Knee Extensor Mechanism Reconstruction With Complete Extensor Allograft After Failure of Patellar Tendon Repair

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Abstract

Disruptions of the extensor mechanism of the knee may be bony or tendinous in nature. The consequences of such disruptions are not favorable because they prevent normal function of the knee, which is critical for independent ambulation. We report on a 30-year-old man who underwent a successful knee extensor mechanism reconstruction with allograft after his initial tendon repair failed.

The extensor mechanism of the knee comprises the quadriceps tendon, the patella, and the patellar tendon. The extensor mechanism may be damaged by injury to these structures, with consequences such as the inability to actively extend the knee and hemarthrosis.[1,2] Disruption of this mechanism is rare, and the most common injury pattern is an eccentric contraction of the quadriceps tendon on a flexed knee causing a tendon (quadriceps or patellar) rupture or a patella fracture.[1,2]

Patellar tendon ruptures are more common in persons younger than 40 years.[1] Treatment is surgical, regardless of age and physical activity. In the acute setting, repair can be end-to-end suture or transosseous tunnel insertion. End-to-end suturing is difficult in chronic patellar tendon ruptures because of patella alta secondary to quadriceps contraction.[3] Treatment options for chronic ruptures may involve transpatellar traction[4] or tendon reinforcement with fascia lata, a semitendinosus band, or synthetic materials.[3-5] Alternatively, tendon autograft and allografts have also been recommended, especially in extreme situations.[1,6] Furthermore, animal experiments have shown that a compact platelet-rich fibrin scaffold (CPFS) has the potential to accelerate healing of patellar tendon defects and to act as a bioscaffold for graft augmentation.[7]

We describe the case of a 30-year-old man who underwent extensor mechanism reconstruction with cadaveric tendon–patellar tendon–bone allograft for failure of an infected primary end-to-end repair. The patient provided written informed consent for print and electronic publication of this case report.

Case Report

A 30-year-old healthy man landed on an empty glass fish tank, resulting in a traumatic right-knee arthrotomy. On initial evaluation, the patient had a negative straight-leg-raise test and impaired knee extension. The patient was taken urgently to the operating room for irrigation and débridement and concurrent repair of the patellar tendon laceration. Antibiotic prophylaxis with 2 g of intravenous (IV) cefazolin was given in the emergency room.

Intraoperatively, after visualizing the patellar tendon laceration and excluding any associated chondral lesions, we proceeded with extensive débridement and irrigation using 9 L of normal saline pulse lavage. After we achieved a clean site, we proceeded to repair the patellar tendon using No. 2 FiberWire sutures (Arthrex, Naples, Florida) with a classic Krackow repair[8] consisting of 2 sutures run in a 4-row fashion through the patella and the patellar tendon. The suture was securely tightened and then tested for stability to at least 90° of knee flexion. The retinaculum was repaired using No. 0 Vicryl sutures (Ethicon, Somerville, New Jersey). After wound closure and dressing, the patient was placed in a hinged knee brace locked in extension at all times after surgery. Antibiotic treatment with IV cefazolin was administered for 48 hours.

Postoperative management consisted of weight-bearing as tolerated on the operative limb and appropriate deep venous thrombosis prophylaxis. The patient followed up in clinic 2 weeks and 4 weeks after surgery. At 4 weeks, the patient was noted to have a secondary wound infection with superficial dehiscence and serosanguineous drainage. No wound opening was noticed, and local wound care was performed with a 1-week course of oral cephalexin. The patient was scheduled to follow up a few weeks later but did not follow up for a year.

At 1-year follow-up, the patient reported that he had had a steady progression of his knee range of motion (ROM) with decreased pain. However, over time, the patient noted subjective instability of the knee, with frequent falls occurring close to his 1-year follow-up. Examination of his knee showed that his active ROM ranged from 20° in extension to 120° in flexion, with a weak extensor mechanism. Passively, his knee could be brought to full extension. His incision was well healed, but it had an area of bogginess in the middle. Radiographs showed

patella alta on the affected knee, with a lengthening of the patellar tendon of 7.70 cm on the right compared with 5.18 cm on the left. Magnetic resonance imaging (MRI) showed moderate-to-severe patellar tendinosis with small fluid pockets around the surgical material and evidence of acute patellar enthesopathy. The laboratory values showed a white blood cell count of 7580/μL (normal, 4500-11,000/μL), an erythrocyte sedimentation rate of 2 mm/h (normal, 1-15 mm/h), and a C-reactive protein level of 1.93 mg/dL (normal, 0.00-0.29 mg/dL). Based on the clinical examination and imaging findings, there was a concern for a possible chronic deep-tissue infection, in addition to failure of the primary patellar tendon repair. Operative versus nonoperative management options were discussed with the patient, and he elected to undergo surgery.

During surgery, the patellar laxity was confirmed, and the patellar tendon was noticed to be chronically thickened and surrounded by unhealthy tissue. Initially, an extensive soft-tissue débridement was performed, and all patellar tendon loculations visualized on the preoperative MRI were drained; a solid purulent-like fluid was expressed. Unfortunately, the extensive and required débridement did not allow the preservation of the patellar tendon. Appropriate cultures were taken and sent for immediate Gram-stain analysis, which returned negative. Tissue samples from the patellar tendon were also sent to the pathology department for analysis. Intraoperatively, the infrapatellar defect was filled temporarily with a tobramycin cement spacer mixed with 2 g of vancomycin in a manner similar to that of the Masquelet technique used for infected long-bone nonunions with bone loss.[9,10] This technique is a 2-stage procedure that promotes the formation of a biologic membrane that allows bone healing in the reconstruction of long-bone defects. The first stage consists of a radical débridement with soft-tissue repair by flaps when needed, with the insertion of a polymethylmethacrylate cement spacer into the bone defect. The second stage is usually performed 6 to 8 weeks later, with removal of the spacer and preserva-

tion of the induced membrane, which is filled with iliac crest bone autograft augmented (if necessary) with demineralized allograft.

The incision was closed primarily, and after surgery, the patient was allowed to bear weight as tolerated in a hinged knee brace locked in extension. Final laboratory analysis from cultures and tissue samples revealed acute and chronic inflammation with more than 20 neutrophils per high-powered field. No organisms grew from aerobic, anaerobic, fungal, or mycobacterial cultures. The infectious disease service was consulted and recommended oral cephalexin.

Because all cultures were negative, all laboratory examinations did not indicate any residual infections, and no bony involvement was noticed intraoperatively or in the preoperative knee MRI, we decided to proceed with the second stage of the Masquelet technique after 2 weeks. The patient returned to the operating room for final reconstruction of his patellar tendon using a custom-ordered cadaveric tendon–patellar tendon–bone allograft, the length of which was determined by measuring the contralateral patellar tendon, ie, 5.18 cm (**Figure 1A**). The previous anterior knee incision was reopened and extended distally past the tibial tuberosity and proximally toward the quadriceps tendon. The antibiotic spacer was removed. We proceeded with a repeat irrigation and débridement and the allograft transfer. The selected allograft was customized by reducing the tibial bone component to an approximately 1×2-cm bone block and by reducing the allograft patellar thickness with an oscillating saw, leaving an approximately 2-mm thick patellar bone graft attached to the patellar tendon. In a similar technique using an oscillating saw, we shaved off the anterior cortex of the patient's patella to accommodate, in a sandwich fashion, the patellar allograft. Proximally, the quadriceps tendon insertion was split longitudinally and partially separated from the superior pole of the patellar tendon to allow seating and fixation of the modified quadriceps allograft tendon component.

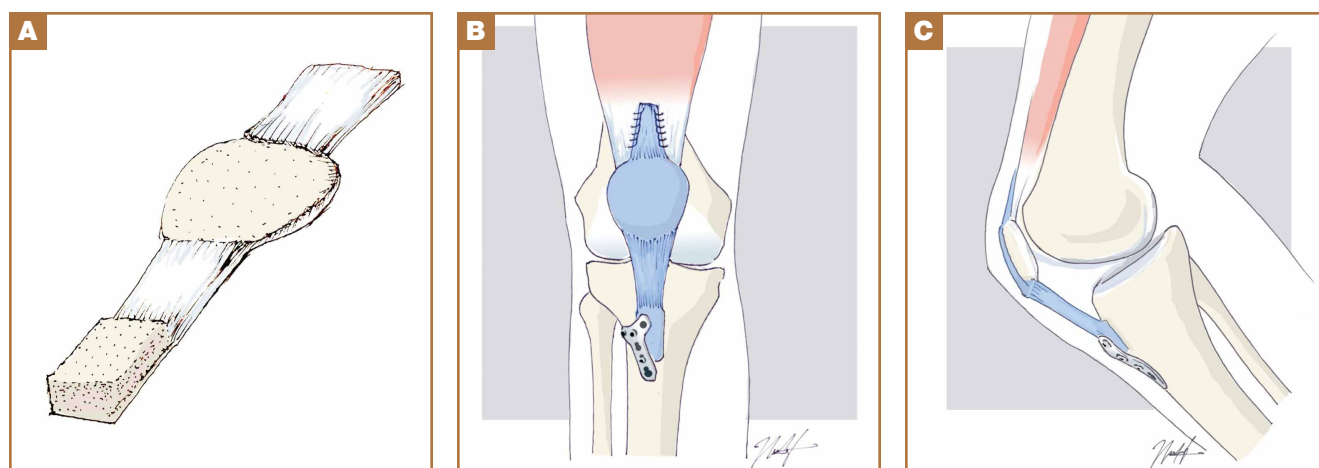We proceeded with the fixation of the allograft first distally

Figure 1. (A) Schematic representation of a full cadaveric tendon–patellar tendon–bone allograft. (B) Anteroposterior and (C) lateral schematic representations of the extensor mechanism reconstruction. The cadaveric allograft (shaded in blue) was customized at the allograft patella, which was reduced in thickness and sandwiched over the customized accepting autograft patella.

on the patella. The anterior cortex of the tibial tuberosity was resected to allow the perfect seating of the bone block allograft. The graft was secured with a 4.0-mm fully threaded cancellous lag screw and reinforced with a 2.4-mm, 3-hole T-volar buttress plate (Synthes, Paoli, Pennsylvania). The plate was contoured to better fit the patient's tibia. We sutured the patellar allograft tendon to the patella using two No. 2-0 FiberWire sutures in Krackow suture technique[8] (Figures 1B, 1C). We obtained good fixation of the patellar tendon, and the distance between the patellar insertion and the inferior patellar pole was the same as before surgery: 5.57 cm and comparable to the contralateral side (Figures 2A-2C). The patellar allograft and autograft sandwich were secured with additional No. 2-0 FiberWire sutures, and the quadriceps allograft and autograft were secured with the cross-stitch technique with the same material. Fine suturing of the quadriceps tendon was done with No. 0 Vicryl sutures. After the fixation was completed, we tested the stability of the reconstruction and found good flexion up to 120°.

The postoperative protocol consisted of weight-bearing as tolerated in full extension and passive knee ROM, using a continuous passive ROM machine from 0° to 45° for the first 4 weeks, followed by active ROM, increased as tolerated, during the next 8 weeks.

The patient was seen in clinic 3 and 9 months after surgery. At the 3-month follow-up appointment, the patient's examination showed knee ROM from 0° extension to 130° of flexion, no secondary infection signs, and radiographic evidence of a well-healing patellar allograft with symmetric patellar tendon length to the contralateral side. At 9-month follow-up, the patient's active ROM was from 0° extension to 140° flexion (Figures 3A, 3B), and he had returned to his preinjury level of functioning.

Discussion

This case report describes the successful reconstruction of a patellar tendon defect with cadaveric tendon–patellar tendon–
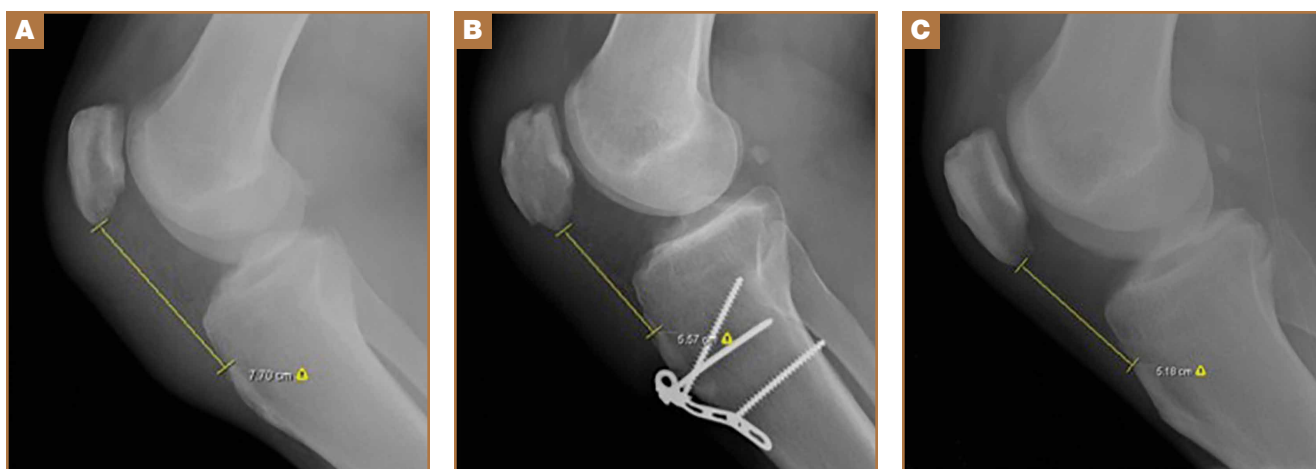

Figure 2. (A) Preoperative patellar tendon length showing patella alta. (B) Postoperative radiograph at 9 months. The patellar tendon has maintained its length and is symmetric to that on the contralateral side. (C) The contralateral patellar tendon length is grossly symmetric to that on the operated side.
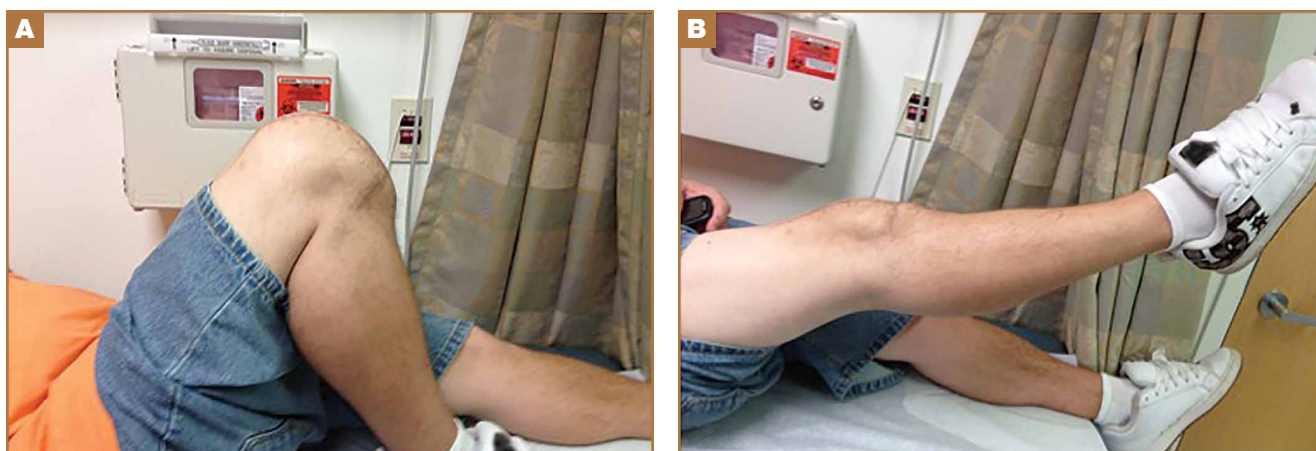

Figure 3. At the 9-month postoperative visit, active knee range of motion varied from (A) 0° to (B) 140°.

bone allograft. Extensor mechanism injuries are uncommon in general, and the incidence of patellar tendon injury is higher in men than in women.[2] Patellar tendon tears occur frequently in active patients younger than 40 years, usually as a result of sudden quadriceps contraction with the knee slightly flexed.[1] Treatment of patellar tendon injury is surgical, and functional outcomes for patients with this injury are equivalent to those of patients with quadriceps tendon injuries or patellar fractures.[2] Acute patellar tendon tears can be repaired by end-to-end suturing or transosseous tunnel insertion in the tibia or patella.[1] Reinforcement is often added between the patella and tibial tuberosity, using a semitendinosus band or wire.[1] End-to-end suture is performed using a thick resorbable suture. It is important to avoid patella alta during suturing, comparing the position of the patella with the contralateral patella with the knee in 45° of flexion. In proximal avulsion, the tendon is anchored to the bone by 2 thick nonresorbable sutures through 2 parallel bone tunnels to the proximal pole of the patella. Distal avulsion is rare in adults, but it can be managed by using staples or suture anchors.[1]

End-to-end suturing of chronic patellar tendon defects is difficult more than 45 days after injury primarily because of difficulties in correcting patella alta secondary to the upward force exerted by the quadriceps tendon.[1,3] Extreme situations similar to the case we present warrant Achilles or patellar tendon allograft for reconstruction of the extensor mechanism.[1,3,6,9]

Extensor mechanism allograft also provides an effective remedy for severe quadriceps deficiency caused by loss of the patella, patellar tendon, and quadriceps tendon in total knee arthroplasty.[10] However, in such cases, late failure is common, and major quadriceps deficiency occurs after removal of the allograft material.[10] To improve outcome, a novel technique using the medial gastrocnemius muscle transferred to the muscular portion of the vastus medialis and lateralis flaps provides a secure and strong closure of the anterior knee, thereby restoring the extensor mechanism of the knee.[10]

Patellar tendon reconstruction with allograft tissue has been successfully used, especially in cases related to chronic patellar tendon ruptures[11] and total knee arthroplasty.[6,12-14] Crossett and colleagues[12] showed that, at 2-year follow-up, the average knee score for pain, ROM, and stability had improved from 26 points (range, 6-39 points) before surgery to 81 points (range, 40-92 points). The average knee score for function had also improved: 14 points (range, 0-35 points) before surgery to 53 points (range, 30-90 points).[12] Primary repair may succeed in early intervention, but in an established rupture, allograft reconstruction is often necessary. Achilles tendon is the preferred allograft, with the calcaneus fragment embedded into the proximal tibia as a new tubercle and the tendon sutured into the remaining extensor mechanism.[1,11] The repair is further protected using a cable loop from the superior pole of the patella to a drill hole in the upper tibia.[9] Techniques have also been described involving passage of the proximal aspect of the allograft tendon through patellar bone tunnels and suture fixation to the native quadriceps tendon.[11,15] However, in our technique, we shaved off the anterior cortex of the patient's

patella to allow a sandwich-type over-position of the allograft to secure fixation to the patella.

Another alternative to allograft reconstruction involves biocompatible scaffolds. Such scaffolds incorporate the use of platelets in a fibrin framework. A CPFS, produced from blood and calcium gluconate to improve healing of patellar tendon defects, has been described in animal studies.[7] In the rabbit model, CPFS acts as a provisional bioscaffold that can accelerate healing of an injured patellar tendon repair, potentially secondary to several growth factors derived from platelets.[7] Platelets are biocompatible sources of growth factors, and CPFS can act as a scaffold to restore the mechanical integrity of injured soft tissue.[7,16] In addition, CPFS can act to lower donor-site morbidity associated with harvesting tissue autograft.[7] However, to our knowledge, such scaffolds have not been used in human trials. The LARS biocompatible ligament (Corin Group PLC, Cirencester, United Kingdom), currently not approved by the US Food and Drug Administration, is used for reconstructions of isolated or multiple knee ligament injuries.[17] This graft requires the presence of healthy tissue with good blood supply from which new tendon or ligament can grow in. Sometimes it is also used for extensor mechanism reconstruction after radical tumor resection around the knee; however, good results are achieved in only 59% of cases,[18] and to our knowledge, only 1 case of primary repair of a patellar tendon rupture has been published.[19]

Techniques involving the use of tendon–patellar tendon–bone graft with fixation via the sandwich-type over-position of the allograft for chronic patellar tendon rupture have not been described in the literature. In our patient, given the extensive patellar tendon lesion and inflammation with chronic tissue degeneration, there was no option but to use allograft. To improve the patient's outcome, we chose the strongest possible allograft, tendon–patellar tendon–bone graft.

Conclusion

Revision patellar tendon reconstruction is a challenging, but necessary, procedure to restore the extensor mechanism of the knee, especially in young, active individuals. Various options to reconstruct the tissue defects are available. Our patient was successfully treated with a tendon–patellar tendon–bone allograft reconstruction.

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This paper will be judged for the Resident Writer's Award.