Functional Outcomes of Anterior Cruciate Ligament Reconstruction with Tibialis Anterior Allograft

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Abstract

Background: Allografts offer potential advantages over autografts in anterior cruciate ligament reconstruction (ACLR), including the absence of donor site morbidity, shorter operative times, improved cosmesis, and easier rehabilitation. There is limited and conflicting outcome data for ACLR with tibialis anterior allograft. The purpose of this study was to evaluate the functional outcomes of ACLR with tibialis anterior allograft.

Methods: We retrospectively evaluated primary ACL reconstructions using tibialis anterior allograft between January 2004 and December 2006. Clinical outcomes were measured by KT-1000 arthrometry, and International Knee Documentation Committee (IKDC), Lysholm, and Tegner scores.

Results: 19 patients were available for follow-up at a mean of 2.7 years (range: 2.0 to 3.2). One patient experienced a traumatic re-rupture that required revision and another patient was advised to undergo revision reconstruction for a failed graft. Based on IKDC and Lysholm scoring, 12 patients (63%) had good or excellent results, 4 (21%) patients had fair results, and 3 (16%) patients had poor results. The mean side-to-side difference was 2.7mm (0 to 8.2) and the mean decrease in Tegner activity level was 1.4 (0 to 6).

Conclusion: An alarming number of patients demonstrated residual laxity after ACL reconstruction with tibialis anterior allograft. We recommend against using tibialis anterior allograft as a first choice graft for high demand patients.

The annual incidence of anterior cruciate ligament (ACL) tears is approximately 1 in 3,000.1 According to the American Academy of Orthopaedic Surgeons, greater than 275,000 anterior cruciate ligament reconstructions (ACLR) are performed annually, making it the sixth most commonly performed orthopaedic procedure.2 Recent series have reported successful outcomes in 90% of total cases.3 Allografts offer several potential advantages over autografts in anterior cruciate ligament reconstruction, including the absence of donor site morbidity, shorter operative times, improved cosmesis, and easier rehabilitation.4 We have found that our soft tissue allograft ACLR patients are able to return to normal braking times on a driving simulator significantly faster than autograft ACLR patients.5 Allografts have also been shown to be cost-effective when compared to autografts.6

Due to these advantages, allografts have increasingly been chosen for ACLR. For example, Bach and coworkers

reported an increase in the use of allografts from 2% of all primary ACLR between 1986 to 1996, to 14% from 1996 to 2001, and 36% in recent years at their institution. National statistics also evidence this trend; according to the American Association of Tissue Banks, musculoskeletal allograft use increased from approximately 1 million in 2004 to 1.5 million in 2006, of which 10% are soft tissue grafts. The experience at our institution has been similar, with increased interest in allograft ACLR both among surgeons and patients.

There are disadvantages, however, to allograft ACLR as compared to autograft. A significant concern in the early years of allograft use was disease transmission and infection. As of 2002, the CDC had documented 26 cases of infectious agent transmission. Currently, the risks of human immunodeficiency virus and hepatitis C transmission are both estimated to be less than 1 in 1 million. A more commonly cited negative factor is loosening and associated failure to restore knee stability. Allografts incorporate more slowly than autografts, as demonstrated in animal and human studies. Some investigators have found increased rates of clinical failure compared to autografts. The majority of these studies have focused on patellar tendon and Achilles tendon allografts, both of which have bony attachments. Information on soft tissue allografts is more limited. However, Schepsis and colleagues and Sun and associates have reported equivalent outcomes in prospective comparisons of hamstring autograft and allograft ACLR with no evidence of increased failure or loosening of the allograft cohorts.

Tibialis anterior tendon has superior biomechanical properties, making it an appealing choice for allograft ACLR. There is limited and conflicting data on ACLR with tibialis anterior allograft, with two series reported at the time we began this study. Nyland and coworkers found 17 of 18 patients had normal or near normal arthrometrics by IKDC standards, and all patients returned to their preoperative activity levels. In a larger study, Singhal and colleagues reported high rates of subsequent surgery, including a high rate of revision ACLR for graft failure. Patients 25 years old and younger fared particularly poorly. The empirical impression at that time at our institution was that the tibialis anterior ACLR cohort recuperated quickly from surgery and had excellent outcomes. Subsequently Smith and coworkers reported that increases in laxity in tibialis anterior ACLR during the first postoperative year were not significant. In light of the limited and conflicting literature, we undertook this analysis. We hypothesized that our patients would demonstrate excellent knee outcome scores and excellent stability on arthrometric testing. The purpose of this study is to evaluate the functional outcomes of ACLR with tibialis anterior allograft.

Materials and Methods

We obtained approval for this study from our institutional review board. We retrospectively evaluated primary ACL reconstructions using tibialis anterior allograft performed at our institution between January 2004 and December 2006. Subjects were identified from operating room logs and office records. All patients were skeletally mature and had magnetic resonance imaging of the affected knee demonstrating complete anterior cruciate ligament rupture. Patients were deemed ineligible for the study if they had any ipsilateral lower extremity pathology that limited their function more than the operative knee. We identified 19 patients (12 male, 7 female) who met inclusion criteria and were available for evaluation.

Our group of surgeons utilized essentially the same operative techniques and non-accelerated rehabilitation protocols during the period of study. All grafts were cryopreserved tibialis anterior tendons (Musculoskeletal Transplant Foundation, Edison, NJ). Grafts were thawed in saline then doubled over a number 2 nonabsorbable suture and placed on a tensioner. The two tails were sutured for 30 mm with number 2 non-absorbable suture in a locked running fashion. The graft was sized to the nearest 0.5 mm and kept moist with saline-soaked sponges. Standard diagnostic arthroscopy was performed. Chondral and meniscal pathology was identified and treated. A limited notchplasty was performed in all cases. A guide-pin was placed centrally in the native ACL tibial insertion. The tibial tunnel was reamed to the size of the graft. An offset guide, sized to leave a 1 mm to 2 mm back wall, was used to place a trans-tibial guide pin in the femur at the 10 or 2 o’clock position. The femoral tunnel was reamed trans-tibially to the size of the graft. The femur was prepared and the graft was passed and fixed with either a Depuy-Mitek Rigidfix or Arthrex Transfix, following the manufacturer’s recommended technique. The graft was checked for impingement and cycled. With each graft limb tensioned and the knee given a forceful posterior drawer at 30° of flexion, tibial fixation was achieved using a DePuy-Mitek Intrafix sheath and screw. The implants utilized provide aperture fixation and have demonstrated efficacy in the literature. All patients followed a non-accelerated rehabilitation protocol emphasizing re-establishment of range of motion, proprioception and closed-chain strengthening in the first 3 months, then progressive strengthening, endurance, power, and agility, with return to sports activities no sooner than 6 months.

At the time of follow-up, we measured Body-Mass Index (BMI), active and passive range of motion of both knees, and circumference of both thighs. Lachman and pivot-shift were assessed on both knees by the operative surgeon. A KT-1000 arthrometer (MEDmetric Corporation, San Diego, CA) was used to measure anterior tibial translation in both knees. Clinical outcomes were measured by subjective International Knee Documentation Committee (IKDC) rating and Lysholm and Tegner scores. Radiographs were obtained on all patients and information regarding further knee surgeries was collected. Finally, patients were asked whether or not they were satisfied with the outcome of their surgery.

Spearman rank analysis was conducted using STATA version 10 software (StataCorp, College Station, TX) to determine if there were significant associations between age
and IKDC score, Lysholm score, Tegner score, and side to side KT-1000 difference using p-value set at 0.05. A similar analysis was performed for BMI and IKDC, Lysholm, Tegner, and KT-1000 difference.

Results

The 19 patients (12 male, 7 female with mean age 39.9; SD: 11.5 years; range: 19 to 60 years) were available for follow-up at a mean of 2.7 years (range: 2.0 to 3.2 years). Mean BMI was 26.2 (SD: 3.2). Overall 17 of 19 patients were satisfied. Mean range of motion was 3° to 131° for the operative knees and 0° to 133° for the contralateral knees. No patients had a flexion contracture of greater than 5° in the operative knee. On exam, three patients had a grade 1 Lachman, and one patient had a grade 2 Lachman. One patient had a positive pivot-shift and another had a pivot-glide. Mean thigh circumference difference was decreased 0.55 cm (SD: 1.27 cm) on the operative side. Mean IKDC was 81.6 (SD: 14; range: 59 to 99). Mean Lysholm score was 79.7 (SD: 12; range: 48 to 95). Tegner scores declined from mean 7.1 preoperatively to 5.7 at follow-up (SD: 1.8; range: 0 to 6). Based on IKDC and Lysholm scoring, 12 (63%) patients had good or excellent results, 4 (21%) patients had fair results, and 3 (16%) patients had poor results.

Overall arthrometric testing showed mean side-to-side KT-1000 difference was 2.7 mm (range: 0 to 8.2 mm; SD: 3.3 mm) under 30 lbs load. Four of 19 patients had greater than 5 mm side-to-side difference on arthrometric testing, meaning their grafts had failed by IKDC standards. The oldest of these patients, age 46, had excellent outcome scores and no decline in Tegner score. The other three patients had mean side-to-side difference of 7.6 mm and mean IKDC of 63.2. Twelve of 19 patients had less than 3 mm side-to-side difference. One patient experienced a traumatic re-rupture that required revision. Another patient was advised to undergo revision reconstruction for symptomatic laxity and an MRI showing a failed graft, but had not done so at the time of latest follow-up. Seven of 19 patients required additional surgery, including one patient who had revision ACLR, one patient who had a meniscal allograft transplant, and one patient who had a microfracture. No patients had lysis of adhesions or manipulation for arthrofibrosis. The remaining surgical procedures were meniscal or chondral debridements. Spearman’s rank correlation analysis did not demonstrate any significant relationships between age and range of motion or any of the following outcome measures: IKDC, Lysholm, Tegner change, and KT-1000 difference. Likewise, no significant relationships or trends approaching significance between BMI and these measures emerged in our analysis. The results are summarized in Table 1.

Discussion

We undertook this study of the functional outcomes of ACLR with tibialis anterior allograft because the literature

Table 1  Summary of Individual and Mean Outcome Results

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on tibialis anterior allograft ACLR is limited and conflicting. Nyland and coworkers showed positive results in a cohort of 18 patients (mean age: 41.1 years) who underwent tibialis anterior ACLR with interference screw fixation. All but one had a normal or near normal IKDC clinical examination scores, with mean side-to-side difference on KT-1000 testing of 1.1 mm. All patients returned to their pre-injury level of activity, which the investigators described as “moderate” for most patients. Functional testing revealed that a high number of patients had significant side-to-side deficits in isokinetic peak quadriceps torque (72%) and poor performance on a hop test (28%), which, the investigators noted, raises concern about the dynamic stabilization capabilities of these knees. They attributed these deficits to a combination of factors including patient noncompliance, poor overall health status, and concurrent meniscal or chondral pathology. Ultimately, the investigators recommend the use of tibialis anterior allograft in ACLR and suggesting that its superior biomechanics may make it a promising graft choice for younger, higher demand patients.

Conversely, Singhal and associates reported unfavorable results in a study of 69 patients (mean age: 31.7 years) who underwent tibialis anterior allograft ACLR. Graft fixation was also obtained with interference screws. These patients underwent an accelerated rehabilitation protocol with return to athletic competition allowed as early as 4 months after surgery. Overall, 16 of 69 patients required revision ACLR for graft failure with younger patients faring particularly poorly. The mean age of failed patients was 22.8 years old versus 34 for patients in whom failure did not occur. This difference was statistically significant. In total, 26 patients (38%) required additional surgery, including one total knee arthroplasty. When the investigators examined the subgroup of patients 25 years old or younger, they found that 17 of 31 (55%) required additional surgery, including 11 revisions (35% revision rate). Patients over 25 had significantly lower rates of additional surgery (24%) and revision ACLR (13%). The investigators attributed the high failure rate to a combination of factors: selecting a graft with slow incorporation, use of an accelerated rehabilitation protocol, early return to sport, and an active, young, high demand patient population. They cautioned against choosing tibialis anterior allograft for younger or higher demand ACLR patients.

Most recently, Smith and coworkers reported results of 19 ACL reconstructions (mean age 37 years) with soft tissue grafts (90% tibialis anterior allograft) analyzed using roentgen stereophotographic analysis with each operative knee serving as its own control. The mean increase in laxity was 1.1 mm at 6 months. Total graft slippage averaged 1.9 mm at 4 months. A self-directed, accelerated rehabilitation protocol was utilized. Four of the 19 patients (21%) had a laxity increase of 3 mm or more. However, these patients had excellent outcome scores. The investigators concluded that the degree of slippage observed was not clinically important.

Our patient population with a mean age 39.9 years resembled that of Nyland and coworkers. We utilized cryopreserved grafts, which avoid the negative biomechanical effects of radiation, chemical sterilization, or freeze-drying, and have been shown to maintain good strength following processing. We utilized tibial and femoral fixation devices with proven efficacy for soft tissue grafts. Biomechanical testing of tibialis anterior fixation with interference screw alone has shown this is a weak construct at time zero. Patients were prescribed a non-accelerated rehabilitation protocol to allow time for graft incorporation. We hypothesized that our analysis would show a high rate of good and excellent results and therefore would support the use of tibialis anterior allograft. By contrast, we found only 65% of patients achieved a good or excellent result based on functional outcome scores. Four of 19 patients had laxity on physical exam with KT-1000 side-to-side difference greater than 5 mm, considered failure by IKDC standards. While Smith and colleagues reported better clinical outcomes, it is notable that the rate of increased laxity in their study was similar to ours. Our Spearman rank analysis did not reveal a significant correlation of age with outcome, but we suspect that this may reflect the number of patients in the study and that a larger study population would uncover a trend toward higher revisions in younger patients and in patients with higher preoperative Tegner scores.

The concerning rate of recurrent laxity and relatively low outcome scores we found with our tibialis anterior patients underscore the larger question of choosing between autograft and allograft in ACLR. Multiple investigators have reported in comparative studies that the outcomes of patellar tendon or achilles allograft ACLR are comparable to autograft. However, a metaanalysis of arthrometric outcomes of patellar tendon autografts versus patellar tendon or Achilles allografts found a significant difference in rates of IKDC failure, with only 5% of autografts compared to 14% of allografts lax at follow-up. Grafe and Kurzweil reported that 5 of 23 (21%) Achilles tendon allograft reconstructions failed by a mean of 28 months follow-up. Excluding three early failures, mean side-to-side KT-1000 difference was 2.9 mm, which reflected a mean 4.5 mm of loosening from the immediate postoperative measurements. The failure rate, KT-1000 data, and mean Tegner results from Grafe and Kurzweil closely resemble those of the present study. A multicenter prospective trial of ACLR outcomes reported their analysis of risk factors for ACLR failure. They found that younger patient age and use of allograft as opposed to autograft were independent risk factors for graft rupture after ACLR.

Conversely, there are studies to support soft tissue allograft use. Edgar and colleagues prospectively compared hamstring autograft and hamstring allograft tendons. At 3- to 6-year follow-up, they found the allografts performed just as well as the autografts, with no significant differences in outcome scores or laxity. Of note, they utilized double fixation on both the tibia and femur. Their results suggest...
that fixation may be an especially critical component in soft-tissue allograft ACLR. Nakata and coworkers reported outcomes in a group of patients who underwent ACLR with soft tissue allografts, including Achilles without bone plug, tibialis anterior, and tibialis posterior. They found 92% of patients had less than 3 mm side-to-side difference on KT-2000 testing, with mean difference 1.6 mm. The mean age at surgery for these 61 patients was 20.9 years old. At follow-up, 29% of patients maintained the same activity level, which the investigators attributed primarily to social factors related to aging. The rehabilitation protocol utilized accounted for the slower incorporation of allografts, with return to sport delayed until 9 to 10 months after surgery. Carey and associates recently published a systematic review of allograft versus autograft literature and concluded that clinical outcomes are not significantly different at short-term follow-up.

In summary, investigators continue to report disparate results and sometimes draw conflicting conclusions regarding the use of allograft versus autograft for ACLR. The clinical use of allografts continues to increase despite limited and conflicting literature on soft tissue-only allografts and specifically on tibialis anterior allografts. Patient age, graft fixation, and rehabilitation protocols may contribute significantly to the final outcome. This study has several limitations, including short-term follow-up, retrospective design, and a sample size that may limit its power. This study’s importance resides in addressing a fundamental question in graft selection—whether or not to use tibialis anterior allografts for ACLR—about which there is limited literature.

Conclusion
We report that an alarming number of patients demonstrated residual laxity after ACLR with tibialis anterior allograft. While 17 of 19 (89%) reported satisfaction with their result, the relatively high percentages of fair or poor outcome scores and residual laxity are concerning. We recommend tibialis anterior allograft not be utilized as a first choice for younger or high-demand patients.

Disclosure Statement
None of the authors have a financial or proprietary interest in the subject matter or materials discussed, including, but not limited to, employment, consultancies, stock ownership, honoraria, and paid expert testimony.

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2. Available at: www5.aaos.org/oko/sports/meniscal/pathophysiology/incidence.cfm.