# Prospective Consecutive Clinical Outcomes After Transtibial Root Repair for Posterior Meniscal Root Tears

## A Multicenter Study

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**Background:** Prospective evaluation of clinical outcomes after posterior meniscal root repair utilizing a transtibial pullout technique is limited, and factors that may contribute to outcomes are unclear.

**Hypothesis:** It was hypothesized that there would be an overall significant improvement in outcomes after root repair and that differences in clinical outcomes would correlate with age, body mass index (BMI), sex, and meniscal extrusion.

**Study Design:** Case-control study; Level of evidence, 3.

**Methods:** Consecutive patients undergoing transtibial medial or lateral meniscal root repair were enrolled prospectively at 2 orthopaedic centers between March 2017 and January 2019. Pre- and postoperative magnetic resonance imaging (MRI) were obtained to assess for meniscal healing, quantification of extrusion, articular cartilage grade, and subchondral bone changes. Patient-reported outcomes including International Knee Documentation Committee (IKDC) scores, Tegner activity scale, and visual analog scale (VAS) for pain were collected preoperatively and 2 years postoperatively. Patients were then subdivided by clinical and demographic characteristics to determine factors associated with clinical outcomes.

**Results:** Included were 45 patients (29 female, 16 male; mean age, 42.3 ± 12.9 years; mean BMI, 31.6 kg/m$^2$) who underwent 47 meniscal root repairs (29 medial and 16 lateral; 2 had both). Significant improvements at 2-year follow-up were seen in IKDC score (41.1 vs 78.4; $P < .001$), Tegner activity level (3 vs 4; $P < .001$), and VAS pain (2.8 vs 0.7; $P < .001$). BMI, preoperative malalignment, cartilage status, and progressive meniscus extrusion ($\Delta = 0.7$ mm) did not have a negative impact on IKDC and Tegner scores 2 years postoperatively. Age greater than or equal to 50 years and extrusion pre- and postoperatively were associated with decreased Tegner scores. Progressive meniscal extrusion was associated with a decreased overall improvement in Tegner scores.

**Conclusion:** Transtibial root repair for medial and lateral posterior meniscal root tears demonstrated significantly improved clinical outcomes at 2 years postoperatively. Increased age, increased BMI, cartilage status, and meniscal extrusion did not have a negative impact on short-term functional outcomes (IKDC), but age greater than or equal to 50 years and extrusion negatively influenced patient activity level (Tegner).

**Registration:** NCT03037242 (ClinicalTrials.gov identifier).

**Keywords:** meniscal extrusion; meniscal tear; meniscus; meniscal root; prospective cohort; transtibial pullout repair

The meniscal root attachment is vital for the functional integrity of the meniscus regarding knee stability, load transmission, and shock absorption.[20,27] Meniscal root tears are defined as bony avulsions or complete radial tears within 9 mm of the meniscal attachment.[17] Untreated root tears result in impaired resistance to hoop stresses and altered tibiofemoral contact mechanics in a manner that is functionally equivalent to a complete meniscectomy, ultimately subjecting the joint to excessive loads and accelerated development of arthritis.[1,18]

Treatment strategies for posterior meniscal root tears historically included nonoperative management and partial meniscectomy. However, several investigations have demonstrated that these options do not adequately restore

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meniscal hoop stress resistance and provide no benefit in halting arthritis progression.[13,16] These unfavorable outcomes have made meniscal root tear repair the preferred treatment strategy. Arthroscopic transtibial pullout is the technique used most commonly for achieving adequate root fixation.[7,25] Patients treated with transtibial root repair have improved long-term survivorship and clinical outcomes compared with those treated with meniscectomy.[2,7] Biomechanical testing of the transtibial pullout technique has demonstrated improved joint kinematics and contact pressures.[20] In addition, clinical outcome studies show increased healing on magnetic resonance imaging (MRI) and second-look arthroscopy.[1,7,18,20,23-25,31] However, transtibial root repair research has focused on the medial meniscus, thus limiting the complete assessment of posterior root tears. There is also a lack of prospective data correlating preoperative and early postoperative radiographic findings with patient-reported outcomes, particularly in patients with an elevated body mass index (BMI).

The purpose of this prospective multicenter investigation was to evaluate patient-reported outcomes in patients with posterior meniscal root tears treated with transtibial pullout. More specifically, we sought to (1) compare clinical outcomes before and after transtibial root repair, (2) compare clinical and demographic characteristics with clinical outcomes, and (3) determine radiographic features associated with clinical outcomes. We hypothesized that knee pain and patient function would improve following root repair and that these differences would correlate with age, BMI, sex, alignment, cartilage status, and meniscal extrusion.

## METHODS

### Study Population and Design

This prospective multicenter study was performed at 2 high volume orthopaedic centers (Mayo Clinic and Columbia Orthopaedic Group). This study was registered prospectively at ClinicalTrials.gov (number NCT03037242). After gaining approval from the Institutional Review Board (IRB ID No. 16-005841), patients were evaluated and consented to participate in the investigation. Patients were enrolled between March 2017 and January 2019. Inclusion criteria consisted of patients aged 18 to 65 years with medial or lateral posterior meniscal root tears defined as posterior horn root avulsions or full thickness tears within 9 mm of the bony root attachment.[17] Patients were excluded if they had skeletal immaturity, Kellgren-Lawrence (KL) osteoarthritis grade greater than 2, worker compensation status, intraoperative Outerbridge chondromalacia grade of at least 3, subchondral collapse on preoperative MRI, or poor-quality meniscal tissue.

### Surgical Technique

Meniscal root repair was performed by fellowship-trained arthroscopic surgeons (A.J.K., P.A.S., B.A.L., C.L.C., and M.J.S.) in an operative setting as described previously.[28] Standard knee arthroscopy portals were created, and diagnostic arthroscopy was first performed to ensure that there were no exclusion criteria.

To ensure access to the posterior meniscal root, an ipsilateral portal was made under direct visualization. This allows the posterior horn attachment to be inspected and assessed. Percutaneous medial collateral ligament (MCL) trephination and/or reverse notchplasty were performed only as needed for appropriate visualization and instrumentation. A tibial socket was created at the anatomic meniscal root attachment. The targeting of the location was accomplished using a specialized transtibial root guide placed through the ipsilateral portal. Once the guide was positioned at the center of the meniscal root footprint, a 6-mm flip cutting drill-reamer was introduced into the joint through the drill sleeve on the proximal-medial tibia. The flip cutting drill-reamer was deployed, and a 6-mm diameter socket was created to a depth of 5 to 10 mm. The flip cutting drill-reamer was then removed and replaced by passing suture to be used later as a shuttle for passage of the meniscal sutures through the tibia. The passing suture was retrieved through the contralateral viewing portal to avoid tangling during suture passage into the meniscus. A cannula was placed through the ipsilateral working portal to both prevent a soft tissue bridge and aid in suture management. A free No. 0 nonabsorbable suture was then passed through the torn meniscus in a cinch-stitch configuration using a self-retrieving suture-passing device. A total of 2 to 3 cinch sutures were placed, and all sutures were shuttled through the tibial socket using the previously

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placed passing suture. The knee was cycled to remove any potential creep from the meniscus-suture interface. Tibial fixation was obtained with a 4.75-mm anchor placed into the proximal-medial tibia through the previous incision near 90° of knee flexion. Centralization of the meniscus was not performed.

### Rehabilitation Protocol

For the first 6 weeks after surgery, patients remained nonweightbearing in a straight leg brace for ambulation. Unweighted knee flexion to 90° was permitted. At 6 weeks postoperatively, weightbearing and knee motion were progressed as tolerated. Knee loading was restricted at flexion angles greater than 90° until at least 4 months after surgery. Return to athletic activity occurred at a minimum of 6 months postoperatively, as indicated.

### Radiographic Outcomes

Preoperatively, long leg standing radiographs were reviewed to assess mechanical axis alignment. In 18 knees without long leg standing radiographs, the anatomic axis was measured on a standing anteroposterior view. Malalignment was defined as greater than or equal to 5° varus for medial root tears and greater than or equal to 5° valgus for lateral root tears. Weightbearing anterior-posterior knee radiographs were also performed 2 years postoperatively. Patients enrolled in the study also underwent MRI preoperatively and 6 months postoperatively. All radiographs and MRI scans were evaluated by an experienced musculoskeletal radiologist who was blinded to preoperative and postoperative status. A 1.5-T and 3-T MRI scanner was used for preoperative and postoperative imaging at the respective sites. The amount of meniscal extrusion, defined as protrusion of the peripheral margin of the meniscus beyond the tibial plateau except for osteophytes, was measured on coronal images at the midpoint of the medial femoral condyle of the initial and final MRI scans. Extrusion was recorded as the distance from a vertical line intersecting the outer margin of the medial tibial plateau to the outer edge of the medial meniscus.[3] Progressive extrusion was defined as a positive difference value of preoperative and postoperative meniscus extrusion (post-pre).[4] Meniscal healing was classified as complete (continuity in sagittal, coronal, and axial MRI views), partial (loss of continuity in any 1 view), and not healed (no continuity in any view).[11] The technique for assessing healing of meniscal root repairs and extrusion has been well established, and previous literature on interobserver reliability assessments have been at least 0.90.[31] The femoral condyles and tibial plateau articular cartilage surfaces were evaluated and graded using the modified Outerbridge classification system.[14] The postoperative MRI results have been published and were used for correlation of clinical outcomes in the current study.[15]

### Clinical Outcomes

Patient baseline demographic and clinical data including age, sex, BMI, laterality, and tear type were evaluated. Traumatic tears were defined as acute tears with a discrete injury event, whereas degenerative tears were defined as chronic tears without an acute injury.[9] Patients completed a subjective questionnaire preoperatively and at 2 years postoperatively, which included the International Knee Documentation Committee (IKDC) Subjective score, Tegner activity scale, and the visual analog scale (VAS) for pain.[8] The preoperative results were compared with the 2-year outcomes for the cohort, and the differences between the 2 values (Δ) were documented. In addition, baseline demographic characteristics and MRI characteristics both preoperatively and postoperatively at 6 months were compared with their 2-year clinical outcomes. The cutoff for age-based differences in clinical outcomes were set at at least 50 years based on previous literature.[19]

### Statistical Analysis

An a priori power analysis determined that a sample size of 36 patients would be able to detect a difference of 13.0 points in pre- to postoperative IKDC scoring.[10] We planned to include 45 patients to allow for 20% attrition due to intraoperative exclusion or loss to follow-up. Univariate analysis was calculated for demographic, clinical, and radiologic variables. The Wilcoxon rank-sum test was used for continuous variables, and Fisher exact test or chi-square analysis for categorical variables. The McNemar test was used to compare dichotomous variables preoperatively and postoperatively. The Wilcoxon signed-rank test was used for comparisons of pre- and postoperative clinical outcome scores. Correlation between continuous variables was assessed by linear regression. All tests were 2-sided, and $P$ values $< .05$ were considered significant. Analysis was performed using SAS JMP Version 14.1.0 (SAS).

## RESULTS

A total of 45 patients (29 female, 16 male) underwent 47 meniscal root repairs between March 2017 and January 2019. Of these 45 patients, 2 had both medial and lateral root repairs on their ipsilateral knee. Overall, 15/45 (33%) patients underwent concomitant ACL reconstruction; 7 patients had patellar chondroplasty, 4 had medial femoral chondroplasty, 1 had lateral femoral chondroplasty, 4 had trochlear chondroplasty, 1 had lateral tibial chondroplasty, 4 had loose body removals, and 1 had both medial femoral condyle and trochlear osteochondral allograft transplantation. Table 1 presents the patient demographic data of the cohort.

### Complications

The overall complication rate was 6% (3/47). Two root repairs developed arthrofibrosis requiring intervention (1 underwent arthroscopic lysis of adhesions and 1 required manipulation under anesthesia) and 1 had symptomatic hardware (anteromedial tibial suture anchor) with removal during the study period. None of the root repairs failed or required revision root repair surgery.

## Outcomes

*Preoperative Versus Postoperative Outcome Scores.* The total follow-up rate was 96% (45/47 root repairs). Of the 45 root repairs, 4 did not complete preoperative questionnaires. Both preoperative and 2-year postoperative outcomes were available for 41 root repairs (Table 2). All analyses reached the a priori power analysis threshold of 36 patients. Patient-reported outcome scores, including IKDC score, Tegner score, and VAS pain levels, were all significantly improved at 2-year follow-up after transtibial root repair ($P < .001$).

TABLE 1
Patient Characteristics[a]

| Characteristic | |
|---|---|
| Age, y, mean (range) | 42.3 (19-63) |
| Sex, female/male, n | 29/16 |
| BMI, mean ± SD | 30.9 ± 7.3 |
| Side, left/right, n[b] | 29/18 |
| Medial/lateral, n[b] | 29/18 |
| Traumatic/degenerative, n[b] | 32/15 |
| Average KL grade of affected compartment | 0.4 |
| Time from symptoms to surgery, days, mean ± SD | 65.5 ± 139.6 |

[a]BMI, body mass index.
[b]Number of posterior meniscal root repairs.

TABLE 2
Comparison of Preoperative and Postoperative Outcomes[a]

| | Preoperative (n = 41) | Postoperative (n = 41) | *P* |
|---|---|---|---|
| IKDC score | 41.0 ± 14.5 (9.2-65.5) | 79.5 ± 15.4 (35.6-100) | **<.001** |
| Tegner score | 3 (2-4) | 4 (3-5.5) | **<.001** |
| VAS pain score | 2.8 ± 1.8 (0-8.1) | 0.7 ± 1.7 (0-7.1) | **<.001** |

[a]Data are presented as mean ± SD (range) or median (IQR). Bolded *P* values indicate statistically significant difference between preoperative and postoperative scores ($P < .05$). IKDC, International Knee Documentation Committee; IQR, interquartile range; VAS, visual analog scale.

*Outcome Scores Based on Clinical Factors.* No significant differences were observed in 2-year IKDC scores based on patient age, BMI, or tear type; however, male patients reported higher IKDC scores at final follow-up ($P = .033$) (Table 3). However, overall improvements in IKDC did not differ based on sex or other clinical factors. Tegner scores were significantly higher in patients younger than 50 years, male patients, and traumatic tears; however, overall improvement in Tegner score was equivalent. No significant differences were seen in VAS pain scores based on clinical factors.

*Outcome Scores Based on Radiographic Characteristics.* A previous investigation compared the preoperative MRI findings of this cohort with postoperative MRI scans at 6-month follow-up (Table 4). There was no significant progression in articular cartilage grade, subchondral edema, insufficiency fracture, subchondral cysts, subchondral collapse, or coronary/meniscotibial ligament abnormality. Overall, there was a high rate of meniscal healing, with 98% having evidence of complete (40%) or partial (58%) healing; 2% did not show evidence of healing. The amount of overall meniscal extrusion increased from an average of 1.9 mm preoperatively to 2.6 mm postoperatively ($P = .03$).[15]

No significant differences were seen in IKDC scores based on preoperative malalignment or meniscal extrusion (Table 5). In addition, preoperative cartilage status of the femur ($P = .550$) and tibia ($P = .723$), cartilage status at 6-month follow-up ($P = .817$ and $P = .958$ for femur and tibia, respectively), subchondral bone changes ($P = .801$), and meniscal healing ($P = .663$) did not affect IKDC scores. Tegner scores were significantly worse in patients with both preoperative ($P = 0.034$) and postoperative extrusion ($P = 0.019$). Progressive extrusion was significantly

TABLE 3
Outcomes Based on Clinical Factors[a]

| | n, % | IKDC[b] | *P* | ΔIKDC[b] | *P* | Tegner[c] | *P* | ΔTegner[c] | *P* |
|---|---|---|---|---|---|---|---|---|---|
| Age ≥50 y | | | .164 | | .925 | | **.014** | | .501 |
| Yes | 18 (40) | 74.0 ± 17.8 | | 38.2 ± 15.3 | | 3.5 (3-4) | | 1 (0.25-2) | |
| No | 27 (60) | 81.4 ± 13.1 | | 38.7 ± 15.9 | | 5 (3-6) | | 1 (0-3) | |
| Sex | | | **.033** | | .078 | | **.001** | | .266 |
| Male | 17 (38) | 85.1 ± 10.1 | | 44.7 ± 17.0 | | 5 (4-6.5) | | 1 (1-4) | |
| Female | 28 (62) | 74.3 ± 16.7 | | 35.1 ± 13.7 | | 3 (3-5) | | 1 (0-2) | |
| BMI >30 kg/m$^2$ | | | .471 | | .278 | | .104 | | .227 |
| Yes | 20 (44) | 80.3 ± 14.1 | | 41.5 ± 15.3 | | 5 (4-6.5) | | 1 (0-2) | |
| No | 25 (56) | 76.9 ± 16.5 | | 36.0 ± 15.5 | | 3 (3-5) | | 1.5 (0.75-3) | |
| Tear type | | | .323 | | .500 | | **.020** | | .397 |
| Degenerative | 15 (33) | 74.9 ± 16.3 | | 42.1 ± 17.3 | | 3 (3-4) | | 1 (0-2.25) | |
| Traumatic | 30 (67) | 80.6 ± 15.0 | | 36.7 ± 14.4 | | 5 (3-6) | | 1 (0-2) | |

[a]Bolded *P* values indicate statistical significance between outcome comparisons ($P < .05$). BMI, body mass index; IKDC, International Knee Documentation Committee; IQR, interquartile range.
[b]Data presented as mean ± SD.
[c]Data presented as median (IQR).

associated with a decreased overall improvement in Tegner score ($P = .025$). The overall reduction in VAS pain levels was significantly lower in patients with femoral or tibial subchondral edema on postoperative MRI scan ($P = .036$).

## DISCUSSION

The major finding of this study was that patients who underwent posterior meniscal root repair utilizing a transtibial pullout technique had significant improvement in clinical outcome scores at 2 years with an overall low complication rate. Demographic features including age of at least 50 years and BMI over 30 kg/m$^2$ were not risk factors for worse clinical outcomes. Furthermore, preoperative malalignment, cartilage status, and meniscal extrusion preoperatively and postoperatively were not risk factors for worse IKDC score; however, extrusion and increasing age did contribute negatively to decreased Tegner scores.

TABLE 4
Summary of MRI Characteristics[a]

| | Preoperative | Postoperative | P |
|---|---|---|---|
| Articular cartilage Outerbridge grade, femur | 1 (0-4) | 1 (0-4) | .66 |
| Articular cartilage Outerbridge grade, tibia | 0 (0-2) | 1 (0-3) | .15 |
| Subchondral edema, femur | 10 (23%) | 7 (16%) | .59 |
| Subchondral edema, tibia | 16 (37%) | 9 (21%) | .15 |
| Insufficiency fracture, femur | 5 (12%) | 0 (0%) | .06 |
| Insufficiency fracture, tibia | 6 (14%) | 1 (2%) | .11 |
| Subchondral cysts, femur | 0 (0%) | 5 (12%) | .06 |
| Subchondral cysts, tibia | 0 (0%) | 0 (0%) | ≥ .99 |
| Subchondral collapse, femur | 2 (5%) | 0 (0%) | .49 |
| Subchondral collapse, tibia | 1 (2%) | 1 (2%) | .0 |
| Coronary/meniscotibial ligament abnormality | 26 (60%) | 30 (70%) | .50 |

[a]Data are reported as mean (range) or n (%).

Interestingly, BMI was not found to be a significant risk factor for inferior clinical outcomes after meniscal root repair. While obesity is a known risk factor for progressive development of osteoarthritis and cartilage degeneration, the results of the present study suggest that patients with increased BMI reach satisfactory clinical outcomes at 2 years postoperatively.[30] An investigation by Chung et al[5] found that BMI was not a significant predictor for poor clinical outcomes after meniscal root repair at 5 years postoperatively. Of note, these authors reported that greater than 70% of their cohort had a BMI less than 27 kg/m$^2$, with an overall average BMI of 25.8 kg/m.[2] Accordingly, these results may not be as generalizable to North American patients. On the other hand, Zhang et al[29] reported that BMI greater than 30 kg/m$^2$ is a risk factor for poor clinical outcomes at 1-year follow-up. These findings may suggest that patients with greater BMI may have worse outcomes initially following root repair, but over a longer follow-up period, having a higher BMI may not necessarily portend a poor clinical outcome.

The literature regarding the impact of meniscal extrusion on clinical outcomes is undecided. Chung et al[6] reported that progressive meniscal extrusion following transtibial root repair is a risk factor for worse clinical outcome scores (Lysholm and IKDC) at 5 years postoperatively. Furthermore, the same authors determined that progressive postoperative meniscal extrusion of at least 0.7 mm was a negative prognostic factor for clinical failure, defined as conversion to total knee arthroplasty within 10 years.[4] The authors appropriately note that their sample sizes are small and their meniscal extrusion analysis may not have been statistically powered. Conversely, Moon et al[22] found no differences in 2-year clinical outcome scores in patients with increased meniscal extrusion at 1 year postoperatively. The findings from the present investigation align with the clinical outcomes reported by Moon et al.[22] The presence of meniscal extrusion on preoperative and postoperative MRI scans had no significant effect on IKDC and VAS pain scores at 2 years postoperatively.

TABLE 5
Outcomes Based on Radiographic Characteristics[a]

| | n, % | IKDC[b] | P | ΔIKDC[b] | P | Tegner[c] | P | ΔTegner[c] | P |
|---|---|---|---|---|---|---|---|---|---|
| Preop malalignment | | | .933 | | .420 | | .945 | | .468 |
| Yes | 8 (18) | 75.4 ± 21.1 | | 35.1 ± 13.9 | | 4 (3-5.75) | | 1 (0.75-1.25) | |
| No | 32 (71) | 79.6 ± 14.4 | | 41.5 ± 15.3 | | 4 (3-5) | | 1 (0.75-2.25) | |
| Preop extrusion | | | .475 | | .058 | | **.034** | | .988 |
| Yes | 32 (71) | 79.5 ± 15.3 | | 41.2 ± 15.1 | | 4 (3-5) | | 1 (0-2.25) | |
| No | 13 (29) | 75.8 ± 16.0 | | 31.2 ± 14.5 | | 6 (3.5-6) | | 1 (0-2) | |
| Postop extrusion | | | .665 | | .286 | | **.019** | | .952 |
| Yes | 34 (83) | 78.9 ± 16.5 | | 40.0 ± 15.4 | | 4 (3-5) | | 1 (1-2) | |
| No | 7 (17) | 77.8 ± 11.0 | | 32.9 ± 17.4 | | 6 (6-6) | | 1 (0-4) | |
| Progressive extrusion | | | .364 | | .342 | | .088 | | **.025** |
| Yes | 23 (56) | 76.9 ± 15.3 | | 36.4 ± 15.0 | | 4 (3-5) | | 1 (0-1.5) | |
| No | 18 (44) | 81.0 ± 16.1 | | 41.7 ± 16.7 | | 5.5 (3-6) | | 2 (1-4) | |

[a]Bolded $P$ values indicate statistical significance between outcome comparisons ($P < .05$). Preop, preoperative; postop, postoperative.
[b]Data presented as mean ± SD.
[c]Data presented as median (IQR)

Furthermore, while meniscal extrusion worsened postoperatively, there were no appreciable differences in clinical outcomes in patients with progressive extrusion. However, both preoperative meniscal extrusion and postoperative meniscal extrusion were associated with decreased activity levels. These findings suggest that while patients can experience similar improvements in clinical outcomes at short-term follow-up, they may have decreased overall activity levels to compensate for symptomatic extrusion.[12]

Our findings suggest that the presence of subchondral edema in the postoperative period is correlated with a decrease in the overall improvement of VAS pain scores at 2 years. It is possible that the subchondral edema may not be fully resolved at 2 years, and this could negatively impact pain levels in these patients.[26] The current data regarding the impact of subchondral edema on clinical outcomes are sparse. While Moon et al[21] reported that preoperative subchondral edema did not significantly impact VAS pain scores at 33 months following medial meniscus posterior root repair, they did not analyze the effects of subchondral edema in the postoperative period.

One of the primary goals for meniscal repair is to halt the progression of osteoarthritis of the affected compartment. While the current investigation was not designed to assess for cartilage degeneration, progressive meniscal extrusion has been associated with increased severity of radiographic evidence of osteoarthritis. Moon et al[22] demonstrated that patients with progressive medial meniscal extrusion after surgery had significantly worse KL grades at 2 years postoperatively. In addition, Zhuo et al[31] reported a significant linear relationship between postoperative lateral meniscal extrusion and progression of cartilage generation at an average 29.9-month follow-up. While meniscal extrusion was not correlated with poor IKDC scores, the present study suggests that overall patients with extrusion may decrease activity level, perhaps to accommodate symptoms. Clinical evaluation at a longer follow-up, along with additional radiographic assessment, may be warranted to further elucidate the relationship between meniscal extrusion and clinical outcomes in patients with posterior root tears.

To the best of the authors' knowledge, this is the first multicenter, prospective study offering a complete assessment of posterior meniscal root tears using a transtibial pullout technique. As a result, these findings may be generalizable and strengthen the findings of the present study. However, we recognize some limitations with the current investigation. First, a mixed series of medial and lateral meniscal root patients with combined procedures adds heterogeneity to the included cohort. Second, the findings from the subgroup analyses regarding the clinical and radiographic risk factors for poor clinical outcomes may be influenced by the small sample size of the subgroups, and these comparisons may not be sufficiently powered. In addition, there may be inherent selection bias from the selection criteria applied to our cohort. While we did not determine a significant impact of cartilage status on clinical outcomes, this assessment may not be complete as we excluded patients with diffuse Outerbridge grade 3 or greater chondromalacia or KL grade greater than 2. Furthermore, we did not analyze the data using a multivariate model, and several factors may confound our findings.

## CONCLUSION

Transtibial root repair for medial and lateral posterior meniscal root tears demonstrated significantly improved clinical outcomes at 2 years postoperatively. Increased age, increased BMI, cartilage status, and meniscal extrusion did not have a negative impact on short-term clinical outcomes (IKDC score), but age greater than or equal to 50 years and extrusion negatively influenced patient activity level (Tegner score).

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