The Effect and Long-term Prognosis of Different Suturing Methods for Meniscus Repair Under Knee Arthroscopy

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AIM: This study aims to evaluate the efficacy and long-term prognosis of all-inside and outside-in suturing methods for meniscus repair under knee arthroscopy.

METHODS: A retrospective analysis was conducted on 120 patients with meniscus injuries who underwent surgical treatment at Yuhuan People's Hospital, Department of Joint Surgery, from January 2019 to March 2021. Based on the suturing method, patients were assigned into two groups: Group A (64 cases, all-inside suturing) and Group B (56 cases, outside-in suturing). Surgical indicators and adverse events were recorded for both cohorts. The variances in proprioception before and after surgery, International Knee Documentation Committee (IKDC) scores, Lysholm scores, knee range of motion (ROM), and Visual Analogue Scale (VAS) pain scores were compared between the two groups.

RESULTS: Group A had significantly shorter operative time, postoperative immobilization, and hospital stay compared to Group B ($p < 0.05$). The overall incidence of adverse events was 12.50% in Group A and 16.07% in Group B, with no significant difference between the groups ($p > 0.05$). There were no substantial differences in preoperative knee proprioception difference values, IKDC scores, Lysholm scores, VAS scores, and knee ROM between the two groups ($p > 0.05$). At three months postoperatively, Group A exhibited lower proprioception difference values at 15°, 45°, and 75° angles compared to Group B ($p < 0.05$). Additionally, at three months and three years postoperatively, Group A showed higher IKDC scores, Lysholm scores, and ROM and lower VAS scores compared to Group B ($p < 0.05$).

CONCLUSIONS: Compared to the outside-in suturing approach, the all-inside suturing method for treating meniscus damage is more effective. It attenuates operative time, postoperative immobilization time, and hospital stay, ameliorates knee proprioception, promotes knee function recovery, alleviates pain, and is safe and reliable.

Keywords: knee arthroscopy; suturing; repair; meniscus injury; efficacy; prognosis

Introduction

The knee joint, one of the most complex joints in the human body, is essential for movement and load-bearing but is highly susceptible to pathological changes due to physiological degeneration or trauma, which can impair normal limb function [1]. Meniscus injuries are among the most common knee joint pathologies. The meniscus is critical in protecting joint cartilage, cushioning impacts, enhancing joint stability, transmitting loads, and preventing joint degeneration [2]. When the meniscus is injured, stress on the knee cartilage and tension on collagen fibers increase, potentially leading to cartilage degeneration and raising the risk of degenerative osteoarthritis (DOA) [3, 4]. Meniscus injuries are more prevalent in men, particularly athletes and individuals engaged in strenuous physical labor [5]. The primary cause of injury is the intense flexion and extension activities of the knee, which subjects the meniscus to significant compressive and rotational shear forces. Clinically, patients typically present with localized swelling, pain, and tenderness in the knee. Without prompt treatment, these injuries can lead to restricted knee range of motion (ROM) and subsequent functional impairment [6, 7]. Therefore, early diagnosis and treatment are crucial to reduce the risk of knee osteoarthritis, improve mobility, and enhance quality of life.

Treatment for meniscus injuries typically involves a comprehensive approach tailored to the specific needs of the patient and the nature of the injury to develop the optimal treatment plan. Surgery is often the preferred option [8]. Historically, open total or sub-total meniscectomy was common in early surgical interventions. Although these procedures effectively alleviated clinical symptoms, their invasive nature and the extensive removal of meniscal tis-

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sue often led to secondary knee cartilage damage and degeneration, impairing knee function and accelerating osteoarthritis progression. Consequently, these methods are now rarely used [9]. Arthroscopic surgery has become the standard for treating meniscus injuries, offering a less invasive alternative with a clear visualization of the injury site and severity. This method allows for either localized resection or repair suturing, preserving as much of the meniscus as possible and improving treatment outcomes [10, 11].

Standard arthroscopic suturing techniques encompass inside-out, outside-in, and all-inside methods. The inside-out technique, while effective for complex internal injuries, is technically challenging and may increase the risk of postoperative infection. The outside-in technique is relatively simpler and causes less trauma but may be less effective for deep injuries. The all-inside technique facilitates quicker postoperative recovery and carries lower infection risk, but it may be less effective for large or complex injuries and is highly dependent on advanced suturing equipment and technology. Given these differences, there is ongoing debate about the advantages, disadvantages, and indications for the outside-in and all-inside techniques in meniscal repair. This study retrospectively analyzed the efficacy of these surgical techniques to provide evidence-based support for clinical practice.

Study Content and Methods

Case Source

A retrospective analysis was conducted on 120 patients who underwent surgical treatment for meniscus injuries at the Department of Joint Surgery, Yuhuan People's Hospital, between January 2019 and March 2021. Based on the chosen suturing technique, 64 patients treated with the all-inside arthroscopic suturing method were designated Group A, while 56 patients treated with the outside-in arthroscopic suturing method were designated Group B. All surgeries were performed by the same medical team. This study was approved by the Medical Ethics Committee of Yuhuan People's Hospital (approval number: 201812-YH-0012) and adhered to the Declaration of Helsinki. Informed consent was obtained from all patients.

Patient Selection

Inclusion criteria: Patients diagnosed with grade III meniscus injuries via Magnetic Resonance Imaging (MRI), with injuries located in the red-red or red-white zone; aged between 18 and 60; no previous knee surgeries; meniscus injury caused by knee sprain; treated with a single therapeutic approach; underwent arthroscopic surgery; and able to attend regular follow-up visits post-surgery.

Exclusion criteria: Patients with severe surgical contraindications; those with fractures, ligament injuries, or other knee joint diseases; discoid meniscus; or prior surgeries on the affected knee.

Baseline Data Collection

Baseline and clinical data were collected, including age, gender, body mass index (BMI), education level, medical history (diabetes, hypertension), American Society of Anesthesiologists (ASA) classification, injury site, injury side, injury region, and wound size.

Study Methods

Group A (all-inside suturing technique): Patients underwent the all-inside suturing technique using a Suture Hook Set, 2/0 Athilon suture, and Cannula. This method is suited for anteromedian edge and posterior angle tears. The tear site was debrided with nibbling forceps, a planer tool, and a meniscal grater to create a fresh, smooth wound surface. Scar tissue and hypertrophic synovium were removed for edges with desquamation or deformities. Bucket-handle, vertical, and horizontal tears in the red or red-white zones were sutured, while meniscal tears within 3 mm of the medial margin were trimmed.

Anteromedian edge tears: A protective channel was inserted under arthroscopic visualization, and a meniscal suture device with an appropriate curvature was selected. A 2/0 suture secured the detached meniscus, anchoring it to the lateral ligament or soft tissue to stabilize and limit movement. The Samsung Medical Center (SMC) knot was employed to tie the sutures, with knots positioned at the outer edge of the meniscus to minimize friction. The arthroscope and protective channel were inserted via the inner or outer posterior approach for posterior angle tears. Guided by a No. 7 needle, the protective channel was placed in the posterior compartment. The entry point was slightly elevated. Scar tissue and adhesions were removed using a soft tissue planer tool, taking care to avoid damage to the posterior vessels, nerves, and posterior cruciate ligament (PCL). A 45° curved meniscal suture device was then used to complete the suturing. In specific cases, the lateral meniscus was additionally sutured and fixed to the tibial attachment of the PCL for stability. Suture knots were tied using the SMC knot.

Group B (outside-in suturing technique): Patients underwent the outside-in suturing technique using an epidural cannula needle, No. 7 long needle, and 2-3/0 Athilon sutures. This method is suitable for bucket-handle, longitudinal, oblique, horizontal, and transverse tears of the anteromedian segment of the meniscus. Tear preparation for suturing was similar to the all-inside technique. Under arthroscopic visualization, a No. 7 long needle was inserted from outside the joint space to the upper part of the tear. A 3/0 Athilon suture was threaded through an epidural cannula needle to form a loop, passing through the lateral soft tissue and exiting approximately 2 mm from the inner side of the tear. The loop was formed within the joint cavity before withdrawing the epidural cannula needle, and a small incision (1 cm) was made along the path of the needle. The needle was then removed, and a second puncture was made

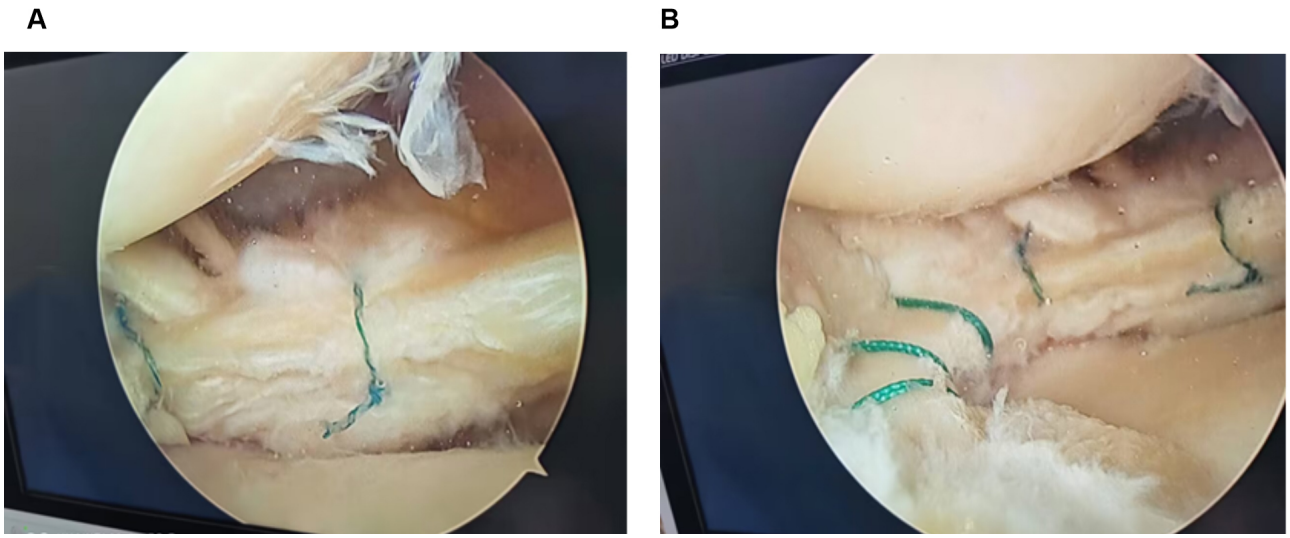

Fig. 1. Arthroscopic images of all-inside and outside-in suture techniques for repairing the meniscus. (A) Arthroscopic all-inside suture technique for repairing meniscus under knee arthroscopy. (B) Arthroscopic outside-in suture technique for repairing meniscus under knee arthroscopy.

from a different entry point to the lateral side of the tear, positioning the needle close to the tear edge. The suture was threaded into the loop, and pulled out to bring the meniscal suture along. The SMC knot was tied with uniform tension on the outer side (Fig. 1).

Postoperatively, both groups received symptomatic treatment, including bandaging, ice compresses, brace immobilization, and limb elevation. Functional training began early, with quadriceps femoris contraction exercises initiated soon after surgery and passive knee joint exercises using a continuous passive motion (CPM) machine starting 2–3 days postoperatively. Gradual weight-bearing walking was introduced based on healing progress, starting 2 to 5 months post-surgery until full weight-bearing was achieved.

Postoperative Follow-up

Patients were thoroughly informed about the postoperative rehabilitation process and advised to attend regular outpatient check-ups. Follow-up lasted up to 3 years and included clinic visits and telephone interviews to assess the long-term prognosis of knee joint function and pain status three years after surgery.

Evaluation of Therapeutic Effects

Surgery-Related Indicators

Data on operative time, intraoperative blood loss, postoperative immobilization duration, hospital stay, and healing time were recorded for both groups.

Proprioception Indicators

Differences in proprioception-associated indicators were recorded for both groups of patients preoperatively and 3 months postoperatively. An isokinetic testing system was used to set angles at 15°, 45°, and 75°. Under visual and auditory block conditions, the knee joint was passively positioned at 90°, and the system extended the knee (angle set at 5%). After a 15-second pause, patients verbally indicated the stopping angle, and the difference between the perceived angle and actual angle was calculated. This difference value is negatively correlated with proprioceptive function: a greater difference denotes poorer proprioceptive function in patients.

Pain Assessment

We recorded the pain status of both cohorts prior to surgery, at 3 months postoperatively, and 3 years postoperatively via the Visual Analogue Scale (VAS) [12]. The VAS score ranges from 0 to 10, where 0 suggests no pain, and 10 reflects severe pain that is unbearable. A higher VAS score signifies higher pain levels in patients. The Cronbach's α coefficient for the VAS scale is 0.833.

Knee Joint Function

Knee joint function was evaluated using the International Knee Documentation Committee (IKDC) scoring system [13], Lysholm scoring [14], and joint range of motion (ROM) assessment before surgery, at 3 months postoperatively, and 3 years postoperatively. The IKDC score covers sports activities, symptoms, and function, with a maximum score of 100 points, where higher scores indicate better knee joint function. The Lysholm score encompasses eight dimensions of knee function (limping, support-using, locking, stair-climbing, squatting, swelling, instability, and pain) with a maximum of 100 points, where higher scores indicate better knee joint function. Higher IKDC and Lysholm scores correlate with greater ROM and better overall knee joint function.

Two orthopedic surgeons and one radiologist evaluated all scores, and the results were averaged. Radiological assessments were made independently by these three doctors, who evaluated and recorded their findings back-to-back. In cases of discrepancies, decisions were made through mutual discussion among the three doctors. Before scoring, the evaluating doctors familiarized themselves with the evaluation standards and gradually achieved consensus on result judgments through mutual discussion. The IKDC scale has a Cronbach's α coefficient of 0.845, and the Lysholm scale has a Cronbach's α coefficient of 0.896.

Safety Evaluation

Adverse events such as knee joint cysts, stiffness, synovitis, quadriceps femoral atrophy, incision infection, and neurovascular injury were recorded postoperatively for both groups. Overall incidence rate was calculated.

Statistical Analysis

Data were processed and analyzed using SPSS 22.0 software (SPSS Inc., Chicago, IL, USA). The internal consistency of project scores was analyzed using Cronbach's α coefficient. The Kolmogorov-Smirnov test was used to assess the normal distribution of the data. Normally distributed data were expressed as mean $\pm$ standard deviation [$\bar{x} \pm$ standard deviation (SD)] and analyzed using *t*-tests, while non-normally distributed data were expressed as median and interquartile range and analyzed using non-parametric rank-sum tests. Categorical data were represented as percentages and analyzed using chi-square (χ^2) tests. Statistical significance was set at $p < 0.05$.

Results

General Data

As shown in Table 1, Group A consisted of 41 males and 23 females, with an average age of 38.46 $\pm$ 5.77 years. The mean duration of the disease was 12.39 $\pm$ 1.88 months, and the mean body mass index (BMI) was 24.31 $\pm$ 1.65 kg/m^2. There were 29 cases with a history of diabetes and 16 with hypertension. American Society of Anesthesiologists (ASA) classification revealed 35 cases at Grade I and 29 at Grade II. Education levels were below junior high school in 33 cases and at or above senior high school in 31 cases. There were 31 left knee injuries and 33 right knee injuries, with 25 cases of medial injuries and 39 cases of lateral injuries. There were 35 cases of injuries in the red zone and 29 cases in the red-white zone. There were 18 cases with tears <0.8 cm, 25 cases between 0.8~2.0 cm, and 21 cases >2.0 cm.

Group B comprised 37 males and 19 females, with a mean age of 39.12 $\pm$ 4.83 years. The average disease duration was 12.58 $\pm$ 1.97 months, and the mean BMI was 24.78 $\pm$ 1.52 kg/m^2. There were 25 cases with a history of diabetes, 18 cases with a history of hypertension. ASA classification indicated 30 cases at Grade I and 26 at Grade II. Education levels were below junior high school in 24 cases and at or above senior high school in 32 cases. There were 29 left knee injuries and 27 right knee injuries, with 16 cases of medial injuries and 40 cases of lateral injuries. There were 24 cases of injuries in the red zone and 32 cases in the red-white zone. There were 19 cases with tears <0.8 cm, 16 cases between 0.8~2.0 cm, as well as 21 cases >2.0 cm.

There were no statistically significant differences in general data between the two groups ($p > 0.05$), indicating comparability.

Surgery-Related Indicators

No significant differences were observed between the two groups in intraoperative blood loss and healing time ($p > 0.05$). However, the mean operation time in Group A was 38.12 $\pm$ 4.55 minutes, significantly shorter than the 45.76 $\pm$ 4.62 minutes in Group B. Postoperative immobilization time and hospital stay in Group A were 3.34 $\pm$ 0.42 days and 12.74 $\pm$ 1.61 days, respectively, both significantly shorter than the 5.71 $\pm$ 0.66 days and 15.86 $\pm$ 2.78 days in Group B ($p < 0.05$), as shown in Table 2. These findings suggest that the all-inside suturing technique significantly reduces operation time, postoperative immobilization time, and hospital stay compared to the outside-in technique, potentially lowering hospitalization costs.

Proprioception Parameters

Preoperative differences in proprioception difference values at 15°, 45°, and 75° were not significantly different between the two groups ($p > 0.05$). At 3 months postoperatively, proprioception difference values at 15°, 45°, and 75° were all lower compared to preoperative values in both groups. In Group A, the proprioception differences at 15°, 45°, and 75° were 3.51 $\pm$ 0.34, 3.43 $\pm$ 0.44, and 3.72 $\pm$ 0.41, respectively, all significantly lower than those in Group B during the same period ($p < 0.05$), as shown in Table 3. These findings confirm that while both the outside-in and all-inside arthroscopic suturing techniques improved postoperative knee proprioception in patients with meniscus injuries, the all-inside technique was more effective.

Incidence of Adverse Events

Adverse events such as joint cysts, stiffness, synovitis, quadriceps femoris atrophy, incision infection, and neurovascular damage were observed in the outside-in and all-inside arthroscopic suturing techniques. The overall incidence of adverse events was 12.50% in Group A and 16.07% in Group B, with no statistically significant difference ($p > 0.05$) (Table 4). This confirmed that both the outside-in and all-inside suturing techniques for treating meniscus damage did not bring about serious adverse events, and any complications were notably relieved after clinical symptomatic treatment. Both approaches demonstrated safety and reliability.

Table 1. Baseline characteristics of the two groups ($\bar{x} \pm$ SD, n).

General data		Group A (n = 64)	Group B (n = 56)	χ^2/t	*p*-value
Gender	Male	41	37	0.053	0.818
	Female	23	19		
Age (years)	-	38.46 ± 5.77	39.12 ± 4.83	0.674	0.502
Course of disease (months)	-	12.39 ± 1.88	12.58 ± 1.97	0.540	0.590
BMI (kg/m^2)	-	24.31 ± 1.65	24.78 ± 1.52	1.615	0.109
Past medical history	Diabetes mellitus	29	25	0.005	0.941
	Hypertension	16	18	0.750	0.386
ASA score	I	35	30	0.015	0.903
	II	29	26		
Education level	Junior high school and below	33	24	0.908	0.341
	Senior high school and above	31	32		
Location of injuries	Left knee	31	29	0.134	0.714
	Right knee	33	27		
Side of injuries	Medial	25	16	1.461	0.227
	Lateral	39	40		
Region of injuries	Red zone	35	24	1.673	0.196
	Red-white zone	29	32		
Tear size	<0.8 cm	18	19	1.476	0.478
	0.8–2.0 cm	25	16		
	>2.0 cm	21	21		

SD, standard deviation; BMI, body mass index; ASA, American Society of Anesthesiologists.

Table 2. Comparison of surgical indicators between the two groups ($\bar{x} \pm$ SD).

Surgical indicators	Group A (n = 64)	Group B (n = 56)	*t*	*p*-value
Operation time (minutes)	38.12 ± 4.55	45.76 ± 4.62	9.111	<0.001
Intraoperative blood loss (mL)	20.08 ± 2.19	19.85 ± 2.43	0.545	0.587
Postoperative immobilization time (days)	3.34 ± 0.42	5.71 ± 0.66	23.758	<0.001
Postoperative hospital stay (days)	12.74 ± 1.61	15.86 ± 2.78	7.636	<0.001
Healing time (months)	3.12 ± 0.39	3.23 ± 0.44	1.452	0.149

Therapeutic Effects and Long-Term Prognosis

No significant preoperative differences were observed between the groups in IKDC scores, Lysholm scores, VAS scores, or joint ROM ($p > 0.05$). At 3 months postoperatively, Group A exhibited IKDC scores of 70.37 ± 6.98, Lysholm scores of 76.49 ± 7.30, VAS scores of 3.95 ± 0.40, and joint ROM of 118.95 ± 10.85°. At 3 years postoperatively, Group A exhibited IKDC scores of 81.32 ± 7.92, Lysholm scores of 87.98 ± 8.99, VAS scores of 2.12 ± 0.25, and joint ROM of 131.77 ± 15.96°. Compared to Group B, Group A had significantly higher IKDC scores, Lysholm scores, and joint ROM and lower VAS scores at both postoperative intervals ($p < 0.05$) (Table 5). These outcomes demonstrated that compared to the arthroscopic outside-in suturing technique, the all-inside technique showed better short-term and long-term outcomes for patients with meniscus damage.

Discussion

The meniscus is critical in maintaining knee joint stability due to its wedge-shaped structure. Positioned between the femoral and tibial joint gaps, it performs essential biomechanical functions, including load transmission, proprioception, enhancing joint stability, shock absorption, and joint lubrication [15]. The incidence of meniscus injuries has escalated with the increasing popularity of mass sports, rising physical activity levels, and changes in daily habits. Given the strong relationship between normal knee physiological function and the integrity of the meniscus, preserving the meniscus is vital for maintaining knee joint health. Therefore, clinical treatments aim to preserve the meniscus as much as possible to ensure optimal postoperative recovery of knee function [16, 17].

Meniscectomy, which involves removing the damaged meniscus, is generally not preferred due to its potential to compromise knee function. Instead, meniscal suturing is the predominant technique in clinical practice that maximizes meniscus preservation [18]. Knee arthroscopy is particularly effective in evaluating meniscus damage and the joint cavity structure, enabling the selection of the most appropriate suturing method and reducing the risk of misdiagnosis. Arthroscopic meniscus repair has been widely adopted in clinical settings, demonstrating precise treat-

Table 3. Proprioception difference values at various angles in the two groups ($\bar{x} \pm$ SD).

Proprioception		Group A (n = 64)	Group B (n = 56)	*t*	*p*-value
Angle set at 15°	Preoperatively	6.45 ± 0.72	6.42 ± 0.68	0.234	0.816
	3 months postoperatively	3.51 ± 0.34	4.68 ± 0.55	14.202	<0.001
Angle set at 45°	Preoperatively	5.85 ± 0.63	5.82 ± 0.69	0.249	0.804
	3 months postoperatively	3.43 ± 0.44	4.46 ± 0.52	11.723	<0.001
Angle set at 75°	Preoperatively	5.66 ± 0.59	5.69 ± 0.63	0.269	0.788
	3 months postoperatively	3.72 ± 0.41	4.53 ± 0.57	9.014	<0.001

Table 4. Incidence of adverse events in the two groups (n, %).

	Group A (n = 64)	Group B (n = 56)	*t*	*p*-value
Joint cysts	2 (3.13)	1 (1.79)		
Joint stiffness	3 (4.69)	2 (3.57)		
Synovitis	0 (0)	1 (1.79)		
Quadriceps femoral atrophy	2 (3.13)	3 (5.36)		
Incision infection	0 (0)	1 (1.79)		
Neurovascular damage	1 (1.56)	1 (1.79)		
Total incidence	8 (12.50)	9 (16.07)	0.313	0.576

ment outcomes and significantly improving postoperative healing rates [19].

Two common techniques for meniscus repair are the arthroscopic outside-in and all-inside suturing methods, which have similar biomechanical properties and are widely used in joint, ligament, and meniscus repairs. Research has unveiled that while the all-inside suturing technique may take longer to perform compared to the outside-in technique during joint capsule repair surgery, both methods yield similar functional outcomes with high patient satisfaction [20]. Nunes *et al*. [21] reported that arthroscopic all-inside repair of the anterior talofibular ligament (ATFL) significantly restores ankle joint stability in patients with chronic ankle instability, enabling them to return to unrestricted sports activities with good clinical outcomes and high satisfaction rates.

In terms of meniscus injuries, research has signified that compared to the transtibial pullout repair of medial meniscus posterior root tears, arthroscopic all-inside repair significantly improves IKDC, Lysholm, and Tegner functional scores. MRI evaluations at 1-year follow-up also showed less extrusion and signal intensity changes in the all-inside repair group, suggesting superior healing outcomes [22]. Furthermore, Keyhani *et al*. [23] observed that posterior knee arthroscopy using the posteromedial all-inside and anteromedial inside-out meniscus suturing techniques achieved favorable clinical outcomes in repairing chronic unstable or irreducible bucket-handle medial meniscus tears, with significant improvements in Lysholm and IKDC scores at the final follow-up. These studies highlight the efficacy of arthroscopic repair techniques in joint and meniscus repairs. In the study, we compared the arthroscopic outside-in and all-inside suturing techniques to evaluate their effectiveness in treating meniscus injuries and their long-term prognosis.

Our research revealed that Group A, which underwent the all-inside suturing technique, demonstrated shorter intraoperative time, postoperative immobilization time, hospital stay, and incidence of adverse events compared to Group B. Additionally, Group A exhibited smaller proprioception differences at 15°, 45°, and 75° knee joint angles, less postoperative pain, and higher IKDC and Lysholm scores as well as better joint ROM at 3 months and 3 years postoperatively. These findings support the superiority of the arthroscopic all-inside suturing technique over the outside-in suturing method for treating meniscus injuries, leading to more favorable long-term outcomes.

Our findings align with previous studies. Bachmaier *et al*. [24] reported that the all-inside fixation provides a higher initial load and notably stronger fixation strength compared to inside-out repair. Meniscal repairs with higher structural stiffness demonstrate increased resistance to gap formation and failure load. The all-inside meniscal repair strategy is superior in this regard. However, there are contrasting opinions in the literature. Elmallah *et al*. [25] found that while all-inside and inside-out suturing techniques achieve similar meniscal healing rates, the all-inside method may reduce surgical time, but outside-in repair has higher healing rates.

The differences in our study may be due to differences in patient selection. Our study included patients with grade III meniscus injuries, with outside-in suturing predominantly used for anterior angle and body repairs, while inside-out

Table 5. Therapeutic outcomes and long-term prognosis in the two groups ($\bar{x} \pm$ SD).

		Group A (n = 64)	Group B (n = 56)	t	p-value
IKDC scores (points)	Preoperatively	56.82 ± 6.12	56.61 ± 5.33	0.199	0.843
	3 months postoperatively	70.37 ± 6.98	63.85±6.15	5.394	<0.001
	3 years postoperatively	81.32 ± 7.92	77.94 ± 8.01	2.320	0.022
Lysholm scores (points)	Preoperatively	66.26 ± 5.64	66.38 ± 6.12	0.112	0.911
	3 months postoperatively	76.49 ± 7.30	72.31 ± 7.19	3.151	0.002
	3 years postoperatively	87.98 ± 8.99	79.55 ± 8.62	5.224	<0.001
VAS scores (points)	Preoperatively	5.83 ± 0.63	5.92 ± 0.53	0.840	0.403
	3 months postoperatively	3.95 ± 0.40	4.61 ± 0.51	7.934	<0.001
	3 years postoperatively	2.12 ± 0.25	3.47 ± 0.32	25.907	<0.001
Joint ROM (°)	Preoperatively	105.43 ± 12.72	106.78 ± 12.79	0.579	0.564
	3 months postoperatively	118.95 ± 10.85	110.26 ± 10.61	4.422	<0.001
	3 years postoperatively	131.77 ± 15.96	125.41 ± 13.44	2.312	0.021

IKDC, International Knee Documentation Committee; VAS, Visual Analogue Scale; ROM, range of motion.

and all-inside techniques were primarily employed for posterior angle and body part repairs [26, 27]. The patients included in our research may have exhibited more posterior angle and body part injuries, leading to better outcomes with all-inside suturing techniques.

The all-inside technique generally causes less trauma as it avoids large incisions and extensive tissue removal, leading to reduced postoperative pain and inflammation. This facilitates earlier rehabilitation and enhances the efficiency of intraoperative and postoperative processes. However, the effectiveness of the all-inside technique is also influenced by the type of meniscal injury. The all-inside technique, which involves repairing entirely within the joint, is generally suitable for posterior horn and body injuries as it reduces trauma and accelerates recovery.

While our study confirms that both outside-in and all-inside meniscal repair techniques are effective for treating meniscus injuries, it primarily emphasizes that the all-inside technique compared to the outside-in technique can shorten intraoperative time, immobilization time, and hospital stay. It also attenuates postoperative pain, decreases proprioceptive difference values, and achieves better long-term outcomes. The reason for these outcomes may be attributed to the fact that the all-inside technique in knee arthroscopy completes all operations through the arthroscopic approach, resulting in less trauma and avoiding the need for additional incisions to complete the repair within the joint [28]. Additionally, this approach allows for quick and flexible adjustments of surgical details based on patient-specific characteristics, facilitating timely corrections to prevent unnecessary damage to cartilage tissues, thereby maximizing the protection of the meniscus and knee joint function, ultimately achieving excellent treatment outcomes and ensuring long-term prognosis [29].

Despite the positive findings, this study has limitations. It was a small-sample retrospective study, and the lack of randomization in patient selection may introduce bias. Moreover, the follow-up period was limited to 3 years, restricting the scope of our conclusions. Future research should involve larger sample sizes and longer follow-up periods to validate these outcomes.

Conclusions

In summary, compared to arthroscopic outside-in repair, all-inside repair achieves better treatment outcomes for meniscus injuries. It not only abates operation time, immobilization duration, and hospital stay, but also dramatically improves proprioception, promotes knee function recovery, alleviates pain, and provides a superior long-term prognosis, demonstrating safety and reliability. Thus, for the clinical treatment of grade III meniscus injuries, we recommend the all-inside suturing technique to enhance short-term and long-term efficacy and improve prognosis.

Availability of Data and Materials

The datasets used during the current study are available from the corresponding author upon reasonable request.

Author Contributions

WJJ and JXC designed the research study; WJJ and JXC performed the research; WJJ and JXC collected and analyzed the data. WJJ and JXC have been involved in drafting the manuscript and both authors have been involved in revising it critically for important intellectual content. Both authors give final approval of the version to be published. Both authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

This study was reviewed and approved by the Medical Ethics Committee of Yuhuan People's Hospital (approval number: 201812-YH-0012), complies with the Declaration

of Helsinki, and patients voluntarily signed informed consent forms.

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Conflict of Interest

The authors declare no conflict of interest.

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