickness of the lateral meniscus was analyzed: it was 5.38 ± 1.09 mm pre-operatively and 4.04 ± 0.71 mm postoperatively. The difference was statistically significant ($P < 0.001$).

3.3. Clinical failure

No significant complications were observed during follow-up. Three patients experienced mild pain (VAS score from four to six) after a long walk, which was relieved after knee injections. Two patients felt swelling on the knee after a long walk and the symptom disappeared at six months postoperatively.

3.4. Revision surgery

No patients required reoperation during the follow-up period.

3.5. Complications

No severe complications – such as articular cartilage damage, neurovascular injury, persistent drainage from portals, and infection – were observed for any patients during follow-up.

4. Discussion

A discoid meniscus is a type of anatomical variant that is frequently observed in the lateral meniscus. Unlike the normal crescent-shaped meniscus, a discoid meniscus is like a disc, which is thick, disorganized in structure, and encompasses a

Table 3
Lysholm and IKDC scores of different types of lateral discoid meniscus.

Type of LM	Pre-operative			Postoperative[a]		
	Complete	Incomplete	*P*	Complete	Incomplete	*P*
Lysholm	64.3 (9.6)	66.3 (6.7)	0.195	94.6 (5.2)	95.4 (3.8)	0.221
IKDC	54.1 (7.9)	54.0 (8.3)	0.811	93.0 (4.1)	91.4 (4.6)	0.591

Data are presented as mean (SD).
LM, lateral meniscus; IKDC, International Knee Documentation Committee.
[a] Postoperative status at 2-year follow-up.

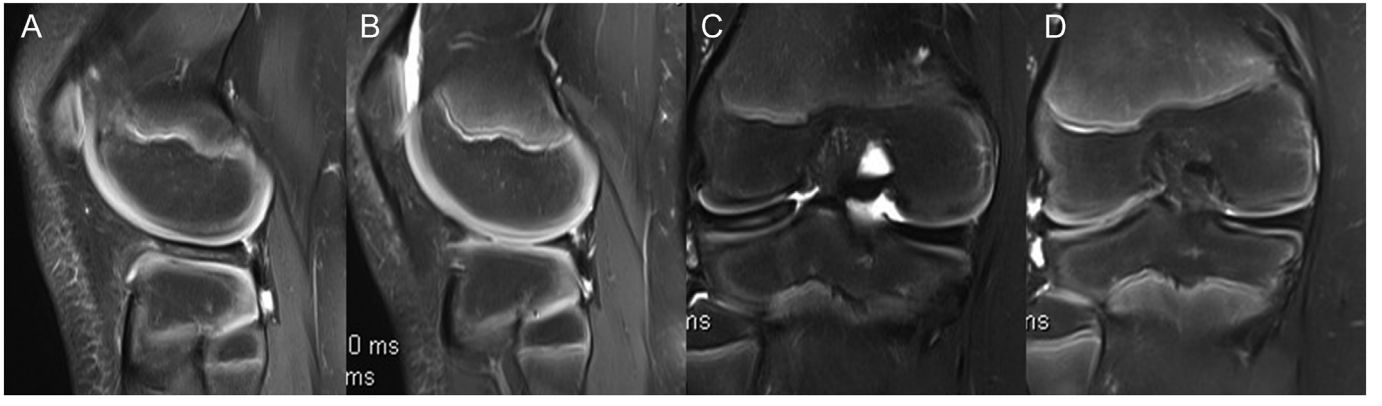

Figure 7. Magnetic resonance images (MRI) of patients who underwent arthroscopic saucerization using assisted inferior anterolateral portal. (A, C) Pre-operative horizontal tear of the lateral discoid meniscus. (B, D) Postoperative images of the lateral meniscus indicated that the lower layer was excised, the upper layer was retained, and the morphology of the lateral meniscus was similar to normal. A: Sagittal MRI images, pre-operatively. B: Sagittal MRI images, postoperatively. C: Coronal MRI images, pre-operatively. D: Coronal MRI images, postoperatively.

maximum area of the lateral tibial plateau. A thick discoid meniscus has less contact area with the femoral condyle and loses the ability to deform, which renders it difficult to endure the mechanical and shear forces in knee flexion, extension and rotation. Thus, compared with a normal meniscus, a discoid meniscus is prone to tear, especially a horizontal tear [16].

Treatment of a symptomatic discoid meniscus is by arthroscopic surgery, including complete meniscectomy and partial meniscectomy (saucerization) with or without meniscus repair. However, recent studies have reported that complete meniscectomy might lead to degenerative changes [17]. For horizontal or complex tears, arthroscopic saucerization is recommended to restore normal anatomy, repair the injured and unstable meniscus, and regain normal stability and function of the knee [18]. Which cleft is excised depends on the thickness and stability of the two layers in the horizontal tear. The collagen fibrils in the femoral surface are dense, thick and well-arranged, while those in the tibial surface are thin, irregularly arranged and without a bundle formation [19]. Therefore, the tibial layer of the lateral meniscus is prone to tear and often needs resection.

In 1984, Hershman et al. introduced a medial inframeniscal portal to treat tears of the posterior third of the medial meniscus [20]. The portal is located at the medial collateral ligament of the medial joint line and can reduce valgus stress during meniscectomy. In 2004, Kim et al. reported an extremely distal anteromedial portal for treatment of the lower leaf of the anterior horn of lateral or medial meniscus [10,21]. The current UAHLM portal is similar to the inframeniscal portal; however, it was located on the lateral side. Through a UAHLM portal, resection of the lower layer of the anterior horn can easily be accomplished, and mid-body and posterior horn tears of the lateral meniscus can be handled without limiting the femoral condyle. The UAHLM portal passes through the cranial tibial ligament of the lateral meniscus with a mini incision (<5 mm) as compared with the inframeniscal portal; this approach slightly affects lateral meniscus stability and the incision of the cranial tibial ligament of the lateral meniscus can self-heal.

Postoperative follow-up and MRI indicated no complications that were associated with an unstable meniscus or joint fluid hernia. Although the UAHLM portal is close to the lateral inferior genicular artery and vein branch, infrapatellar arterial plexus, anterior tibial recurrent artery and vein, and common peroneal nerve branch, which are near the lateral side of the knee, no neurovascular complications were observed during follow-up. Katarina et al. reported an overall complication rate of 1.1% and the reported incidence of neurovascular complications was very low [22,23]. Small et al. reported an incidence of 0.06% neurovascular complications in 375,069 knee arthroscopies [24]. To ensure blood vessel and nerve safety, the knife was only used for skin incision, and tissues from subcutaneous to articular capsule were blunt separated to avoid neurovascular injury. A slotted cannula was used when passing through sharp instruments such as shaver and arthroscopy forceps. In addition, the arthroscopic operation through the UAHLM portal was carried out in accordance with the common approaches of the surgeons with a smooth learning curve.

Re-tear of the meniscus after meniscectomy is a major issue that affects the outcome of the operation, thereby leading to a controversial point with respect to saucerization of a discoid meniscus. Spahn et al. reported 21 knee cases that underwent repeated arthroscopies, of which nine were tears of the lateral discoid meniscus that remained untreated during the primary operation [25]. According to previous studies, as much meniscus volume should be left after resection of a tear in the central part; however, a high volume has been associated with a high rate of re-tear. Vandermeer et al. recommended four to five millimeters left over from the periphery, and Hayashi et al. recommended six to eight millimeters for complete or incomplete tears [26,27]. Currently, several groups have recommended preserving six to eight millimeters from the periphery to absorb the impact between the femoral condyle and tibial plateau [28,29]. In addition, the lateral meniscus thickness was reformed as close to its normal status as possible. The thickness of a normal human lateral meniscus is 4.33 mm in the anterior horn, 4.94 mm in the mid body and 5.36 mm in the posterior horn [30]. After resection of the lower layer, the lateral meniscus thickness was polished with a shaver through the UAHLM portal. However, the exact thickness was hard to measure through arthroscopy and a new measuring method needs to be developed to achieve a more suitable lateral meniscus.

Through two traditional portals and a UAHLM portal, saucerization was performed by excising the lower layer of the lateral discoid meniscus in order to retain the integrity of the upper layer and restore the anatomical structure of the knee joint. Overall, the advantage of a UAHLM portal was that the lower leaf of the lateral discoid meniscus could be more easily dealt with. First, surgical instruments could reach the lower leaf of the lateral discoid meniscus without affecting the femoral condyle, intercondylar eminence and anterior cruciate ligament, compared with an anteromedial portal. Second, it gave good vision and operation space for treating anterior and posterior horns of the lateral meniscus, compared with the anterolateral portal. Last, it did not affect the vital nerves, vessels and tendons. The disadvantage of the UAHLM portal is an incision into the cranial tibial ligament of the lateral meniscus. No postoperative re-tears or instability of the lateral meniscus have been found in the current patients. It is believed that the incision spontaneously healed after the operation.

4.1. Limitations

This study had several limitations. First, the follow-up period was short, and hence, a long-term follow-up is essential. Second, a postoperative inspection of the lateral meniscus and cartilage was lacking. Third, not all patients' MRIs were analyzed due to missing data. In addition, the number of patients was insufficient, and there was no control group. However, it is believed that an assisted portal can lessen the blind spot of the inferior layer of the lateral meniscus and the cartilage surface of the lateral plateau, and reduce the incidence of iatrogenic injury.

5. Conclusions

The technically assisted UAHLM portal was convenient for arthroscopic discoid meniscus plasty and meniscus repair. This technique would be an effective method for patients with symptomatic discoid lateral meniscus.

Declaration of Competing Interests

The authors have no conflicts of interest to declare.

Acknowledgments

This research was funded by Logistic Support Department of China's Central Military Commission (16CXZ011). We would like to acknowledge and thank our physiotherapy specialist, Fanfu Fang, and our research assistants Zeya Ju and Jun Jiang for all their help and expertise with our patients.

Authors' contributions

ZW performed the surgery in all cases. ZZ, LX and ZW conceived and designed the study and drafted the manuscript. CH and YZ performed the statistical analysis. CX and GZ participated in its design and coordination and helped to draft the manuscript. SQ helped in performing the study. All authors read and approved the final manuscript.

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