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Survival and Reoperation Rates After Meniscal Allograft Transplantation

Analysis of Failures for 172 Consecutive Transplants at a Minimum 2-Year Follow-up

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Background: Meniscal allograft transplantation (MAT) is a treatment option for knee pain in young patients with meniscal deficiency in the setting of intact articular surfaces, ligamentous stability, and normal alignment. It is being performed with increasing frequency, and the need for reoperations is not uncommon. A mean survival rate of allografts and indications for reoperations would be helpful information when counseling patients regarding the procedure.

Purpose/Hypothesis: The purpose of this study was to quantify survival for MAT and report findings at reoperation. The hypothesis was that the reoperation rate would be frequent and that the most common secondary surgery would be arthroscopic debridement.

Study Design: Case series; Level of evidence, 4.

Methods: A retrospective review of a prospectively collected database of patients who underwent MAT from 2003 to 2011 was conducted; all surgeries were performed by a single surgeon. The reoperation rate, timing of reoperation, procedure performed at reoperation, and findings at surgery, including the status of the meniscal and articular cartilage, were reviewed. Survival was defined as a lack of revision MAT or knee arthroplasty. Descriptive statistics, log-rank testing, cross-tabulation, and χ^2 testing were analyzed, with an α value of .05 set as significant.

Results: Of 200 patients who underwent MAT during the study period, 172 patients (86%; mean age, 34.3 $\pm$ 10.3 years) were evaluated at a mean of 59 months (range, 24-118 months) with a minimum 2-year follow-up. Forty-one percent of MATs were isolated, while 60% were performed with concomitant procedures. Sixty-four patients (32%) returned to the operating room after their index procedure. Arthroscopic debridement was performed in 59% (38/64) of these patients. The mean time to subsequent surgery was 21 months (range, 2-107 months), with 73% occurring within 2 years. Eight of 172 patients (4.7%) went on to require revision MAT or total knee replacement. Patients requiring secondary surgery within 2 years had an odds ratio of 8.4 (95% CI, 1.6-43.4) for future arthroplasty or MAT revision (P = .007).

Conclusion: In this series, there was a 32% reoperation rate for MAT, with simple arthroscopic debridement being the most common surgical treatment (59%), and a 95% allograft survival rate at a mean of 5 years. Those requiring additional surgery still benefited, having an 88% allograft survival rate, but were at an increased risk of failure. Patients requiring secondary surgery within 2 years had an odds ratio of 8.4 for future arthroplasty or MAT revision.

Keywords: meniscal allograft transplantation; survival analysis; reoperation rates; knee

The meniscus is a critical structure for proper function of the knee. It serves to distribute loads along the cartilage, provide shock absorption, and improve joint stability.[1,17] Removal of meniscal tissue, such as in the setting of an irreparable tear, may compromise these functions and lead to dysfunction and pain in the short term and osteoarthritis in the long term.[18]

For young, active patients with meniscal deficiency, meniscal allograft transplantation (MAT) is a treatment option that has been shown to improve pain and function.[16] Numerous case series demonstrate good to excellent results at short-term and midterm follow-up,[10-12,16] with 70% of transplants surviving for longer than 10 years.[21] In 1 study, MAT was reported to halt the progression of cartilage destruction in 30% to 40% of patients.[22] It may be performed in isolation or in conjunction with cartilage

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procedures such as autograft or allograft transplantation and/or realignment procedures.[4]

A recent meta-analysis, however, demonstrated a high reoperation rate for patients undergoing biological knee reconstruction, including MAT, where up to 50% required at least 1 follow-up surgery.[6] The indications, operative findings, treatments, and prognoses for secondary surgery after MAT are not well characterized. Thus, the purpose of this study was to determine the survival rate of MAT in a large cohort of patients as well as to characterize procedures and findings at reoperation.

MATERIALS AND METHODS

After receiving institutional review board approval, we conducted a retrospective review of prospectively collected data for patients undergoing MAT (in isolation or in combination with cartilage repair or regeneration techniques and bony realignment procedures) from January 2003 to April 2011, as performed by the senior author (B.J.C.). Each patient's medical records were reviewed, and patients were contacted by telephone or letter to encourage follow-up for the purpose of this study. Patients undergoing subsequent surgery after MAT were identified. An orthopaedic surgeon reviewed the operative report and clinic notes and classified the indication, operative findings, and treatment rendered. Changes evaluated as diffuse Outerbridge grade $\geq$3 lesions were a contraindication to inclusion.

Subsequent surgery was defined as any subsequent surgical procedure on the operative knee[5,8]; this included surgical debridement, manipulation under anesthesia, revision MAT, or knee arthroplasty. Subsequent surgery indications were characterized as (1) debridement, scar excision, or manipulation under anesthesia; (2) progressive disease treated within the same compartment; (3) progressive disease treated in a different compartment; (4) graft failure that required resection of less than 50% or meniscal re-repair; (5) revision MAT; (6) second-look arthroscopic surgery or surgical indication for a reason other than joint-related issues; or (7) knee arthroplasty. Concomitant procedures were classified as (1) isolated MAT; (2) MAT with a cartilage procedure (microfracture, drilling, abrasion arthroplasty, autologous chondrocyte implantation [ACI], cartilage autograft implantation system, DeNovo NT natural tissue graft (Zimmer, Warsaw, Indiana, USA), osteochondral allograft, or osteochondral autograft/mosaicplasty); (3) MAT and a cartilage procedure with osteotomy (distal femoral osteotomy or high tibial osteotomy); (4) MAT with anterior cruciate ligament (ACL) reconstruction (bone-tendon-bone allograft using an anatomic technique); and (5) MAT with osteotomy. Alignment was assessed preoperatively with weightbearing double-stance long-leg axis radiographs. The time from transplantation to subsequent surgery was defined in months.

Surgical Technique

The MAT procedure was performed with a bridge-in-slot technique[2] with the exception of patients undergoing ACL reconstruction, in which case the bone slot was modified to facilitate ACL graft passage. In these instances, the tibial and femoral tunnels for the ACL graft, as well as the meniscal slot on the tibia, were drilled. Graft placement occurred in a sequential fashion, with femoral tunnel fixation of the ACL graft performed first, followed by meniscal transplantation, and then by tibial fixation of the ACL graft. Fixation of the ACL on the tibial side as the last step allowed for maximum separation of the tibiofemoral joint during MAT. In all cases, the meniscal allograft was sized according to a previously published protocol.[20] In all cases, fresh-frozen, nonirradiated meniscal allografts were used. In cases with concomitant osteotomy, osteotomy was performed immediately after MAT to protect the procedure from the abduction/adduction movements required during the meniscal transplantation procedure. The goals of correction were to restore alignment to neutral.

Rehabilitation Protocol

The postoperative rehabilitation protocol consisted of a 4- to 6-week period of protected weightbearing in a hinged knee brace, followed by progression to full weightbearing thereafter. Early weightbearing range of motion (0°-90° until 6 weeks after surgery and then as tolerated) was allowed. When warranted, patients progressed to sport-specific activities by 4 to 6 months after surgery for isolated MAT and by 8 to 12 months for those undergoing concomitant procedures.

Statistical Analysis

Reporting of data utilized descriptive statistics, and data are reported as mean $\pm$ standard deviation. A Kaplan-Meier survival analysis was performed with survival defined as the absence of revision MAT or knee arthroplasty. The analysis assumed a nonparametric distribution of time-dependent survival, similar behavior between cases that were performed at different time periods, and similar survival behavior between censored (patients not yet met the endpoint of failure) and uncensored patients (those who met failure criteria). A comparison of survival between medial, lateral, and bicompartmental meniscal transplantation was conducted via the log-rank test.

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TABLE 1
Patient Demographics[a]

	Surgical Cohort (N = 200)	Subsequent Surgery Cohort (n = 64)	Revision or TKA Cohort (n = 8)
Age, mean ± SD, y	34.3 ± 10.3	34.3 ± 10.6	37.9 ± 10.8
Female sex, %	50	50	50
BMI, mean ± SD, kg/m^2	25.0 ± 3.4	26.1 ± 4.7	26.7 ± 3.2
WC status, %	10	20	16
Medial laterality, %	57	67	50

[a]There was no statistical difference between cohorts with regard to age, sex, body mass index (BMI), workers' compensation status, or laterality. TKA, total knee arthroplasty.

TABLE 2
Distribution of Concomitant Procedures Performed (n = 119 Patients)[a]

Procedure[b]	Patients, n (%)
Isolated MAT	81 (41)
MAT with a cartilage procedure	74 (37)
MAT, cartilage procedure, and osteotomy	14 (7)
MAT with ACL reconstruction	23 (11)
MAT with osteotomy	8 (4)

[a]ACL, anterior cruciate ligament; MAT, meniscal allograft transplantation.
[b]Cartilage procedure defined as microfracture, drilling, abrasion arthroplasty, autologous chondrocyte implantation, cartilage autograft implantation system, DeNovo NT natural tissue graft, osteochondral allograft, or osteochondral autograft/mosaicplasty; osteotomy included distal femoral osteotomy or high tibial osteotomy; ACL reconstruction defined as bone-tendon-bone allograft.

Odds ratios were obtained using cross-tabulation, and a 2-tailed Fisher exact probability test was performed to assess statistical significance. A statistical analysis was performed with SPSS software for Windows (version 8.0, SPSS, Chicago, Illinois, USA). An α value of .05 was set as significant.

RESULTS

From January 2003 to April 2011, a total of 200 patients underwent MAT. The mean age of the patients was 34.3 ± 10.3 years (range, 16-56 years). Eighty-one patients (41%) had isolated MATs, while 119 (60%) underwent concomitant procedures at the time of transplantation; 127 underwent medial, 71 underwent lateral, and 2 underwent bicompartmental MAT. Demographics are listed in Table 1, and the distribution of concomitant procedures is listed in Table 2. Of the initial 200 patients, 172 (86%) completed clinical follow-up at a mean of 59 months after surgery (range, 24-118 months) (Figure 1).

Sixty-four patients (32%) returned to the operating room after the index procedure. The majority of subsequent surgeries (44/64; 69%) were for debridement or hardware removal. The mean time to subsequent surgery was 21 months (range, 2-107 months), with 40% occurring within the first year and 73% within 2 years (Figure 2).

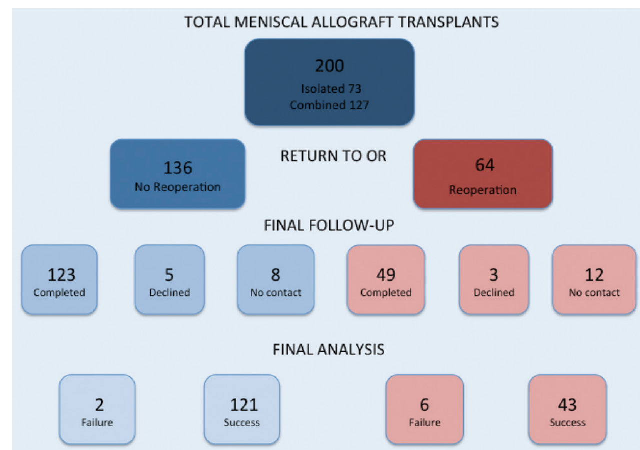

Figure 1. Flow diagram of patient status after undergoing meniscal allograft transplantation (MAT). Of 200 eligible patients, 172 (86% follow-up rate) were evaluated at a mean of 59 months (range, 24-118 months). Eight patients (4.7%) went on to meet surgical failure criteria and require revision MAT or total knee replacement. OR, operating room.

The operative findings at the secondary surgical procedure are listed in Table 3. Eight of 172 patients (4.7%) were considered failures and went on to require revision MAT or total knee replacement within the follow-up period. A survival analysis after MAT is illustrated in Figure 3. There was no difference in survival between medial, lateral, or bicompartmental MAT (P = .6180) (Figure 4).

Those who required subsequent surgery were still likely to retain the transplant survival rate with an 88% chance of success. However, compared with the patients who did not require an additional surgical intervention, whose transplant survival rate was over 98%, patients requiring subsequent surgery within 2 years had an odds ratio of 8.4 (95% confidence interval, 1.6-43.4) for future revision MAT or arthroplasty (P = .007).

DISCUSSION

The purpose of this study was to review a consecutive case series to determine the survival rate of meniscal allografts and to provide more detail regarding reasons for a return

TABLE 3
Secondary Procedures After MAT (n = 64 Patients)[a]

Secondary Procedure	Patients, n (%)
Debridement, scar excision, MUA	38 (59)
Treatment of progressive disease	
Same compartment	9 (14)
Different compartment	2 (3)
Meniscal graft repair or debridement of <50% removal	3 (4)
Revision MAT	4 (6)
Second-look arthroscopic surgery (reason other than joint)	3 (4)
Total knee replacement	4 (6)

[a]Debridement was the most common procedure performed. A small distribution of patients had progression of disease (same or other compartment) or graft failure. A smaller portion underwent second-look arthroscopic surgery at the time of hardware removal. Percentages do not equal 100 because of rounding. MAT, meniscal allograft transplantation; MUA, manipulation under anesthesia.

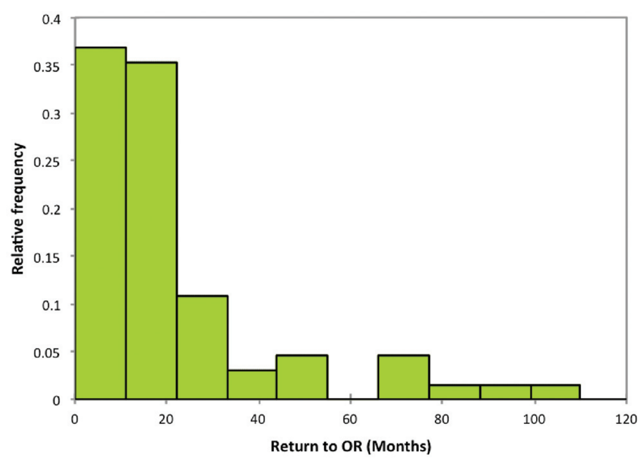

Figure 2. A histogram plot demonstrates that the mean time to secondary surgery was 21 months. However, 40% of surgeries were performed within the first year after the index operation and 73% within the first 2 years. The frequency of return to the operating room (OR) diminished after 2 years.

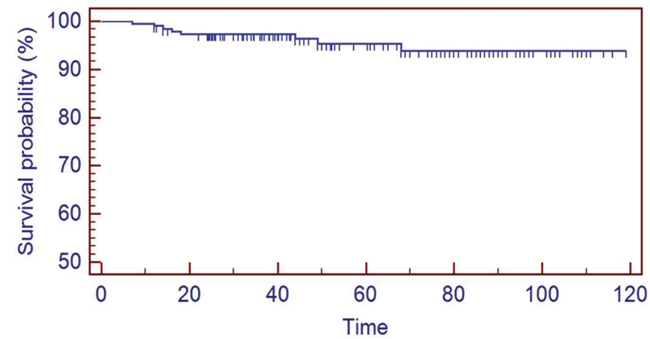

Figure 3. A Kaplan-Meier survival analysis (n = 172 patients), with survival defined as the absence of revision meniscal transplantation or knee arthroplasty. The analysis assumed a nonparametric distribution of time-dependent survival, similar behavior between cases that were performed at different time periods, and similar survival behavior between censored and uncensored patients.

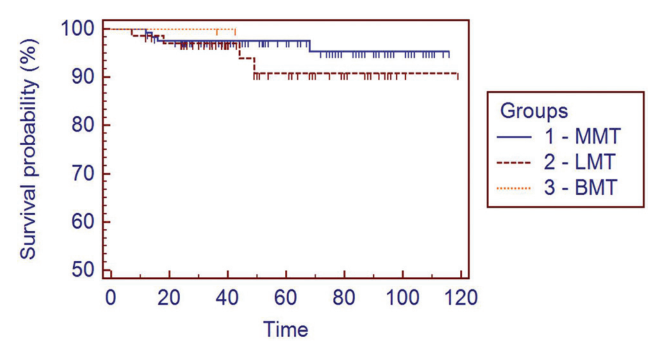

Figure 4. A Kaplan-Meier survival analysis was performed between medial (MMT), lateral (LMT), and bicompartmental meniscal transplantation (BMT) via the log-rank test. There was no difference in survival between MMT, LMT, or BMT (P = .6180).

to surgery. In this series, which represents the largest series in the literature, to our knowledge, there was a 32% reoperation rate for MAT. Thus, we confirmed our hypothesis: Surgical debridement was the most common procedure performed after MAT, with a small number of meniscal tears or disease progression requiring treatment. Revision MATs were performed between 1 to 2 years after initial transplantation, with the majority of secondary surgeries performed within the first 2 years. Overall, there was a 4.7% failure rate (revision MAT or knee arthroplasty) at a mean of nearly 5 years' clinical follow-up. Those requiring subsequent surgery had a survival rate of 88%, while those without secondary surgery had a survival rate of 98% at final follow-up. This represented an odds ratio of 8.4 for allograft failure in the subsequent surgery cohort.

The younger age and activity level of the patients included in this study make them significantly at risk for the development of knee osteoarthritis.[14] The major indication for surgical intervention is to treat current symptoms of pain and associated loss of function. This stance is further supported by a recent systematic review by Verdonk and colleagues,[22] reporting that 75% to 90% of patients achieve fair to excellent clinical results after undergoing MAT (with and without concomitant procedures). Similarly, a recent prospective analysis of MAT (with and without concomitant procedures) revealed an 88% success rate at long-term follow-up.[16] While the present study discusses reoperation rates and MAT failure as opposed to the clinical outcomes after MAT, as reported in the 2 studies described above, based on the survival analysis within this cohort, patients can be advised of a high chance of allograft survival at a mean of 5 years, provided concomitant injuries are addressed and the degree of arthritic progression is limited.

Surgeons performing MAT can advise patients of an approximately 1 in 3 chance of undergoing an additional operation. However, the vast majority of subsequent surgeries will be associated with less morbidity and more rapid recovery compared with their index MAT. This study also demonstrates that the surgeon will need to continue close postsurgical surveillance, especially within the 2-year period, of these transplants as this represents the time period at highest risk for additional surgery. After 2 years, the risk for subsequent surgery diminishes. Those who do require subsequent surgery are at an increased risk (odds ratio, 8.4) for future clinical failure as compared with those not requiring surgery.

The present findings are comparable with those previously reported in the literature. A recent meta-analysis of meniscal allograft surgery, with or without associated cartilage procedures, found a 12% failure rate, defined as requiring revision surgery (either meniscal allograft or cartilage surgery).[6] Of the failures, 11 (85%) were isolated MAT failures. The authors also found a 50% reoperation rate with up to 76% survival at 10 years. The lower rates of subsequent surgery and failure in the present cohort may be caused by advancements in technique and knowledge regarding the procedure as compared with earlier studies.

Stone et al[19] reported a revision rate of 6.7% (8/119) in patients undergoing MAT with severe osteoarthritis at the time of surgery (Outerbridge grades 3 and 4). Failure of allograft transplantation was defined as removal of the allograft without revision or progression to total or unicompartmental knee replacement. While this is a higher failure rate, this cohort comprised patients undergoing MAT with Outerbridge grade 3 or 4 changes at the time of transplantation.[19] Thus, this series included patients who were clearly indicated for a final salvage option, and most revision surgeries in that series were performed within the first year.[19] In a prospective series of 100 transplants, Verdonk et al[21] reported a survival rate of 70% at 10 years and projected 50% at 11.6 years after surgery. Within this cohort, the authors reported a 21% failure rate, with failure defined as moderate or severe occasional or persistent pain or as poor knee function. A modified Hospital for Special Surgery (HSS) subscore for pain of <30 points indicated moderate occasional or persistent pain. A modified HSS functional score of <80 points was arbitrarily chosen to define poor function. While the authors chose the criterion as an indication for failure, the findings at surgery were not characterized. This higher failure rate is likely based on the fact that a minority of patients will continue to have persistent pain yet not warrant knee replacement, which anecdotally was also seen within the surgical cohort in the present study. It should be noted that the above study by Verdonk et al[21] reported clinical outcomes after MAT, including the HSS score, which we did not examine in the present study.

Alternatively, the reoperation rate may be more a manifestation of the invasiveness of transplantation surgery rather than of the surgical technique. In comparison, a review of the literature reported the overall ACI reoperation rate as 33%, with more recent techniques reducing the rate to 18%.[7] In contrast, meniscal repair has a 20% reoperation rate,[13] and ACL reconstruction surgery has up to a 26.8% reoperation rate over an extended time period.[9] A commonality among all of these procedures is intra-articular bleeding, which may predispose the knee to scar tissue and stiffness and the need for surgical debridement and release. As with other large series reporting on clinical results after MAT,[6,8,11,12] the laterality of MAT did not influence the reoperation or failure rates in the present series.

This study is not without limitations. There is a potential for significant detection bias within the methods. The non-responding patients may have sought surgical care at another institution without our knowledge, which may bias the results, notably with an underestimation of failure rates. This is compounded by selection bias in which there was a lower percentage of patient follow-up within the operative cohort. One must consider a possible performance bias, as this is a study with a single high-volume surgeon using a single technique. There is also a clinical susceptibility bias in which these patients received a joint salvage procedure and had a guarded prognosis at baseline. The methods may include a transfer bias in which those who are doing poorly are more likely to return for care and affect the reoperation rates. Finally, isolated MAT procedures were performed in 41% of the cohort, with the remainder of patients undergoing concomitant procedures. Thus, the outcomes and reoperation rates presented in this study may have been influenced by the concomitant procedures. However, this patient population often presents with multiple coexisting lesions, including articular cartilage disease, and can require multiple procedures in addition to MAT. Other authors presenting large series of patients undergoing MAT also have substantial populations with concomitant articular cartilage procedures.[3,15,16,19,21]

CONCLUSION

In the largest consecutive series reported in the literature, MAT has a 32% reoperation rate, with simple arthroscopic debridement being the most common surgical treatment (59%), and a 95% allograft survival rate at a mean of nearly 5 years. Those requiring additional surgery still benefit, having an 88% allograft survival rate, but are at an increased risk of failure.

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