VIDEO Abstract

Return to Sport After ACL Reconstruction With Meniscal Allograft Transplantation Versus Isolated ACL Reconstruction

A Matched-Cohort Study

Victoria Rigsby,* PT, Joshua Shaw,* PT, Caroline Stankaitis,* PT, Steven Higbie,*† PT, Jacquelyn Kleihege,* PT, William Brooks,‡ MD, Walter R. Lowe,‡ MD, and Lane B. Bailey,* PT, PhD
Investigation performed at Memorial Hermann Rockets Sports Medicine Institute, Department of Sports Medicine & Rehabilitation, Houston, Texas, USA

Background: Meniscal allograft transplantation (MAT) is indicated in the setting of anterior cruciate ligament (ACL) reconstruction to restore proper arthrokinematics and load distribution for the meniscus-deficient knee. Objective outcomes after ACL reconstruction with concomitant MAT in athletic populations are scarcely reported and highly variable.

Purpose: To compare patient outcomes using an objective functional performance battery, self-reported outcome measures, and return-to-sport rates between individuals undergoing ACL reconstruction with concomitant MAT and a matched group undergoing isolated ACL reconstruction.

Study Design: Cohort study; Level of evidence, 3.

Methods: A single-surgeon ACL reconstruction database (N = 1431) was used to identify patients undergoing ACL reconstruction with concomitant MAT between 2014 and 2019. Patients were age-, sex-, and revision-matched to a group undergoing isolated ACL reconstruction. Baseline patient and surgical data were obtained. Patients completed an objective functional performance battery at the time of return to sport that included range of motion, single-leg squat performance, single-leg hop test performance, self-reported function (International Knee Documentation Committee [IKDC] score), and psychological readiness (ACL Return to Sports After Injury scale). Between-limb comparisons were assessed using limb symmetry indices. Injury surveillance was conducted for 2 years and included the Single Assessment Numeric Evaluation (SANE), reinjury rates, complications, and current level of sports participation. Between-group comparisons at the time of return to sport and 2 years later were analyzed using generalized linear models for parametric and nonparametric equivalents with an a priori alpha level of .05.

Results: A total of 46 patients were included in the ACL reconstruction with concomitant MAT group (38 medial MAT, 8 lateral MAT), and 46 patients were included in the isolated ACL reconstruction group. Baseline differences existed between groups, with the MAT group exhibiting lower body weight (84.0 ± 14.1 vs 93.2 ± 191.8 kg; $P = .036$) and Marx scores (4.8 ± 4.5 vs 9.3 ± 4.1; $P = .024$) than the isolated ACL reconstruction group, respectively. At the time of return to sport, the MAT group reported lower IKDC scores (83.2 ± 12.6 vs 91.1 ± 11.3; $P = .037$); however, no other functional performance or self-reported differences were observed. At 2 years, no significant differences existed between groups for SANE score (87.8 ± 12.3 vs 89.3 ± 11.4; $P = .793$), ACL graft reinjury rates (6.5% vs 2.2%; $P = .688$), or level of return to sport ($P > .05$). The MAT group demonstrated a significantly lower rate of return to previous level of sport (69.5% vs 78.3%; $P = .026$).

Conclusion: The majority of patients (87%) undergoing ACL reconstruction with concomitant MAT were able to return to some level of sports participation at 2 years with a low risk of revision ACL reconstruction or meniscal transplant failure. Patients receiving a concomitant MAT exhibited lower self-reported function at return to sport compared with matched controls undergoing isolated ACL reconstruction; however, these differences were not present at 2 years. Clinicians should consider patient characteristics, self-reported function, and return-to-sport rates when counseling patients regarding ACL reconstruction with MAT.

Keywords: ACL reconstruction; meniscal transplant; return to sport; knee

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Meniscal injuries commonly occur in the setting of an anterior cruciate ligament (ACL) tear and often require surgical intervention to restore knee stability and prevent

further joint damage.[23,27] Given the prevalence of these injuries and an appreciation of the role of the menisci in patient function, evidence supports alternative treatment options when surgical repair of the meniscus is not a feasible option.[4] In the setting of irreparable meniscal injury or significant volumetric tissue loss, meniscal allograft transplantation (MAT) may be a viable option to restore knee stability, prevent further tissue damage, and mitigate or delay the need for joint arthroplasty.[3] The incidence rate for MAT has been estimated at 0.24 per 100,000 individuals, with the majority of these procedures performed in male patients younger than 35 years.[6] Despite the increasing use of the MAT procedure, few studies have examined the functional outcomes of these patients, especially in those receiving a concomitant ACL reconstruction. In addition, comparison studies are challenging to conduct because patients undergoing MAT often have complex medical histories and varied patient and surgical characteristics, making cohort matching difficult.

Overall improvements in self-reported function have been documented after MAT as evidenced by positive changes in International Knee Documentation Committee (IKDC) self-reported knee score, Lysholm score, Knee injury and Osteoarthritis Outcome Score, Western Ontario and McMaster Universities Arthritis Index, and visual analog scale scores.[1,12,14,17,20,25,26] Return-to-sport rates vary widely, ranging from 50% to 92% for individuals undergoing an isolated MAT or MAT with concomitant ACL reconstruction.[5,10,12,17,25] A meta-analysis reported a pooled return-to-sport rate of 77%,[10] whereas a case series reported a return-to-sport rate among professional soccer players of 92%.[12] Additional studies have reported a mean return-to-sport time of 7.6 to 16.5 months after a MAT procedure.[5,10,17,25]

The current literature is equivocal when evaluating objective functional outcomes after ACL reconstruction with MAT and sparse with respect to assessing return to sport among active cohorts. Specifically, only 2 studies have reported outcomes of MAT in higher level athletes with the intention of returning to their preinjury level of sport.[5,12] Common themes and limitations of the existing literature are small sample sizes, short follow-up periods, and a general lack of objective functional performance outcomes. Therefore, the purpose of this study was to compare patient outcomes using an objective functional performance battery, self-reported outcomes, and return-to-sport rates between individuals undergoing an ACL reconstruction with concomitant MAT and a matched group undergoing isolated ACL reconstruction. We hypothesized that patients undergoing ACL reconstruction with MAT would exhibit lower performance on objective functional performance tests, delayed time to return to sport, and lower return-to-sport rates when compared with those undergoing isolated ACL reconstruction.

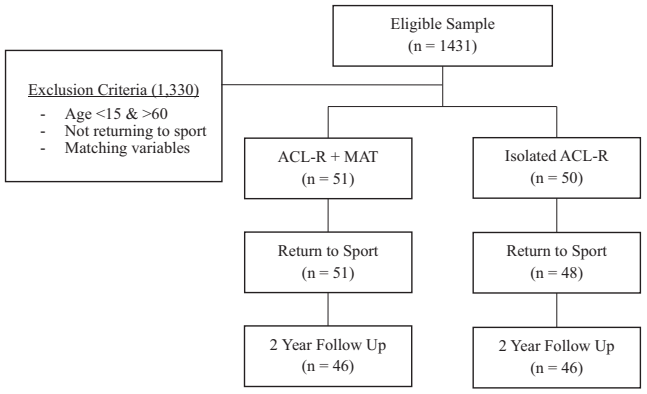

Figure 1. STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) outline for selection of individuals. ACLR, anterior cruciate ligament reconstruction; MAT, meniscal allograft transplant.

METHODS

Study Design

A matched case-controlled study was conducted in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines, approved by the University of Texas Health Sciences Center Institutional Review Board (HSC-MH-14-0734), and registered with ClinicalTrials.gov (NCT03704376). A single-surgeon database (N = 1431) was reviewed to identify patients who underwent ACL reconstruction between 2014 and 2019 (Figure 1). Eligible patients undergoing ACL reconstruction with MAT were between the ages of 15 and 60 and reported a goal of returning to sport after surgery. Patients receiving MAT had significant volumetric meniscal tissue loss, irreparable tear patterns, or chronic complex tears that were deemed appropriate for MAT by the treating surgeon. Patients were excluded if they had systemic vascular, neurological, or musculoskeletal disease or did not desire to return to sport. Patients who received a primary or revision ACL reconstruction with concomitant MAT were matched by age, sex, and revision status to patients who received an isolated ACL reconstruction.

†Address correspondence to Steven Higbie, PT, Memorial Hermann Rockets Sports Medicine Institute, Department of Sports Medicine & Rehabilitation, 6400 Fannin St., #1600, Houston, TX 77030, USA (email: steven.higbie@memorialhermann.org).
*Memorial Hermann Rockets Sports Medicine Institute, Department of Sports Medicine & Rehabilitation, Houston, Texas, USA.
‡McGovern Medical School at UT Health, Department of Orthopaedic Surgery, Houston, Texas, USA.
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Data Collection

Baseline patient characteristics included age, sex, body mass index (BMI), and Marx activity rating scale.[13] Surgical reports were reviewed to compare revision status, graft type, associated chondral injuries, and concomitant procedures. Patients presented for objective functional performance testing when they were seeking medical release to their desired sport and were at least 6 months after surgery. Outcomes collected at time of return to sport included passive knee range of motion (ROM), single-leg squat performance,[9,15] and 4 single-leg hop tests.[16] Three successive trials were completed on each limb and then averaged to calculate the limb symmetry index (LSI) (involved limb ÷ uninvolved limb). Components of the functional testing battery were deferred if the patient had not performed the task at the time of testing or did not desire to return to jumping or pivoting sports. All outcomes were collected by licensed physical therapists who completed reliability training and were selected for participation by the surgeon. Patients completed serial functional testing every 4 to 8 weeks until demonstrating >90% LSI for all appropriate tests and being released by the surgeon. Self-reported function at time of return to sport included the IKDC[11] and the ACL Return to Sports After Injury (ACL-RSI) psychological readiness scale.[24] Two-year injury surveillance and outcome tracking were conducted using electronic and telephone survey and included the Single Assessment Numerical Evaluation (SANE) score,[22] graft reinjury rate, and level of current sports participation.[7]

Surgical Procedure

The surgeon began MAT with a diagnostic arthroscopy before converting to an open procedure.[8,18] The procedure began with tibial preparation, ensuring that all native meniscus was debrided down to a 2-mm rim of tissue for suture capture. Preparation of the allograft specimen was completed on a separate table. Thawed, size-matched allografts were used with all excess capsular tissue removed, given that graft mismatch >5% can produce negative effects.[19,21] The meniscal allografts were fashioned with a bone plug that runs from the anterior to posterior meniscus horn insertion sites. This bone plug was shaped to correspond to a trough prepared in the recipient tibial plateau. The allograft specimen was then shuttled into place by sutures exiting via posterolateral or posteromedial knee incisions, depending on the side of the knee receiving the transplant. Final fixation of the allograft was secured via press-fit of the bone plug with interference screw as needed and a combination of suture anchors, zone-specific sutures, and all-inside sutures placed in a vertical mattress fashion from the periphery of the meniscus tissue to the joint capsule. Anatomic single-bundle ACL reconstruction was performed as previously described with patellar tendon autograft, free quadriceps tendon autograft, or an Achilles allograft.[2]

Postoperative Rehabilitation

Patients undergoing ACL reconstruction with MAT had protected weightbearing and flexion ROM for the first 4 weeks after surgery. Those in the isolated ACL reconstruction group were allowed immediate weightbearing and ROM as tolerated. Under the supervision of licensed physical therapists, all patients adhered to postsurgical protocols administered by the treating surgeon. Patients in the MAT group began jogging at 6 months after surgery as deemed appropriate by the treating surgeon and physical therapist. Return to sport and sport-specific progressions were initiated based on performance on the functional testing battery and surgeon approval.

Statistical Analysis

The study sample was assessed by examining previous work from Shelbourne and colleagues,[22] who reported SANE score outcomes for 11,939 patients after knee arthroscopy. Based on these results and a moderate effect size (d = 0.3), a 2-tailed a priori alpha level of .05, and power of 0.80 for 1-way analysis of variance, the estimated sample size was 45 participants per group, for a total of 90 patients. Case-control matching was conducted for age, sex, and revision setting using the ACL reconstruction with MAT group as the referent group. Fuzziness tolerances for each variable were as follows: age (2), sex (0), and revision setting (0). Between-group differences in baseline patient characteristics and surgical report information were assessed via independent t tests for continuous data and chi-square analysis for nonparametric data. Generalized linear models and nonparametric equivalents were used for all statistical comparisons. Statistical analyses were performed using SPSS Statistics (Version 24, IBM Corp) statistical software. A statistical level of significance of $\alpha < .05$ was used for all models.

RESULTS

Of the 1431 patients in the registry database, 46 patients were identified who underwent ACL reconstruction with concomitant MAT (38 medial MAT, 8 lateral MAT) (Figure 1) and were matched to a comparison group of 46 patients who underwent an isolated ACL reconstruction. Baseline demographic and surgical report data are shown in Table 1. Between-group differences existed, whereby the ACL reconstruction with concomitant MAT group had significantly lower body weight (P = .036) and a lower preinjury Marx score (P = .024). No significant differences existed between groups regarding ACL graft type.

Self-reported and objective functional performance outcomes at time of return to sport are reported in Table 2. At this time, the concomitant MAT group reported significantly lower IKDC scores compared with the isolated ACL reconstruction group (83.2 ± 12.6 vs 91.1 ± 11.3,

TABLE 1
Baseline Patient and Surgical Characteristics[a]

Characteristic	ACLR + MAT (n = 46)	Isolated ACLR (n = 46)	P
Age, y	31.2 ± 9.4	31.5 ± 9.1	.902
Female sex	14 (30.4)	14 (30.4)	≥.999
Height, cm	174.2 ± 9.9	175.8 ± 8.9	.518
Weight, kg	84.0 ± 14.1	93.2 ± 19.8	.036[b]
Body mass index	27.7 ± 5.4	30.2 ± 6.5	.057
Marx score (0-16)	4.8 ± 4.5	9.3 ± 4.1	.024[b]
Revision surgery, %	76.1	76.1	≥.999
Medial meniscal repair	NA	14 (30.4)	—
Lateral meniscal repair	NA	17 (37.0)	—
Medial meniscal transplant	38 (82.6)	NA	—
Lateral meniscal transplant	8 (17.4)	NA	—
Graft type, %			.249
Patellar tendon autograft	54.3	69.6	
Hamstring tendon autograft	6.5	13.0	
Quadriceps tendon autograft	23.9	15.2	
Achilles allograft	15.2	2.2	

[a]Data are reported as mean ± SD or frequency (%) unless otherwise noted. ACLR, anterior cruciate ligament reconstruction; MAT, meniscal allograft transplant; NA, not applicable.
[b]Significant at $P < .05$.

TABLE 2
Outcomes at Return to Sport[a]

Outcome	ACLR + MAT (n = 46)	Isolated ACLR (n = 46)	P
No. of months until release	10.0 ± 3.0	8.1 ± 2.5	.084
IKDC score (0-100)	83.2 ± 12.6	91.1 ± 11.3	.037[b]
ACL-RSI scale (0-100)	71.4 ± 15.7	80.2 ± 15.9	.181
Extension ROM deficit, deg	2.1 ± 1.9	2.0 ± 2.5	.920
Flexion ROM deficit, deg	5.2 ± 5.0	3.0 ± 5.0	.742
Single-leg squat symmetry, %	95.1 ± 5.7	95.9 ± 6.2	.839
Single-leg hop symmetry, %	93.5 ± 5.6	95.5 ± 7.0	.506

[a]Data are reported as mean ± SD. ACLR, anterior cruciate ligament reconstruction; ACL-RSI, ACL Return to Sports After Injury; IKDC, International Knee Documentation Committee; MAT, meniscal allograft transplant; ROM, range of motion.
[b]Significant at $P < .05$.

TABLE 3
Two-Year Outcomes[a]

Outcome	ACLR + MAT (n = 46)	Isolated ACLR (n = 46)	P
SANE score	87.8 ± 12.3	89.3 ± 11.4	.793
ACL graft reinjury (%)	6.5	2.2	.688
MAT reinjury (%)	0.0	—	—
Infection (%)	0.0	0.0	≥.999
Venous thrombosis (%)	0.0	0.0	≥.999
Anterior knee pain (%)	19.6	15.2	.635
Return to previous level of sport (%)	69.5	78.3	.026[b]
Level of sport (%)			.914
Level I	23.9	19.5	
Level II	19.6	26.1	
Level III	43.5	39.1	
No sport	13.0	15.2	

[a]Data are reported as mean ± SD or percentage. ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction; MAT, meniscal allograft transplant; SANE, Single Assessment Numerical Evaluation. Level 1, jumping, pivoting, hard cutting (basketball, football, soccer); Level II, lateral motion, less hard jumping than Level 1 (baseball, racket sports, skiing); Level III, Other sports (jogging, running, swimming).
[b]Significant at $P < .05$.

respectively; $P = .037$). No other significant between-group differences were found for time to return to sport (10.0 ± 3.0 vs 8.1 ± 2.5 months; $P = .084$), ACL-RSI scores ($P = .181$), knee ROM, single-leg squat LSI ($P = .839$), or single-leg hop for distance LSI ($P = .506$) for the concomitant MAT group compared with the isolated ACL reconstruction group, respectively.

Two-year follow-up outcomes are listed in Table 3. Patients who underwent ACL reconstruction with concomitant MAT reported significantly lower rate of return to previous level of sport versus the matched group undergoing isolated ACL reconstruction (69.5% vs 78.3%; $P = .026$). No significant between-group differences were found for SANE scores (87.8 ± 12.3 vs 89.3 ± 11.4; $P = .793$), current level of sports participation ($P = .914$), and ACL graft reinjury rates (3 [6.5%] vs 1 [2.2%]; $P = .688$).

DISCUSSION

Contrary to our hypotheses, patients undergoing ACL reconstruction with concomitant MAT did not demonstrate lower objective functional performance tests, delayed time to return to sport, or ability to return to level sports compared with their matched counterparts. Patients who received concomitant MAT exhibited lower rates of return to their previous level of sport; however, 87% of those patients were able to participate in some level of sports at 2 years.

Return-to-sport outcomes after ACL reconstruction with concomitant MAT have not been well established, with previous studies omitting the comparison of outcomes to a known group undergoing an isolated ACL reconstruction. This study demonstrated that individuals undergoing ACL reconstruction with MAT demonstrated similar return-to-sport timelines compared with those receiving an isolated ACL reconstruction (10.0 ± 3.0 vs 8.1 ± 2.5 months, respectively; $P = .084$). The MAT group demonstrated lower self-reported function (IKDC score) at the time of return to sport, although no differences were observed for psychological readiness or objective functional performance. At 2 years, the MAT patients reported lower rates of return to previous level of sports participation; however, these group differences were present before surgery as indicated by the baseline Marx scores, suggesting that matched individuals undergoing isolated ACL reconstruction had higher levels of preoperative function than those undergoing the combined procedure.

Significant demographic differences existed between groups, with the MAT group having lower body weight and reporting a lower preinjury Marx sport score. The mean age of 31.2 ± 9.4 years was similar to MAT cohorts in previously reported literature.[10,17,25] The release-to-sport timeline in this study aligns with a previously reported cohort of 18 athletes who had a mean return to

sport of 9.1 months[17] and with the pooled return-to-sport time of 9.2 months in a recent meta-analysis of MAT patients.[10] Those in the MAT group also demonstrated a significantly lower rate of return to previous level of sport than the group undergoing isolated ACL reconstruction (69.5% vs 78.3%, respectively). The return-to-sport rate in this study is within a previously reported range of 50% to 92%[5,12,17,25] and slightly lower than the pooled return-to-sport rate of 77% from a recent meta-analysis.[10]

At time of return to sport, the MAT group reported significantly lower self-reported function, although the between-group differences for the IKDC scores did not exceed the previously reported minimal clinically important differences.[14] The IKDC scores for the MAT group, although significantly lower than those in the isolated ACL reconstruction group, were higher than those reported in previous studies.[5,12] No between-group differences existed regarding psychological readiness, ROM, single-leg squat performance, or single-leg hop performance. At 2-year follow-up, participants in the MAT group reported similar SANE scores to the ACL reconstruction group. No significant differences existed between groups for ACL graft reinjury or current level of sports participation. The results of this study indicate that individuals receiving MAT are likely to be able to return to at least level III[7] sports within 2 years of surgery with low risk of ACL graft failure. Additionally, inherent demographic and baseline characteristic differences likely exist between individuals receiving an isolated ACL reconstruction versus those receiving an ACL reconstruction with MAT, which could affect postoperative rehabilitation and return to sport. Surgeons should consider these factors when counseling patients regarding ACL reconstruction with concomitant MAT.

Limitations

Limitations of this study include its retrospective design and exclusion of patients who did not desire to return to sport, as these factors carry potential for selection bias. Future studies comparing similar populations may consider matching based on graft type, preinjury Marx scores, or BMI or subgrouping MAT patients based on transplant location (medial, lateral, both); however, controlling for these variables may be difficult because the sample size required to perform these matching procedures would be substantial. Postoperative Marx scores were not collected, which may have influenced the outcome scores and reinjury risk. Last, because few long-term comparison studies exist, assessing patient timelines further out than 2 years may provide additional clarity regarding long-term outcomes of these procedures.

CONCLUSION

The majority of patients (87%) undergoing ACL reconstruction with concomitant MAT were able to return to some level of sports participation at 2 years with a low risk of revision ACL reconstruction or meniscal transplant failure. Patients receiving a concomitant MAT exhibited lower self-reported function at return to sport compared with matched controls undergoing isolated ACL reconstruction; however, these differences were not present at 2 years. Clinicians should consider patient characteristics, self-reported function, and return-to-sport rates when counseling patients about ACL reconstruction with MAT.

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