Two-Year Patient-Reported Outcomes Are Predictive of Mid- and Long-term Outcomes After Meniscal Allograft Transplantation

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Purpose: To determine whether short-term patient-reported outcomes (PROs) after meniscal allograft transplantation (MAT) correlate with mid- to long-term PROs at a minimum of 5-year follow-up. **Methods:** A retrospective review was performed of MATs performed between 2001 and 2019 that had preoperative, 2-year, and minimum 5-year postoperative PROs. PROs of interest assessed included International Knee Documentation Committee Score, all subscales of the Knee Injury and Osteoarthritis Outcome Score, and Lysholm score. Short-term, midterm, and long-term PROs were defined as 2 years, 5 to 10 years, and ≥10 years respectively. Midterm and long-term outcomes were analyzed separately. Patients were evaluated for the achievement of previously reported thresholds for minimally clinically important difference, patient acceptable symptomatic state, and substantial clinical benefit. Logistic regression was used to compare improvements in PROs with respect to reoperation. Linear regression was used to analyze the correlation between short-term and mid- to long-term improvements in PROs. **Results:** In total, 54 patients (48.1% male, 51.9% female) with a mean age of 30.0 ± 10.5 years and body mass index of 26.2 ± 4.2 were included. Mean follow-up for the entire cohort was 10.4 ± 4.4 years. Minimally clinically important difference achievement ranged from 70.0% to 95%, patient acceptable symptomatic state from 55.6% to 78.6%, and substantial clinical benefit from 38.5% to 69.2%. We found significant positive correlations between short-term and midterm as well as short-term and long-term improvements in all outcomes, with the exception of Lysholm scores in the ≥10 years group. 18 patients (33.3%) had any subsequent reoperation on the same knee, 5 of which (9.2%) included conversion to arthroplasty. **Conclusions:** Two-year improvements in PROs after MAT are predictive of sustained success at midterm and long-term follow-up, with significant correlations observed between 2-year outcomes and those at 5 to 10 and ≥10 years. **Level of Evidence:** Level IV, retrospective case series.

See commentary on page 4005

Meniscal allograft transplantation (MAT) is a surgical option for meniscal deficiency in the properly indicated patient. In the setting of neutral mechanical alignment, ligamentous stability, and absence of focal or diffuse chondral pathology (or with concomitant procedures to address these conditions), MAT can provide long-term pain relief, improvement in patient-reported outcomes (PROs), graft survivorship, and even return to sport.[1-8] With improving indications, surgical technique, and resultant patient outcomes, the popularity of MAT, both in practice and in the literature, has slowly grown over the years.[9-14] As increasing numbers of MATs are being performed, it becomes increasingly important to be able to identify which patients will have successful outcomes.

In addition to being able to determine who will be a good candidate for MAT on the basis of preoperative or intraoperative parameters, the ability to predict whether patients will maintain improved clinical outcomes on the basis of short-term follow-up PROs is an important prognosticator. Several studies in the hip arthroscopy literature have shown that patients who achieved greater improvements in PROs at short-term follow-up (6 months to 2 years) were predictive of maintaining improved PROs, achieving clinically significant improvements, and survivorship at longer-term follow-up (2-10 years).[15-17] Other research has shown

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the maintenance of long-term PROs in MAT, but data specifically correlating short-term improvements with long-term outcomes are limited.[18-20]

The purpose of our study was to determine whether short-term PROs after MAT correlate with mid- to long-term PROs at a minimum of 5-year follow-up. As secondary aims, we sought to explore the relationships between improvement in PROs with demographic and intraoperative variables as well as reoperation rates in order to identify any confounding variables. We also calculated the percentage of patients who met previously established thresholds for minimally clinically important difference (MCID), patient acceptable symptom state (PASS), and substantial clinical benefit (SCB). We hypothesized that there would be a significant relationship between PROs at or before 2 years and 5 year or longer PROs and the achievement of clinical significance as measured by MCID, PASS, and SCB.

Methods

Study Design and Patient Inclusion

This was a retrospective review of a prospectively maintained database of all patients who underwent either a lateral or medial MAT performed by the senior author (B.J.C.) for the treatment of meniscal deficiency between 2001 and 2019. Patients in this database have been reported on in other investigations.[1-3,21-24] Approval from the institutional review board at Rush University Medical Center was obtained for this study (ORA# 23121208-IRB01). Indications for medial or lateral MAT were symptomatic patients with meniscal insufficiency who had did not respond to previous conservative management or previous meniscal surgery. Patients were included if they had undergone MAT and had available preoperative, 2-year postoperative, and minimum 5-year postoperative PROs. Only patients undergoing primary MAT were included in this study.

Surgical Technique and Rehabilitation Protocol

The senior author's preferred technique for MAT and postoperative rehabilitation have been previously described.[23,25] The senior author prefers the bridge-in-slot technique for medial and lateral MATs with fresh-frozen, nonirradiated meniscal grafts (Fig 1). Additional abnormalities, such as cartilage defects, ligamentous insufficiency, and malalignment are treated concomitantly as appropriate. The meniscus is evaluated and debrided until a bleeding peripheral rim of 1 to 2 mm

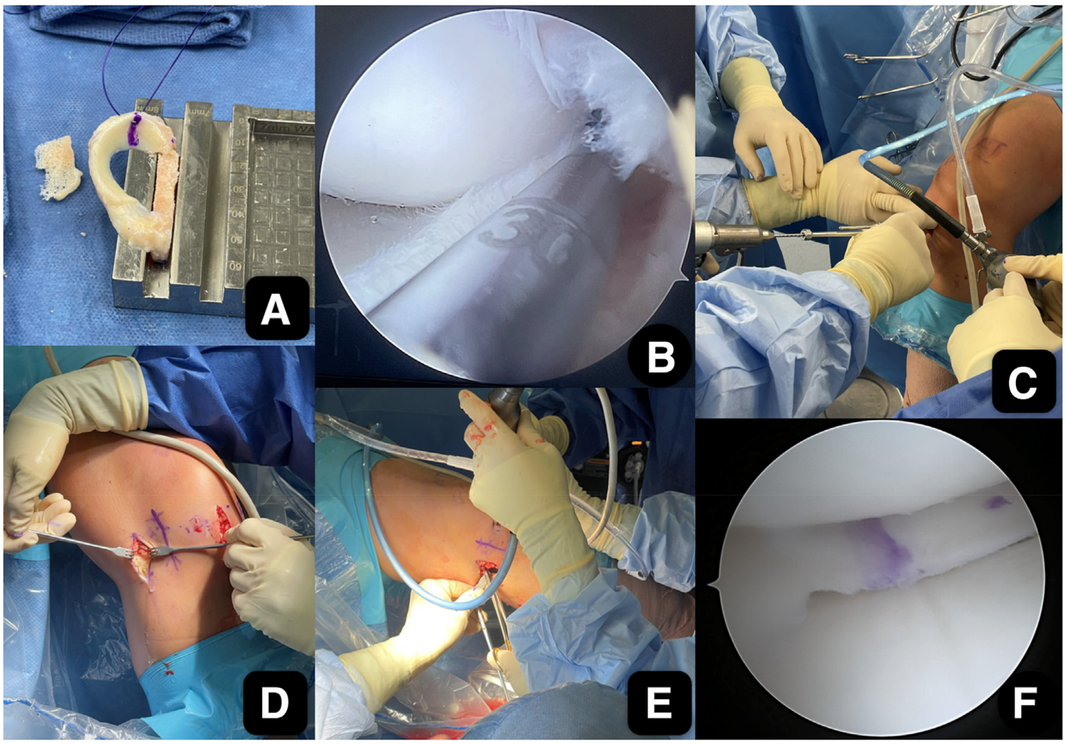

Fig 1. Surgical technique of a medial meniscal allograft transplantation in a left knee. (A) allograft preparation with a bridge in slot 7 mm in width and depth. A shuttling 0 PDS is passed in mattress fashion through the posterior horn. (B) The slot is created straight anterior to posterior, starting the trough with a 5.5-mm bone cutter along the medial tibial spine. (C) The guide pin is drilled to the posterior tibial cortex for cannulated 7 mm reaming of the slot. (D) Once slot creation is completed, a posteromedial inside-out approach is made. (E) After graft shuttling into the joint via the PDS sutures, 8 to 10 inside-out double-ended repair sutures are passed through the meniscus out the rescue incision and caught by an assistant. (F) Intraoperative arthroscopic image showing the final graft. (PDS, polydioxanone.)

is left, and the anterior and posterior horns are then resected. An initial guide slot is first made with a 4.5-mm burr, and a guide pin is then placed using the slot guide. A 7-mm reamer is used to over-ream the guide pin, and the slot is then refined using a box cutter, rasp, and a bone-cutting shaver. During the preparation of the tibial slot, the allograft is thawed in normal saline. Once the graft is thawed, a 7-mm bone bridge is created between the anterior and posterior horns of the donor graft. A suture is then placed through the posterior meniscus, which is used for inserting the meniscus into the joint and the tibial slot using an inside-out technique. While the knee is in flexion, an interference screw is used for bone bridge fixation. Standard posterolateral and posteromedial incisions are used for inside-out lateral and medial meniscocapsular repair, using 8 to 10 sutures alternating above and below the meniscus. After confirming satisfactory placement, the incisions are closed in standard fashion.

Postoperatively, patients remain heel-touch weight-bearing in a knee brace locked in full extension for 2 weeks. From postoperative weeks 2 to 6, patients begin range of motion from 0 to 90°. After week 6, patients progress to full weight-bearing. At week 8, patients progress to closed chain activities and are cleared for sport-specific exercises by the senior author at a minimum 5 months after surgery.

Patient Demographics and Surgical Characteristics

Demographic variables including age, sex, race, ethnicity, and body mass index were recorded. Relevant intraoperative variables, such as laterality and type of transplant (medial or lateral) also were recorded. In addition, concomitant procedure, including osteotomy (distal femoral or high tibial osteotomy), anterior cruciate ligament reconstruction, osteochondral allograft, osteochondral autograft transplantation, or matrix-induced autologous chondrocyte implantation, were recorded. The senior author is aggressive with indications for concomitant procedures, particularly in regards to coronal malalignment, chondral defects, and ligamentous instability in MAT procedure to provide the optimal environment for the MAT. Indications for high tibial osteotomy or distal femoral osteotomy include hip-knee-angle ≥5° in the affected compartment. Any subsequent knee surgeries also were recorded.

Patient-Reported Outcomes

PROs of interest included the Lysholm score, International Knee Documentation Committee (IKDC) score, and all Knee Injury and Osteoarthritis Outcome Score (KOOS) subscales: pain, symptoms, activities of daily living (ADL), sport, and quality of life (QOL). Written or electronic questionnaires were e-mailed by PRO-collection platforms (PatientIQ, Chicago, IL and Outcomes Based Electronic Research Database, Columbia, MO) or provided to patients in-person by trained research staff. PROs were scored manually by research staff or automatically by the PRO platform. Patients were separated on the basis of the date of their follow-up; midterm follow-up was defined as 5 to 10 years, and long-term follow-up was defined as greater than or equal to 10 years. Patients with data available in both time points were included in both groups. Outcome improvement, defined as the change from preoperative scores, was assessed at all time periods.

Statistical Analysis

Continuous variables are reported as means with standard deviation, range, or 95% confidence intervals, and categorical variables are reported as frequencies and percentages. We reported the percentage of patients who achieved previously calculated values of MCID, PASS, and SCB for MAT.[23] We defined improvement as the difference in preoperative and postoperative scores at the time point in question. We defined short-term as 2 years, midterm as 5 years, and long-term as 10 years. We used IKDC as the primary PRO for analyzing demographic and operative variables with respect to short-term outcomes. This allowed us to reduce the likelihood of a type I error without including several statistical analyses for each PRO. Linear regression and logistic regression were used to correlate continuous and categorical demographic and intraoperative variables with short-term improvements in IKDC. Student paired *t* tests were used to compare differences in all PROs preoperatively, at 2 years, 5 to 10 years, and 10+ years follow-up. Logistic regression also was used to analyze the relationship between improvements in IKDC at different time points between patients who underwent reoperation and those who did not. Linear regression was used to assess correlations between improvement at two-years to improvement at either 5- to 10-year or ≥10-year follow-up. For linear regression, we interpreted correlation coefficients of 0.00 to 0.19 as very weak, 0.20 to 0.39 as weak, 0.40 to 0.59 as moderate, 0.60 to 0.79 as strong, and 0.80 to 1.00 as very strong.[26] Statistical analysis was performed using Microsoft Excel (Version 2308; Microsoft Corp, Redmond, WA) and in RStudio, Version 4.2.0 (RStudio, Boston, MA).

Results

Patient Demographics and Concomitant Procedures

In total, 102 patients had both preoperative and 2-year postoperative PROs within our study cohort (Fig 2). In total, 54 had PROs at a minimum of 5 years (52.9% follow-up). 33 patients had PROs available at 5 to 10 years, and 28 had PROs available to 10 years or beyond. Seven patients had PROs at both 5 to 10 years and ≥10 years and were included in both groups.

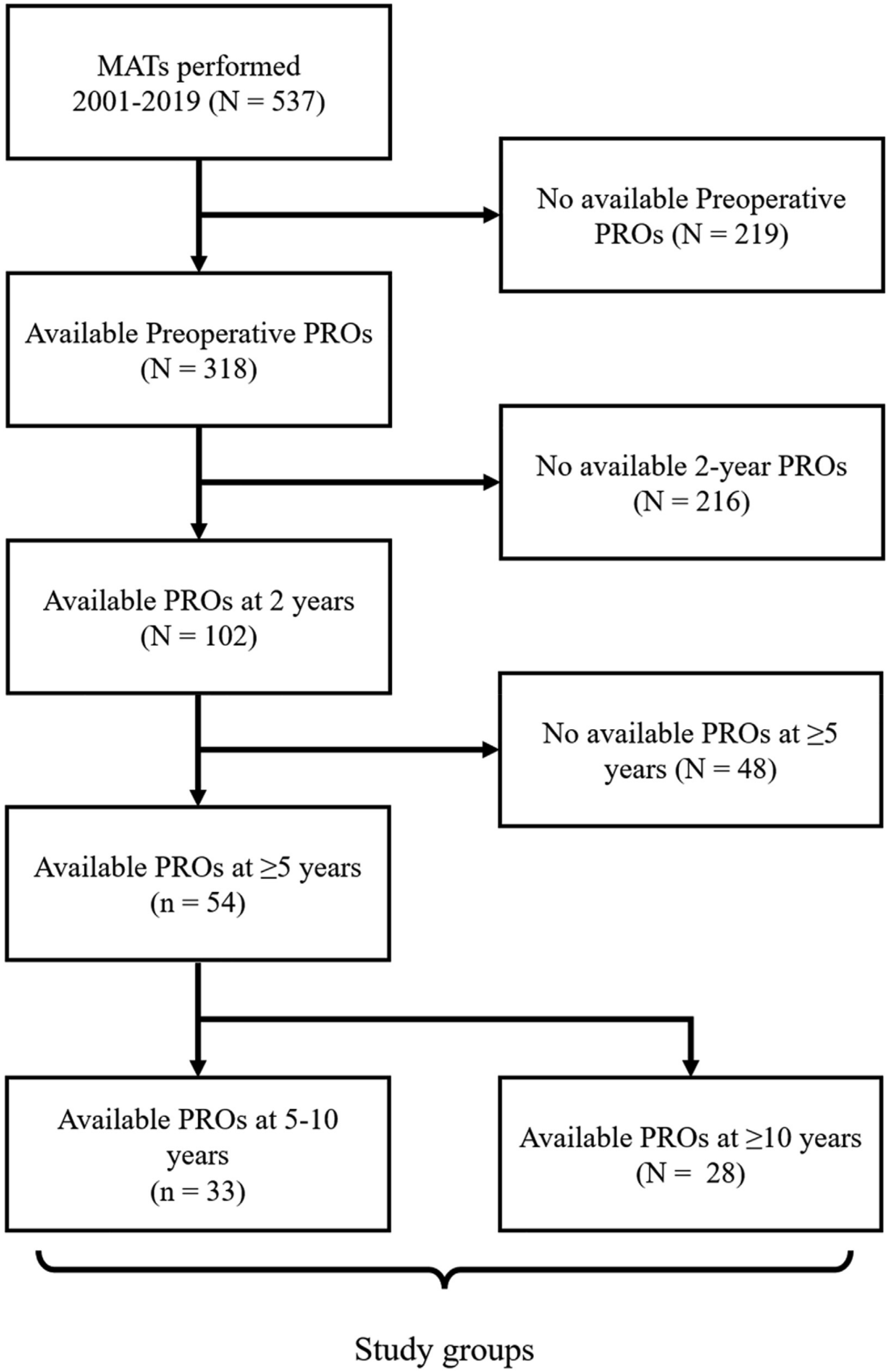

Fig 2. Flow diagram for study population. During the study period, 537 meniscal allograft transplantations (MATs) were performed; 219 patients did not have available preoperative patient-reported outcomes (PROs), and an additional 216 lacked 2-year postoperative PROs. Of the 102 patients who had both preoperative and 2-year postoperative PROs, 54 had PROs at a minimum of 5 years (52.9% follow-up). In total, 33 patients had PROs available at 5-10 years and 28 had PROs available at 10 years or beyond. Seven patients had PROs at both 5 to 10 years and 10 years and were included in both groups.

Table 1. Baseline Demographic and Intraoperative Characteristics of the Cohort and Correlation With Short-term Improvements (Difference in Preoperative and 2-Year Postoperative Values) in IKDC Score

Characteristic	Total (N = 54)	OR	95% CI	*P* Value
Age, yr (range)	30.0 (14.8-46.6)			.406*
BMI (range)	26.2 (19.8-40.4)			.883*
Sex		0.999	0.973-1.026	.963†
Male	26 (48.1%)			
Female	28 (51.9%)			
Race/ethnicity		1.001	0.972-1.031	.948†‡
White	37 (68.5%)			
Hispanic	3 (5.6%)			
Black/African American	3 (5.6%)			
Asian	1 (1.9%)			
Unknown	10 (18.5%)			
Mean time to follow-up (IQR**)**				.172*
Total cohort	10.4 (6.4-14.0)			
5-10 yr (n = 33)	6.8 (5.5-8.5)			
≤10 yr (n = 28)	14.6 (12.2-16.5)			
Laterality		1.018	0.9901-1.0460	.203†
Left	25 (46.3%)			
Right	29 (53.7%)			
Type of transplant		0.990	0.963-1.018	.485†
Medial	35 (64.8%)			
Lateral	19 (35.2%)			
Concomitant procedure	38 (70.4%)	1.003	0.973-1.033	.862†
OCA/OATS	25 (46.3%)	1.009	0.982-1.036	.528†
MACI	7 (13.0%)	1.007	0.968-1.047	.721†
Osteotomy	5 (9.3%)	0.983	0.945-1.024	.418†
ACL reconstruction	5 (9.3%)	0.984	0.935-1.035	.530†
Microfracture	2 (3.7%)	1.101	0.901-1.346	.347†

ACL, anterior cruciate ligament; BMI, body mass index; CI, confidence interval; IKDS, International Knee Documentation Committee; IQR, interquartile range; MACI, matrix-induced autologous chondrocyte implantation; OATS, osteochondral autograft transplantation; OCA, osteochondral allograft transplantation; OR, odds ratio.

*Linear regression comparing variable of interest with increase in IKDC from baseline to 2 years.

†Logistic regression comparing variable of interest with increase in IKDC from baseline to 2 years.

‡For race/ethnicity, logistic regression was used to compare White versus non-White individuals.

A total of 54 patients met all inclusion criteria: 26 (48.1%) were male and 28 (51.9%) were female, with an average age of 30.0 ± 10.5 years (range 14.8-46.6 years) and a body mass index of 26.2 ± 4.2 (range 19.8-40.4). In total, 37 patients (68.5%) were White and 10 (18.5%) had no data on race/ethnicity recorded. The average time to most recent follow-up was 10.4 ± 4.4 years. A total of 35 patients (64.8%) had a medial MAT, whereas the remaining 19 (35.2%) received a lateral MAT. None of the demographic variables had an association with short-term increase in IKDC (Table 1). 38 patients (70.4%) had at least 1 major concomitant procedure, and 6 patients (11.1%) had 2 concomitant procedures. There was no significant association between short-term increase in IKDC with the presence of any concomitant procedure (Table 1).

Patient-Reported Outcomes

For all PROs, there was a significant increase in scores from baseline to 2-year follow-up. The previously reported MCID thresholds for MAT were 12.1 for IKDC, 11.0 for KOOS pain, 11.0 for KOOS symptoms, 10.5 for KOOS ADL, 16.2 for KOOS Sport, 13.6 for KOOS QOL, and 8.6 for Lysholm. The previously reported values for PASS were 55.6 for IKDC, 70.7 for KOOS pain, 60.8 for KOOS symptoms, 90.3 for KOOS ADL, 47.4 for KOOS Sport, 40.5 for KOOS QOL, and 74.5 for Lysholm. The previously reported values for SCB were 29.1 for IKDC, 25.1 for KOOS Pain, 19.6 for KOOS symptoms, 17.9 for KOOS ADL, 37.5 for KOOS Sport, 37.3 for KOOS QOL, and 32.5 for Lysholm.[23] For the 33 patients who completed PROs at preoperative baseline and at midterm 5- to 10-year follow-up, there were significant increases in all patient-reported outcomes (Table 2). Similarly, for the 28 patients who completed PROs at preoperative baseline and at long-term follow-up 10 years and beyond, significant increases were noted in all PROs at a minimum 10-year follow-up. Achievement of clinical significant measures for MCID, PASS, and SCB at both midterm and long-term follow-up are reported in Table 2.

Failure and Reoperation

No patients in this cohort underwent revision MAT at most recent follow-up. Five patients (9.2%) underwent

Table 2. Baseline and 2-Year PROs for the Entire Cohort, Baseline and 5- to 10-Year PROs for the Midterm Cohort, and Baseline and ≥10-Year PROs for the Long-term Follow-Up Cohort

Outcome	Preoperative*	2 Years*	% Achieved MCID	% Achieved PASS	% Achieved SCB	*P* Value†
Baseline and 2-yr PROs for the entire cohort (N = 54)						
IKDC	37.4 (32.8-41.9)	62.8 (56.5-69.0)	67.4%	66.0%	44.2%	**<.001**
KOOS Pain	55.7 (51.1-60.4)	76.5 (70.9-82.1)	64.3%	67.4%	38.1%	**<.001**
KOOS Symptoms	54.0 (49.1-58.9)	73.9 (68.4-79.3)	71.1%	76.1%	53.3%	**<.001**
KOOS ADL	70.1 (65.4-74.7)	86.4 (81.6-91.3)	63.6%	58.7%	47.7%	**<.001**
KOOS Sport	29.8 (22.7-36.9)	51.4 (43.6-59.2)	47.2%	55.8%	38.9%	**<.001**
KOOS QOL	25.2 (20.5-30.0)	51.0 (44.0-58.1)	64.4%	58.3%	28.9%	**<.001**
Lysholm	44.0 (38.2-49.9)	72.1 (65.1-79.2)	90.9%	63.4%	39.4%	**<.001**
Baseline and 5- to 10-yr PROs for the midterm cohort (n = 33)	Preoperative*	5-10 yr*	% Achieved MCID	% Achieved PASS	% Achieved SCB	*P* Value† (vs Baseline)
IKDC	39.7 (33.5-45.9)	61.2 (52.9-69.6)	51.9%	56.7%	37.0%	**<.001**
KOOS Pain	55.3 (49.6-61.0)	75.6 (68.3-82.9)	68.0%	63.3%	44.0%	**<.001**
KOOS Symptoms	57.5 (51.1-63.8)	69.6 (62.7-76.5)	60.7%	63.3%	50.0%	**<.001**
KOOS ADL	69.8 (63.3-76.2)	83.8 (77.1-90.5)	55.6%	54.8%	44.4%	**<.001**
KOOS Sport	35.5 (26.1-45.0)	55.3 (45.5-65.2)	54.5%	65.5%	31.8%	**<.001**
KOOS QOL	24.9 (18.9-30.9)	48.3 (38.8-57.9)	57.7%	62.1%	34.6%	**<.001**
Lysholm	48.6 (39.7-57.6)	69.0 (60.7-77.3)	64.3%	38.1%	28.6%	**<.001**
Baseline and ≥10-yr PROs for the long-term follow-up cohort (n = 28)	Preoperative*	10+ yr*	% Achieved MCID	% Achieved PASS	% Achieved SCB	*P* Value† (vs Baseline)
IKDC	37.1 (31.1-43.0)	70.7 (63.7-77.7)	87.5%	78.6%	54.2%	**<.001**
KOOS Pain	58.6 (52.3-64.9)	82.2 (75.8-88.6)	80.8%	85.2%	50.0%	**<.001**
KOOS Symptoms	51.8 (45.5-58.1)	76.4 (69.0-83.9)	76.9%	77.8%	69.2%	**<.001**
KOOS ADL	73.3 (67.3-79.3)	87.9 (81.4-94.3)	57.7%	55.6%	38.5%	**<.001**
KOOS Sport	24.8 (16.2-33.3)	60.5 (49.6-71.3)	70.0%	70.4%	60.0%	**<.001**
KOOS QOL	25.7 (19.0-32.5)	61.5 (50.9- 72.2)	80.0%	77.8%	52.0%	**<.001**
Lysholm	43.5 (36.6-50.4)	80.8 (75.3-86.2)	95.0%	77.3%	55.0%	**<.001**

ADL, activities of daily living; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; MCID, minimally clinically important difference; PASS, patient acceptable symptomatic state; PRO, patient-reported outcome; QOL, quality of life; SCB, substantial clinical benefit.

*Reported as mean (95% confidence interval).

†Student paired *t* test comparing outcomes at baseline and at time point of interest. Bold indicates statistical significance ($P < .05$).

arthroplasty at mean of 8.9 ± 5.5 years postoperatively, with 4 total knee arthroplasties and 1 unicompartmental arthroplasty. Two patients (3.7%) underwent subsequent cartilage repair (osteochondral allograft transplantation and microfracture). In total, 18 patients (33.3%) had any subsequent operation on the same knee, most commonly articular cartilage debridement (16.7%) and meniscectomy (11.1%). We found no significant differences in short-term increases in PROs when comparing patients who did and did not have a subsequent operation apart from KOOS Quality of Life. Repeating the analysis with mid/long-term increases in PROs (the difference from preoperative values to most recent follow-up), we found no significant differences based on reoperation status apart from KOOS symptoms (Table 3).

Correlation Between Improvements in Short-term PROs and Sustained Improvements in Long-term PROs

Within patients with midterm follow-up between 5 and 10 years (n = 33), we found significant correlations between short-term improvements in PROs and midterm improvements in PROs for all PROs of interest (Table 4). The correlation coefficients ranged from 0.579 for IKDC (indicating moderate correlation) to 0.859 for KOOS Pain (indicating a very strong correlation). Within patients with long-term follow-up ≥10 years (n = 28), we found significant correlations between short-term improvements in PROs and long-term improvements in PROs for all PROs of interest, with the exception of Lysholm scores. Of the measurements that were statistically significant, the

Table 3. Comparison of PRO Improvement in Patients With and Without Subsequent Reoperation

Outcome	No Reoperations* (n = 36)	Reoperation* (n = 18)	Odds Ratio	*P* Value†
Mean increase in outcome from baseline to 2 yr				
IKDC	28.0 (19.8-36.2)	14.5 (3.4-25.7)	0.973 (0.946,1.002)	.069
KOOS Pain	21.9 (14.6-29.2)	15.2 (1.9-28.6)	0.985 (0.954,1.017)	.350
KOOS Symptoms	21.4 (15.9-26.8)	15.9 (7.6-24.3)	0.978 (0.937,1.020)	.293
KOOS ADL	18.8 (13.8-23.7)	11.8 (1.3-22.3)	0.972 (0.930,1.015)	.190
KOOS Sport	29.3 (18.2-40.4)	7.5 (-10.1-25.1)	0.972 (0.944,1.001)	.061
KOOS QOL	34.8 (26.4-43.2)	1.5 (-8.5-11.4)	0.911 (0.856,0.969)	**.003**
Lysholm	31.1 (23.8-38.4)	23.3 (14.1-32.5)	0.971 (0.925,1.019)	.230
Mean increase in outcome from baseline to most recent follow-up (5+ years)				
IKDC	27.1 (19.7-34.5)	21.4 (8.9-33.8)	0.987 (0.958,1.018)	.413
KOOS Pain	23.2 (15.3-31.1)	21.1 (8.5-33.7)	0.996 (0.967,1.025)	.786
KOOS Symptoms	22.1 (15.5-28.7)	7.3 (-2.2-16.7)	0.962 (0.929,0.996)	**.029**
KOOS ADL	14.5 (8.1-20.9)	15.0 (5.2-24.8)	1.001 (0.966,1.037)	.960
KOOS Sport	33.3 (21.3-45.3)	15.2 (-11.3-41.6)	0.986 (0.967,1.006)	.168
KOOS QOL	30.8 (20.9-40.6)	21.5 (3.8-39.2)	0.989 (0.966,1.012)	.338
Lysholm	30.9 (22.1-39.7)	26.2 (2.3-50.1)	0.990 (0.948,1.035)	.666

ADL, activities of daily living; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; QOL, quality of life.

*Reported as mean (95% confidence interval).

†Logistic regression. Bold indicates statistical significance ($P < .05$).

correlation coefficients were between 0.405 (moderate correlation) for KOOS ADL and 0.791 (strong correlation) for KOOS Pain.

Discussion

The main findings of this study were that not only were there statistically and clinically significant improvements in PROs at short-, mid-, and long-term follow-up after MATs. In addition, short-term improvements in IKDC, Lysholm, and all KOOS subscales significantly predicted sustained mid- to long-term improvements in the same PROs, with the exception of Lysholm at ≥10-year follow-up. Short-term improvements in PROs not only reflect adequate postoperative

Table 4. Correlation Between Short-term (Baseline to 2-Year), Midterm (Baseline to 5- to 10-Year Follow-Up) (n = 33), and Long-term (Baseline to ≥10-Year Follow-Up) Increases in Patient-Reported Outcomes (n = 28)

PRO	R	Adjusted R^2	Slope*	*P* Value†
5-10 yr				
IKDC	0.579	0.307	0.541 (0.220-0.862)	**.002**
KOOS Pain	0.859	0.727	0.895 (0.659-1.130)	**<.001**
KOOS Symptoms	0.495	0.213	0.604 (0.157-1.051)	**.010**
KOOS ADL	0.812	0.645	0.698 (0.482-0.914)	**<.001**
KOOS Sport	0.613	0.343	0.725 (0.276-1.174)	**.003**
KOOS QOL	0.737	0.523	0.822 (0.497-1.147)	**<.001**
Lysholm	0.609	0.308	0.948 (0.078-1.817)	**.035**
≥10 yr				
IKDC	0.730	0.510	0.843 (0.475-1.211)	**<.001**
KOOS Pain	0.791	0.608	0.760 (0.500-1.021)	**<.001**
KOOS Symptoms	0.714	0.489	0.732 (0.429-1.035)	**<.001**
KOOS ADL	0.405	0.127	0.323 (0.008-0.638)	**.045**
KOOS Sport	0.553	0.267	0.488 (0.124-0.853)	**.012**
KOOS QOL	0.778	0.589	0.819 (0.534-1.104)	**<.001**
Lysholm	0.279	0.024	0.242 (-0.184-0.667)	.247

ADL, activities of daily living; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; QOL, quality of life; R, Correlation Coefficient.

*Reported as mean (95% confidence interval).

†Linear regression. Bold indicates statistical significance ($P < .05$).

recovery but may also serve as an indicator for the long-term success of an MAT. This provides important prognostic information for surgeons performing medial or lateral MATs with or without concomitant procedures as well as the patients undergoing these significant surgeries.

Although there is some research on the maintenance of long-term PROs in MAT, data correlating short-term improvements with long-term outcomes remain limited. Grassi et al.[18] reported significant improvements on all PROs with consistent maintenance at an average follow-up of 5.7 years. The most relatable orthopaedic studies looking specifically at correlations between short and mid- to long-term PROs involve hip arthroscopy for the treatment of femoroacetabular impingement syndrome.[15,16] These studies show that early statistically and clinically significant improvements in PROs typically are correlated with sustained improvements at mid- and long-term follow-up in hip arthroscopy, which our study showed for MATs.

Our study revealed statistically significant improvements in IKDC, Lysholm, and all KOOS subscales at 2-year, 5- to 10-year, and ≥10-year follow-up, with a graft survival rate of 90.8%. In addition, there were high rates of clinically significant improvement, with more than 85% achievement of MCID and more than 75% achievement of PASS at 10 years for IKDC and Lysholm scores. There have been several recent publications of 10-plus year outcomes for MATs in the literature.[8,18,24,27-29] Grassi et al.[18] reported in their cohort of 46 patients with a mean age of 36.6 years and minimum 10-year follow-up a survival rate of 86% at 10 years and a 60% to 82% PASS achievement rate for the various KOOS subscales, which compares favorably to our study's 55.6% to 85.2% PASS achievement rate for the various KOOS subscales.[27] In their larger cohort with mean 5.7-year follow-up, Grassi et al.[18] reported in 324 consecutive patients with MATs (with a 58% concomitant procedure rate), significant and sustained improvements in Lysholm and Tegner scores with, with a 21.6% clinical failure rate. Romandini al.[28] showed in a series of 47 patients with a mean age of 43.5 years and 11.1-year follow-up, a survival rate of 89.4% at 10 years, and significant improvements in visual analog scale, Lysholm, and Tegner at 5- and 10-year follow-up, although they did not correlate improvements between short and long-term follow-up and also did not report on clinical significance. Lee et al.[19] recently reported minimum 15-year follow-up in 54 knees, with significant improvements in Lysholm score, 70.4% rate of meeting MCID, and a cumulative clinical survival rate of 87.0%. These sustained improvements in PROs and overall high survival rate of MAT at 10+ year follow-up were reiterated in this systematic review by Novaretti et al.,[29] in which 11 studies with 688 MATs with a mean age of 33.1 years showed survivorship rates of 73.5% at 10-year follow-up and 60.3% at 15 years. They also reported postoperative Lysholm scores ranging from 61 to 75 and IKDC scores from 46 to 77, of which our study compares favorably. It should be noted that several of these long-term outcome studies have been published by either the senior author or the Rizzoli Orthopaedic Institute.[8,18,27,28]

There was no correlation between demographic factors, medial or lateral MAT, or concomitant procedures on short-term improvements in IKDC in our cohort. The correlation between these factors and outcomes after MAT is mixed in the literature. Frank et al.[22] found no relationship between age <40 or ≥40 years or sex on postoperative PRO improvement in MATs, with the exception of a greater revision surgery rate in female patients. In contrast to our study, Grassi et al.[27] found significantly greater failure rates in lateral MAT (73%) compared with medial MAT (96%), whereas Bin et al.[30] found no differences in survival rate between lateral and medial MAT in a meta-analysis of 694 MATs. Similar to our study, Grassi et al.[18] and Romandini et al.[28] had a high concomitant procedure rate in their study cohort of 58% and 70.2%, respectively, and also found no significant effect on clinical outcomes with or without the presence of concomitant procedures.[28] Our cohort had a high rate of concomitant procedures, primarily cartilage, osteotomy, or ligamentous procedures. However, MATs are often performed with 1 or more concomitant procedures to optimize the mechanical and biologic environment of the MAT, and we believe this increases the external validity of our findings. In addition, our analysis revealed no significant correlation between the presence of concomitant procedures and short-term improvements in IKDC.

Limitations

There are several limitations to our study. This was a relatively small cohort of 54 patients, given our strict inclusion criteria of MATs with the presence of preoperative baseline, 2-year, and mid- or long-term PROs. Only 7 patients had PROs recorded at all 4 time points. In addition, some of the additional analyses may have been underpowered as the result of the small sample size. For example, only 18 patients underwent reoperation in our cohort, and the majority of the concomitant procedures were too few in number to create adequately powered comparisons. In addition, patients from this prospectively maintained database have been used in other studies.[1-3,21-24] There is substantial overlap between those and the present study, although these investigations did not specifically compare the relationships between PROs at separate time points.

In addition, this was a retrospective study with no comparative group from a single surgeon. We did not include any information on preoperative coronal limb alignment or postoperative objective physical examination or imaging. Given the small sample size, we were unable to further analyze the data by disaggregating it by sex, because of concerns of statistical power.

Conclusions

Two-year improvements in PROs after MAT are predictive of sustained success at midterm and long-term follow-up, with significant correlations observed between 2-year outcomes and those at 5 to 10 and ≥10 years.

Disclosures

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