An Original Study

Anterior Cruciate Ligament Reconstruction With Achilles Tendon Allografts in Revisions and in Patients Older Than 30

Michael W. Grafe, MD, and Peter R. Kurzweil, MD

Abstract

We evaluated the results of anterior cruciate ligament (ACL) reconstruction using an Achilles tendon allograft in revisions and in patients older than 30. Results from 23 consecutive patients (mean age, 43 years) who underwent ACL reconstruction with fresh-frozen, irradiated (22/23) Achilles allografts were retrospectively reviewed. Seven cases were revisions. Patients were evaluated with physical examination, questionnaires, and x-rays.

Twenty of the 23 patients were evaluated a mean of 28 months after surgery. There were 5 failures (21%); 3 acute failures were not evaluated at follow-up. One patient had an infection that required graft removal, 2 patients had mechanical failure of the grafts, and 2 had displacements of more than 5.5 mm as measured with a KT-1000 arthrometer. The 18 clinically successful cases had full motion, no thigh atrophy, and no effusion. Pivot shift scores were 55% A and 45% B on the International Knee Documentation Committee (IKDC) scale. Lachman scores were 40% A, 55% B, and 5% C on the IKDC scale. The KT-1000 difference was a mean of 2.9 mm at final follow-up. However, knees loosened a mean of 4.5 mm from the immediate postoperative measurements (P<.0001). Mean Lysholm and Tegner scores were 86.8 and 5.2, respectively. Tibial tunnel diameter increased by 3.1 mm on anteroposterior x-rays and 3.0 mm on lateral x-rays. Five patients developed mild medial compartment arthritis. Four of the 5 grafts with failures were from donors older than 40. Postoperative complications included deep vein thrombosis and inflammatory effusion (white blood cell count, 15,000).

Twenty-one percent of ACL reconstructions with Achilles tendon allografts failed. Grafts deemed successful still had significant loosening at final follow-up. Allografts from donors older than 40 may have played a role in these failures. From the data in this study, it appears that surgeons should scrutinize the source of the allograft tissue and the age of the donor.

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Anterior cruciate ligament (ACL) reconstruction in patients older than 30 is becoming more common.[1-4] Men and women in this age group regularly participate in sports that place significant rotational forces on the knee[5-7] and their knees at risk for ACL injury.[8] For many surgeons, the first choice for primary ACL reconstruction is the bone–patella tendon–bone (BPTB) or hamstring autograft[9-12]; others recommend allograft tissue. This is particularly true with revisions and with older patients in whom donor-site morbidity is thought to be detrimental to postoperative recovery.[2,3,13,14]

"We prefer the Achilles tendon allograft over other all-soft-tissue allografts...because this graft provides osseous fixation in the femoral tunnel."

We hypothesized that ACL reconstruction with Achilles tendon allografts in the revision or chronic setting, or with older individuals, will have satisfactory results.

As BPTB autografts are often the preferred choice for ACL reconstructions, it is not surprising that they are also a very popular selection for allografts.[4,15] The popularity of this type of allograft has led to a decreased supply, often resulting in difficulty obtaining these grafts in a timely fashion.[16] There are also potential problems with graft-tunnel mismatch with BPTB grafts.[17-19] To avoid these issues, many surgeons have turned to Achilles tendon allografts.[1]

We prefer the Achilles tendon allograft over other all-soft-tissue allografts (tibialis anterior tendon or hamstring tendons) because this graft provides osseous fixation in the femoral tunnel. Although improvements have been made in soft-tissue fixation to bone, an animal model has shown increased mechanical properties in bone-to-bone healing in the first 3 weeks after ACL reconstruction.[20-22] Thus, we believe that bone-to-bone healing in one of the tunnels is superior to soft-tissue-to-bone healing in both tunnels.[20-22]

Table. ACL Achilles Allografts: Patient Age, Results, and Donor Age

						KT-1000 Side-to-Side Difference (mm)			Tibial Tunnel Diameter Change (mm)			Donor
Patient	Age (y)	Lysholm	Tegner	Pivot	Lachman	Preop	Postop	Follow-Up	AP X-Ray	Lateral X-Ray	Failure/ Other	Age (y)
1	29	78	3	A	B	4	–1	1	5	5	Revision	41
2	49	84	4	B	B	5	—	3	0	0	Revision	31
3	48	100	8	A	A	8	–3	2	0	1	Revision	17
4	36	95	6	A	A	7	–2	1	—	—	Revision	54
5	31	—	—	—	—	8	–3	—	—	—	Revision, failure	41
6	25	—	—	—	—	4	–1	—	—	—	Revision, failure	50
7	53	—	—	—	—	6	–2	—	—	—	Revision, bacterial infection, failure	53
8	46	89	1	B	B	9	—	8	5	9	KT-1000 failure	41
9	41	80	6	B	B	6	–2	6	10	4	Inflammatory effusion, KT-1000 failure	31
10	49	89	6	A	A	9	0	3	8	12	—	51
11	43	100	6	B	B	6	0	3	–2	2	—	55
12	43	98	4	B	B	5	–2	2.5	5	5	—	23
13	35	59	4	A	A	6	–3	—	—	—	—	51
14	45	87	7	A	A	5	–1	3	—	—	—	58
15	43	98	6	A	A	6	0	0	—	—	—	31
16	38	93	3	B	B	3	–2	2	—	—	—	19
17	57	94	6	B	B	7	–3	3	1	2	—	55
18	59	90	4	B	C	5	1	2	5	–3	—	22
19	33	72	9	B	B	6	–1	2	0	4	—	45
21	55	71	4	A	B	6	0	4	1	1	—	54
22	46	86	6	A	A	3	–4	4	0	1	—	16
23	47	95	6	A	A	4	–4	1	—	—	—	41
24	53	95	6	A	B	7	–1	3	3	1	—	33
Mean	43.2	86.8	5.2	—	—	5.9	–1.6	2.9	3.1	3.0	—	39.7

Abbreviations: Preop, preoperative; Postop, postoperative; AP, anteroposterior.

In this article, we examine our experience with ACL reconstruction using Achilles tendon allograft with interference fixation in chronic injuries (>3 months) or revision cases.

Methods

Between 1999 and 2003, 24 patients underwent ACL reconstruction with an Achilles tendon allograft. These patients presented with instability and/or pain in the knee. Patients were evaluated by symptom history, physical examination, and magnetic resonance imaging. Only patients with positive findings in all 3 areas were offered surgery. Graft options were discussed in detail with each patient. Patients were allowed to choose between allograft and autograft reconstructions. When allografts were chosen, type of allograft to be used was not discussed. Allografts were recommended to all patients with chronic injuries and to patients in need of revision surgery. Age, sex, side of injury, and mechanism of injury were recorded for all patients. Institutional review board approval was obtained for this retrospective review. Excluded patients had open physes or injuries sustained less than 3 months before presentation.

All ACL reconstructions were performed under general anesthesia in the same manner as previously described.[18] KT-1000 arthrometer measurements of both knees were made after an examination under anesthesia. Appropriate débridement and meniscal surgery were completed before ACL reconstruction. A 6.5-mm over-the-top guide (Stryker, Mahwah, NJ) was inserted through the anteromedial portal to mark a point at either 1 o'clock (left knee) or 11 o'clock (right knee). The tibia tunnel was then created. The tip of the tibial tunnel guide was placed through the anteromedial portal and inserted 7 mm anterior to the posterior cruciate ligament. This spot was found by following an arc of the posterior rim of the anterior horn of the lateral meniscus to the medial tibial spine. The length of the tibial tunnel was set at 40 mm in all cases and was completed with a 10-mm drill bit. The angle of the calibrated guide was adjusted until the desired tunnel length was achieved. The femoral tunnel was then drilled through the tibial tunnel. A guide pin was retrograded through the tibial tunnel to the previously selected point on the notch. This was done with the knee in at least 70° of knee flexion. A 10-mm acorn-shaped drill bit was then placed by hand through the tibial tunnel and through the joint. It then drilled to a depth of 30 mm in the femur. After the drill bit was removed, a small notch was made in the femoral tunnel at 2 o'clock (left) or 10 o'clock (right). The interference screw guide was placed here later in the procedure.

The graft was then brought through the knee joint by connecting the graft to a Steinmann pin retrograded through the tibial and femoral tunnels and out the anterolateral thigh. A guide wire for the cannulated interference screw was then inserted through an accessory medial portal. The guide wire was placed parallel to the cancellous surface of the bone plug. With the knee flexed at 90°, a 7-mm tap was used over the interference guide wire. The calcaneal bone plug (fashioned to fit into a femoral tunnel 10 mm in diameter) was fixed with an 8×23-mm bioabsorbable interference screw (Arthrex, Naples, Fla). With the femoral fixation in place, the knee was cycled through a flexion/extension arc 15 times. Then with the knee in 35° of flexion, a posterior drawer force was placed on the tibia, and maximal distal traction was placed on the graft. No attempt was made to overconstrain the graft. Tibial fixation was achieved with an 11×35-mm bioabsorbable Delta interference screw (Arthrex, Naples, Fla). This gave both proximal aperture fixation and distal cortical fixation. Tibial fixation was enhanced by running No. 2 Ethibond or Ticron sutures along the entire intratunnel portion of the tendon.[22] KT-1000 measurements were obtained immediately after surgery, with patients still asleep. This was done in the operating suite, under sterile conditions, before placement of dressings.

Fresh-frozen Achilles tendon allografts were obtained from 3 tissue banks: Central Florida Tissue Bank, Northern California Tissue Bank, and Community Tissue Service. The 15 grafts from Northern California Tissue Bank were procured under aseptic conditions, sterilized with 1.8 mrad of gamma radiation, and stored at –70°C. The 1 graft from Community Tissue Service was obtained under aseptic conditions. According to the company's literature, it treats tissue with flushing, centrifugation, and ultrasonication. The graft was then soaked and rinsed in antibiotics (polymyxin B sulfate and bacitracin), hydrogen peroxide, alcohol, sterile water, and Allowash solutions. Allowash contains detergents, such as polyoxyethylene-r-lauryl ether, octylphenolethyleneoxide, and poly(ethylene glycol)-p-nonyl-phenyl-ether. The 7 grafts from Central Florida Tissue Banks were harvested aseptically, frozen at –80°C, and subjected to 1.5 to 2.5 mrad of gamma radiation. After the tissue arrived at the hospital, the grafts were stored at the recommended –40°C or less. Mean donor age for the grafts was 40 years (range, 17-58 years).

After surgery, patients were allowed immediate full weight-bearing but were encouraged to use crutches for 2 weeks to minimize swelling. A knee immobilizer was used for the first 14 days when sleeping and walking. Home exercises were started the day after surgery, and formal physical therapy was started on the fourth day.

During the study period, all patients were contacted to return to the office for evaluation. At follow-up, they were evaluated with Tegner and Lysholm activity scores and the Lysholm Knee Outcome Scale.[23,24] Physical examination included checks for effusion, range of motion (ROM), thigh circumference, pivot shift, and the Lachman test. KT-1000 manual maximum measurements were also made of the operative and nonoperative knees.

The system developed by Noyes and Barber[25] was used to classify KT-1000 measurements as functional (<5.5 mm of increased displacement vs nonoperative knee) or failure (>5.5 mm of displacement). The IKDC scale was used to grade Lachman tests (A, 1-2 mm of displacement; B, 3-5 mm; C, 6-10 mm; D, >10 mm) and pivot shift (A, normal; B, glide; C, clunk; D, gross instability).[26]

X-rays, which were obtained at follow-up to evaluate tunnel diameter and arthritis in the knee joint, consisted of standing anteroposterior (AP) and tunnel views, plus lateral and sunrise views, of the knee. All x-rays were taken in the exact same manner, with the tube 100 cm from the knee. The authors compared these follow-up x-rays with the immediate postoperative x-rays. On both sets, they measured the widest diameter of the tunnel and the distance from that diameter to the articular exit site of the tunnel. The authors were blinded to each other's findings. Intraobserver and interobserver reliability was not interpreted.

> **"...surgeons must be aware of the policies and procedures of their tissue banks and should request that grafts come from donors younger than 40 ."**

Data were analyzed with SAS 8.2 software (SAS Institute, Cary, NC). KT-1000 results were evaluated with the paired *t* test and with the Wilcoxon signed rank test, the nonparametric version of the paired *t* test. The Fisher exact test and the χ^2 test were used to analyze the rest of the data. Statistical significance was set at $P<.05$.

Results

There were 23 patients in our group. Mean age was 43 years (range, 25-59 years). The study group consisted of 10 women and 13 men (17 left knees, 6 right knees). Mean follow-up was 27.3 months (range, 14-44 months). Three patients were classified as failures and did not have a formal follow-up, and 5 patients were followed for less than 2 years; thus, 15 patients had more than 2 years of follow-up. Seven injuries had been sustained while snow skiing, and 6 were the result of a fall. Nine reconstructions were in patients with chronic ACL deficiency (>3 months after injury), and 6 were revision surgeries. Four of the revisions were performed secondary to a fall or trauma in the postoperative period, and 2 were performed for mechanical or technical failures in the immediate postoperative period. Mean time from injury to surgery was 23.1 months. Partial medial and lateral meniscectomies were performed in 5 patients. A partial medial meniscectomy was performed in 8 knees. A partial lateral meniscectomy was performed in 3 patients. Seven cases had intact medial and lateral menisci. One patient had a medial meniscal repair with an inside-out suture technique (Table).

Three of the 23 patients in the study were early failures, leaving 20 patients in the study group, all of whom were located and returned for follow-up evaluation. For these 20 patients, mean Lysholm score was 86.8, and mean Tegner score was 5.2. Fifty-five percent of the patients had a pivot shift score of A, and 45% had a score of B. Forty percent had a Lachman score of A, 55% had a score of B, and 5% had a score of C. Mean

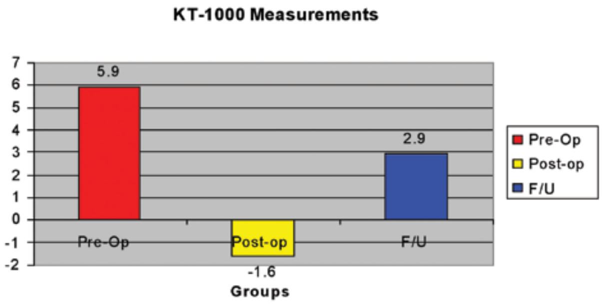

Figure 1. Mean KT-1000 arthrometer measurements of injured knee (immediate preoperative, immediate postoperative, follow-up). Mean follow-up measurement was 2.7 mm. Changes between all groups were significant (*P*<.0001).

effusion score was 0 (none). Thigh circumference was a mean of 1.0 cm less than on the nonoperative side. Mean ROM was 0° to 138°, maintaining symmetry with the contralateral knee (Table). Mean preoperative KT-1000 measurement was 5.9 mm of increased anterior translation of the injured knee. After surgery, mean anterior knee translation decreased by 7.5 mm, with the immediate mean postoperative KT-1000 measurement of –1.6 mm. This change in translation was significant (*P*<.0001). However, the mean final follow-up side-to-side KT-1000 difference was 2.9 mm. Thus, after 2 years, there was a mean of 4.5 mm of loosening compared with the immediate postoperative value. This change was also significant (*P*<.0001) (Figure 1). Therefore, at final evaluation, the operated knees remained a mean of 3.0 mm tighter than their preoperative values.

Eleven of the 12 patients with radiographic follow-up showed some amount of tibial tunnel widening. Mean change in tibial tunnel diameter was 3.1 mm (–2 to 10 mm) on AP x-rays and 3.0 mm (–3 to 12 mm) on lateral x-rays. Obvious femoral tunnel widening could be seen only on 1 x-ray. This patient also had a large increase in tibial tunnel diameters: 4 mm and 9 mm on AP and lateral x-rays, respectively (Figure 2).

Five patients showed progression of mild osteoarthritis of the medial compartment with squaring of the medial femoral condyle, joint space narrowing, and a small osteophyte on the medial femoral condyle. One patient had moderate to severe, baseline, tricompartmental osteoarthritis, which was stable at 44-month follow-up.

Three of the reconstructions were considered failures. One of these patients developed an acute infection within 1 week after surgery. Cultures grew *Staphylococcus epidermidis*. This patient underwent arthroscopic débridement with graft retention, but the infection persisted, necessitating removal of the graft and interference screws 3 months after surgery. The other 2 patients had traumatic failures within 2 years of the reconstruction, in one case while the patient was snowboarding and in the other case while the patient was playing soccer. All 3 failures occurred in patients who had undergone revision ACL reconstruction.

There were 2 other failures, defined by KT-1000 measurements of more than 5.5 mm of increased tibial translation. These 2 patients had the second and third largest tibial tunnel diameter widening (9 mm, 10 mm). However, KT-1000–defined failures did not correlate with poor results on the Lachman, pivot shift, Lysholm, or Tegner test.

Figure 2. Anteroposterior x-ray shows tibial tunnel diameter of 12 mm.

There were adverse events in the immediate postoperative period in 3 patients. One patient developed a deep venous thrombosis (DVT) in the ipsilateral lower leg 3 weeks after surgery. This was treated with coumadin for 6 months. A hematologic workup revealed a family history of DVTs and a blood test positive for factor V Leiden (factor V Leiden, a thrombophilic condition that arises from inherited resistance to activated protein C, increases risk for DVT up to 80 times in homozygous patients).[27] The second patient developed a large, persistent effusion. This fluid was aspirated several times and showed a white blood cell count of 14,000. Cultures of the aspirations were all negative. There was some concern about an immunologic reaction with this patient. Blood tests for sedimentation rate, C-reactive protein, and immunoglobulins G and M were all negative. The effusions subsided after several months and 2 intra-articular corticosteroid injections. The third patient was diagnosed with hepatitis B within 4 weeks after surgery. The tissue bank that supplied this graft was contacted. Testing on the graft had been done, and was negative by antibody testing. The patient had lifestyle risk factors for hepatitis transmission, and his primary care physician had been following his liver function tests for 2 years before surgery. In the 20 patients evaluated, there was no correlation with Lysholm or Tegner scores, meniscus status, presence of arthritis, or changes in tibial tunnel diameters. However, the patients with 2 of the 3 largest changes in tibial tunnel diameters had the largest changes in follow-up KT-1000 measurements.

Four of the 5 patients with failures received grafts from donors older than 40. Although more failures occurred in

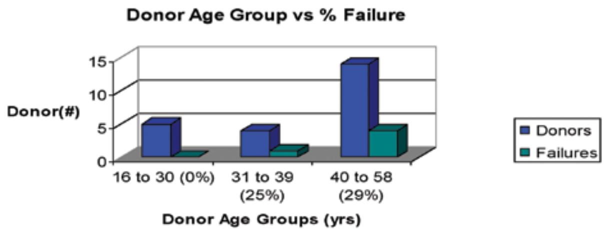

Figure 3. Donors are divided into 3 age groups. Blue column: all donors in age group. Green column: number of failures in age group. Failure seems to increase with increasing donor age (not statistically significant).

older donors, the relationship between donor age and failure was not statistically significant (Figure 3). Graft failure did not have a relationship with the specific tissue bank used. Both mechanical failures occurred in the group's youngest patients (ages 25 and 31).

Discussion

Eighteen (78%) of 23 patients in this study had excellent results with ACL reconstruction with Achilles tendon allograft. However, this may be an overestimation of failure. Two of these patients were considered failures only because their KT-1000 measurements were more than 5.5 mm. These 2 patients had high Lysholm scores (89, 80) and were satisfied with their results. Nevertheless, we considered 5 (22%) of the 23 patients to be failures: 1 infection with graft removal, 2 mechanical failures, and 2 KT-1000–defined failures.

Our allograft failure rate is lower than that reported by Noyes and Barber-Westin[3] (30%) but higher than that reported by Siebold and colleagues[13] (13.3%), Levitt and colleagues[28] (12%), and Indelli and colleagues[1] (0%). Noyes and Barber-Westin used BPTB allografts in patients with symptomatic arthrosis. Eighty percent of their grafts had received 2.5 mrad of gamma radiation. Siebold and colleagues used fresh-frozen, nonirradiated Achilles and BPTB grafts secured with titanium interference screws and staples (7.3% of the Achilles grafts were failures in this study). Levitt and colleagues used a combination of fresh-frozen and freeze-dried Achilles and BPTB allografts. Radiation use was not mentioned. The bone portion of the Achilles graft was fixed with a press-fit technique into the femur and staples into the tibia. Indelli and colleagues used the most similar surgical technique: Achilles allograft fixed with bioabsorbable interference fit screws in the femoral and tibial tunnels. However, they used a cryopreserved, nonirradiated allograft, and mean patient age was 36 years. Eighteen percent of their patients were college or professional athletes, and there were no revision surgeries. Thus, our patient populations were different.

In our study, 22 of 23 grafts were irradiated for sterilization. Perhaps this is why our failure rate is higher than that in other studies and similar to that found by Noyes and Barber-Westin.[3] A recent in vitro biomechanical study showed that irradiated BPTB grafts elongated more and had higher loads to failure when compared with nonirradiated grafts.[29] However, other recent clinical and animal studies have shown that, with long-term follow-up, irradiated tissue and nonirradiated tissue do not differ.[30,31] In a rat model, during the first 4 postoperative weeks, mechanical properties of irradiated tissue were inferior to those of nonirradiated tissue. By 24 weeks, irradiated tissue and nonirradiated tissue had similar biomechanical properties.[30]

Including the postoperative DVT gives our study an overall complication rate of 26%. According to the literature, the mean DVT rate in the setting of ACL surgery is 1.5%.[32] In our small series (24 patients), the rate was high at 4%, but that represents only 1 patient, so this complication cannot be specifically related to use of allograft. Two of our postoperative complications (postoperative infection, aseptic effusion) were possibly linked to the processing of an allograft tendon. The rate of postoperative infection after ACL reconstruction has been reported to range from 0.14% to 1.7%.[33] Although 1 of our patients developed hepatitis B after surgery, we believe this was not related to the allograft tissue. Zou and colleagues[34] estimated the probability of hepatitis B viremia at time of tissue donation to be 1:34,000. They thought that the addition of nucleic acid amplification to the screening of tissue donors would reduce the risk for hepatitis B to 1:100,000. In addition, following the recommendations made by Kainer and colleagues[35] for processing and screening allograft tissue for bacterial and viral diseases may have helped prevent these complications.

Our findings regarding tibial tunnel widening are similar to those of Indelli and colleagues.[1] Their mean tibial tunnel widening was 2.7 mm. We also could not find a correlation between tunnel widening and graft laxity at follow-up, in keeping with the findings by Indelli and colleagues[1] and Linn and colleagues.[36] Linn and colleagues used Achilles allograft but did not have a bone plug on the femoral side and secured the tibial side with a screw and washer. Recent studies have shown that, in comparison with autografts, allografts do not increase tibial tunnel widening.[37,38] Buelow and colleagues[39] believed that tibial tunnel soft-tissue grafts fixed with interference screws will enlarge the bone tunnel through compression of the surrounding cancellous bone. See the Box on the next page for evidence that donor age may decrease graft strength.

Of particular interest are our KT-1000 data. We tightened reconstructed knees a mean of 7.1 mm in the operating room, making them tighter than normal knees by a mean of 1.5 mm. At final follow-up, operated knees averaged 2.7 mm more translation than normal knees did—a change in loosening of 4.2 mm over 28 months. However, follow-up knees were still a mean of 2.9 mm tighter than preoperative knees. These findings are similar to those of Pedowitz and Popejoy,[45] who found a mean of 2.8 mm of loosening on KT-1000 measurements at 6-month follow-up and no difference in loosening between the BPTB group (50 BPTB autografts) and the hamstring group (7 quadrupled hamstring autografts). Their data and our data suggest that ACL reconstruction loosening does not depend on whether allograft or autograft tissue is used.

KT-1000 measurements can be affected by anesthesia and knee effusions. KT-1000 measurements performed on unconscious patients (vs conscious patients) tend to produce larger values.[46] Thus, our follow-up laxity measurements, compared with immediate postoperative measurements taken on unconscious patients, may underestimate true laxity. Knee effusions of more than 30 cm^3 may also increase KT-1000 values in a cadaver model. Effusions become particularly relevant when they are large enough to make the patellae blottable.[47] Although all knees measured in the immediate postoperative period were swollen and had some effusion, we did not notice an effusion large enough to make the patellae blottable.

This study had several weaknesses. It was retrospective and had a relatively small sample size. The small sample size did not allow us to make any definitive conclusions about donor age and failure, arthritic changes and allograft use, or tunnel widening and failure. In addition, data collection was incomplete. Seven of the 20 patients who returned for evaluation declined to have x-rays taken, which made it difficult to determine statistical significance for tibial tunnel widening and postoperative arthritis.

Allograft tissue was obtained from 3 different tissue banks. We could not determine if the problems encountered were related to processing at a particular tissue bank or simply to use of allograft tissue. The tissue bank that provided allograft to the patient who became infected with hepatitis B performed only antibody testing. Polymerase chain reaction testing was not conducted on the tissue, making it difficult to determine if this patient truly was not infected by the allograft. Testing the second patient who received tissue from the same donor would also have helped clarify the issue.

Preoperative thigh circumference measurements were not obtained. As half the cases studied were revisions or chronically ACL-deficient, thigh atrophy could have been present before surgery. For the 3 failures, data were not collected for long-term follow-up, likely making our outcome scores higher than they were, as these data were not averaged with our successful patients' data.

Conclusions

We did not show that Achilles tendon allograft can be successfully used to reconstruct ACL-deficient knees, even in the setting of chronic injury or revision surgery. Our goal was not to define the indications for Achilles tendon allograft use. Surgeons should be aware of the possible complications associated with allografts. It appears but is difficult to prove that one of our patients developed a bacterial infection from allograft and that another had an immunologic reaction to allograft. Furthermore, we found a trend of failure increasing with donor age, though this was not statistically significant. Thus, surgeons must be aware of the policies and procedures of their tissue banks and should request that grafts come from donors younger than 40. This study also demonstrated increases in KT-1000 measurements at final follow-up. As these increases have been found in other studies with autografts, they appear not to be related to allograft tissue or to its mode of sterilization and preparation. Thus, our results support the finding that single-bundle ACL allograft reconstructions stretch out over a 2-year period. The amount of stretch is comparable to that found for BPTB autografts in other studies.[45]

Effect of Donor Age on Graft Strength

Previous authors have found that ACL strength decreases with donor age.[40,41] However, Blevins and colleagues[42] and Flahiff and colleagues[43] showed that donor age (17-55 years) does not affect the biomechanical properties of BPTB grafts. Lewis and Shaw[44] showed that increasing age has only a moderately negative effect on the ultimate tensile strength of Achilles tendons. However, their study included only embalmed specimens, and the age range for older specimens was 79 to 100 years. Thus, the donors in our study would be considered young from the standpoint of Lewis and Shaw. Although 4 of our 5 failures occurred in grafts from donors older than 40, our sample was too small to show any statistical significance for this observation.

Authors' Disclosure Statement and Acknowledgment

The authors report no actual or potential conflict of interest in relation to this article.

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