Clinical Outcome of Revision Meniscal Allograft Transplantation: Minimum 2-Year Follow-up

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Purpose: The purpose of this study was to assess the clinical and radiographic outcomes after revision meniscal allograft transplantation (RMAT). **Methods:** Eleven patients underwent RMAT performed by the senior author (B.J.C.). These patients were studied prospectively and completed standardized outcome surveys (including International Knee Documentation Committee [IKDC], Cincinnati Knee-Rating System, Tegner score, Lysholm score, Short Form-12, Knee Injury and Osteoarthritis Outcome Score [KOOS], and overall satisfaction) preoperatively and annually thereafter for a minimum of 2 years. Radiographic analysis before surgery and at the most recent follow-up included anteroposterior, Rosenberg, lateral, and sunrise views graded by the Kellgren and Lawrence (K & L) scale. The status of the articular cartilage was graded intraoperatively using the Outerbridge classification. Two patients were lost to follow-up and one declined further participation. **Results:** The average time to RMAT from the index procedure was 3.45 ± 2.52 years, with a mean follow-up after RMAT of 3.83 ± 1.3 years. One patient progressed to arthroplasty during follow-up and was not included in subjective outcome score follow-up. Clinical outcome scores that demonstrated significant improvements included IKDC (43 ± 12 to 61 ± 16; $P = .03$) and KOOS pain score (66 ± 12 to 79 ± 11; $P = .047$). Along with this, the subjective symptom rate significantly improved from 5.0 ± 0.9 preoperatively to 6.7 ± 1.8 postoperatively ($P = .011$). Radiographic ($P = .7$) and Outerbridge ($P = .809$) grading did not show progression. Seven of 8 patients would have surgery again, and satisfaction at final follow-up was 7.6 ± 2.6. **Conclusions:** In this small series with short-term follow-up, RMAT resulted in high patient satisfaction and significant symptom reduction on validated outcome scores (IKDC and KOOS pain score), proving the original hypothesis that outcomes after RMAT would be improved compared with preoperative conditions. Identifiable causes of MAT failure may help predict response to RMAT. Because arthroplasty is still not favored in young active patients, a thorough discussion with the patient is necessary to best align their goals with those of the surgery when considering revision meniscus transplantation. **Level of Evidence:** Level IV, therapeutic case series.

Some meniscal tears are irreparable and are thus treated with meniscectomy to alleviate mechanical and inflammatory symptoms.[1-5] Patients may experience recurrent effusions, pain, and subjective instability, which has been referred to collectively as the post-meniscectomy syndrome.[1]

Meniscal allograft transplantation (MAT) has been shown to result in significant symptomatic improvement at short-term and midterm follow-up in this setting.[1,2,4-7] However, 6% to 16% of these patients fail to achieve lasting clinical success after MAT because of acute failure or chronic graft degeneration. Residual pain, swelling, mechanical symptoms, and limitation in activity can be significantly disabling for these patients.[8-12] If the source of failure seems identifiable and can be addressed surgically (e.g., acute graft rupture, concomitant focal chondral damage, misalignment), these patients may be candidates for revision MAT (RMAT). The purpose of this study was to assess the clinical and radiographic outcomes after RMAT, with a case-by-case analysis of factors thought to contribute to failure or success. We hypothesized that outcomes after RMAT would be improved compared with preoperative conditions.

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Methods

Patient Enrollment and Follow-up

After Rush University Institutional Review Board approval, (IRB No. 09090306), all patients undergoing MAT, either primary or revision, underwent an informed consent process and were followed as part of a prospective database of cartilage restoration procedures. Inclusion criteria included skeletally mature patients who underwent RMAT and had radiographic and outcome scores available at a minimum follow-up of 2 years. Although all revision procedures were performed by the senior author (B.J.C.), 2 of the primary MAT procedures (including the patient who progressed to total knee arthroplasty) were initially performed at outside institutions. Exclusion criteria included follow-up less than 2 years after RMAT. Patients who underwent concomitant procedures—including cartilage restoration, ligamentous reconstruction, or realignment osteotomies—were included. Patients in whom RMAT failed and who underwent knee arthroplasty were considered failures and were not included in the outcome score analysis. Data collected preoperatively and at final follow-up included physical examination and several standardized outcome scores, including International Knee Documentation Committee (IKDC, subjective portion),[13] Cincinnati Knee-Rating System (subjective portion),[14] Tegner score,[15] Lysholm score,[16] 12-question Short-Form quality of life score (SF-12) with both the physical component summary and mental component summary, and Knee Injury and Osteoarthritis Outcome Score (KOOS).[17] These scoring systems were administered using a paper questionnaire. Physical examination was performed by the senior author for all patients. They were also asked whether or not they would undergo surgery again if given the chance. Standard radiographs included a weight-bearing bilateral anteroposterior view, an anteroposterior 45° flexion (Rosenberg) view, a sunrise view, and a lateral view.[18] These radiographs were graded using the Kellgren and Lawrence (K & L) scale for osteoarthrosis (grade 1: osteophyte formation at the tibial spine; grade 2: periarticular osteophyte formation; and grade 3: joint space narrowing and sclerosis; grade 4: subchondral cysts and increased sclerosis and narrowing).[19] Comparisons between preoperative and postoperative imaging were performed using the radiographic view, which showed the higher K & L grade when comparing the AP and Rosenberg views. Similarly, the narrowest point between the tibia and femur in the affected compartment was measured using a digital caliper and was compared before and after surgery. Evaluation of radiographs was performed in a blinded manner by an orthopaedic surgery sports medicine trained fellow (A.B.Y.) and senior orthopaedic surgery resident (P.N.C.). The status of the articular cartilage was graded intraoperatively using the Outerbridge classification (grade 1: chondral softening; grade 2: fragmentation and fissuring <0.5-inch diameter; grade 3: fragmentation and fissuring >0.5-inch diameter; and grade 4: exposed subchondral bone).[20]

Surgical Planning, Technique, and Rehabilitation

All transplant procedures were performed with a bridge-in-slot technique with fresh-frozen nonirradiated menisci.[3] The sizing protocol and operative technique were similar to those used for primary MAT and have been previously described by Pollard et al.[21] and Cole et al.,[6] respectively. The postoperative rehabilitation protocol used after RMAT is similar to that used for primary MAT, and has been previously described by Cole et al.,[6] with a 6-week period of protected weight bearing, maximum flexion of 90°, heel slides, quadriceps sets, and straight leg raises. This is then advanced to full weight bearing, closed chain strengthening, and progression to sport-specific activities by 3 months and full training by 4 months postoperatively, with alterations to account for combination procedures as necessary.

Statistical Analysis

Statistical analysis was performed using PASW Statistics for Windows, version 18.0 (SPPS, Chicago IL). Descriptive analysis included means and standard deviations. Analysis of descriptive and continuous variables was performed using the Wilcoxon and paired *t* tests, respectively. $P < .05$ was deemed significant. A post hoc power analysis was performed using the IKDC outcomes data, and with a sample size of 7 our achieved power was 76%.

Results

Eleven patients met inclusion criteria, 2 of whom were lost to follow-up (2-year follow-up data not available) and one who declined further participation in the study. The remaining patients yielded a 73% follow-up rate and included 3 men and 5 women with a mean age of 31.6 ± 10.2 years with 6 lateral and 2 medial menisci involved (Table 1). The average time to RMAT from the index procedure was 3.45 ± 2.52 years (range, 1.2 to 9 years). Mean follow-up after RMAT was 3.83 ± 1.3 years (range, 2 to 5.85 years). The single patient who progressed to total knee arthroplasty (patient 4) was considered a clinical failure and is included in demographic analysis but not in clinical outcomes because of cross-over. Patient 4 underwent total knee arthroplasty at 34 months after RMAT. The Cincinnati Knee-Rating System score ($P = .514$), Tegner score ($P = .488$), Lysholm score ($P = .168$), SF-12 physical component score ($P = .358$), SF-12 mental component score ($P = .395$), and KOOS symptom ($P = .873$), daily living ($P = .221$), sport ($P = .140$), and quality of life

Table 1. Demographic Data, Outerbridge Grading, Kellgren & Lawrence (K & L) Grading, Concomitant Procedures, and Reason for Failure for Each Patient

Patient Number	Sex	Age, y	Side	Compartment	MAT to RMAT, mo	Concomitant Procedures	Outerbridge at RMAT	Reason for Failure	Status of Graft at Time of RMAT
1	Male	45	Left	Lateral	28	—	NA	Acute	Bucket handle tear
2	Male	36	Left	Medial	41	ACLR	2 (OA graft)	Chronic Instability (ACL)	Degenerated
3	Female	18	Right	Lateral	14	—	3	Acute	Torn and incorporated
4	Male	46	Right	Lateral	26	—	2 (OA graft)	Arthritic compartment	Degenerated
5	Female	21	Right	Lateral	54	DFO	4	Arthritic compartment and malalignment	Maceration of incorporated graft because of OA
6	Female	30	Right	Lateral	16	OA graft LFC	4	Arthritic compartment	Extensive degeneration
7	Female	31	Left	Medial	108	—	2	Unknown	Idiopathic degeneration of incorporated graft
8	Female	26	Left	Lateral	44	OA graft LFC	3	Ipsilateral femoral condyle degeneration	Torn and incorporated
Total	3 Male/ 5 Female	31.6 ± 10.2	4L,4 R	6 lateral, 2 medial	41.3 ± 30.3	—	—	—	—

NOTE. When appropriate, totals are reported as mean ± standard deviation.

ACLR, anterior cruciate ligament reconstruction; DFO, distal femoral osteotomy; LFC, lateral femoral condyle; MAT, meniscal allograft transplantation; NA, not available; OA, osteoarticular; RMAT, revision allograft meniscal transplantation.

scores (P = .232) did not show improvement with RMAT (Table 2), However, the IKDC score (43 ± 12 to 61 ± 16; P = .03) and the KOOS pain score (66 ± 12 to 79 ± 11; P = .047) showed significant improvements. The subjective symptom rate was significantly improved from 5.0 ± 0.9 preoperatively to 6.7 ± 1.8 postoperatively (P = .011).

The average K & L grades before RMAT (2.6 ± 1.14) and at final follow-up (2.68 ± 1.03) were not statistically different (P = .7) Patients 4 and 8 showed radiographic progression, whereas patients 5 and 6 improved postoperatively (Fig 1). Overall, the amount of joint space remaining after RMAT was insignificant (4.5 ± 3.2 to 5.0 ± 2.6 mm; P = .80). The average Outerbridge grade at initial MAT and at RMAT was 3.0 ± 0.9 and 2.8 ± 1.0, respectively (P = .809).

Postoperatively, 7 of 8 patients said that given the opportunity they would still have undergone RMAT, including patient 4 who progressed to arthroplasty at final follow-up. Two patients were completely satisfied and 6 patients were mostly satisfied. On a 10-point scale, mean satisfaction at final follow-up was 7.6 ± 2.6.

Individual Case Analysis

A summary of the clinical course of each patient is presented in Table 1. Of the 8 patients with clinical follow-up, treatment failed in 2 patients because of acute trauma, treatment failed in one patient failed because of chronic instability (anterior cruciate ligament [ACL]), treatment failed in 2 patients because of an arthritic compartment (lateral in both cases) (Fig 2), treatment failed in one patient because of a combination of malalignment and an arthritic compartment (lateral), treatment failed in one patient because of isolated femoral condyle degeneration (lateral), and treatment failed in one patient for unknown reasons. This last patient initially underwent medial MAT, followed by ipsilateral-compartment autologous chondrocyte implantation 2 years later. She did well for 7 years, when she presented to our office with insidious-onset pain and swelling over several months. Magnetic resonance imaging (MRI) showed shrinkage and degeneration of the graft, whereas radiographs showed K & L grade 1. Being 31 years of age, the patient elected to undergo RMAT, and a degenerative MAT with minimal Outerbridge changes was found (Fig 3). She has not experienced any recurrence of her symptoms 3.5 years after revision and was entirely satisfied with her surgical result. In this case, the cause of failure was felt to be idiopathic biological degeneration of the graft.

Patient 9 was lost to follow-up; however, he was considered a clinical failure based on the most recent information available. Before RMAT, this patient was found to have K & L grade 2 changes in the medial

Table 2. Outcomes Before and After Revision for Each Patient

Patient No.	Follow-up After RMAT, mo	K & L Before	K & L After	IKDC Before	IKDC After	Cincinnati Knee-Rating System Before	Cincinnati Knee-Rating System After	Lysholm Before	Lysholm After	Tegner Before	Tegner After	KOOS Before*	KOOS After*	SF-12 Before†	SF-12 After†	Surgery Again?
1	66	NA	NA	53	76	90	90	62	90	9	9	69	83	49	45	Yes
2	46	3	NA	45	44	40	40	46	43	3	3	64	81	38	34	Yes
3	39	3	3	29	44	0	20	31	44	0	2	64	61	49	34	Yes
4	34 until TKA	3+	4	–	–	–	–	–	–	–	–	–	–	–	–	Yes
5	70	4	3	60	70	40	75	71	72	3	6	83	86	50	48	Yes
6	45	3+	2	47	45	20	20	37	38	2	2	67	67	34	29	No
7	44	1	1	33	72	90	20	20	95	9	2	44	86	43	48	Yes
8	34	2	2+	32	77	90	20	73	81	9	2	69	89	46	46	Yes
Totals	47.0 ± 13.6	2.6 ± 11.14	2.67 ± 1.03	43 ± 12	61 ± 16	53 ± 37	41 ± 30	49 ± 12	66 ± 24	5 ± 4	4 ± 3	66 ± 12	79 ± 11	44 ± 6	41 ± 8	
P Value		.48		**.031**		.514		.168		.488		**.047**		.358		

NOTE. Totals are given as mean ± standard deviation. Values in bold are statistically significant ($P < .05$).

IKDC, International Knee Documentation Knee subjective score; K & L, Kellgren and Lawrence; KOOS, Knee Injury Osteoarthritis Outcome Score; NA, not available; RMAT, revision allograft meniscal transplantation; SF-12, Short Form-12; TKA, total knee arthroscopy.

*KOOS pain.

†SF-12 physical.

compartment, 6° of varus, and MRI evidence of anterior horn extrusion. The patient declined arthroplasty at 46 years of age and underwent RMAT. Intraoperative findings at RMAT showed mild femoral condyle cartilage thinning and anterior horn changes possibly caused by MAT malposition. At 6-month follow-up, the patient was considered a clinical failure because he continued to have debilitating knee pain preventing him from returning to work, and the patient was referred for arthroplasty consultation. Failure in this case was likely caused by multiple factors, including Workers Compensation and radiographic arthritis.

Discussion

At a mean of 3.8 years of follow-up, 7 of 8 patients were completely or mostly satisfied and would undergo the procedure again. The most significant subjective improvements in validated outcomes scores occurred in IKDC scores and KOOS pain scores. Along with this, symptom rate scores showed significant improvement. The subjective symptom rate and KOOS pain index may be more sensitive indicators of knee symptoms than the remainder of the measured validated outcome sores in this population with multiply-operated knees and baseline knee discomfort. Although subgroup analysis was not possible, patients with a successful interval after MAT and an identifiable cause of MAT failure (e.g., trauma, malalignment, ACL failure) appeared to respond more favorably to RMAT. In this case, if one of the concomitant procedures was not successful at the time of MAT (ACL repair, MAT, cartilage procedure, osteotomy), the transplantation was less likely to be successful.[22,23]

Radiographic evidence of arthritis before RMAT did not directly correlate with final patient outcome. Generally, MAT is performed with the goal of preventing arthritis and alleviating symptoms; however, radiographic evidence of arthritis tends to progress.[24] In this cohort, most patients had the same or slightly worse K & L grade, whereas one patient improved. Although generally there was no significant change in K & L grading, others have shown that graft status does not correlate with radiographic or MRI appearance.[25] Although direct conclusions cannot be drawn from this study, RMAT in the setting of grade 3 or 4 K & L changes should be approached with caution.

To our knowledge, this series represents the first clinical series of patients undergoing RMAT. Although numerous authors have reported results of primary meniscus transplantation, none has included solely patients who have undergone revision transplantation.[6,9,26-28] In their series of 40 patients who underwent MAT, LaPrade et al.[29] reported on 3 patients who had undergone previous transplantation but did not subdivide this group to report their outcomes. Stone et al.[30] reported performing RMAT in 8 patients in their

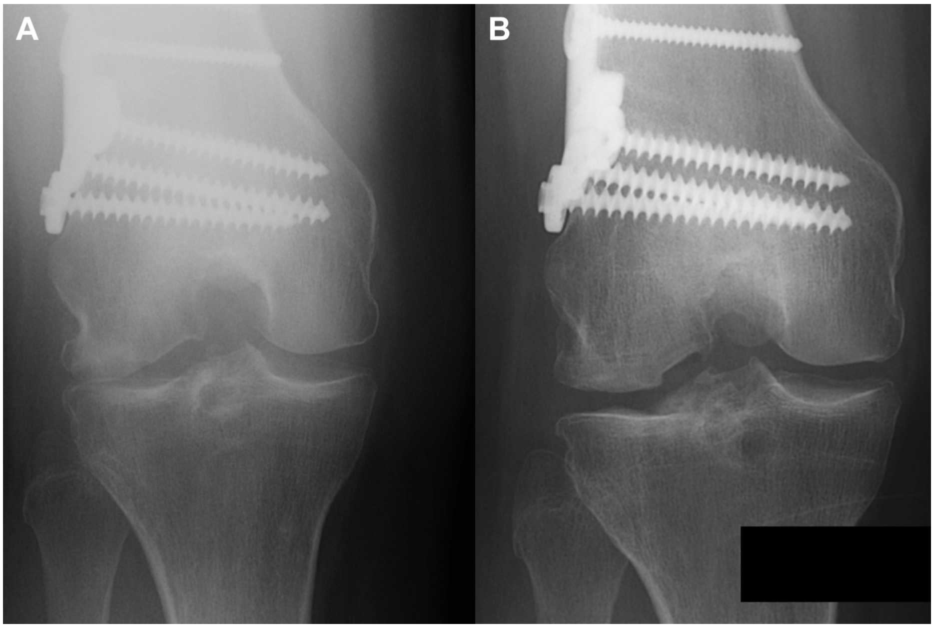

Fig 1. (A) Preoperative and (B) postoperative radiographs of the right knee of patient 6 showing radiographic improvement after revision meniscus transplantation, although this patient would not choose to undergo surgery again.

series of 118 MAT procedures, 6 of which were performed within "the early postoperative period at a mean of 7 months." Of these 8 patients, 3 required further surgery, including a second RMAT, one allograft removal, and one arthroplasty, with the remainder considered clinical successes by the authors. Comparison between our series and this clinical series may not be valid given the extensive preoperative chondral damage in these patients, the large number of patients who underwent concomitant cartilage paste grafting, and the difference in clinical decision making given the number of revisions within 1 year of primary transplantation.

Limitations

There are several limitations to our study. Our small sample size (3 of 11 patients were lost to follow-up) limits the generalizability of our results and increases the likelihood of type II error within those outcome variables in which there was no significant difference. However, because significant differences were found in several outcome variables, the study is not statistically underpowered. Although our follow-up period is similar to that of other studies, extended follow-up would be useful to determine long-term results and the ability to postpone arthroplasty.[26,28,31] In addition, several of these patients presented with concomitant

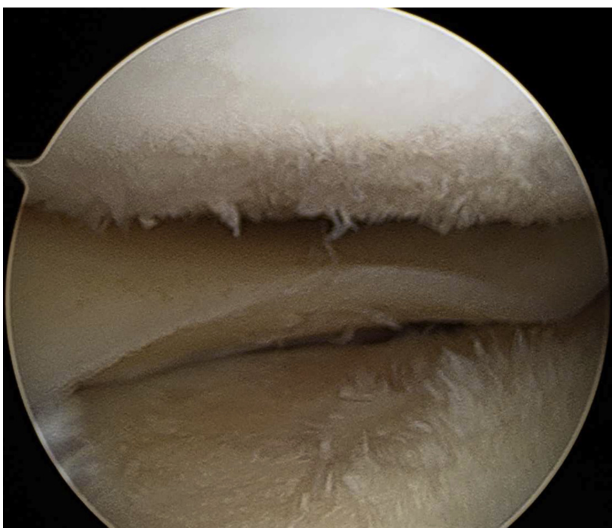

Fig 2. Arthroscopic image of incorporated right lateral meniscal allograft transplantation (MAT) with concomitant diffuse tibial and femoral chondral damage.

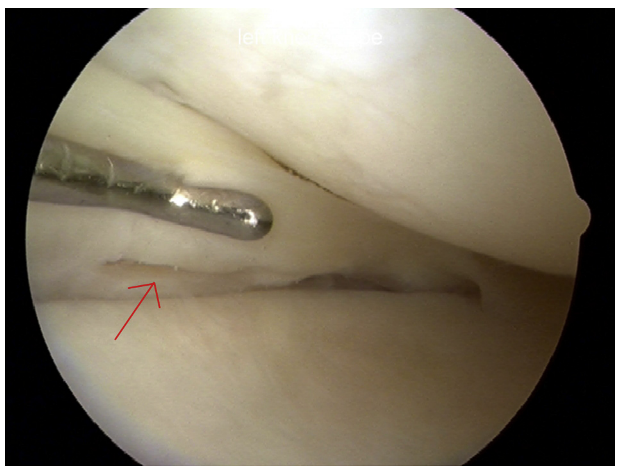

Fig 3. Arthroscopic image of incorporated left medial meniscal allograft transplantation (MAT) with subsequent graft shrinkage, biological degeneration, and undersurface tears (red arrow).

ligamentous and cartilaginous pathologic conditions, which also limits comparability between our patient population and other patient populations. However, most of the studies examining MAT include patients with multiple knee comorbidities requiring concurrent intervention.[9,29,32] Our study is also limited by the lack of follow-up with either advanced imaging (including MRI) or second-look arthroscopy. As a result, we are unable to comment on the pathologic status of the transplanted menisci in these cases, only on the clinical symptoms of these patients. However, numerous studies show that MRI evidence of graft extrusion or shrinkage does not correlate with patient symptom rate.[33-35]

Conclusions

In this small series with short-term follow-up, RMAT resulted in high patient satisfaction and significant symptom reduction on validated outcome scores (IKDC and KOOS pain), proving the original hypothesis that outcomes after RMAT would be improved compared with preoperative conditions. Identifiable causes of MAT failure may help predict response to RMAT. Because arthroplasty is still not favored for young active patients, a thorough discussion with the patient is necessary to best align their goals with those of the operation when considering revision meniscus transplantation.

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