Novel Treatment of a Failed Quadriceps Tendon Repair in a Diabetic Patient Using a Patella-Quadriceps Tendon Allograft

Sasha C. Druskin, BA · Scott A. Rodeo, MD

Received: 30 October 2011/Accepted: 4 June 2012/Published online: 28 September 2012
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Abstract Recurrent quadriceps tendon rupture is a debilitating condition that may be challenging to treat, especially in the presence of systemic disease such as diabetes mellitus. Many surgical treatment protocols have been proposed. We report the case of a diabetic male with multiple treatment failures. He ultimately sustained a good outcome following treatment with a novel surgical technique that utilized a patella quadriceps tendon allograft. Tendon allograft-to-native bone healing had previously failed in this patient, so we used a bone-tendon construct allograft to provide an allograft bone-to-native bone healing site. Now, 13 months postoperative, the patient has increased strength, minimal pain, 20° of extensor lag and 130° of flexion.

Introduction

Patients with diabetes mellitus, gout, or those who use steroids are known to be at increased risk for complete rupture of the quadriceps tendon [1, 8, 13]. The increased incidence of complete rupture in patients with diabetes mellitus is possibly due to non-enzymatic glycosylation of the collagen in the tendon, which leads to alterations in collagen cross-linking and subsequent changes in the properties of the tendon material [11]. It has been established that diabetes mellitus is associated with

abnormal collagen structure and synthesis and causes weakened tendons [13], but there is also some evidence that diabetes mellitus inhibits healing of tendons after their rupture [2–4]. Chbinou and Frenette [3] showed that following collagenase-induced injury of the Achilles tendon in rats with type 1 diabetes mellitus, the tendon displayed a decreased accumulation of neutrophils and both ED1⁺ and ED2⁺ macrophages, decreased angiogenesis, and a decreased concentration of proliferative cells, indicating that diabetes mellitus may disrupt early-stage tendon healing. Bedi et al. [2] reported impaired tendon-to-bone healing in diabetic rats in a supraspinatus tendon repair model. Chen et al. [4] documented potentially increased rates of repair failure in diabetic human patients undergoing rotator cuff repair. Each of these studies suggests that diabetes may predispose a patient to impaired tendon healing, possibly contributing to the failure of tendon repair.

Several surgical techniques are used in the treatment of a complete rupture of the quadriceps tendon [1, 6, 8, 9, 12]. The standard repair technique involves the use of sutures that attach the tendon to the patella via drill holes [1, 8]. However, failed healing or re-rupture can present a difficult challenge. There is limited information in the literature on techniques for managing recurrent tears where the tendon is retracted, especially if the tendon is scarred and/or attenuated. However, several approaches have been used for such cases at our institution. Techniques that utilize a flap of tissue from the native quadriceps tendon have been used. Furthermore, various graft options have been used, including autografts (e.g., the semitendinosus tendon), allografts (e.g., the Achilles tendon), and synthetic grafts; extracellular matrix (ECM) materials have been utilized as well.

We report the case of a 67-year-old male with a history of type II diabetes mellitus and several failed repairs of a complete quadriceps tendon rupture. We ultimately achieved a successful result using a patellar bone-quadriceps tendon

S. C. Druskin, BA
Weill Cornell Medical College,
1300 York Avenue,
New York, NY 10065, USA

S. A. Rodeo, MD (✉)
Sports Medicine and Shoulder Service,
Hospital for Special Surgery,
535 East 70th Street,
New York, NY 10021, USA
e-mail: rodeos@hss.edu

allograft. This novel approach provides a viable option for patients who have failed quadriceps tendon-to-patellar bone healing.

Case Report

A 67-year-old male sustained rupture of his right quadriceps tendon after tripping in a hole while playing golf. His medical history included type II diabetes mellitus managed with oral metformin, hypertension, hyperlipidemia, coronary artery disease, a myocardial infarction, deep vein thrombosis, and aortic aneurysm repair. His injury was initially managed at an outside institution where he underwent surgical repair of the quadriceps tendon approximately 25 days after the injury. Soon after, he developed a postoperative wound infection and the repair failed to heal. He underwent a revision repair but approximately 9.5 months after the initial injury he came to our institution complaining of persistent pain and weakness in his right knee. At that time he used a cane to ambulate and he was able to walk a maximum of ten blocks at a time. Physical examination demonstrated patella baja, a 45° extensor lag, flexion to 120°, and a palpable defect at the quadriceps tendon insertion point at the superior pole of the patella. Magnetic resonance imaging (MRI) evaluation showed failure of the quadriceps tendon repair. Blood work and joint fluid cultures were negative for infection.

Revision repair was performed approximately 3 months later. The quadriceps tendon appeared to be retracted approximately 1 cm from the patella, and there was no evidence of infection. At the site of the previous repair, the quadriceps tendon was thin and deficient with extensive scar tissue. The lateral and medial aspects of the quadriceps tendon were incised to mobilize the tendon, and the distal

end of the tendon and the superior pole of the patella were debrided. Three Bunnell stitches with #2 Fiber Wire (Arthrex, Naples, FL) were placed in the quadriceps tendon, and then two longitudinal holes with a 5.0 mm diameter were drilled into the patella for suture passage. Next, a semitendinosus allograft was tubularized using whipstitches placed in both ends of the graft using #2 Fiber Wire, and the graft was woven through small stab incisions in the quadriceps tendon. The sutures that had been passed through the quadriceps tendon and the ends of the sutures in the semitendinosus allograft were passed through the patellar drill holes. The ends of the semitendinosus allograft were pulled into the holes in the patella, and the sutures exiting the distal end of the patella were tied together while the leg was in full extension. Finally, an ECM patch derived from human dermis (GraftJacket, Wright Medical Technology, Inc., Arlington, TN) was secured over the anterior aspect of the quadriceps tendon using 3–0 Vicryl suture (Ethicon, Somerville, NJ) in order to augment the repair [5].

Postoperatively, the leg was immobilized in full extension and quadriceps isometrics and straight leg raise exercises began immediately. The knee was immobilized in full extension for the first 4 weeks, after which the patient began active flexion and passive extension. Flexion was initially limited to 45° and progressively increased to 80° by 8 weeks postoperatively. Active knee extension was initiated 6 weeks postoperatively. Despite this conservative motion program, the patient developed a progressive extensor lag over the ensuing 3–4 months, with associated pain and swelling around the superior pole of the patella. An MRI study indicated failed tendon-to-bone healing, with a recurrent gap at the repair site (Fig. 1a–c). Blood work and culture of the knee aspirate did not indicate the presence of infection.

Based on the patient's significant functional disability, revision repair was recommended. Since tendon-to-bone healing had been previously unsuccessful in this patient, it was felt

Fig. 1. Sagittal plane magnetic resonance images of the patient's right knee following failure of tendon-to-bone healing after a repair of his quadriceps tendon that utilized a tubularized semitendinosus allograft passed through longitudinal drill holes in the patella. **a** The tendon detached from the patella and retracted proximally. **b** A more distal view of the failed repair. Here, too, a gap is seen between the patella and the retracted tendon. **c** The allograft within one of the longitudinal drill holes in the patella

that repeat reattachment of the quadriceps tendon to the patella was likely to have a high risk of recurrent failure. Thus, a bone-tendon allograft consisting of the anterior aspect of the patella with its attached quadriceps tendon was used.

During the surgery, the previously placed allograft tissue appeared degenerative, and there was extensive scar tissue around the quadriceps tendon. There was no gross evidence of infection, intraoperative cultures were negative, and intraoperative analysis of frozen sections showed no evidence of acute inflammation. A coronal plane osteotomy of the native patella was made to remove the anterior aspect of the bone. The patellar bone-quadriceps tendon allograft was fashioned by making a coronal plane osteotomy of the allograft patella, removing the articular surface, and maintaining the quadriceps tendon attachment to the anterior part of the bone. The allograft bone was trimmed to the appropriate size intraoperatively to replace the anterior part of the native patella that had been removed. The allograft patella was fixed to the native patella with three screws (two 3.5-mm screws and one 2.7-mm screw). Unicortical screws were used to avoid penetration of the articular cartilage; we achieved adequate fixation to the dense patellar bone. Intraoperative fluoroscopy was used to verify satisfactory placement and length of the screws. To aid bony healing, recombinant human bone morphogenetic protein-2 (rhBMP-2) on an absorbable collagen sponge (INFUSE® Bone Graft, Medtronic Spinal and Biologics, Memphis, TN) was used at the patellar osteosynthesis site [14]. With the knee in full extension, the quadriceps tendon on the allograft was placed in the middle of the native quadriceps tendon and secured to the native tendon with multiple Bunnell sutures. This was done while the allograft tendon was pulled proximally and the native tendon was pulled distally in order to create maximal tension in the extensor mechanism. Intraoperatively, the patellar height was matched to that of the contralateral knee using radiographic measurements of that knee made preoperatively. Additionally, we prepped the contralateral knee during surgery so that we could match patellar position by direct comparison. The vastus lateralis and medialis were secured to the allograft tendon using #2 Fiber Wire sutures. Finally, the pre-patellar tissues that had been preserved were secured over the patella allograft.

Following the operation, radiographs showed proper placement of the bony allograft (Fig. 2a and b). An ambulatory assist device was used for the first 8 postoperative weeks. The patient's knee was maintained in extension for the first 6 weeks. Active flexion was begun 6 weeks postoperatively, with a gradual progression to 90° by 12 weeks. Active knee extension was initiated at 8 weeks. This was followed by progressive quadriceps strengthening and gait training. Additionally, physical therapy emphasized strengthening of the proximal musculature (hip muscles, core muscles, etc.) and proprioception and balance training. At the 13 month follow-up visit the patient had minimal pain, his strength had improved, he had 20° of extensor lag, and 130° of flexion. Radiographs demonstrated progressive bridging trabeculae between the native and allograft patellar bones (Fig. 3).

Fig. 2. Lateral (a) and anteroposterior (b) radiographs of the patient's right knee immediately following quadriceps tendon rupture repair using a patella-quadriceps tendon allograft show proper placement of the allograft and radiolucency at the allograft patella-native patella contact site. In the lateral view, only two of the three screws used to attach the allograft patella to the native patella can be seen clearly. In the anteroposterior view, all three screws are visible

Discussion

Many of the common techniques used in quadriceps tendon repair involve placing sutures into the ruptured quadriceps tendon and then either passing those sutures through holes drilled into the patella or attaching the sutures to the patella via bone anchors [1, 8]. However, these standard repair techniques may be inadequate for the management of chronic ruptures, where the quadriceps tendon may be retracted and degenerated [8, 12]. Various surgical techniques have been developed to

Fig. 3. A lateral radiograph of the patient's right knee approximately 5 months after quadriceps tendon rupture repair using a patella-quadriceps tendon allograft shows progressive healing at the allograft patella-native patella contact site compared to that seen immediately postoperatively in Fig. 2a. Only two of the three screws used to attach the allograft patella to the native patella can be seen clearly

repair chronically ruptured quadriceps tendons [1, 8, 12]; furthermore, grafts can be employed to augment poor quality tendons [12]. In the present case we used a bone-tendon allograft to re-establish the extensor mechanism.

A number of techniques utilize local tissue to span the gap between the retracted quadriceps tendon and the patella [12]. One such technique, the Scuderi method, involves isolating a 3- to 4-mm-thick triangular flap of tendon from the anterodistal aspect of the ruptured quadriceps tendon [1, 8]. The distal side of the triangle remains attached to the distal end of the ruptured tendon, and the proximal part of the flap is folded distally over the rupture site and patella, and then sutured in place [1, 8]. The Codivilla technique is similar to the Scuderi technique - it involves the isolation of a full-depth, partial-width flap of tissue from the distal aspect of the ruptured tendon [1, 8]. Medial and lateral struts of tissue remain on either side of the flap, maintaining tissue continuity [1, 8]. This flap is folded down over the patella and sutured in place [1, 8]. These techniques rely on tendon tissue that is often attenuated and of poor quality, and the native tendon is necessarily weakened by the procedure. As a result, we generally do not recommend such techniques.

The graft options available for the augmentation of the quadriceps tendon include autograft, allograft, or synthetic grafts [12]. Possible autograft options include the semitendinosus or gracilis tendon [12]. For allografts, we have used Achilles, tibialis anterior, and semitendinosus tendons in the past. Using allograft tissues provides the advantage of avoiding donor-site morbidity and allows implantation of a large graft [10]. However, the use of allograft tissue carries some risk of transmission of infectious disease and there can be delayed biologic incorporation, perhaps due to a subtle immune response to the foreign tissue [7]. Our experience demonstrates that the graft can be woven through the quadriceps tendon and then attached to the patella with suture anchors or by passing the tendon through longitudinal drill holes in the patella. An alternative fixation technique is to pass the graft over the patella and then to fix it in a drill hole at the tibial tuberosity. As for synthetic grafts, one reported technique makes use of the synthetic vascular graft Dacron [9]. The tubular graft is woven through the patellar tendon and the quadriceps tendon and tied at its ends with tension [9]. Carbon fiber materials have also been used in quadriceps tendon repair [6].

ECM materials, derived from either allograft or xenograft tissue, have also been used to supplement the surgical repair of tendons [5]. ECM materials derived from human or porcine dermis or porcine small intestine submucosa are available for tendon augmentation and provide a temporary, resorbable scaffold that can support tendon growth [5]. Growth factors, cytokines and other chemicals in ECM materials may also have inductive effects, influencing angiogenesis, collagen production, and other cellular processes in the host [5]. However, there is very little information currently available in the literature on the use of these materials for quadriceps tendon repair.

This report details a novel technique that made use of a bone-tendon allograft to treat a chronic quadriceps tendon

rupture after several failed repairs. We elected to use this technique since tendon-to-bone healing had clearly failed in this patient. This failed healing may have been due, at least in part, to the patient's underlying diabetes [2–4]. The diabetes may have contributed to his postoperative infection following the initial surgery at the outside institution [11] and may also have inhibited healing of the tendon via other mechanisms [2–4]. These mechanisms include the potential adverse effects of diabetes on inflammation, cell proliferation, and angiogenesis in the healing tendon as described above [3].

Because the quadriceps tendon had failed to heal to the patella, our goal was to transfer the healing site to one that relied on bone-to-bone healing instead. In an attempt to optimize healing between the allograft bone and the native patella, we chose to incorporate an absorbable collagen sponge containing rhBMP-2, a recombinant cytokine that may augment healing at sites of osteosynthesis [14]. We used rhBMP-2 due to the potential for impaired healing in this diabetic patient. However, we would not recommend routine use of rhBMP-2 in this application due to its cost.

Our technique requires healing of the allograft tendon to the native quadriceps tendon. However, recognizing that tendon healing may be inhibited in diabetics [2–4], we used a broad graft to provide a large surface area of contact with the native quadriceps tendon, followed by secure suture fixation and a conservative postoperative rehabilitation program. Although further investigation is certainly needed to determine the usefulness of this technique, we present this as a treatment option for patients where impaired tendon-to-bone healing has been demonstrated.

Disclosures Each author certifies that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

Each author certifies that his or her institution approved the human protocol for this investigation; that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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