Original Article

Allograft Reconstruction for Extensor Mechanism Injuries

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J Knee Surg

Abstract

Previous case reports have documented the successful use of allograft for extensor mechanism reconstruction. We hypothesized that extensor mechanism reconstruction with allograft would restore extensor power and allow patients to return to a relatively high activity level. Between 2000 and 2007, 17 patients (18 knees) underwent extensor mechanism reconstruction with either nonirradiated Achilles or whole bone-patellar tendon-bone allograft at our institution. Two patients were lost to follow-up and one underwent a total knee arthroplasty and was considered a failure. The remaining 14 patients (15 knees) returned for clinical and radiographic evaluation at a minimum 24 months postoperatively. Patients completed questionnaires using the International Knee Documentation Committee (IKDC), Tegner, Lysholm, Knee Injury Osteoarthritis Outcome Score (KOOS), Noyes sports activity, and Short Form-12 (SF-12) scoring systems. Fourteen patients with an average age at surgery of 46.48 years (range, 18–70) returned for evaluation at a median follow-up of 52 months (range, 31–98 months). Twelve of the 14 patients underwent previous surgery before allograft reconstruction. Postoperatively, the median IKDC score was 74 (range, 28–90), Tegner 8 (range, 0.5–10), Lysholm 62 (range, 28–100), KOOS pain 92 (range, 36–100), KOOS symptom 64 (range, 21–100), KOOS ADL 82 (range, 51–100), KOOS sport 50 (range, 5–95), KOOS QOL 44 (range, 12.5–100), Noyes 90 (range, 5–100), SF-12 physical 43 (range, 29–47), and SF-12 mental 49 (range, 28–64). All patients were able to perform a straight leg raise postoperatively. Five patients had an extensor lag at final evaluation averaging 8 degrees (range, 3–18). Thigh girth differential between the surgical and contralateral leg was 1.3 cm diameter. There were no postoperative infections or reruptures. Two patients required additional procedures. We believe extensor mechanism reconstruction with allograft is an effective salvage procedure in this challenging patient population.

Keywords
- allograft
- extensor mechanism reconstruction
- patellar tendon
- quadriceps tendon

received
June 12, 2013
accepted
January 1, 2014

DOI http://dx.doi.org/10.1055/s-0034-1370899.
ISSN 1538-8506.

Table 1 Patient demographic and surgical information

Case	Gender, age at op. (y)	Previous surgeries	Allograft type	Additional surgeries	Follow-up (mo)
1	M, 36	ORIF patella Fx with PT repair, ROH	Achilles	None	56
2	M, 60	PT repair, ROH, PT reconstruction with Achilles allograft, I&D ×3, latissimus free flap with LOA	Bone patellar tendon bone	Arthroscopic/open LOA (2 mo)	98
3	F, 17	PT repair	Achilles	ACL reconstruction (3 mo)	60
4	F, 37	Hauser procedure, Maquet procedure, arthroscopy with partial MMx, open proximal realignment with ROH	Achilles	None	35
5	M, 62	PT repair	Achilles	None	40
6	M, 34	None, PT rupture 1.5 y prior	Achilles	None	27
7	M, 44	QT repair, revision QT repair	Achilles	None	34
8	F, 35	Lateral release, Elmslie-Trillat procedure, patellectomy	Achilles	None	64
9	M, 36	PT repair	Achilles	None	40
10	M, 57	Quad repair	Achilles	None	30
11	M, 70	Patellar tendon	Bone patellar tendon bone	None	55
12	M, 42	PT repair and revision	Achilles	None	31
13	M, 47	Quad repair	Achilles	None	50
14	M, 20	None	Bone patellar tendon bone	None	48

Abbreviations: F, female; Fx, fracture; I&D, irrigation and debridement; LOA, lysis of adhesions; M, male; MMx, medial meniscectomy; ORIF, open reduction internal fixation; PT, patellar tendon; QT, quadriceps tendon; ROH, removal of hardware.

Extensor mechanism disruption is a potentially disabling injury in the active individual. Prompt recognition and treatment with direct primary repair with or without augmentation of the ruptured patellar or quadriceps tendon provides favorable outcomes in the majority of cases.[1–5] In chronic ruptures of the extensor mechanism, significant adhesions, quadriceps atrophy, patella retraction, and poor remaining tissue quality commonly preclude successful repair. Approximation of remaining native tendon to the patella may also be difficult, if not impossible, in patients presenting after failed repair or other prior surgical procedures. Several reconstruction options have been reported including delayed augmented repair,[6] external fixation,[7,8] the use of synthetic materials,[9,10] autograft,[4,8,11–16] and allograft tissues.[10,17–23] No clear consensus exists regarding treatment for these injuries. Although clinical outcomes following extensor mechanism allograft reconstruction have been described in patients with a prior total knee arthroplasty, only case reports have detailed the results of this procedure in nonarthroplasty knees.[24–28] The purpose of this study was to report the clinical outcomes in a series of patients without prior total knee arthroplasty treated with an extensor mechanism allograft reconstruction.

Materials and Methods

Over a 7-year period, 17 patients (18 knees) underwent extensor mechanism reconstruction with allograft at our institution. This retrospective study was approved by the institutional review board. Despite extensive telephone, Internet, and certified mail searches, two patients could not be located. One patient underwent total knee arthroplasty and was excluded. Fourteen patients (15 knees) were evaluated at a median 52 months postoperative follow-up (range, 31–98 months). The average age of the patients at the time of surgery was 46.48 years (range, 18–70 years). Twelve of the patients had previous surgery on the affected knee (►**Table 1**). All patients presented with complaints and physical findings indicative of an incompetent extensor mechanism. Frequent subjective complaints included pain, weakness, and a sense of instability of the knee during gait. Physical examination revealed inability to perform a straight

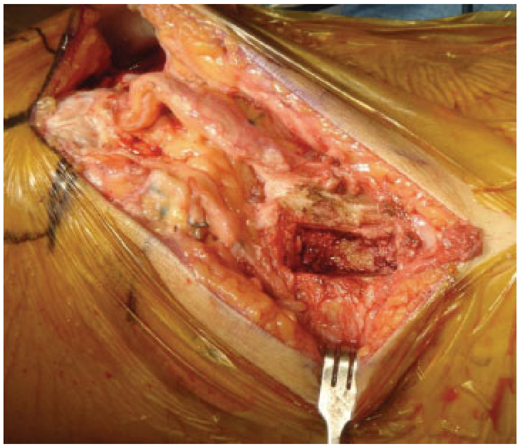

Fig. 1 Creation of bone trough at the tibial recipient site with an oscillating saw and osteotomes.

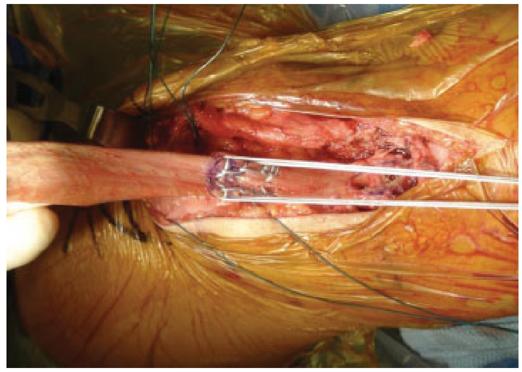

Fig. 3 Achilles tendon sutured with no. 5 nonabsorbable suture.

leg raise or active knee extension while seated, an obvious extensor lag, quadriceps atrophy, and migration of the patella. Surgical reconstruction of the extensor mechanism with an allograft was performed when the native tissues were determined to be unsuitable or absent, precluding repeat or delayed primary repair. The ultimate decision to proceed with allograft reconstruction was determined based on intraoperative findings including quality of native remaining tissues, patellar mobility after appropriate releases, and chronicity of condition.

Surgical Technique

Two techniques were used depending on surgeon preference: an Achilles allograft or whole bone-patellar tendon-bone (BTB) allograft. In both techniques, the extensor mechanism was exposed through a longitudinal approach. Adhesions were released in the suprapatellar pouch and along the medial and lateral gutters for patellar mobilization. All scar tissue in the region of the native patellar tendon was removed. At the tibial tubercle, a bone trough is created, typically 25 mm in length, 15 mm in width, and 15 mm in depth (►**Fig. 1**). For reconstruction with an Achilles allograft, three transosseous patellar tunnels were created with a 3/32″ smooth Steinmann pin. The calcaneal bone block was prepared to match the recipient site at the tibial tubercle. The bone block was then press fit into the prepared tibial tubercle. Final fixation was achieved with two 3.5-mm AO screws (►**Fig. 2**). Next, two no. 5 nonabsorbable sutures were woven through the Achilles allograft in a Krackow fashion (►**Fig. 3**). The four suture ends exited and entered the allograft at a distance equal to the patient's contralateral patellar tendon length as determined preoperatively. These four suture ends were passed through the previously created transosseous patellar tunnels. The patella was reduced as tension was applied to the sutures. The sutures were tied over the superior pole of the patella with the knee in full extension (►**Fig. 4**). Of importance, the allograft was tightly tensioned in full extension in all cases. The remainder of the Achilles allograft aponeurosis was spread out over the patella, quadriceps tendon, and the medial and lateral retinaculum. The allograft

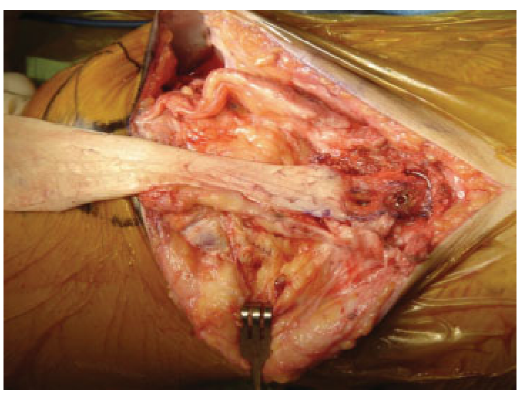

Fig. 2 Calcaneal bone block matched to press fit the tibial trough. Bicortical screws are placed in lag technique for final fixation.

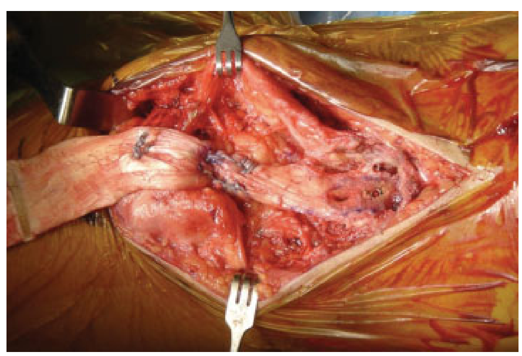

Fig. 4 Suture fixation over patella.

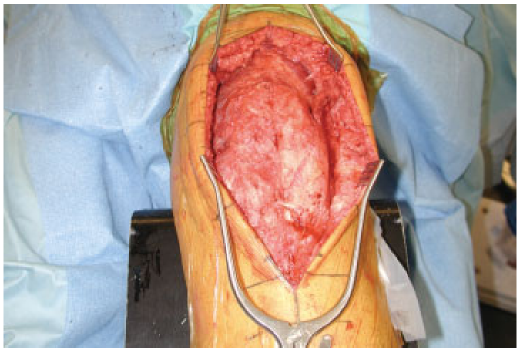

Fig. 5 Extensor mechanism exposure through a midline approach. Thick skin flaps are created.

was then sutured in place with a no. 1 nonabsorbable suture for reinforcement.

The surgical exposure, tibial preparation, and tibial fixation used with a whole BTB allograft were similar with the exception that the proximal fixation was achieved with a dovetail technique (►**Fig. 5**). A bony trough was created in the central distal third of the patella (►**Fig. 6**). Several small transverse drill holes were created with a K-wire at the posterior aspect of the created trough. Small 23-gauge wires were passed through the drill holes. The prepared BTB allograft was press fit into the recipient site on the patella. Final proximal fixation was achieved as the wires were tied in a cerclage fashion securing the bone block to the patella with the knee in full extension (►**Fig. 7**).

Patients were allowed to weight bear as tolerated with a hinged knee brace locked in extension for the first 6 weeks following surgery. Motion was limited for the first 6 weeks to protect the reconstruction based on intraoperative findings. In general, a progressive range of motion was allowed and increased at 2-week intervals (0–30, 0–60, and 0–90 degrees). Active knee flexion and passive knee extension was allowed. Assisted leg transfers were encouraged. The brace was discontinued at the point in which patients demonstrated good quadriceps control typically at 8 weeks postoperatively. Formal physical therapy was initiated at 6 weeks postoperatively, and isometric and early concentric exercises were begun. At 12 weeks postoperatively, eccentric quadriceps and more stressful exercises continue in supervised rehabilitation. Patients were involved in supervised physical therapy ranging from 4 to 6 months postoperatively.

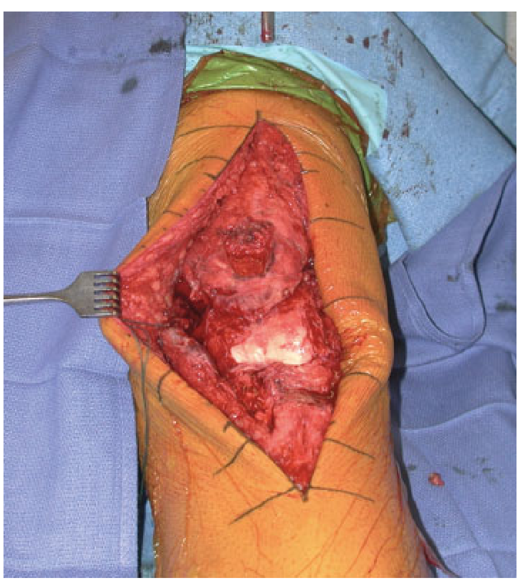

Fig. 6 Creation of bony trough in the patella and tibial tubercle to receive the bone-patellar tendon-bone allograft.

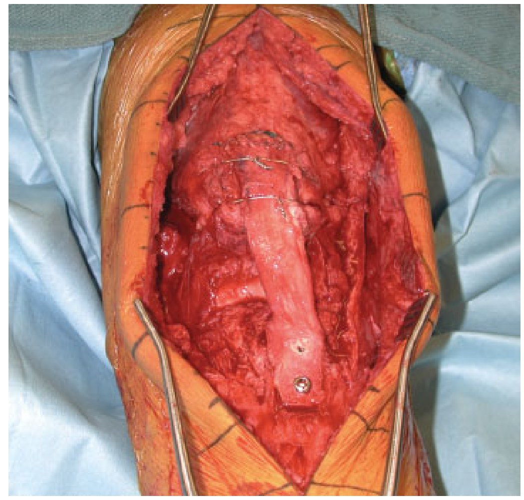

Fig. 7 Final fixation of the allograft.

Patients who underwent extensor mechanism reconstruction with allograft were evaluated at final follow-up with the International Knee Documentation Committee (IKDC) score,[29] Lysholm score,[30] Tegner score,[30] Knee Injury Osteoarthritis Outcome Score (KOOS),[31] Noyes sports activity score,[32,33] and Short Form-12 (SF-12) score. Patients were asked to use a numeric rating scale to rate their satisfaction with surgical outcome from 1 (completely unsatisfied) to 10 (completely satisfied). All follow-up clinical examinations were performed at a minimum 24 months postoperatively (mean 48 months). Physical examination included evaluation of range of motion measured with a handheld goniometer, thigh girth measured 10 cm proximal to the patella with the knee extended, and the ability to perform a straight leg raise. The presence and degree of an extensor lag if present was noted. Patellar mobility was assessed.

Results

The median active range of motion for the operative and contralateral knee at follow-up was equal at 130 degrees. The median amount of thigh girth atrophy measured 10 cm proximal to the patella with the knee extended was 1.3 cm

Table 2 Observed extensor lag, thigh girth differential, and range of motion

Patient	Extensor lag	Thigh girth differential	Motion (surgical)	Motion (contralateral)
1	4	0	6–120	2–130
2	18	1.5	18–103	0–135
3	3	2	3–112	0–125
4	0	0	0–120	0–140
5	0	1.5	0–135	0–135
6	0	0	0–140	0–140
7	0	0	0–110	0–120
8	0	1	0–135	0–135
9	10	3.5	0–135	10–135
10	0	1.5	0–135	0–135
11 (right)	0	0	0–130	0–130
11 (left)	0	0	0–130	0–130
12	0	5	0–90	0–120
13	5	2	5–115	0–125
14	0	2	0–130	0–130
Mean	6.5 degrees	1.33		

(range, 0–3.5) compared with the contralateral lower extremity. All patients could perform a straight leg raise at final follow-up; however, five patients were noted to have an extensor lag. The average extensor lag present in these five patients was 8 degrees (range, 3–18) (►**Table 2**).

Postoperatively, the median IKDC score was 74 (range, 28–90), Tegner 8 (range, 0.5–10), Lysholm 62 (range, 28–100), KOOS pain 92 (range, 36–100), KOOS symptom 64 (range, 21–100), KOOS ADL 82 (range, 51–100), KOOS sport 50 (range, 5–95), KOOS QOL 44 (range, 12.5–100) (►**Fig. 8**), Noyes sport activity 90 (range, 5–100), SF-12 physical 43 (range, 29–47), and SF-12 mental 49 (range, 28–64). The overall patient satisfaction on a 0 to 10 scale, 10 being most satisfied, had a median score of 6 (min 2, max 10, SD 2.5).

There were no infections, postoperative reruptures, or patellar fractures. Two patients required additional surgery. One patient underwent a planned anterior cruciate ligament reconstruction 3 months after her extensor mechanism reconstruction. The other patient required combined arthroscopic and open lysis of adhesions procedures at 2 and 8 months after his reconstructive procedure. This patient before our reconstruction had a virtually ankylosed knee joint secondary to sepsis after previous failed patellar tendon repair.

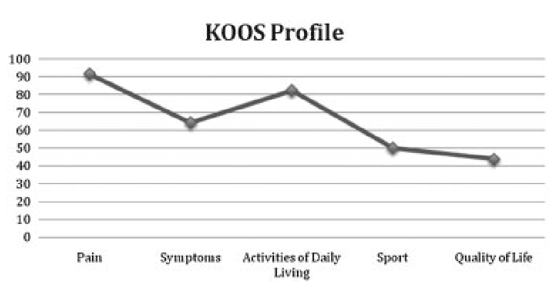

Fig. 8 KOOS profile of outcomes at final follow-up at median 48 months postoperatively. KOOS, Knee Injury Osteoarthritis Outcome Score.

Discussion

The most important finding from this present study is that extensor mechanism reconstruction with allograft is an effective salvage procedure in the restoration of extensor function and return to activities at 4 years postoperatively. In this case series of 14 patients, the extensor construct provided patients with minimal postoperative extensor lag, pain, and afforded similar range of motion to the contralateral knee. Although return to high-level function was guarded, return to activities of daily living was certainly achieved within the cohort. Interestingly, patients achieve excellent outcomes on physical exam and score well on outcome measures that assess pain, yet overall patient satisfaction is median 6 out of 10 with standard deviation of 2.5. This rather large standard deviation may suggest patients were either very satisfied or dissatisfied with their outcomes despite clinical improvement and decrease in pain, a result that warrants further study of preoperative predictors of satisfaction.

In all cases, patients had chronic tendon disease either with previous primary repair or long-standing rupture. In each situation, the remaining local tissues were inadequate for repair because two patients required reconstruction.

Depending on surgeon preference, allograft reconstruction was performed with either a fresh-frozen nonirradiated Achilles or whole BTB allograft.

The use of allograft tissue for reconstruction in young, active individuals has been described in previous case reports.[17–19,21–23,34] Other reports have detailed the effectiveness of the use of allograft reconstruction for extensor mechanism rupture after total knee arthroplasty in large series of patients.[24–28] Nazarian and Booth[28] reported on 36 patients treated with a fresh-frozen whole extensor mechanism allograft including quadriceps tendon, patella, patella tendon, and tibial tubercle. At an average 3.6 years follow-up, 34 patients were noted to have a successful result. Eight reruptures requiring repeat allograft reconstruction were reported. Fifteen of 36 patients had an extensor lag averaging 13 degrees. The average Knee Society functional score improved from 37 to 68 after surgery. Burnett et al[25] reported on 19 patients treated with either a whole extensor mechanism allograft (9 patients) or Achilles allograft (10 patients) at a mean 56 months follow-up. Overall, an extensor lag was present in all but three patients with a mean lag of 14 degrees. Eighty-nine percent of patients were satisfied with the procedure. The authors found both types of allografts to be successful. In another study, Burnett et al[24] evaluated the results in 20 patients following reconstruction with a whole extensor mechanism allograft after total knee arthroplasty. All seven patients in whom the allograft was initially minimally tensioned were considered clinical failures with an average postoperative extensor lag of 59 degrees (range, 40–80). In the remaining 13 cases, the allograft was initially tensioned tightly in full extension resulting in clinical success and an average postoperative extensor lag of 4.3 degrees (range, 0–15) at a minimum 24-month follow-up.

Chronic extensor mechanism deficiency leads to significant disability with complaints of instability, pain, and weakness. Although many different surgical techniques have been described, this study demonstrates an allograft reconstruction to be an effective salvage procedure in this difficult patient population. Favorable clinical outcomes were noted following allograft reconstruction in young, active patients similar to previous case reports.

The strengths of this study include the length of follow-up and the use of validated outcome measures to allow direct comparison to other studies and techniques. Regardless of the technique or graft choice, extensor power was restored in all patients with no clinical failures or rerupture. All patients demonstrated 5/5 motor strength against manual resistance with the ability to perform a straight leg raise; however, a slight extensor lag was noted in five patients ranging from 3 to 18 degrees. Perhaps, the greatest strength of this study is that it captures objective clinical data as well as subjective patient-reported data including overall satisfaction. The clinical data suggest good outcomes at follow-up based on minimal extensor lag and thigh girth discrepancy which does not necessarily correlate in all cases with the patient reported data.

There are multiple limitations of this study. It is a retrospective case series with no preoperative outcome measurements available for postoperative comparison and determination of true treatment effect. Multiple surgeons were involved with two different techniques and grafts used based on surgeon preference. With the numbers available, we were unable to make a direct meaningful comparison. Minor variations occurred between the techniques performed using Achilles tendon allograft that was surgeon dependent. Seventeen patients (18 knees) met criteria for inclusion, but two patients could not be located for follow-up, and one patient underwent a total knee arthroplasty and was excluded. The small cohort available for study was heterogeneous with various pre-reconstruction conditions and challenges. Although the thigh circumference of each extremity was measured to evaluate for quadriceps atrophy, no direct quadriceps strength testing or functional tests were performed on these patients to objectively quantify extensor power.

Conclusion

The use of fresh-frozen Achilles or BTB allograft is effective option for restoring extensor function and range of motion in this challenging patient population. The use of allograft is a viable alternative when the remaining tissues are either absent or attenuated precluding direct repair with or without augmentation. In a patient population with significant preoperative impairment, extensor mechanism reconstruction with allograft should be considered, however, as a salvage procedure. As such, patient postoperative expectations should be managed appropriately. Based on the results of this study, this procedure reliably decreases pain and increases ability to perform activities of daily living but results in moderate patient satisfaction and may not return patients to high-level activity.

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