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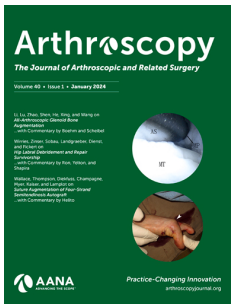

PROMIS Captures Clinically Meaningful Improvement After Transtibial Pull-Out Repair of Medial Meniscus Posterior Root Tears: Two-Year Outcomes

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Notification of Exemption from IRB Review

To: Jorge Chahla
ORA #: 23083005-IRB01
Project Title: Root Tear Repository
Date Exemption Granted: 10/16/2023

Dear Jorge Chahla,

This exemption was granted in accordance with:

45 CFR 46.104(d)(4) - Secondary research for which consent is not required: Secondary research uses of identifiable private information or identifiable biospecimens, if at least one of the following criteria is met:

(iii) The research involves only information collection and analysis involving the investigator's use of identifiable health information when that use is regulated under 45 CFR parts 160 and 164, subparts A and E, for the purposes of "health care operations" or "research" as those terms are defined at 45 CFR 164.501 or for "public health activities and purposes" as described under 45 CFR 164.512(b).

Waiver of HIPAA authorization for secondary analysis of data chart review has been granted under 45 CFR 164.512(i)(2)(ii), where the Board determined that the waiver of authorization satisfies the following criteria:

(**A**) The use or disclosure of protected health information involves no more than a minimal risk to the privacy of individuals, based on, at least, the presence of the following elements;

(**1**) An adequate plan to protect the identifiers from improper use and disclosure;

(**2**) An adequate plan to destroy the identifiers at the earliest opportunity consistent with conduct of the research, unless there is a health or research justification for retaining the identifiers or such retention is otherwise required by law; and

(**3**) Adequate written assurances that the protected health information will not be reused or disclosed to any other person or entity, except as required by law, for authorized oversight of the research study, or for other research for which the use or disclosure of protected health information would be permitted by this subpart;

(**B**) The research could not practicably be conducted without the waiver or alteration; and

(**C**) The research could not practicably be conducted without access to and use of the protected health information.

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John Cobb, BA, CIP
Rush University Medical Center
Director, IRB Administration

PROMIS Captures Clinically Meaningful Improvement After Transtibial Pull-Out Repair of Medial Meniscus Posterior Root Tears: Two-Year Outcomes

Running title: PROMIS Captures Meniscus Root Repair Outcomes

Abstract

Purpose: (1) Establish cohort-specific minimal clinically important difference (MCID) and patient acceptable symptom state (PASS) thresholds for Patient-Reported Outcomes Measurement Information System (PROMIS) values and legacy knee-specific patient reported outcome measures (PROM) following isolated medial meniscus posterior root tear (MMPRT) repair using the transtibial pull-out repair technique; (2) determine achievement rates; (3) analyze correlations among scores.

Methods: Patients undergoing primary isolated MMPRT transtibial pull-out repair with preoperative and minimum 2-year postoperative data were analyzed. PROMs included PROMIS-Pain Interference (PI), PROMIS-Physical Function (PF), PROMIS-Depression (D), Knee Disability and Osteoarthritis Outcomes Score Jr (KOOS Jr), and International Knee Documentation Committee (IKDC). Paired two-tailed Student t-tests evaluated PROM changes pre- to post-operative, with significance at $p < 0.05$. MCID thresholds were determined using the distribution-based method, while PASS thresholds were anchored-based. Pearson correlation coefficients were employed to compare PROM scores.

Results: Sixty-eight patients (mean age: 57.2 ± 9.7 years, 75.0% female; mean body mass index: 32.2 ± 6.1 kg/m^2) were included and followed for 32.9 ± 10.6 months. Preoperative to final follow-up, all PROMs significantly improved ($P<0.05$). MCID thresholds and achievement rates were: PROMIS-PF (6.5, 63%), PROMIS-PI (-5.7, 69%), PROMIS-D (-4.8, 50%), IKDC (10.5, 87%), and KOOS Jr (10.3, 75%), respectively. PASS thresholds and rates were: PROMIS-PF (47.8, 59%),

PROMIS-PI (53.6, 54%), PROMIS-D (40.5, 49%), IKDC (67.7, 66%), KOOS Jr (72.3, 66%). Strongest correlations: PROMIS-PI with KOOS Jr (r = -0.687) and IKDC (r = -0.660). PROMIS-D showed weakest correlation with KOOS Jr and IKDC (r = 0.395, -0.399). Knee-specific PROMs correlated strongly (r = 0.710).

Conclusion: This study establishes cohort-specific MCID and PASS thresholds for PROMIS subscales, IKDC, and KOOS Jr. at a minimum 2-year follow-up following isolated transtibial pull out MMPRT repair. At 2 years, MCID and PASS were achieved by 63% and 59% of patients for PROMIS-PF, 69% and 54% for PROMIS-PI, and 50% and 49% for PROMIS-D. For IKDC and KOOS Jr, MCID and PASS rates were 87% and 66%, and 75% and 66%, respectively. .

Level of Evidence: IV, Retrospective case series

INTRODUCTION

The Patient-Reported Outcomes Measurement Information System (PROMIS) is a system developed by the National Institutes of Health (NIH) which enhances evaluations in physical, mental, and social health domains, and is increasingly utilized to assess orthopaedic surgery outcomes.[1] By employing item response theory (IRT) in a computer adaptive test (CAT) format, PROMIS streamlines question sequences to reduce survey length and address limitations of legacy measures such as the Knee Disability and Osteoarthritis Outcomes Score Jr (KOOS Jr) and the International Knee Documentation Committee (IKDC) score.[2,3] Notably, orthopaedic surgeons most frequently use the PROMIS Pain Interference (PROMIS-PI) and PROMIS Physical Function (PROMIS-PF) subscales.[1,4,5] However, considering the increasingly recognized influence of mental health on outcomes of orthopaedic procedures, the PROMIS Depression (PROMIS-D) subscale has emerged as a valuable metric.[6,7]

All PROMIS measures yield standardized T-scores (mean = 50, SD = 10) that theoretically range from 0 to 100, though most clinical scores span 20–80.[8–10] Higher scores on PROMIS Physical Function indicate better function, while higher scores on PROMIS Pain Interference or Depression indicate greater symptom severity.[8–11] Raw responses from short forms or CAT are converted into T-scores through PROMIS-specific calibration tables informed by large reference samples. By adaptively selecting items based on previous responses, CAT maximizes measurement precision and minimizes respondent burden.[8–11]

Contemporary research, exemplified by Vogel et al., highlights PROMIS as a promising alternative to traditional PROMs, particularly in the context of hip arthroscopy.[12] Moreover, a recent systematic review reaffirmed PROMIS's efficacy in assessing patient outcomes across

various arthroscopic procedures involving the hip, knee, and shoulder, with PROMIS-PF demonstrating particularly strong correlations with measures of physical function and quality of life.[13] Although PROMIS scores primarily reflect the function of the targeted joint, they may also be influenced by the overall musculoskeletal health of the patient.[9]

The exploration of PROMIS within orthopaedic research also extends to its role in defining clinically significant outcomes, utilizing cohort-specific minimal clinically important difference (MCID) and the patient acceptable symptom state (PASS) thresholds as key indicators.[14,15] These metrics, when tailored specific study populations, provide a valuable framework for understanding postoperative outcomes by helping to identify the smallest change in patient condition that is perceptible and deemed important, and to evaluate if postoperative symptoms have reached an acceptable level, respectively.[15,16]

Given the evolving recognition of meniscal root tears' significance in knee health and function, and their impact on quality of life, the comparison of PROMIS scores with established PROMs in this context is crucial.[17–20] While previous studies have explored the use of PROMIS following arthroscopic meniscal surgery and indicated its possible superiority over knee-specific legacy PROMs in detecting clinical change, the applicability of PROMIS for meniscal root tear repair remains unexplored.[21] Upon thorough review, no study has investigated its utility in this context, and neither MCID nor PASS thresholds have been established.

Therefore, the purpose of this study was to (1) Establish cohort-specific minimal clinically important difference (MCID) and patient acceptable symptom state (PASS) thresholds for Patient-Reported Outcomes Measurement Information System (PROMIS) values and legacy knee-specific patient reported outcome measures (PROM) following isolated medial meniscus posterior root tear

(MMPRT) repair using the transtibial pull-out repair technique; (2) determine achievement rates; (3) analyze correlations among scores. Based on prior investigations,[12] the authors hypothesized stronger correlations among knee-specific legacy PROM scores compared to those among PROMIS CAT scores, expecting an overall high achievement rate for MCID and PASS.

METHODS

Study Design

Approval for this study was granted by the institutional review board (23083005-IRB01), with informed consent waived due to its retrospective nature, involving data from patients who underwent medial meniscus posterior root tear repair by the senior authors (J.C., A.B.Y., B.J.C., N.N.V.). The patients analyzed in this study cohort has not been included in any prior publications. Inclusion criteria consisted of patients who underwent primary isolated medial meniscus posterior root tear repair between January 2017 and January 2021, were aged 18 or older, had complete pre- and post-operative PROMS at a minimum 2-year follow-up. Exclusion criteria included patients undergoing revision medial meniscus posterior root tear repair, concomitant ligamentous repair or reconstruction, concomitant meniscus repair or meniscectomy, concomitant bony procedure, history of ipsilateral knee surgery, Kellgren-Lawrence (KL) grade 3-4, incomplete PROMs at baseline or final follow-up, and lack of pre-operative posteroanterior (PA) flexed knee radiographs and magnetic resonance imaging (MRI).

Demographic Information

Patient demographic information and traits such as age, gender, body mass index (BMI), medical and surgical history, and tobacco use were prospectively documented at the initial clinic visit and retrospectively analyzed. Based on prior literature, injury chronicity was categorized as acute if the time interval between the injury and repair was less than 12 weeks, and chronic if it was 12 weeks or more.[22,23]

Patient-Reported Outcome Measurements

Preoperative and minimum two-year postoperative scores were prospectively collected and retrospectively analyzed for PROMIS-PF, PROMIS-PI, PROMIS-D, IKDC, and KOOS Jr. IKDC and KOOS Jr were denoted "legacy PROMs". Ceiling and floor effects were assessed by determining the number of patients who reached the maximum and minimum scores for each PROM. A percentage of ≥15% was designated as a significant ceiling or floor effect.[24,25] Higher scores on IKDC, KOOS Jr, and PROMIS-PF signified greater functionality. Higher scores on PROMIS-PI signified greater pain. Higher scores on PROMIS-D signified greater depression.

Clinical and Radiographic Evaluation

Patients were evaluated for osteoarthritis using standard procedures, including weight-bearing PA knee radiographs taken at 45° of flexion (Rosenberg view) following the method described by Rosenberg et al.[26], and graded using the Kellgren-Lawrence system.[27,28] An experienced residency-trained orthopaedic surgeon (F.A.) analyzed the radiographs, measuring joint space width on Rosenberg views using the midpoint method as described by Ravaud et al.[29], and assessing knee mechanical axis angle via standing mechanical axis radiographs as either varus (>180 degrees) or valgus (<180 degrees).[30] Medial tibial slope was determined from MRI images using Hudek et al.'s method[31], and extrusion of the medial meniscus was measured in millimeters (mm) from the medial tibial plateau margin on the coronal cut at the medial femoral condyle midpoint, as outlined by Costa et al.[32] Meniscal width was measured using Lee et al.'s method and the percentage of extrusion was calculated using the formula: Percentage of extrusion = [(degree of extrusion (mm))/(width of meniscus (mm))] x 100.[33]

Surgical Technique and Rehabilitation

Arthroscopic transtibial pull-out repair of medial meniscus posterior root tear (MMPRT) was performed by one of four sports medicine fellowship-trained surgeons (J.C., A.B.Y., B.J.C., N.N.V.). Patients were positioned supine for surgery, received general anesthesia, and underwent a bilateral knee examination. The operative leg was secured with a high-thigh tourniquet and placed in a leg holder, while the non-operative leg was positioned in an abduction stirrup. A diagnostic arthroscopy was performed through two standard parapatellar portals to confirm the presence and extent of the MMPRT, assessed adjacent tissues for repair feasibility, and examined the notch and lateral compartment for any additional pathology.

The anatomic location of the root was identified, and the torn fragment was mobilized to this location. The footprint was prepared with a curved ring curette, and a grasper was used to position the torn meniscal root for repair. Either one or two transtibial tunnels were created, per attending preference, positioned at the anatomic footprint of the posterior medial meniscus root. A root aiming guide was used to ensure precise tunnel placement, and when two tunnels were used, an offset guide was employed. Sutures were passed through the transtibial tunnels using an arthroscopic cannula and a suture-passing device, with care taken to avoid intraarticular tangling. The sutures were threaded through either a suture anchor or cortical button, ensuring optimal placement and tension on the anterior tibia to achieve a thorough and effective repair.

A standard postoperative rehabilitation regimen was implemented, mandating a six-week period of non-weight bearing complemented by the support of a hinged knee brace. For the first four weeks, movement of the knee was limited to a range of 0-90 degrees. At six-weeks postoperatively, patients were permitted to gradually resume weight-bearing activities as manageable, phase out the knee brace, and work towards restoring complete range of motion.

Starting at eight weeks, closed-chain exercises were introduced, and permission for jogging was given at the three-month mark.

Statistical Analysis

Data analysis was performed using R version 4.3.1 (2023-06-16) -- 'Beagle Scouts,' provided by the R Foundation for Statistical Computing. For continuous variables, means and standard deviations were reported, while categorical variables were described using frequencies and percentages. The analysis included comparing PROMs before surgery and at a minimum of two years after surgery using the paired two-tailed Student t-test. To evaluate the relationship between PROMs at least two years after surgery, Pearson correlation coefficients (r) were calculated. The strength of correlation was defined as strong (≥0.7), moderate (between <0.7 and ≥0.3), and weak (<0.3). Statistical significance was set *a priori* at $p < 0.05$ for all statistical tests. Based on Vogel et al.'s[12] retrospective review establishing MCID and PASS thresholds for PROMIS subscales and correlating to legacy PROMS following hip arthroscopy, which demonstrated statistical significance with 65 patients, we estimated a sample size of 65 patients will be sufficient to meet these statistical goals.

The MCID was established through a distribution-based method specific to this cohort, set at half the standard deviation of the observed change in PROM scores from preoperative and minimum-2-year postoperatively.[15,34] The PASS was identified using an anchor-based approach tailored to this cohort.[24,35] Patients were asked a yes/no question at minimum-2-year postoperatively regarding their satisfaction: "Taking into account all the activities you have during your daily life, your level of pain, and also your functional impairment, do you consider that your current state is satisfactory?" The answers to this question facilitated the creation of receiver

operating characteristic (ROC) curves for each PROM, with an area under the curve (AUC) of 0.70 or above deemed clinically significant. The Youden J statistic was applied to determine PASS thresholds for each PROM. The rate of reaching both the MCID and PASS for each PROM, covering PROMIS subscales and validated knee-specific PROMs such as IKDC and KOOS Jr, was recorded. Calculations were tailored to the study cohort to ensure that the results reflect the specific characteristics and outcomes of this population.

RESULTS

The initial review identified 173 patients treated with transtibial pullout repair of a MMPRT between January 2017 and January 2021. The selection process, following Consolidated Standards of Reporting Trials (CONSORT) guidelines,[36] is outlined in **Figure 1**. There were 90 patients excluded, including 58 for incomplete preoperative PROMs, 15 due to a history of ipsilateral knee surgery, 13 for concomitant ligamentous repair or reconstruction, 2 for concomitant femoral drilling decompression, 1 for revision MMPRT repair, and 1 for being under the age of 18 years. Eighty-three patients were eligible for inclusion. A total of 15 patients were lost to follow-up; hence, 68 patients were included, with a compliance rate of 81.9%. The mean follow-up duration was 32.9 ± 10.6 months.

Patient Characteristics

The 68 patients included in the study had a mean age at surgery of 57.2 ± 9.7 years and a mean body mass index (BMI) of 32.2 ± 6.14 kg/m^2 (**Table 1**). Female patients constituted 75.0% of the cohort. Rates of smoking tobacco use, diabetes mellitus, workers' compensation were low, at 14.7%, 11.8% and 4.4%, respectively. Chronic injuries were present in 57.3% of cases.

Imaging Characteristics

Preoperatively, the mean KL Grade was 1.80 ± 0.56, with a mean joint space of 4.5 ± 0.97 mm (**Table 2**). The mean absolute meniscal extrusion measured 4.16 ± 1.11 mm, while the mean relative meniscal extrusion was 45.11 ± 15.42%. The average medial tibial slope was 5.16 ± 2.61 degrees, and the knee mechanical axis averaged 181.36 ± 3.64 degrees.

Patient-Reported Outcomes

Significant improvements in all PROMs from preoperative to 2 years postoperative ($P < .005$) were observed (**Figure 2**). The largest mean changes were seen in IKDC and KOOS Jr scores, with changes of 33.19 ± 21.82 and 26.04 ± 22.67, respectively. PROMIS scores showed smaller changes: 7.17 ± 16.58 for PROMIS-PF, -8.47 ± 11.48 for PROMIS-PI, and -2.62 ± 10.05 for PROMIS-D. A ceiling effect, where the maximum score was reached, was observed: PROMIS-PF at 0%; PROMIS-PI at 0%; PROMIS-D at 0%; IKDC at 1.47%; and KOOS-Jr at 17.06%. A floor effect, where the minimum score was reached, was observed: PROMIS-PF at 0%; PROMIS-PI at 0%; PROMIS-D at 0%; IKDC at 1.47%; and KOOS-Jr at 2.94%.

Thresholds for MCID and PASS were established for each PROM and are presented in **Table 3**, along with their corresponding sensitivity and specificity values. All ROC curves demonstrating an AUC ≥0.70, indicating strong discriminative ability and supporting the clinical relevance of these thresholds in this population.. Higher MCID achievement rates suggest that a greater proportion of patients experienced clinically meaningful improvement, while higher PASS rates indicate that more patients reached a symptom state they considered acceptable for daily function. For present study's specific cohort, the highest achievement rates for MCID and PASS

were observed in IKDC (MCID, 87%; PASS, 66%) and KOOS Jr (MCID, 75%; PASS, 66%). PROMIS-PF and PROMIS-PI had similar achievement rates (MCID, 63% and 69%, respectively; PASS, 59% and 54%, respectively), while PROMIS-D showed the lowest rates (MCID, 50%; PASS, 49%) (**Figure 3**).

Pearson correlation coefficients revealed statistically significant relationships among all PROMs ($p < 0.001$) (**Table 4**), providing insight into how different measures relate to one another. Stronger correlations suggest overlapping constructs, while weaker correlations indicate distinct factors influencing patient outcomes. Specifically, PROMIS-PI scores showed moderate negative correlations with both IKDC and KOOS Jr scores ($r = -0.660$ and $r = -0.687$, respectively), indicating that as pain interference decreased, functional scores improved. Conversely, PROMIS-PI had a moderate positive correlation with PROMIS-D scores ($r = 0.399$), suggesting that greater pain interference was associated with higher depressive symptoms. PROMIS-PF scores exhibited a moderate negative correlation with PROMIS-PI ($r = -0.537$), reflecting the expected relationship between physical function and pain interference. Its weak negative correlation with PROMIS-D scores ($r = -0.287$) suggests that depressive symptoms may have a lesser but still measurable impact on physical function. PROMIS-PF demonstrated moderate positive correlations with IKDC and KOOS Jr scores ($r = 0.566$ and $r = 0.710$, respectively), indicating that while it reflects aspects of knee function, it measures functional status more broadly than knee-specific PROMs, capturing elements beyond joint-specific outcomes. The IKDC and KOOS Jr scores demonstrated a strong positive correlation with each other ($r = 0.710$), reinforcing their shared role in assessing knee function and patient-reported outcomes.

DISCUSSION

The most important finding of this study was that MCID thresholds were achieved by 63% of patients for PROMIS-PF, 69% for PROMIS-PI, and 50% for PROMIS-D, while PASS thresholds were achieved by 59%, 54%, and 49%, respectively. Similarly, 87% and 75% of patients met MCID thresholds for IKDC and KOOS Jr, with 66% achieving PASS thresholds for both, suggesting that knee-specific PROMs captured substantial functional improvement and symptom resolution, while PROMIS-PF and PROMIS-PI reflected moderate functional gains with some persistent symptom burden, and PROMIS-D demonstrated the lowest rates, indicating that psychological recovery may be less predictable in this population. These findings highlight the utility of PROMIS in evaluating outcomes for this population and underscore the importance of establishing population-specific thresholds.

These thresholds are specific to this cohort and highlight the need for future studies to define similar population-specific thresholds for accurate clinical interpretation.

Patient reported outcome measures play a crucial role in assessing patients' perspectives on health, function, and quality of life following orthopaedic interventions.[37–40] Clinically, Achieving MCID indicates a meaningful change in a patient's symptoms, while reaching PASS suggests that the patient considers their symptom state satisfactory. Among the PROMs evaluated, IKDC and KOOS Jr have been extensively utilized to evaluate outcomes following knee surgery, encompassing various procedures such as meniscal, ligamentous, and arthroplasty surgeries.[41–47] In our study, we observed significant improvements in IKDC and KOOS Jr scores at the 2-year follow-up after medial meniscus posterior root repair. These findings provide valuable insights into patient outcomes specific to our cohort and underscore the importance of tailoring outcome measures to the characteristics of the study population. Although prior literature reports improvements in IKDC and KOOS Jr scores following meniscal root repair, MCID and PASS

thresholds for these PROMs remain underexplored.[48–51] Maheshwer et al.[14] evaluated 60 patients undergoing meniscal repair, with various meniscal tear patterns, including cases with concomitant anterior cruciate ligament reconstruction. The authors reported an IKDC MCID threshold of 10.9 with an achievement rate of 65% and a PASS threshold of 69 with an achievement rate of 51.7%. In comparison, our study observed an IKDC MCID threshold of 10.5 with an achievement rate of 87% and a PASS threshold of 67.7 with an achievement rate of 66%. Despite variations in study populations, such as tear types and concomitant procedures, our results align with these findings, further emphasizing the relevance of population-specific thresholds for clinical interpretation.[14]

While PROMs offer valuable insights into patients' outcomes, the extensive nature of these questionnaires may burden patients, potentially impacting their responsiveness.[13,52] PROMIS employs item response theory, allowing individual questions or combinations thereof to assess specific outcomes of interest.[53–55] This approach, including computer adaptive testing, has demonstrated high reliability, content validity, and responsiveness to change.[2,56] Notably, PROMIS has emerged as a promising alternative to traditional PROMs, offering validity, efficiency and a reduced burden in evaluating patient-reported outcomes.[57] A study by Hancock et al.[57] underscores the validity and efficiency of PROMIS-PF CAT in assessing outcomes following meniscal injury surgery, corroborating our findings regarding PROMIS' validity in assessing outcomes following MMPRT repair.

PROMIS-PF showed a significant correlation with currently used PROMs of physical function and demonstrated no ceiling effects for patients requiring surgery, further highlighting its utility.[57] While all correlations were statistically significant ($p < 0.001$), their clinical relevance may vary. The strongest correlation was between IKDC and KOOS Jr ($r = 0.710$), which was expected given that both are knee-specific PROMs designed to assess overlapping aspects of knee

function and patient-reported outcomes. PROMIS-PI showed moderate negative correlations with IKDC (r = -0.660) and KOOS Jr (r = -0.687), reinforcing the link between pain interference and functional impairment. PROMIS-PF had moderate positive correlations with IKDC (r = 0.566) and KOOS Jr (r = 0.585), indicating it captures aspects of knee function but not as strongly as legacy PROMs. Weaker correlations with PROMIS-D (r = -0.287 to 0.399) suggest depression potentially influences outcomes but reflects a distinct construct. These findings highlight PROMIS as a complementary tool for knee-specific PROMs in MMPRT repair assessment.

This study also identified a significant correlation between IKDC and KOOS Jr with PROMIS through Pearson's analysis ($p<0.001$), and found a significant ceiling effect for KOOS Jr but none for PROMIS-PF, PROMIS-PI, or PROMIS-D. In previous studies, PROMIS CATs have consistently minimized ceiling and floor effects.[24,54,58,59] As it is reported in a study by Vogel et al., where the authors defined MCID and PASS thresholds for PROMIS and PROMs following primary hip arthroscopy for femoroacetabular impingement syndrome, they outlined the lack of floor and ceiling effects found in PROMIS (0%) when compared to legacy PROMs (HOS-ADL, 12.3%; HOS-SS, 19.2%; iHOT-12, 5.0%; VAS pain, 14.0% for ceiling effects and HOS-ADL, 0.0%; HOS-SS, 1.9%; iHOT-12, 1.7%; VAS pain, 1.8%, for floor effect).[12] The absence of ceiling and floor effects in PROMIS enhances its ability to detect meaningful clinical changes, avoiding measurement saturation that can limit legacy PROMs. Ceiling effects, where patients reach the highest possible score, and floor effects, where patients cluster at the lowest score, can obscure improvements or deteriorations in patient status.[25] PROMIS mitigates these issues through computer adaptive testing, which tailors questions to individual patient responses, ensuring more precise measurements.[55] Vogel et al. demonstrated that PROMIS had no detectable ceiling or floor

effects (0%), whereas traditional PROMs showed ceiling effects up to 19.2%.[12] This highlights PROMIS as a superior tool for evaluating postoperative recovery following MMPRT repair.

Beyond preoperative PROM collection, standardized imaging is essential for assessing meniscal root tears preoperatively. Our study utilized MRI to evaluate meniscal root tears, measure meniscal extrusion, and assess medial tibial slope, along with radiographic assessment of KL grading, joint space width, and mechanical axis. This methodology aligns with prior studies and ensures consistent evaluation of preoperative joint status and structural integrity.[60–62]

While recent studies helped expand our understanding of PROMIS utility in orthopaedic contexts by reporting MCID and PASS thresholds for PROMIS following different orthopaedics procedures, such as hip arthroscopy and meniscus surgery, these thresholds were tailored to different populations and procedures.[12,21,24] In hip arthroscopy, Bodendorfer et al. established clinically significant thresholds at a 1-year follow-up, reinforcing the importance of procedure-specific MCID and PASS values.[24] Similarly, Vogel et al. evaluated these thresholds at a 2-year follow-up for femoroacetabular impingement syndrome, demonstrating that PROMIS-PF provides a reliable measure of functional improvement in this population.[12] These findings underscore the clinical relevance of defining PROMIS thresholds for specific patient populations, as our study establishes similar benchmarks for MMPRT repair, facilitating the interpretation of postoperative outcomes. Okoroha et al.[21] pioneered the evaluation of PROMIS after meniscal surgery, calculating MCID and PASS for PROMIS-PF at 6 months postoperatively following partial meniscectomy. The authors reported a lower MCID threshold (2.09) than we did (6.55), and similar PASS threshold (46.1 vs 47.8) for PROMIS-PF at 6 months.[21] These differences highlight the importance of calculating population-specific thresholds rather than generalizing findings across studies or procedures.

Limitations

The study's findings should be interpreted in the context of its limitations. First, despite having an acceptable number of patients lost to follow up (18.1%), this may still create selection bias that could influence the calculated MCID and PASS thresholds. Second, the 2-year follow-up period may not capture long-term outcomes adequately, warranting longer-term investigations. The predominance of middle-aged females in our study cohort may limit generalizability to other patient populations and influence achievement rates of clinically significant outcome. Additionally, excluding over 30% of the cohort due to missing preoperative PROMs may introduce selection bias and limit generalizability, though this was necessary to ensure valid MCID calculation. Finally, the significant sex imbalance in our cohort (75% female, 25% male) limits the feasibility of meaningful statistical comparisons by sex, as the small sample size of male patients results in underpowered subgroup analyses.

CONCLUSION

This study establishes cohort-specific MCID and PASS thresholds for PROMIS subscales, IKDC, and KOOS Jr. at a minimum 2-year follow-up following isolated transtibial pull out MMPRT repair. At 2 years, MCID and PASS were achieved by 63% and 59% of patients for PROMIS-PF, 69% and 54% for PROMIS-PI, and 50% and 49% for PROMIS-D. For IKDC and KOOS Jr, MCID and PASS rates were 87% and 66%, and 75% and 66%, respectively.

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Figure Legend:

Figure 1. Diagram of Patient Selection and Inclusion per Consolidated Standards of Reporting Trials (CONSORT) guidelines.[36] *MMPRT, medial meniscus posterior root tear; PROM, patient reported outcome measure.*

Figure 2. Preoperative and minimum 2-year postoperative scores for patient-reported outcome measures.

*IKDC, International Knee Documentation Committee; KOOS Jr, Knee Disability and Osteoarthritis Outcomes Score Jr; PROMIS-D, Patient-Reported Outcomes Measurement Information System Depression; PROMIS-PF, Patient-Reported Outcomes Measurement Information System Physical Function; PROMIS-PI, Patient-Reported Outcomes Measurement Information System Pain Interference. *Statistical significance at P < .05.*

Figure 3. Achievement of the minimal clinically important difference (MCID) and patient acceptable symptom state (PASS) for each patient-reported outcome (PRO) measure at minimum 2-year postoperative follow-up.

IKDC, International Knee Documentation Committee; KOOS Jr, Knee Disability and Osteoarthritis Outcomes Score Jr; PROMIS-D, Patient-Reported Outcomes Measurement Information System Depression; PROMIS-PF, Patient-Reported Outcomes Measurement Information System Physical Function; PROMIS-PI, Patient-Reported Outcomes Measurement Information System Pain Interference.

596 **Table 1.** Patient Demographic Information

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598 **Table 2**. Preoperative Imaging Characteristics

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600 **Table 3**. Cohort-Specific Clinically Significant Outcome Thresholds at Minimum 2-Year

601 Follow-up

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603 **Table 4.** Pearson Correlation Coefficients for Preoperative and 2-Year Minimum Follow-Up

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605 # Tables:
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Table 1. Patient Demographic Information

	n = 68
Age (years)	57.2 ± 9.78
Sex (female)	51 (75.0%)
BMI (kg/m^2)	32.2 ± 6.14
Laterality (left)	33 (48.5%)
Tobacco Smoking (current or former)	10 (14.7%)
Diagnosis of Diabetes Mellitus	8 (11.8%)
Chronic Injury	39 (57.3%)
Workers' Compensation	3 (4.4%)

Data are shown as mean + SD or percentage.
BMI, Body mass index

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Table 2. Preoperative Imaging Characteristics

	n = 68
Preoperative KL Grade	
1	13 (19.1%)
2	55 (80.9%)
3	0 (0%)
4	0 (0%)
Joint space (mm)	4.5 ± 0.9
Meniscal extrusion (mm)	4.2 ± 1.1
Relative meniscal extrusion (%)	45.1 ± 15.4
Medial tibial slope (°)	5.2 ± 2.6
Knee mechanical axis (°)	181.4 ± 3.6

KL, Kellgren-Lawrence; mm, millimeter; °, degree; %, percent
Data are shown as mean + SD.

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Table 3. Cohort-Specific Clinically Significant Outcome Thresholds at Minimum 2-Year Follow-up

	MCID	PASS			
	Threshold	**Threshold**	**AUC**	**Sensitivity**	**Specificity**
PROMIS-PF	6.6	47.8	0.839	0.765	0.936
PROMIS-PI	-5.7	53.6	0.892	0.786	0.917
PROMIS-D	-4.9	40.5	0.720	0.719	0.83
IKDC	10.5	67.8	0.878	0.768	0.917
KOOS Jr	10.3	72.3	0.812	0.871	0.957

Sensitivity and specificity were determined with the Youden J statistic.

AUC, area under the receiver operating characteristic curve; IKDC, International Knee Documentation Committee; KOOS Jr, Knee Disability and Osteoarthritis Outcomes Score Jr; MCID, minimal clinically important difference; PASS, patient acceptable symptom state; PROMIS-D, Patient-Reported Outcomes Measurement Information System Depression; PROMIS-PF, Patient-Reported Outcomes Measurement Information System Physical Function; PROMIS-PI, Patient-Reported Outcomes Measurement Information System Pain Interference.

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Table 4. Pearson Correlation Coefficients for Preoperative and 2-Year Minimum Follow-Up

	Preoperative			
	PROMIS-D	**PROMIS-PI**	**PROMIS-PF**	**KOOS JR**
IKDC	-0.399	-0.660	0.566	0.710
KOOS Jr	-0.395	-0.687	0.710	-
PROMIS-PF	-0.287	-0.537	-	-
PROMIS-PI	0.399	-	-	-
PROMIS-D	-	-	-	-

Pearson correlation coefficients listed. All Pearson correlation coefficients were significant at <0.001.

IKDC, International Knee Documentation Committee; KOOS Jr, Knee Disability and Osteoarthritis Outcomes Score Jr; PROMIS-D, Patient-Reported Outcomes Measurement Information System Depression; PROMIS-PF, Patient-Reported Outcomes Measurement Information System Physical Function; PROMIS-PI, Patient-Reported Outcomes Measurement Information System Pain Interference.

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