RESEARCH ARTICLE

Comparison of Medial Meniscus Root Repair with Two Surgical Techniques Using Medial and Lateral Tunnels: A Prospective Cohort Study

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Abstract

Objectives: This study aimed to compare the clinical outcomes of trans-tibial pullout repair of the medial meniscus posterior root using the lateral tibial tunnel versus the conventional medial tibial tunnel.

Methods: In this prospective cohort study, patients with posterior root tears of the medial meniscus who underwent surgical repair were divided into two groups based on the tibial tunnel used for fixation: the medial tunnel technique (Group 1) and the lateral tunnel technique (Group 2). The Lysholm score was recorded preoperatively and 12 months postoperatively to assess knee function and the return to daily and sports activities. Demographic data, including age, gender, and associated injuries, were also documented. Statistical analysis was performed using the one-sample t-test, independent t-test, and Pearson correlation.

Results: The mean Lysholm score in the medial tunnel group was 92.67 ± 9.28, while in the lateral tunnel group, it was 88.02 ± 13.59. Statistical analysis revealed no significant difference in the Lysholm scores between the two groups ($p > 0.05$), indicating comparable clinical outcomes for both techniques.

Conclusion: Both medial and lateral tibial tunnel techniques for trans-tibial pullout repair of the medial meniscus root yield comparable functional outcomes. The choice of tunnel may be guided by anatomical considerations or surgeon preference, as no significant difference was observed in postoperative recovery, as measured by the Lysholm score.

Level of evidence: II

Keywords: Knee surgery, Lateral tunnel technique, Lysholm score, Medial meniscus root tear, Medial tunnel technique, Trans-tibial pullout repair

Introduction

The meniscus is a crucial structure that significantly contributes to the knee's load-bearing capacity.[1] he meniscus is responsible for approximately 40 to 80% of load transmission in the knee joint.[2]

The posterior root of the medial meniscus serves to connect the meniscus to the bone. A tear in the posterior root disrupts the conversion of axial stress into hoop stress, thereby adversely affecting load transmission through the meniscus.[3] Historically, treatment options for posterior root tears of the medial meniscus have included conservative management or partial meniscectomy. However, several studies have demonstrated that these approaches do not adequately restore the hoop stress capacity of the meniscus and are ineffective in preventing the progression of osteoarthritis.[4-6] The primary goal in treating posterior root tears is to prevent the onset of osteoarthritis. Recently, meniscus preservation through root repair has emerged as a widely adopted technique.[7] Repairing a posterior root tear of the medial meniscus can reduce contact pressure on the medial compartment by increasing the contact area,[8] leading to better clinical outcomes compared to non-surgical interventions.[9] Meta-

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analyses have shown that repairing the posterior root tear yields favorable clinical results and slows the progression of osteoarthritis, with less progression compared to non-surgical treatment or meniscectomy.[10-14] Based on these findings, the treatment approach for meniscus tears has shifted from meniscectomy to meniscus preservation.[15,16]

Meniscus tears can be classified into various types based on their location and patterns, each with distinct characteristics.[17,18] Among these, a posterior root tear of the medial meniscus is considered particularly detrimental, as it creates conditions similar to those following a complete meniscectomy.[19,20] Posterior root tears of the medial meniscus account for approximately 10% of all meniscus tears and 22% to 28% of medial meniscus tears.[21-23]

A posterior root tear of the medial meniscus leads to dysfunctional meniscal conditions, resulting in detrimental biomechanical changes in the knee. However, it has been reported that surgical repair can improve this condition.[24,25] Based on a cadaveric study by Padalecki et al., repairing a posterior root tear of the medial meniscus has been shown to restore knee loading profiles to levels indistinguishable from those of a healthy meniscus.[24]

The methods for repairing a posterior root tear of the medial meniscus include two techniques: one involving the use of a suture anchor (suture anchor repair) and the other utilizing a trans-osseous tunnel (trans-tibial pullout repair). In suture anchor repair, a suture anchor is placed at the site of the posterior root tear of the medial meniscus, above the posterior tibial plateau.[26-28]

Based on the study by Feucht et al., as well as the results of Cerminara et al., in the trans-tibial pullout repair, suture strands are sewn onto the torn edge of the posterior root tear of the medial meniscus and passed through a trans-osseous tunnel created to the outer cortex of the tibia. Fixation is then performed at the anterior tibial cortex. This method may have potential disadvantages, such as micromotion and suture abrasion.[29,30] However, it is considered less technically challenging compared to the suture anchor technique and carries a relatively lower risk of damaging the vital structures of the knee joint.[31] Additionally, it prevents complications associated with suture anchor loosening.[32] Therefore, most surgeons prefer the trans-tibial pullout repair technique for posterior root tears of the medial meniscus.[10]

In the study by Dragoo et al., it was demonstrated that another drawback of the trans-tibial pullout repair is the risk of suture abrasion within the bone tunnel, as well as suture creep, both of which can compromise the repair's strength and increase the likelihood of suture rupture.[33]

Advantages: Meniscus repair and preservation offer better long-term outcomes in terms of joint function and delay the progression of osteoarthritis compared to non-surgical treatment or meniscectomy.

Disadvantages: The current trans-tibial pullout repair technique, which uses fixation at the anterior tibial cortex, presents several drawbacks, including a suboptimal fixation angle and potential tunnel convergence.

Objective: This study aimed to evaluate a modified trans-tibial pullout repair technique, in which fixation of the medial meniscus root is performed through a lateral tibial tunnel.

Materials and Methods

Study design

This study was designed as a prospective cohort study with a sample size of 91 patients. The inclusion criteria were patients diagnosed with medial meniscus root tears without an associated bony fragment. The exclusion criteria included patients with concomitant fractures, osteoarthritis grades 3 and 4, a history of infection, smoking, a body mass index (BMI) greater than 32, those with an anterior cruciate ligament (ACL) tear in addition to medial meniscus root tears, or patients who had undergone concurrent osteotomy or any other procedure aside from the medial meniscus root repair.

The patients were divided into two intervention groups based on the surgical technique they received:

Group One: Patients undergoing medial meniscus root repair using the medial tunnel technique.
Group Two: Patients undergoing medial meniscus root repair using the lateral tunnel technique.

Sampling

In this study, participants were categorized into two groups based on the type of surgical technique they underwent. A total of 45 participants were included, with each group consisting of patients who received a specific surgical approach. The mean age of participants in both groups was 55.04 ± 7.48 years.

Specifically, the mean age in Group One was 56.86 ± 7.41 years, while the mean age in Group Two was 53.17 ± 7.16 years. Additionally, the majority of participants in both groups were female, with 80.4% female in Group One and 91.1% female in Group Two.

Before surgery, the Lysholm score was assessed in all patients diagnosed with a posterior medial meniscus root tear. Both groups were followed for 12 months to evaluate their return to activity. After 12 months, participants' return to activity was assessed using the Lysholm checklist,[34] which evaluates ligament injuries and other knee-related conditions, including cartilage damage. Additionally, during the follow-up period, participants received instruction in physiotherapy and exercises designed to prevent excessive pressure on the knee.

Surgical methods and techniques

In both surgical techniques, Fiberwire Arthrex sutures were used for medial meniscus root repair. The procedure is identical in both techniques, with the primary difference being the path of the tunnel.

1. Step One: In both techniques, two knots were placed at the medial meniscus root using the Scorpion device with Arthrex sutures to provide initial stability.
2. Step Two: A tibial tunnel was then created using the ACL Tibia Guide, precisely through the tibial bone.
3. Step Three: After the tunnel was created, the sutures were passed through the tunnel and secured with a button, which provides final fixation for the meniscus root. This process was standardized and identical in both techniques.
4. Tunnel Path Difference: In the lateral tunnel technique, the tunnel was created in alignment with the traction force of the medial meniscus.

In the medial tunnel technique, the tunnel is created in the opposite direction to the traction force of the medial meniscus, thereby providing better fixation for the meniscus root. These surgical procedures were performed according to standard protocols by skilled surgeons. Following surgery, all patients received post-operative care, including physiotherapy and rehabilitation programs to facilitate recovery and promote a return to normal activity. The same orthopedic surgeon performed both surgical techniques to ensure consistency in procedure and minimize variability in surgical outcomes. Additionally, key steps of the repair procedure were documented arthroscopically to provide a visual record of the surgical technique.

Measurement variables and indicators

In this study, the Lysholm score[35] was used as the primary variable to assess knee function and return to activity after surgery. The Lysholm score was evaluated using the standard Lysholm questionnaire, which includes questions related to pain, daily activities, and knee stability.

Secondary variables assessed in this study included:

1. Age: The patients' age at the time of enrollment was recorded as a demographic variable.

2. Gender: The gender of the patients was recorded as a demographic variable.

Data analysis method

Statistical analyses were performed using SPSS version 25. The normality of the data was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. A one-sample t-test was employed to compare the preoperative Lysholm score with the postoperative Lysholm score. An independent t-test was conducted to compare postoperative Lysholm scores between the two groups. Pearson's correlation test was used to evaluate the relationship between age and the Lysholm score. A p-value of less than 0.05 was considered statistically significant. Multiple statistical tests were performed, and appropriate corrections were applied as necessary to account for multiple comparisons.

Ethics and obtaining permits

Institutional ethical committee approval was obtained under code IR.KMU.AH.REC.1403.105.

Results

The general demographic characteristics of both groups are presented in [Table 1]. The mean preoperative Lysholm score was 52.46 ± 8.5 in Group One and 44.67 ± 7.9 in Group Two. Additionally, the mean postoperative Lysholm score in Group One was 92.67 ± 9.28, and in Group Two, it was 88.02 ± 13.59.

Table 1. General information of patients.

	Group one	Group two
Age (year)	56.86 ± 7.41	53.17 ± 7.16
Prevalence of male sex	15.6%	8.1%
Prevalence of female sex	80.4%	91.9%
Follow-up time(month)	12	12

A one-sample t-test was used to compare the preoperative and postoperative Lysholm scores within each group. In Group One, the mean Lysholm score increased from 52.46 ± 8.5 preoperatively to 92.67 ± 9.28 postoperatively. In Group Two, the mean Lysholm score increased from 44.67 ± 7.9 preoperatively to 88.02 ± 13.59 postoperatively. In both groups, the improvement was statistically significant (p-value = 0.000).

Since the variability in scores between male and female patients was unequal (Levene's test, $p < 0.05$), Welch's t-test was used to compare their Lysholm scores. The results showed a statistically significant difference ($p = 0.041$).

Similarly, due to unequal variances between the surgical technique groups (Levene's test, $p = 0.018$), Welch's t-test was applied. However, the difference in Lysholm scores between the two techniques was not statistically significant ($p = 0.061$).

Pearson's correlation analysis between age and the Lysholm score revealed no significant relationship between these two variables ($p = 0.113$). Although there was a statistically significant difference in mean age between the two surgical groups ($p = 0.018$), an ANCOVA was performed with age as a covariate and the Lysholm score as the dependent variable. The results showed that neither age ($p = 0.242$) nor group ($p = 0.122$) had a statistically significant effect on the Lysholm score. This suggests that age did not act as a confounding variable.

Additionally, a Chi-square test was conducted to evaluate the gender distribution between groups, and no significant difference was found ($p > 0.05$), indicating that the gender balance was well-maintained and unlikely to influence the results. Postoperative radiographic images were analyzed in both groups [Figure 1].

A B

Figure 1. Postoperative X-ray: (A) Group one (medial tunnel technique) and (B) Group two (lateral tunnel technique), demonstrating comparable healing patterns at 12 months

Key arthroscopic steps of the medial meniscus root repair procedure are demonstrated in a single composite image, including suture placement (a), anterior displacement of the meniscus with suture tension (b), suture passage through the bone tunnel (c), and final fixation after tightening (d) [Figure 2]. Postoperative Lysholm subscale scores for both groups are summarized in [Table 2].

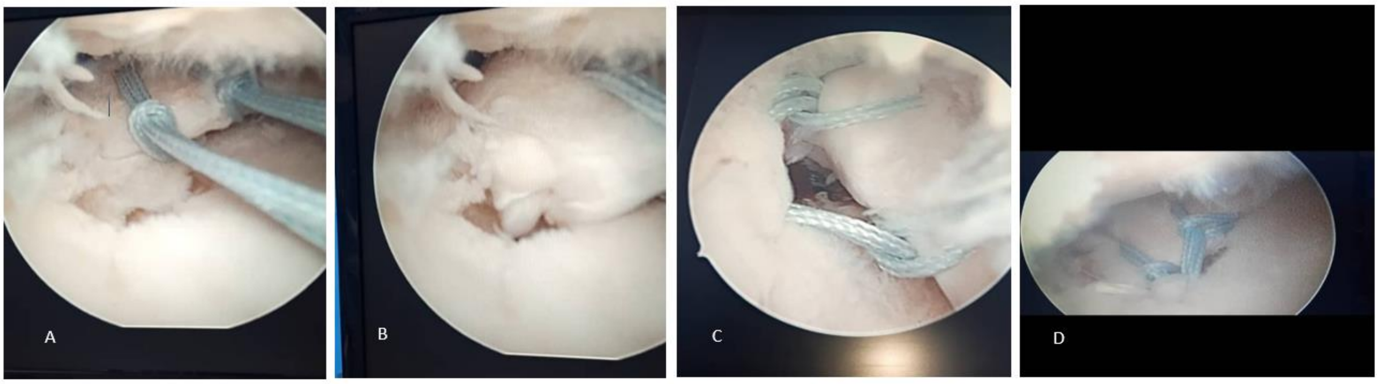

Figure 2. Arthroscopic images of key steps in medial meniscus root repair: (A) placement of sutures in the meniscal root, (B) anterior advancement of the meniscus after pulling sutures, (C) suture passage through the tibial tunnel, and (D) final view after fixation

Table 2. Mean postoperative scores and standard deviations for the eight Lysholm score variables in group one and group two.

Variable	Group one (Mean±SD)	Group two (Mean±SD)
Limp	4.82±0.08	4.70±0.09
Support	5±00	5±00
Locking	14.89±0.10	14.77±0.15
Instability	25.56±0.34	24.66±0.33
Pain	22.93±0.45	19.77±1.20
Swelling	8.69±0.40	8.44±0.50
Stair Climbing	7.91±0.47	7.02±0.54
Squatting	3.84±0.24	3.55±0.27

Discussion

In this cohort study comparing two surgical techniques for internal meniscus root repair, our primary outcome measure—the Lysholm score—yielded unexpected results. Contrary to our hypothesis, the group that underwent the medial tunnel technique—a widely accepted and routine method—demonstrated higher Lysholm scores than the group that received the lateral tunnel technique, a more recent approach. This finding contradicts our initial expectations, which anticipated that the newer technique would yield superior results.

Several factors may explain this discrepancy. First, it is essential to consider the technical nuances between the medial and lateral tunnel techniques. The medial tunnel technique, being well-established and widely practiced, likely benefited from a more refined surgical approach due to its more extended history of use. Surgeons may have had greater experience and a deeper understanding of potential complications and optimizations when performing the medial tunnel procedure. In contrast, the lateral tunnel technique, while promising, presented a steeper learning curve and was more technically demanding, which could have contributed to the slightly lower scores.

To ensure that demographic differences did not influence the outcomes, additional statistical analyses were performed. Although the mean age significantly differed between the groups ($p = 0.018$), ANCOVA analysis revealed that neither age ($p = 0.242$) nor surgical group ($p = 0.122$) had a significant effect on postoperative Lysholm scores. Furthermore, gender distribution was statistically comparable between the groups (Chi-square test, $p > 0.05$). These findings suggest that age and gender did not confound the comparison of surgical techniques.

Additionally, the follow-up period may not have been sufficient to fully assess the long-term benefits of the lateral tunnel technique. While the medial tunnel technique has demonstrated consistent results over time, the lateral tunnel technique, being newer, may require a longer duration to reveal its potential advantages.

Both the medial and lateral tunnel techniques in our study yielded favorable outcomes, as evidenced by high mean Lysholm scores in both groups (92.68 ± 9.28 in the medial tunnel group and 88.02 ± 13.59 in the lateral tunnel group). These scores indicate excellent and good functional results, respectively, reflecting the overall effectiveness of both surgical approaches. In comparison, a study by Jun Li et al., conducted on 40 patients with posterior root tears of the medial meniscus, randomly divided participants into two groups: one group underwent the transtibial pullout technique, and the other received the all-inside repair technique. The results showed that the average Lysholm score in the transtibial pullout group was 84.41 ± 4.31 postoperatively, while the all-inside repair group had an average score of 79.32 ± 4.88. While previous studies have reported lower Lysholm scores following similar meniscal repair procedures,[36] our techniques demonstrate superior functional recovery. This suggests that our surgical methods may offer improved outcomes in terms of knee function and patient satisfaction.

Most prior research on medial meniscal root repair has primarily utilized the medial tunnel technique. However, limited data exist regarding factors influencing treatment outcomes, such as the quality of the repaired meniscus, pullout direction, tunnel placement, and repair methods. In contrast, a study employing a combined technique for medial meniscal root repair with open-wedge osteotomy identified several potential advantages. This technique was considered beneficial due to its alignment with the physiological direction of meniscal pull, particularly given the C-shaped structure of the meniscus, which directs towards the tibia, and the favorable pull angle resulting from medialization.[37]

The technique used in that study, which is similar to the lateral tunnel approach in our research, employs a lateral pullout for meniscal repair. While the physiological benefits of the lateral technique have been emphasized, our current study's results indicate that the conventional medial tunnel technique outperformed the lateral approach. This difference may be attributed to variations in the mechanics and biomechanics of the meniscus, as well as the changes induced by the tunnel's positioning.

In the lateral tunnel technique, the button is positioned on the anterolateral cortex due to the tibia's triangular cross-section. While this placement makes tying the button more challenging, it minimizes patient discomfort. In contrast, the medial tunnel technique places the button on the anteromedial cortex, allowing for easier tying of the button; however, the proximity to the skin surface may result in greater patient discomfort.[38]

In another study, it was suggested that the lateral pullout technique may require a longer plate screw compared to the medial technique due to the potential interference of the plate screw with the bone tunnel pullout. However, Nejima et al.[39] reported that in cases of osteotomy, plate screws do not interfere with the bone tunnel. Nevertheless, insufficient screw insertion could still compromise the stability of the plate fixation. Therefore, when designing plate screws for techniques involving lateral pullout, such as the lateral tunnel approach evaluated in our study, it is essential to minimize any potential interference with the bone tunnel pullout as much as possible.

In the study by Takigami et al., a surgical technique was described that combines lateral pullout with open-wedge osteotomy. The advantages of this combined method include: first, a physiologically favorable direction for the repaired meniscus pullout from the lateral tibia; second, a reduced risk of neurovascular injury; third, the possibility of using a longer plate screw, which can minimize interference with the bone tunnel; and fourth, ease in creating the bone tunnel from the lateral tibia. Given that our novel method also involved the lateral tunnel approach, these points are particularly relevant and suggest that lateral techniques may offer unique advantages compared to medial techniques.[40]

Conclusion

The findings suggested that the medial tunnel technique, despite being a routine procedure, may offer advantages in terms of surgeon familiarity and technical refinement, which could explain the better functional outcomes observed in this group. However, while the lateral tunnel technique is promising, it may require further refinement and additional experience to fully realize its potential benefits. This study underscored the need for continued investigation into the long-term outcomes of both techniques, as well as the importance of conducting further research with larger sample sizes and more stringent selection criteria to better understand the factors influencing the success of meniscus root repair. Future studies should focus on exploring the biomechanical implications of both techniques, as well as patient-specific factors that may affect clinical outcomes. Additionally, a more extended follow-up period would provide a clearer understanding of the long-term benefits and potential complications associated with each technique.

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