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Original Research Article

Clinical Outcome of Medial Meniscus Root Reconstruction Versus Root Repair in Managing Medial Meniscus Posterior Root Tear

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Abstract

Introduction:
Optimal treatment of a medial meniscus posterior root tear (MMPRT) is essential for restoring joint kinematics, and contact pressures, and preventing the progression of knee osteoarthritis (OA). Recently, transtibial pull-out repair has been the preferred treatment for MMPR tear. However, the repair techniques do not provide any biological structure to enhance biological healing. Reconstruction of the meniscus root with gracilis autograft may reproduce the ligamentous structure resembling the original root. The objective of this study is to assess and compare the clinical effectiveness of medial meniscus root reconstruction and root repair.

Method:
Patients who received arthroscopic surgical treatment for MMPRT were included in this study. Twenty patients who had been diagnosed with MMPR tear were divided into two groups: those who underwent transtibial pull-out repair (10 cases) and those who underwent meniscus root reconstruction with gracilis autograft (10 cases). Each patient then underwent a surgical procedure according to their respective group. Clinical outcomes were assessed using visual analog score (VAS) and KOOS score in 3 months follow-up.

Result:
Both groups had no significant differences in the baseline characteristics. Compared to the repair group, the reconstruction group demonstrated significant mean VAS reduction (p= 0,001) at 3 months. However, there was no significant difference in the mean KOOS score at 3 months (p=0.481).

Conclusion:
The meniscus root reconstruction using gracilis autograft offers significant benefits with superior outcomes in VAS score compared to transtibial pull-out repair, however, there were no differences on clinical outcome at 3 months follow-up

Introduction

The meniscus root is an essential component that plays a crucial role in maintaining the normal function of the meniscus as both a shock absorber and a secondary stabilizer.[1] Medial meniscus posterior root tear (MMPRT) may cause meniscus extrusion (ME), which leads to the rapid development of joint space narrowing and disrupts the ability of the knee to withstand hoop strain, thereby resulting in increased contact pressure, kinematic alterations, and subchondral bone edema.[2,3] These consequences were indistinguishable from total meniscectomy.[2] In the end, the notable reduction in the area of contact and the rise in pressure on the weight-bearing part result in a faster deterioration of the joint; hence, optimal treatment of MMPRT is essential for restoring joint kinematics and contact pressures and preventing the progression of knee OA.

A range of surgical interventions are utilized in the management of meniscus root injuries, such as meniscectomy, meniscal repair, and reconstruction of the meniscus root.[4] Recently, transtibial pull-out repair has been the preferred treatment for MMPRT, and it has been reported to have favorable clinical outcomes. However, the repair techniques do not provide any biological structure to enhance biological healing since the medial meniscus root attachment to the tibial plateau comprises a ligamentous structure.[5,6] The poor healing outcome may have occurred due to the restricted suture fixation within the area between the anterior tibia cortex and degenerative tissue. It has been reported that this structure is considerably weaker than the native root.[7]

Therefore, Lee *et al*.[8] developed the arthroscopy technique using gracilis autograft to reconstruct the MMPRT focused on using the ligament structure to recreate the native root. The purpose of this study is to compare the clinical effectiveness of medial meniscus posterior root reconstruction and repair.

Materials & Methods

Patient selection

Prior to enrollment in this study, all patients were required to submit written informed consent. This study protocol received approval from the Hospital Ethics Committee. Clinical findings and non-contrast knee magnetic resonance imaging (MRI) findings, including the cleft sign, ghost sign, and giraffe neck sign, were utilized to diagnose MMPRT in patients.[9] Based on line characteristics, age, gender, and body mass index (BMI) were acquired. Criteria for inclusion include: Patients (1) who have been diagnosed with MMPRT, (2) who do not have knee osteoarthritis, or grade I-II based on Kellgren Lawrence. The study excluded participants who met the following exclusion criteria: (1) those with concurrent injuries such as anterior cruciate ligament (ACL) or multi-ligamentous injuries; and (2) those with obvious knee deformities.

Twenty MMPRT patients who underwent tibial tunnel-based posterior root reattachment treatment were included in this study. The patients were categorized into two groups: ten patients received arthroscopic surgical reconstruction utilizing a gracilis tendon autograft, while the other ten patients underwent arthroscopic surgical repair accompanied by double tunnel transtibial pull-out repair. One orthopedic surgeon performs all surgical procedures.

Data collection

Age, gender, body mass index (BMI), comorbidities, Kellgren and Lawrence grade of OA knee (K-L), treatment for MMPRT, pre-operative and follow-up VAS score, and KOOS score of the affected knee were collected as baseline characteristics. Three months following the operation, clinical examinations were conducted, including a knee functional assessment using the VAS score and KOOS score. The visual analog scale (VAS) was initially developed by Hayes and Patterson in 1921 as a pain rating scale. The scores are determined by self-reported assessments of symptoms ranging from "no pain" (score = 0) at the left end to "worst pain" (score = 10) at the right end of the scale. The VAS score is an accurate and reliable instrument for quantifying pain at a specific moment in time. (α= 0.88).[10,11]

For young, middle-aged, and elderly adults with knee injury and/or knee osteoarthritis (OA), the Knee Injury and Osteoarthritis Outcome Score (KOOS) is a PROM that can be used to track disease progression and outcomes after surgical, pharmacological, and other interventions. (1) Pain (comprising nine items); (2) Additional Symptoms (comprising seven items); (3) Activities of Daily Living (ADL), comprising seventeen items; (4) Sport and Recreation function (comprising five items); and (5) Quality of life associated with the knee (QoL), comprising four items. A distinct score is assigned to each subscale, ranging from zero (indicating severe knee problems) to one hundred (indicating no knee problems). A recent meta-analysis has determined that the KOOS exhibits sufficient levels of construct validity, responsiveness, content validity, internal consistency, and test-retest reliability for subscales that are pertinent to age and condition. This is supported by a pooled overall alpha of 0.86.[12]

Surgical techniques

Standard anterolateral and anteromedial arthroscopic portals are established, and an arthroscopic visualization is conducted to confirm the existence of a rupture in the posterior root of the medial meniscus. (Figure 1). To enhance the visibility of the medial posterior compartment during arthroscopy, the medial collateral ligament is released using an inside-out technique utilizing an 18-gauge needle. In the transtibial pull-out techniques, following confirmation of the MMPRT by arthroscopic examination, the ruptured margin of the meniscus root is refreshed with a shaver. To create the tibial tunnel, a standard tip-to-tip anterior cruciate ligament reconstruction tibial tunnel guide is utilized. A small incision over the anteromedial proximal tibial tibia is made and a 2.0 mm guide pin is drilled from that incision to the posterior horn root of the knee. The tip edge of the detached portion of the meniscus is sutured using a No.2 Fiber wire (Rejoin) and the tail of the suture is shut down to the tibial tunnel. The tail of the sutures is then fixated using either the ET button (Rejoin) or anchor screw with the washer to the tibial. (Figure 2).

To perform the meniscus root reconstruction techniques, a 2-cm longitudinal skin incision is made medial to the tibial tuberosity to harvest the gracilis

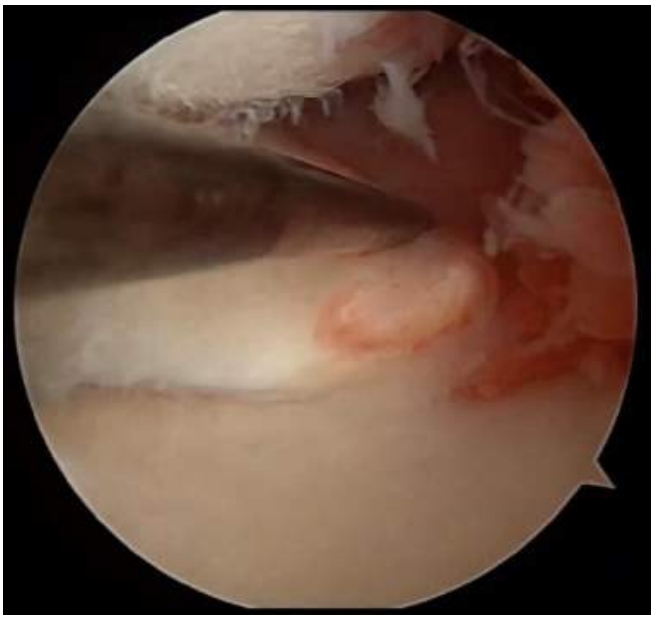

Figure 1. Arthroscopic evaluation of medial meniscus posterior root tear

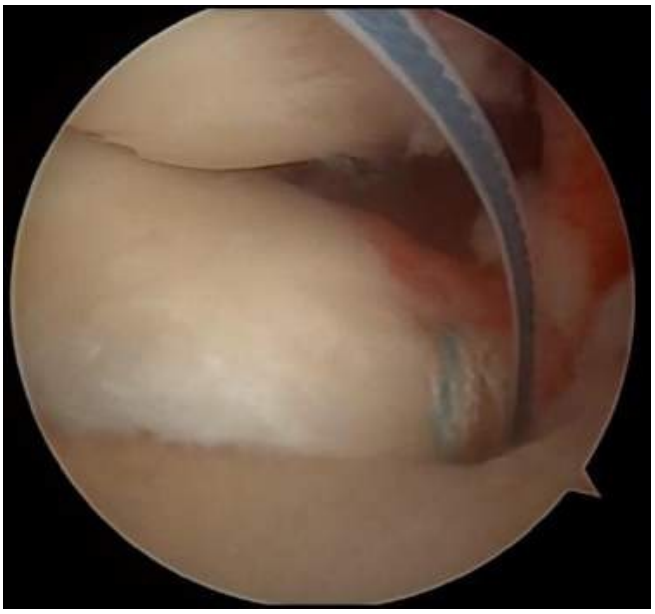

Figure 2. Transtibial pull-out techniques for MMPRT, the tail of suture was shuttle into the tibial tunnel

tendon. The graft is extracted using a tendon stripper after the gracilis is dissected in its entirety. The graft is tapered to fit through the tunnel and had a final length of approximately 6 cm and a diameter of 3 mm. Through the incision used for graft harvest, a 2.0-mm guide pin is inserted and advanced to the meniscus root attachment site of the knee. Following that, a 6-mm cannulated drill is utilized to excessively drill the guide pins. A suture hook or mini-scorpion may be utilized to create a hole in the posterior portion of the medial meniscus. (Figure 3). After suturing the posterior meniscus with a suture lasso, the meniscus is dilated using two no. 2 Ethibond sutures in a back-and-forth jigsaw motion until the desired diameter is achieved, allowing the graft to pass through the meniscus. Then, using a shuttle suture, the graft of the gracilis tendon is passed through the meniscus hole (Figure 4). The posterior horn displacement is subsequently reduced, and stabilization is achieved by applying adequate tension into the tibial tunnel (Figure 5). A 6 mm PEEK interference screw (Rejoin) is utilized to firmly fasten the graft in place to the tibial while the knee is flexed at an angle ranging from 30 to 45 degrees. A final arthroscopic assessment is conducted to validate the tension of the entire medial meniscus and the integrity of the reconstructed posterior root.

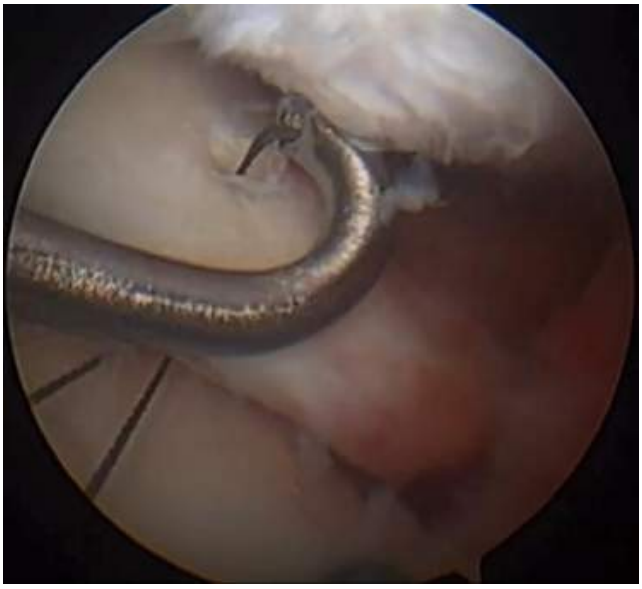

Figure 3. Suture hook is use to create a hole in the posterior portion of the medial meniscus

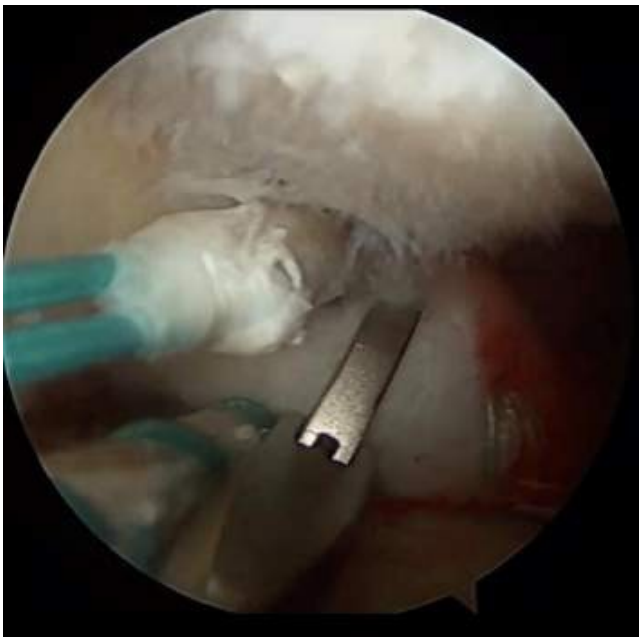

Figure 4. The graft of gracilis tendon is passed through the dilated meniscus hole

Figure 5. The gracilis tendon graft is passed through the tibial tunnel to reconstruct the medial

Statistical Analysis

Windows IBM SPSS V25 software (IBM, Armonk, New York, USA) was used for statistical analysis. Baseline characteristics between the two groups were compared. Non-parametric numerical data and nominal data were assessed using the Mann-Whitney U test and the Chi-square test, respectively (if the expected count <5 more than 20% is continued with the Fisher-exact test). The normality of the data was assessed using the Saphiro-Wilk test, and the mean score of PROs was compared between both groups using an independent t-test if the data is normally distributed. In case of non-normally distributed data Mann-Whitney U test were utilized. $P < 0.05$ was considered statistically significant.

Results

Patient Demographics

As presented in Table 1, ten patients were included in both reconstruction groups (mean 57.6±9.2 age years) and repair groups (mean 59±9.1 age years). A Mean BMI of the reconstruction group is (27.3±3.3) and the repair group is (27±2.9) respectively. The mean preoperative VAS scores for the reconstruction and repair group were (7.5±0.5) and (8 ±0.7) respectively. Mean preoperative KOOS scores were (35.5±5.2) and (36±5.1). There was no statistical difference in baseline characteristics between both groups.

Clinical Outcome

The range of postoperative VAS scores for the reconstruction group is 1 to 2 with a mean VAS score (1.6 ±0.51) while the repair group is 2 to 4 with mean (3.2 ±0.79). The mean post-operative VAS score showed statistically significant improvement at 3 month (p=0.001). The range of postoperative KOOS score is 70 to 79 in the reconstruction group and 80 to 88 in the repair group, mean KOOS score at 3 months showed no difference in both groups (p=0.481).

Discussion

This present study involved a comparison of VAS score and KOOS score at 3 months follow up. The findings (Table 2.) show that compared to the repair group, the reconstruction group demonstrated a significant reduction in the mean VAS score (p=0.001), however, there was no difference in the mean KOOS score (p=0.481). Furthermore, no significant differences were observed in the initial characteristics of the two groups. Two distinct suture configurations were utilized to suture the meniscus in the transtibial pull-

Table 1. Patient demographics between two groups

	Reconstruction group (n=10)	Repair group (n=10)	p value
Age (Mean ± SD)	57.6 ± 9.2	59 ± 9.1	0.631¶
BMI (Mean ± SD)	27.3 ± 3.3	27 ± 2.9	0.912#
Sex (M/F)	4/6	1/9	0.303¶
KL grade	Grade 0 (n= 3) Grade 1 (n= 3) Grade 2 (n= 4)	Grade 0 (n= 3) Grade 1 (n= 5) Grade 2 (n= 2)	-
Comorbidities	Hypertension (n= 3) DM 2 (n= 2) Obesity (n= 3)	Hypertension (n= 4) DM 2 (n= 2 Obesity (n= 1)	-
Suture configuration		Horizontal mattress suture (n= 3) Cinch suture (n=7)	-
Pre VAS score (Mean ± SD)	7.5 ± 0.5	8 ± 0.7	0.143#
Pre KOOS score (Mean ± SD)	35.5 ± 5.2	36 ± 5.1	0.739#

M: Male ; F: Female ; KL: Kellgren Lawrence ; SD : Standard Deviation ; BMI : Body Mass Index ;VAS: Visual Analog Scale; KOOS: Knee Osteoarthritis Score ; DM 2 : Diabetes Mellitus type 2.
*Chi-square test # Mann-whitney U test ¶Continuity correction of Chi-square test with Fisher-exact test.

Table 2. Clinical outcome of the study groups

	Reconstruction group (n=10)	Repair group (n=10)	P value
Post VAS score (Mean ± SD)	1.6 ± 0.51	3.2 ± 0.79	0.001[€]
Post KOOS score (Mean ± SD)	81.5 ± 5.9	8.37 ± 3.2	0.481[#]

Visual Analog Scale; KOOS: Knee Osteoarthritis Score; SD: Standard Deviation
[#]Mann-whitney U test
[€]Independent t-test

out repair group. Seven patients underwent a cinch suture, whereas three patients received a horizontal mattress suture. Nevertheless, Jackson et al.[13] conducted a study on the clinical results of medial meniscus posterior root repairs utilizing different suture configurations. They found that all participants showed improvement in clinical outcomes, and no significant differences were noted. Thus, it may not emerge as a significant factor that can influence the clinical result.

Studies have established a significant correlation between meniscal root tears, which result in the cessation of circumferential hoop stresses, and the progressive development of symptomatic joint arthritis.[14] Consequently, the majority of studies have shown that surgery is advisable for individuals with substantial needs and mild osteoarthritis.[15,16] The transtibial pull-out technique for the meniscus root procedure facilitates anatomic reduction and fixation of the meniscus root. By restoring the meniscus to its initial anatomical position, meniscus root repair has been associated with encouraging functional improvements in the knee.[17] While the pull-out technique has been previously regarded as the recommended repair method for managing MMPRT, it is linked to relatively low rates of healing. In a comprehensive investigation conducted by Feucht et al [18], it was discovered that only 62% of patients achieved a state of 'complete' healing, while 34% experienced 'partial' healing, and 4% were classified as having 'failed' healing. This unfavorable healing outcome might be the result of a fixation involving only a non-absorbable high-tension suture attached to the anterior tibia cortex. Furthermore, the utilization of a pulling suture to repair the meniscus may result in excessive stress on the meniscus, which differs from its natural origin. It may be the cause responsible for the lower improvement of the VAS score in the transtibial pullout repair group compared to the meniscus reconstruction group. In an animal model, Feutch et al.[7] documented a displacement of the meniscus root after root repair utilizing the trans-tibial pull-out technique while subjecting the root to cyclic loading. A substantial distance may exist between the footprint, the site of the tear, and the tibial fixation points, which increases the susceptibility to the "bungee effect," which has the potential to hinder the healing of the meniscus. Several studies have also documented the inability of numerous repairs to halt the progression of symptomatic knee arthritis and the inadequacy of meniscal healing rate outcomes.[19–21]

Over the last decade, there has been a surge of interest in MMPRT reconstruction techniques. Lee *et al*.[8] developed the arthroscopy technique using gracilis autograft to reconstruct the MMPRT. The utilization of the graft serves to establish a connective tissue link between the original meniscus root attachment site and the grafted meniscus root footprint, hence facilitating an accelerated healing process and improving the clinical outcome. This method also involves the utilization of an interference screw or button to anchor the graft to the bone, therefore improving control over tension to prevent micro-motion or the bungee effect compared to the repair technique. The study conducted by Li et al.[6] demonstrated that meniscus root reconstruction using a gracilis autograft is beneficial for treating patients, as it results in higher rates of meniscus healing. Specifically, 51% of patients in the repair group achieved complete healing, while 82.7% of patients in the meniscus root reconstruction using gracilis autograft group achieved complete healing. Wendel et al.[5] have provided evidence that meniscus root reconstruction can facilitate optimal healing by reattaching to the anatomic footprint with a cartilaginous graft that resembles the native root. Reconstruction of the MMPRT was likely an option that is expected to overcome the limitation of the arthroscopic transtibial pull-out repair. In this study we found that significant reduction of the mean VAS score in the meniscus root reconstruction group; however, the mean postoperative KOOS score between both groups was not any significant, this may be attributed to short follow-up time, as meniscus root needed more time to heal. Furthermore, as previously stated, the act of pulling the suture of the meniscus during transtibial pullout repair may result in increased stress on the meniscus, which might potentially diminish the significance of the improvement in VAS scores.

This study has also identified several limitations. First, our current study is limited to a single center, which means it was conducted in a single facility. Additionally, the study included a very small number of patients and had a short follow-up duration. These factors may introduce bias into the results. Second, there is a discrepancy in the fixation technique employed in the transtibial pull-out group. However, studies have demonstrated that there was no significant difference was discovered among those techniques. Third, there is no randomization in this study. To resolve this problem, further observational studies are recommended to conduct with a larger sample size and a longer duration of follow-up.

Conclusion

In comparison to transtibial pull-out repair, meniscus root reconstruction with gracilis yields superior outcomes as measured by the VAS score; however, at the three-month follow-up, there was not a significant difference in clinical outcome. Additional research incorporating a more extended follow-up period is required to comprehensively assess the advantages between these two procedures.

References

1. Fukubayashi T, Kurosawa H. the contact area and pressure distribution pattern of the knee: A study of normal and osteoarthrotic knee joints. *Acta Orthop*. 1980;51(1-6):871-879. doi:10.3109/17453678008990887.
2. Bhatia S, Laprade CM, Ellman MB, Laprade RF. Meniscal root tears: Significance, diagnosis, and treatment. *Am J Sports Med*. 2014;42(12):3016-3030. doi:10.1177/0363546514524162.
3. Lee DW, Ha JK, Kim JG. Medial meniscus posterior root tear: A comprehensive review. *Knee Surg Relat Res*. 2014;26(3):125-134. doi:10.5792/ksrr.2014.26.3.125.
4. Srimongkolpitak S, Chernchujit B. Current concepts on meniscal repairs. *J Clin Orthop Trauma*. 2022;27:101810. doi:10.1016/j.jcot.2022.101810.
5. Holmes SW, Huff LW, Montoya KJ, Durkin MW, Baier AJ. Arthroscopic Medial Meniscal Root Reconstruction With Gracilis Autograft Is Safe and Improves 2-Year Postoperative Patient-Reported Outcomes. *Arthrosc Sport Med Rehabil*. 2022;4(4):e1339-e1346. doi:10.1016/j.asmr.2022.04.018
6. Li H, Nie S, Lan M. Medial meniscus posterior root tear reconstructed with gracilis autograft improve healing rate and patient reported outcome measures. *BMC Musculoskelet Disord*. 2022;23(1):1-8. doi:10.1186/s12891-022-06067-1.
7. Feucht MJ, Grande E, Brunhuber J, et al. Biomechanical comparison between suture anchor and transtibial pull-out repair for posterior medial meniscus root tears. *Am J Sports Med*. 2014;42(1):187-193. doi:10.1177/0363546513502946.
8. Lee DW, Haque R, Chung KS, Kim JG. Arthroscopic Medial Meniscus Posterior Root Reconstruction Using Auto-Gracilis Tendon. *Arthrosc Tech*. 2017;6(4):e1431-e1435. doi:10.1016/j.eats.2017.07.014.
9. Choi SH, Bae S, Ji SK, Chang MJ. The MRI findings of meniscal root tear of the medial meniscus: Emphasis on coronal, sagittal and axial images. *Knee Surgery, Sport Traumatol Arthrosc*. 2012;20(10):2098-2103. doi:10.1007/s00167-011-1794-4.
10. Delgado DA, Lambert BS, Boutris N, et al. Validation of Digital Visual Analog Scale Pain Scoring With a Traditional Paper-based Visual Analog Scale in Adults. *J Am Acad Orthop Surg Glob Res Rev*. 2018;2(3). doi:10.5435/JAAOSGlobal-D-17-00088.
11. FKersten P, White PJ, Tennant A. Is the pain visual analogue scale linear and responsive to change? An exploration using rasch analysis. *PLoS One*. 2014;9(6). doi:10.1371/journal.pone.0099485.
12. Collins NJ, Prinsen CAC, Christensen R, Bartels EM, Terwee CB, Roos EM. Knee Injury and Osteoarthritis Outcome Score (KOOS): systematic review and meta-analysis of measurement properties. *Osteoarthr Cartil*. 2016;24(8):1317-1329. doi:10.1016/j.joca.2016.03.010.
13. Jackson GR, Lee JS, Asif S, et al. Different Suture Configurations for Transtibial Pullout Repair for Medial Meniscus Root Tear Yield Improved Mid-term Clinical Outcomes: A Systematic Review. Published online 2023:1-8.
14. Zhuo H, Chen Q, Zhu F, Li J. Arthroscopic side-to-side repair for complete radial posterior lateral meniscus root tears. *BMC Musculoskelet Disord*. 2020;21(1):1-6. doi:10.1186/s12891-020-3156-1.
15. Jing L, Liu K, Wang X, et al. Second-look arthroscopic findings after medial open-wedge high tibial osteotomy combined with all-inside repair of medial meniscus posterior root tears. *J Orthop Surg*. 2020;28(1):1-8. doi:10.1177/2309499019888836
16. Ulku TK, Kaya A, Kocaoglu B. Suture configuration techniques have no effect on mid-term clinical outcomes of arthroscopic meniscus root repairs. *Knee*. 2020;27(3):676-682. doi:10.1016/j.knee.2020.04.017.
17. Moon HS, Choi CH, Jung M, Lee DY, Hong SP, Kim SH. Early Surgical Repair of Medial Meniscus Posterior Root Tear Minimizes the Progression of Meniscal Extrusion: Response. *Am J Sports Med*. 2021;49(1):NP3-NP5. doi:10.1177/0363546520974380.
18. Feucht MJ, Kühle J, Bode G, et al. Arthroscopic Transtibial Pullout Repair for Posterior Medial Meniscus Root Tears: A Systematic Review of Clinical, Radiographic, and Second-Look Arthroscopic Results. *Arthrosc - J Arthrosc Relat Surg*. 2015;31(9):1808-1816. doi:10.1016/j.arthro.2015.03.022.
19. Krych AJ, Nauert RF, Song BM, et al. Association Between Transtibial Meniscus Root Repair and Rate of Meniscal Healing and Extrusion on Postoperative Magnetic Resonance Imaging: A Prospective Multicenter Study. *Orthop J Sport Med*. 2021;9(8):1-8. doi:10.1177/23259671211023774.
20. Seo HS, Lee SC, Jung KA. Second-look arthroscopic findings after repairs of posterior root tears of the medial meniscus. *Am J Sports Med*. 2011;39(1):99-107 doi:10.1177/0363546510382225.
21. Chung KS, Ha JK, Ra HJ, Nam GW, Kim JG. Pullout Fixation of Posterior Medial Meniscus Root Tears. *Am J Sports Med*. 2017;45(1):42-49. doi:10.1177/0363546516662445.