

Original Article

Effects of arthroscopic outside-in sutures versus all-inside sutures in the treatment of lateral disc meniscus injury of the knee joint under arthroscopy

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Abstract: Objective: To compare the clinical efficacy of arthroscopic outside-in suturing and all-inside suturing in the treatment of discoid lateral meniscus (DLM) injury, and to analyze the influencing factors for clinical efficacy. Methods: We retrospectively selected 30 patients with DLM injury who received arthroscopic all-inside suturing at Wuzhou Workers' Hospital from January 2020 to December 2022 as the observation group. Another 30 patients who received arthroscopic outside-in suturing during the same period were enrolled as the control group. The surgical indicators, pre- and post-operative knee scores and proprioception difference of knee joint, postoperative complications and clinical efficacy were compared between the two groups. Factors affecting clinical efficacy of patients with DLM injury were identified using Logistic regression analysis. Results: Significant differences were observed in operation time, hospital stay, blood loss and clinical efficacy between the two groups (all $P < 0.05$); however, there was no significant difference in complications ($P > 0.05$). The visual analog score (VAS) scores of both groups decreased over time at 1, 3, 5, 7, 15, and 30 days post-surgery, with the observation group scoring lower than the control group (all $P < 0.05$). At 1, 3, and 6 months after the surgery, the international knee documentation committee (IKDC), Lysholm, and Tegner scores of both groups increased over time, with the observation group scoring higher than the control group (all $P < 0.05$). Six months post-surgery, proprioception differences at 15°, 45°, and 75° of knee flexion were significantly decreased, with greater improvements observed in the observation group ($P < 0.05$). Univariate analysis showed that operation time, IKDC and Lysholm scores at 6 months post-operation, postoperative complications, and suture method were factors influencing treatment outcomes in patients with DLM injury (all $P < 0.05$). Multivariate Logistic regression analysis identified postoperative complications as an independent risk factor for poor treatment outcome in patients with DLM injury ($P < 0.05$). Conclusion: Arthroscopic all-inside suturing for DLM injury offers significant clinical benefits, including shorter operation time and hospital stay, less blood loss, and improved knee joint function with fewer complications. Prolonged operation time, low IKDC and Lysholm scores at 6 months post-operation, postoperative complications and outside-in suturing technique are associated with poorer treatment outcomes in patients with DLM injury.

Keywords: Discoid meniscus injury, outside-in suture method, all-inside suture method, arthroscopy, clinical efficacy

Introduction

The meniscus is composed of fibrocartilage, which is crucial for ensuring voluntary the knee joint movement. It protects the articular cartilage, reduces the weight-bearing load of the knee joint, and absorbs shocks during joint movement [1]. Meniscus injuries are common in sports-related knee injuries, often resulting in severe pain, swelling, and noise during knee joint activity. In severe cases, the knee may

lock during flexion and extension, preventing normal movement. If left untreated, it can lead to muscle atrophy around the knee joint and increase the risk of arthritis [2]. Discoid lateral meniscus (DLM) injury is a prevalent type of meniscus injury, with a higher incidence than normal meniscus. It has a high incidence in China and is a major focus of clinical attention [3]. Currently, the primary treatment for DLM injury is surgery. Minimally invasive technology is constantly maturing, which promotes the con-

tinuous optimization of the treatment plan for DLM injury [4]. Arthroscopic suturing is a common treatment for DLM injury, with the characteristics of minimal trauma, effective healing promotion, and improved patient prognosis. However, choosing the appropriate suture method during arthroscopy remains a significant challenge [5]. Therefore, this study investigated the effects of different suture methods under arthroscopy in the treatment of DLM injury and analyzed the factors affecting the treatment outcomes.

Materials and methods

General information

We retrospectively selected 30 patients with DLM injury who underwent arthroscopic surgery with all-inside suturing at Wuzhou Workers' Hospital from January 2020 to December 2022 as the observation group. Another 30 cases who underwent arthroscopic surgery with outside-in suturing during the same period served as the control group, matched by age and gender (the filtering process is illustrated in **Figure 1**). This study was approved by the Medical Ethics Committee of Wuzhou Workers' Hospital.

Inclusion criteria: Patients meeting the diagnostic criteria for DLM injury with confirmed diagnosis of lateral discoid meniscal injury through imaging [6]; The affected area was tender, and McCauley's sign was positive; All meniscal tears were lamellar fractures; The tear site was in the white area or the red-white area. **Exclusion criteria:** Presence with cognitive and mental disorders; Presence of severe bone and joint degeneration; Combined cruciate ligament injury or articular cartilage injury; Previous history of meniscus surgery; Incomplete medical records.

Treatment methods

All patients underwent epidural anesthesia in the supine position. The electric balloon tourniquet was applied, and the injured edge of DLM was refreshed following routine joint exploration and debridement using a 30° arthroscope.

In the control group, the outside-in suture method was used (**Figure 2A**). With the lead puncture guide needle, a suture was inserted, through the skin and the injured meniscus tis-

sue, into the joint, about 2-4 mm the first needle entry point, and the second guide needle was inserted in the same way, with second guide needle, guide the sutures out of the skin, pull the sutures to the same skin puncture and tie tied. The skin was carefully sutured, and elastic bandages were applied after operation. The number of double needles used depended on the extent of meniscus tear.

The observation group was treated with the all-inside suture method (**Figure 2B**). Using conventional medial and lateral approaches, the arthroscope was inserted, and the entire knee was examined. A probe was used to determine the extent and length of the injury. Before repair, the DLM was temporarily repositioned and fixed with a fine needle or probe (through another incision). The sleeve length was determined using the probe, and a Fast-Fix delivery needle was inserted through the fissure sleeve, passing through the torn part of the DLM and reaching the bottom of the depth limiter. The guide needle was swiveled approximately 90°, and then pulled out from the meniscus. The trigger was slid forward to insert the second fixator, ensuring full insertion. All patients had a layered tear, and the suture direction was perpendicular to the tear direction. The delivery needle was then removed from the joint after the suture was passed.

Both groups received the same postoperative treatment, which included applying compression bandages and using adjustable leg braces to immobilize the affected limb in a straight position. Patients were instructed to perform quadriceps isometric contractions and ankle pump exercises immediately after surgery. The knee was allowed to move within a range of 0-90° with brace support within 6 weeks after surgery. The brace was removed based on the patient's condition after 6 weeks. Full weight-bearing was permitted 8 weeks after surgery, and normal activities could be resumed 6 months after surgery.

Observation index

Primary evaluation indicators: (1) Postoperative pain: Pain intensity was rated on a visual analog scale (VAS) [7] before the surgery, and at 1, 3, 5, 7, 15, and 30 days post-surgery. The VAS score ranges from 0 to 10, with higher the

Discoid lateral meniscus

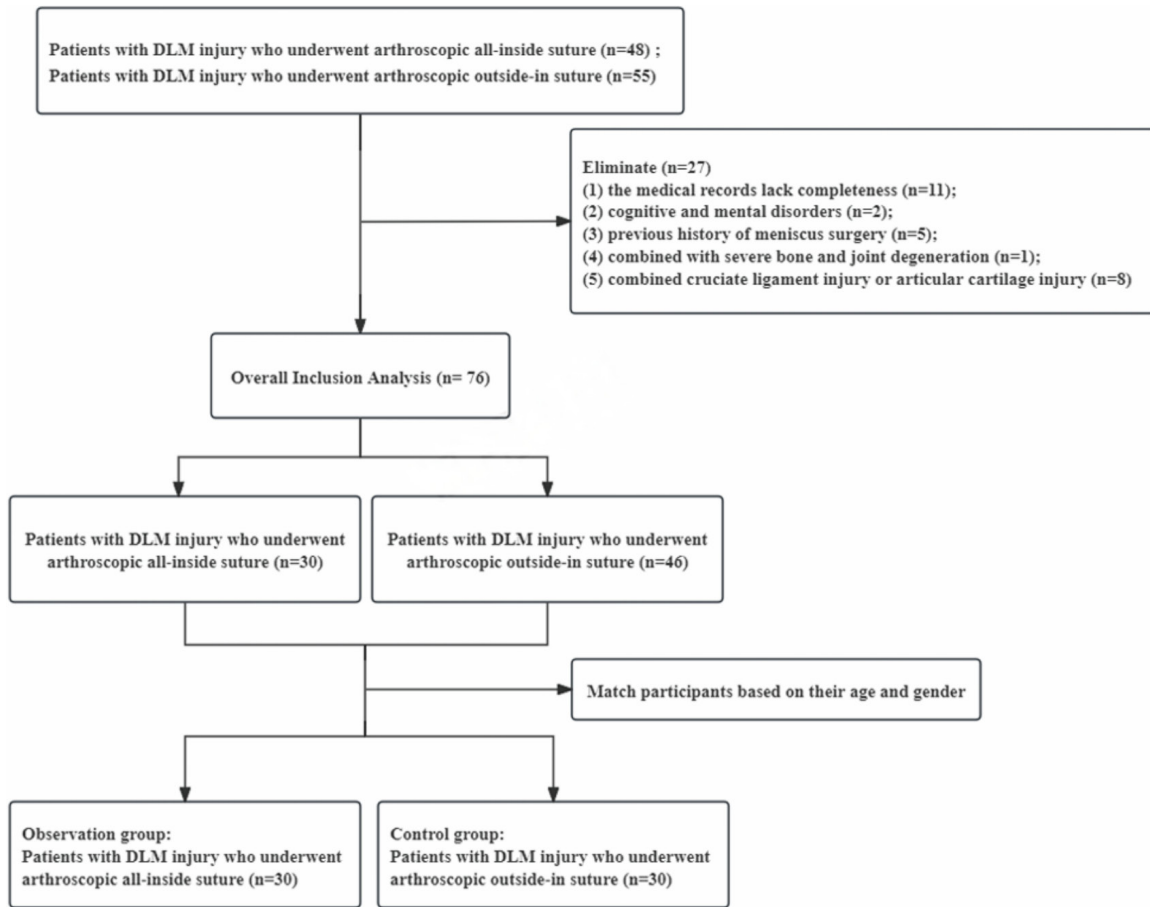


Figure 1. Flow chart of case selecting. DLM: discoid lateral meniscus.

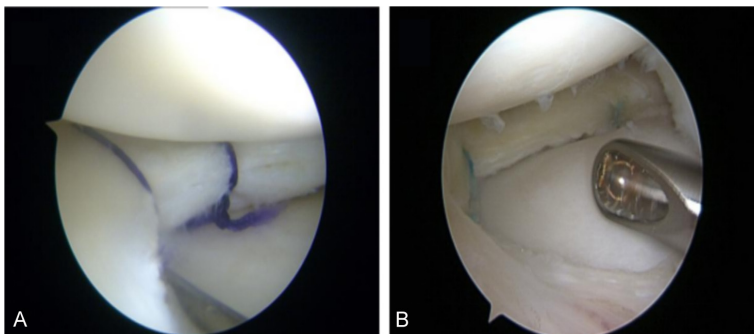


Figure 2. Suture procedure for DLM injury. A: Outside-in suture; B: All-inside suture. DLM: discoid lateral meniscus.

score indicating stronger pain. (2) Restoration of knee function: International knee documentation committee (IKDC) score [8] and Lysholm score [9], each totaling 100 points, were used to assess knee function preoperatively, and at 1 month, 3 months, and 6 months postoperatively. Higher scores indicate better knee functionality. Furthermore, the Te-

gner score [10], ranging from 0 to 10, was also assessed, with higher score reflecting better knee function. (3) Somatosensory: The passive angle of bilateral knee joints was measured using a knee isokinetic test system preoperatively and at 1 month, 3 months and 6 months postoperatively. Patients wore an eye mask and earplugs while sitting on the kinetic muscle strength tester with their hip and distal leg fixed. Test

angles were set at 15°, 45°, and 75°, respectively. The knee joint was passively straightened with the assistance of the strength tester, and patients were asked to sense the stop angle. The difference between the sensed angle and the test angle was recorded. Each angle was tested 3 times, and the average value was taken.

Discoid lateral meniscus

Table 1. Comparison of the two groups in general information

Data	Observation group (n = 30)	Control group (n = 30)	t/ χ^2	P
Age (years, $\bar{x} \pm s$)	34.60 \pm 6.13	35.67 \pm 5.52	0.708	0.482
Gender [n (%)]			0.601	0.438
Male	17 (56.67)	14 (46.67)		
Female	13 (43.33)	16 (53.33)		
BMI (kg/m ² , $\bar{x} \pm s$)	22.78 \pm 1.85	23.62 \pm 2.25	1.588	0.118
Underlying disease [n (%)]				
Hypertension	17 (56.67)	22 (73.33)	1.832	0.176
Diabetes	6 (20.00)	10 (33.33)	1.364	0.243
Injury area [n (%)]			0.300	0.584
Red and white area	9 (30.00)	11 (36.67)		
White area	21 (70.00)	19 (63.33)		
Nature of injury [n (%)]			1.714	0.190
Acute	20 (66.67)	15 (50.00)		
Chronic	10 (33.33)	15 (50.00)		
Injury side [n (%)]			1.699	0.196
Left knee	12 (40.00)	17 (56.67)		
Right knee	18 (60.00)	13 (43.33)		

Note: BMI: body mass index.

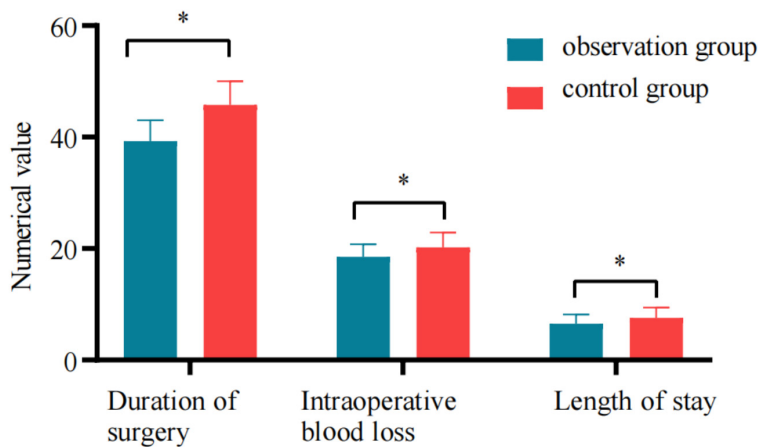


Figure 3. Comparison of surgical index between the two groups. * compared with the control group, $P < 0.05$.

Secondary evaluation index: (1) Surgical indicators: Intraoperative blood loss, operation time and hospital stay were recorded and compared between the two groups. (2) Complications: Complications after surgery were noted, mainly including prolonged postoperative pain, nerve and vascular injury, muscle atrophy, and early arthritis. (3) Clinical curative effect evaluation: The treatment effectiveness was evaluated 6 months post-operation. Cured: No limitation in knee joint activity, and no pain or swelling. Markedly Effective: No limitation in knee joint activity, with significant relief of

symptoms such as pain and swelling. Effective: No obvious limitation in knee joint movement, with some pain and clicking symptoms. Ineffective: No obvious limitation in knee joint movement, with some pain and clicking symptoms [11]. Total effective rate = (cured + markedly effective + effective) cases/total cases \times 100%.

Statistical methods

SPSS 27.0 was used for data analysis. Count data were expressed as [n (%)], and χ^2 test was used for comparison. The measurement data conforming to a normal distribution were expressed as ($\bar{x} \pm s$), with paired sample t-test used for intra-group comparisons and independent sample t-test for inter-group comparisons. Quantitative data that deviated from a normal distribution were described using the median and interquartile range [M (Q_{25} , Q_{75})], and the rank sum test was employed for comparison. Comparisons among different time points were conducted using repeated measure ANOVA or generalized estimation equation. Logistic regression analysis was performed.

Discoid lateral meniscus

Table 2. Comparison of complications between the two groups [n (%)]

Group	Persistent pain	Nerve and vascular injury	Muscle atrophy	Early arthritis	Total
Observation group (n = 30)	2 (6.67)	1 (3.33)	1 (3.33)	2 (6.67)	6 (20.00)
Control group (n = 30)	3 (10.00)	2 (6.67)	2 (6.67)	3 (10.00)	10 (33.33)
χ^2					1.364
<i>P</i>					0.243

Table 3. Comparison of VAS scores between the two groups [M (Q₂₅, Q₇₅)]

Time	Observation group (n = 30)	Control group (n = 30)	Z	<i>P</i>
Pre-surgery	6.5 (5, 9)	6 (4, 8)	0.404	0.687
1 day post-surgery	5.5 (5, 6) [#]	6 (4.75, 7) [#]	1.348	0.178
3 days post-surgery	4.5 (4, 6) [#]	5 (4.75, 7) [#]	1.992	0.046
5 days post-surgery	4 (3, 5) [#]	5 (4, 6) [#]	2.590	0.010
7 days post-surgery	3 (2, 4) [#]	4 (3, 5) [#]	2.850	0.004
15 days post-surgery	2 (1, 3) [#]	4 (2.75, 4) [#]	4.446	<0.001
30 days post-surgery	1.5 (1, 2) [#]	3 (2, 3) [#]	5.201	<0.001

Note: [#]compare to pre-surgery, *P*<0.05. VAS: visual analog score.

med to identify the related influencing factors for curative effect. A *p*-value of <0.05 was considered statistically significant.

Results

Comparison of general data between the two groups

No significant differences were observed in terms of age, gender, body mass index (BMI), underlying diseases, injury area, nature of injury, and injury side between the two groups (all *P*>0.05), see **Table 1**.

Comparison of surgical indicators and complications between the two groups

Compared to the control group, the observation group demonstrated significantly shorter operation time, hospitalization time and less blood loss (*P*<0.05), see **Figure 3**. The incidence of complications in the observation group was slightly lower than that in the control group (20% vs 33.3%), with no statistical difference (*P*>0.05), as shown in **Table 2**.

Comparison of postoperative pain between the two groups

At 1, 3, 5, 7, 15, and 30 days post-surgery, the VAS scores in the observation group was statistically lower compared to those in the control

group, indicating a significant main effect of group (all *P*<0.001). Both groups demonstrated a declining trend in VAS scores over time, with a significant main effect of time ($\chi^2 = 2633.394$, *P*<0.001). Furthermore, an interaction effect between group and time was observed ($\chi^2 = 69.465$, *P*<0.001). See **Table 3** for details.

Comparison of knee joint function between the two groups before and after the surgery

At 1, 3, and 6 months post-surgery, the IKDC, Lysholm, and Tegner scores in the observation group were significantly higher than those in the control group, indicating a significant main effect of group (*F* = 29.866/9.453/5.682, *P*<0.05). Both groups demonstrated an increasing trend in IKDC, Lysholm, and Tegner scores over time, with a significant main effect of time (*F* = 762.981/2527.872/1102.396, *P*<0.05). Furthermore, an interaction effect between group and time was observed (*F* = 17.014/57.373/10.437, *P*<0.05), see **Figure 4**.

Comparison of proprioception difference of knee joint before and after operation

Six months after surgery, the proprioceptive difference values at 15°, 45° and 75° knee flexion angles decreased in both two groups, and the observation group showed a more significant decrease (*P*<0.05), see **Figure 5**.

Discoid lateral meniscus

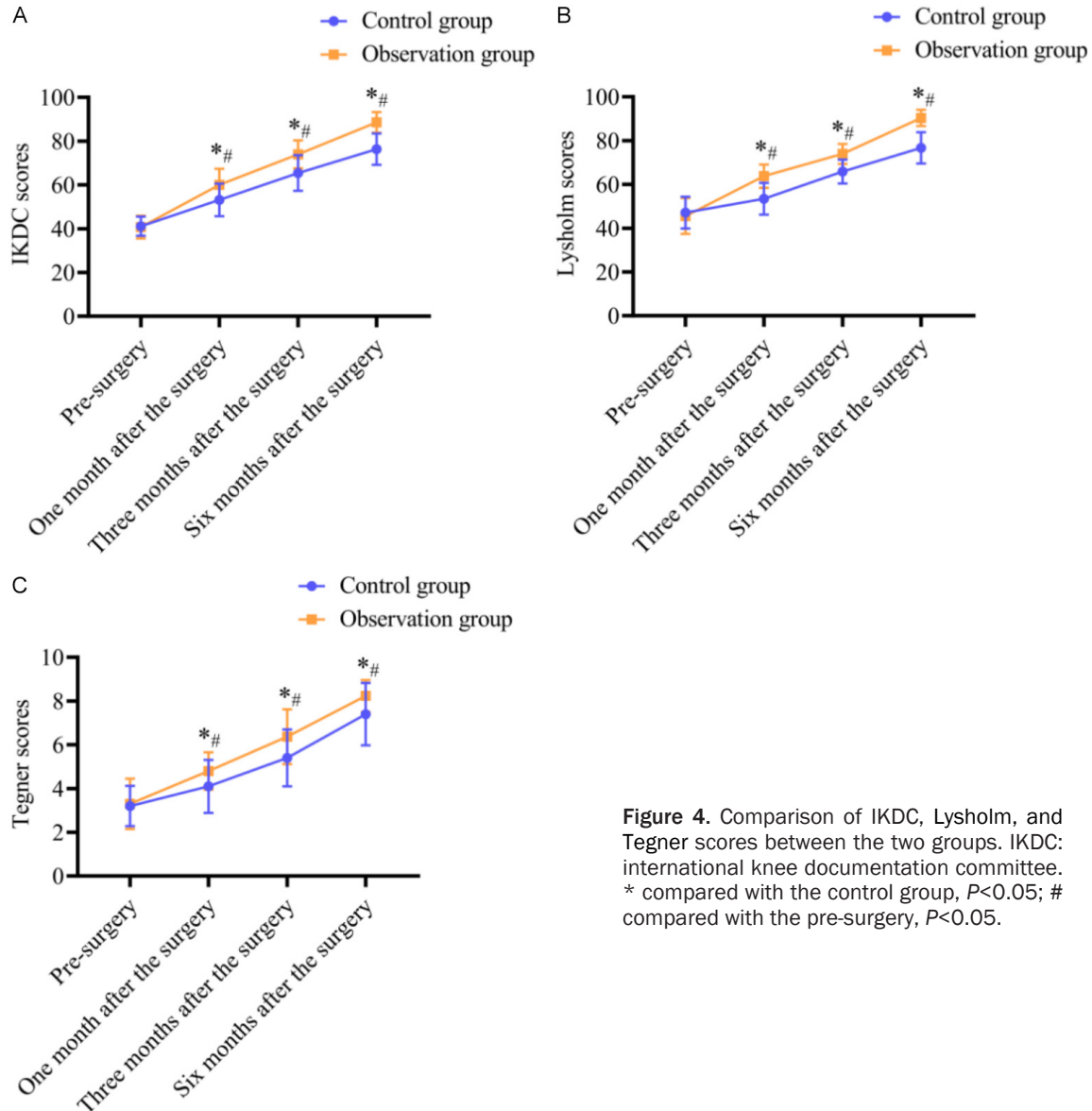


Figure 4. Comparison of IKDC, Lysholm, and Tegner scores between the two groups. IKDC: international knee documentation committee. * compared with the control group, $P < 0.05$; # compared with the pre-surgery, $P < 0.05$.

Identification of factors affecting treatment efficacy

The clinical effective rate of the observation group was 86.67%, which was higher than 63.33% of the control group ($\chi^2 = 4.356$, $P = 0.037$). The patients were further grouped into an effective group ($n = 45$) and an ineffective group ($n = 15$) based on the treatment efficacy.

Univariate analysis identified operation time, IKDC and Lysholm scores at 6 months after operation, postoperative complications, and suture method were found to be influencing

factors for treatment efficacy in patients with DLM injury (all $P < 0.05$, **Table 4**). The above meaningful variables were incorporated into multivariate Logistic regression, and the assignment is shown in **Table 5**. The results showed that post-operative complications were a risk factor for the poor treatment effect of DLM injury ($P < 0.05$), see **Table 6**.

Discussion

Due to the lack of ligament guidance in the hypertrophic part of the discoid lateral meniscus (DLM), the femoral condyles are unable to deform accordingly during knee motion. This

Discoid lateral meniscus

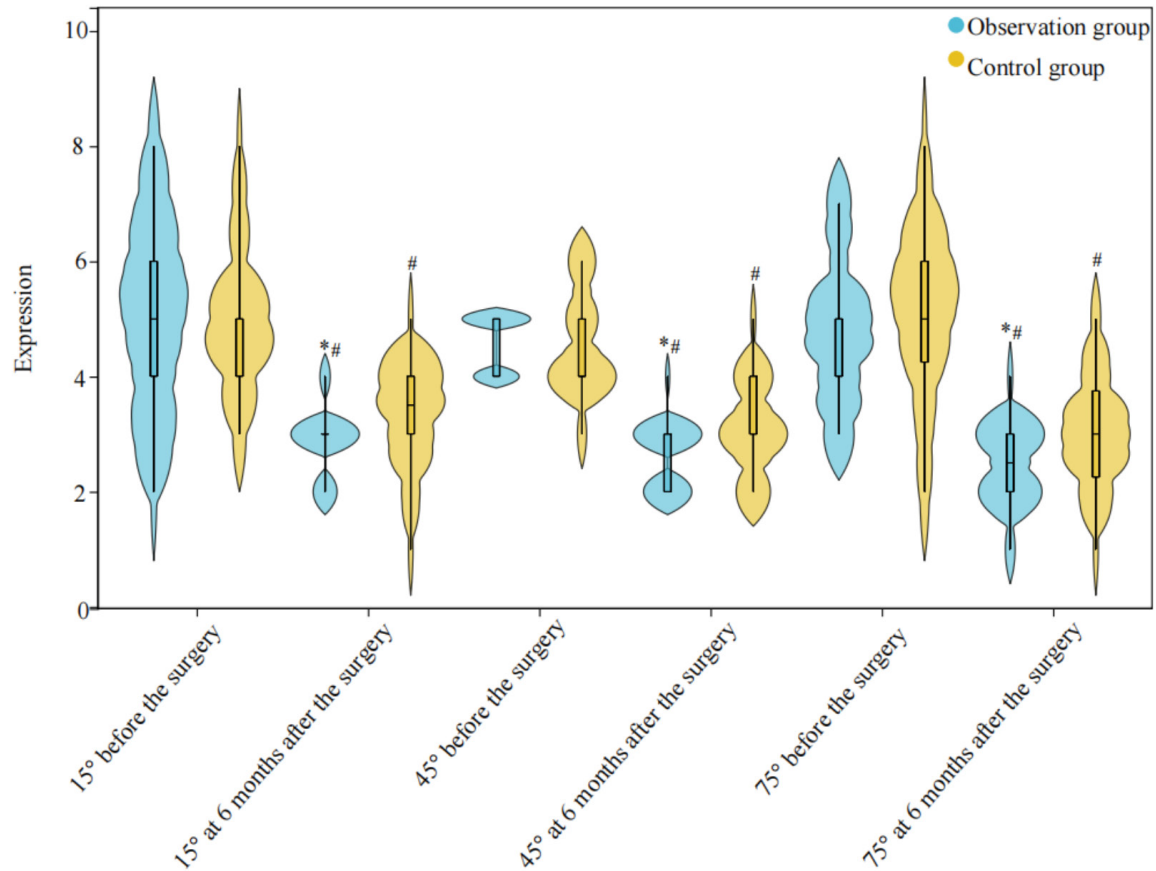


Figure 5. Comparison of proprioception difference of knee joint between the two groups before and after operation. * compared with the control group, $P < 0.05$; # compared with the pre-surgery, $P < 0.05$.

lack of concentrated stress leads to intra-articular injury [12]. At present, the mainstream treatment of DLM injury is arthroscopic surgery, but different suture methods have different therapeutic effects [13]. This study compared the clinical effects of outside-in sutures and all-inside sutures to determine the optimal treatment for DLM injury and improve patient prognosis.

This study demonstrated a significant decrease in VAS score for both groups following surgical intervention; notably, the score was lower in the observation group compared to the control group. Furthermore, there were marked improvements in IKDC, Lysholm, and Tegner scores in both groups post-surgery; and the improvements were more pronounced in the observation cohort as compared to the control cohort. These outcomes underscore that the all-inside suture approach can substantially ameliorate postoperative discomfort while promoting the recovery of knee joint functionality.

Several factors may contribute to this effect, such as smaller incision, minimized meniscus damage, and efficient technique. (1) Smaller Incision: the all-inside suture technique requires only one portal for all necessary operations, resulting in a smaller incision compared to the outside-in suture. There is no need for a cut on the lateral side of the meniscus, reducing the risk of unnecessary nerve injury. (2) Minimized Meniscus Damage: the all-inside suture technique obviates the necessity of extracting meniscal tissue from the wound, thereby minimizing additional damage to the meniscus. (3) Efficient Suture Technique: the all-inside suture technique, combined with the Fast-Fix system, utilizes only two suture-guided fixators during surgery to minimize the number of knots at the joint. This approach alleviates postoperative discomfort and facilitates adherence to rehabilitation exercises, thereby enhancing knee function recovery [14-16]. Subsequent assessments revealed reductions in proprioceptive differences across 15°, 45°, and 75°.

Discoid lateral meniscus

Table 4. Univariate analysis of factors influencing treatment efficacy

	Effective (n = 45)	Ineffective (n = 15)	χ^2/t	P
Age (years, $\bar{x} \pm s$)	35.91 \pm 5.79	32.80 \pm 5.39	1.832	0.072
Gender [n (%)]			0.556	0.456
Male	22 (48.89)	9 (60.00)		
Female	23 (51.11)	6 (40.00)		
BMI (kg/m ² , $\bar{x} \pm s$)	23.25 \pm 2.02	23.02 \pm 2.32	0.316	0.753
Underlying disease [n (%)]				
Hypertension	30 (66.67)	9 (60.0)	0.220	0.639
Diabetes	17 (37.78)	3 (20.00)	1.600	0.206
Injury area [n (%)]			1.600	0.206
Red and white area	17 (37.78)	3 (20.00)		
White area	28 (62.22)	12 (80.00)		
Nature of injury [n (%)]			0.571	0.450
Acute	25 (62.50)	10 (66.67)		
Chronic	20 (44.44)	5 (33.33)		
Injury side [n (%)]			0.090	0.764
Left knee	25 (62.50)	9 (60.00)		
Right knee	20 (44.44)	6 (40.00)		
Operation time (min, $\bar{x} \pm s$)	41.71 \pm 5.48	45.00 \pm 2.78	2.224	0.030
Blood loss (mL, $\bar{x} \pm s$)	19.00 \pm 2.59	20.47 \pm 2.39	1.933	0.058
Length of hospital stay (day, $\bar{x} \pm s$)	7.09 \pm 1.78	6.93 \pm 1.98	0.285	0.777
IKDC score ($\bar{x} \pm s$)				
Before the surgery	41.02 \pm 4.66	40.60 \pm 5.19	0.295	0.769
6 months after the surgery	84.00 \pm 8.24	76.67 \pm 8.42	2.970	0.004
Lysholm score ($\bar{x} \pm s$)				
Before the surgery	45.49 \pm 7.90	48.93 \pm 6.53	1.522	0.133
6 months after the surgery	82.82 \pm 8.20	76.33 \pm 10.07	2.505	0.015
Tegner score ($\bar{x} \pm s$)				
Before the surgery	3.33 \pm 1.02	3.00 \pm 1.07	1.081	0.284
6 months after the surgery	7.82 \pm 1.25	7.80 \pm 1.08	0.062	0.951
VAS score [M (Q ₂₅ , Q ₇₅)]				
Before the surgery	6 (5, 8)	8 (4, 9)	0.578	0.563
30 days after the surgery	2 (1, 3)	2 (1, 2)	0.667	0.505
Development of complications [n (%)]			13.067	<0.001
Yes	6 (13.33)	9 (60.00)		
No	39 (86.67)	6 (40.00)		
Suturing way [n (%)]			4.356	0.037
All-inside suture	26 (57.78)	4 (26.67)		
Outside-in suture	19 (42.22)	11 (73.33)		

Note: BMI: body mass index; IKDC: international knee documentation committee.

and 75° between the two cohorts following interventions, and Values recorded in the observation group were significantly better compared to those in the control group. These

observations proves the efficacy of adopting an all-inside suturing modality for augmenting restoration of proprioceptive faculties in afflicted knees. The precision-based rectification strate-

Discoid lateral meniscus

Table 5. Variable assignments

Variable	Assignment
Clinical effects	1 = effective, 0 = invalid
Operation time	1 = ≥ 46 min, 0 = < 46 min
IKDC score 6 months after surgery	1 = ≥ 89 score, 0 = < 89 score
Lysholm score 6 months after surgery	1 = ≥ 87 score, 0 = < 87 score
Suturing way	1 = all-inside suture, 0 = outside-in suture
Development of complications	1 = happen, 0 = not happen

Note: IKDC: international knee documentation committee.

Table 6. Multivariate Logistic regression analysis

Variable	<i>B</i>	<i>SE</i>	Wald χ^2	<i>P</i>	<i>OR</i>	95% <i>CI</i>
Operation time	-0.198	0.829	0.057	0.811	0.820	0.162-4.161
IKDC score 6 months after surgery	1.904	1.251	2.318	0.128	6.716	0.579-77.959
Lysholm score 6 months after surgery	1.843	1.271	2.103	0.147	6.316	0.523-76.274
Suturing way	0.121	0.883	0.019	0.891	1.129	0.200-6.366
Development of complications	-2.362	0.813	8.435	0.004	0.094	0.019-0.464

Note: IKDC: international knee documentation committee.

gies target compromised DLM structures with minimal impact on overall stability and reduced soft-tissue trauma, thereby facilitating subsequent rehabilitative efforts aimed at functional reinstatement [17].

This study also showed that the surgical duration and hospitalization period for the observation group were shorter compared to those of the control group, with less blood loss. We posit that all-inside suturing offers enhanced precision, minimizing damage to surrounding tissues without necessitating an external incision, thereby reducing surgical time and blood loss. Furthermore, patients undergoing all-inside suturing experience milder postoperative pain, facilitating earlier engagement in activities and rehabilitation exercises, consequently leading to a shortened hospital stay. Nevertheless, there is no significant disparity in postoperative complication rates between the two groups. This may be attributed to the minimally invasive nature of both procedures, which reduces the complications like infection, nerve and vascular injury, joint swelling and pain, as well as muscle atrophy commonly associated with open suturing [18, 19].

Many studies have indicated that some patients with DLM injury have poor clinical efficacy [20, 21]. In this study, multivariate logistic regression analysis was conducted to identify the factors affecting their curative efficacy. The results

showed that the operation time, IKDC and Lysholm scores at 6 months after operation, postoperative complications, and suture methods were associated with treatment effect in patients with DLM injury. The duration of operation and postoperative complications are related to the severity of DLM injury. In cases of more severe injuries, such as degree III or IV, the integrity of the meniscus is greatly compromised, increasing the complexity of the surgery and requiring longer operation times. Additionally, severe DLM injuries are more prone to complications, which can negatively impact postoperative outcomes [22]. The choice of surgical suture method also affects the therapeutic effect in patients with DLM injury. Currently, commonly used suture methods include inside-out sutures, outside-in sutures and all-inside sutures, each with its own characteristics. For example, all-inside suturing has less trauma, but it is not suitable for all patients, and sometimes it needs to be combined with other suture methods [23]. Therefore, selecting appropriate suture methods according to the specific conditions of the patient and performing meticulous operation are crucial for successful operation and good recovery.

Conclusion

Arthroscopic all-inside sutures in the treatment of DLM injury has significant clinical effect, with

Discoid lateral meniscus

short operation time and hospitalization time, and less blood loss, which is helpful to the recovery of knee joint function and reduces complications. Long operation time, low IKDC and Lysholm scores at 6 months after operation, postoperative complications, and the use of outside-in sutures are associated with poor treatment efficacy in patients with DLM injury. Clinical intervention can be tailored for high-risk patients to promote their recovery.

Disclosure of conflict of interest

None.

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Discoid lateral meniscus

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