Management of Patella Tendon Rupture

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Giles R. Scuderi, Nicholas B. Frisch, Richard A. Berger, James A. Browne, Mark E. Mildren, Andrea Baldini, Vincenzo Franceschini, and Michele D'Amato

Introduction

Giles R. Scuderi

Rupture of the patella tendon during or following total knee arthroplasty (TKA) can be an extremely challenging complication to manage. The following case reports will describe several surgical options for the management of patella tendon ruptures, but it is important to identify those patients who are at greater risk for rupture of the patella tendon. Those patients at higher risk tend to be obese, have limited preoperative range of motion, have had prior surgery, or have a metabolic condition or connective tissue disorder that may compromise the patella tendon.

Tibial tubercle avulsion is the most common intraoperative injury to the patella tendon during TKA. This is an intraoperative complication that should be avoided than treated, and care should be taken to protect the patella tendon insertion on the tibial tubercle during TKA. Three specific steps to avoid this complication include: (1) Protect the patellar tendon at the insertion site by extending the medial arthrotomy distally and peel the patellar tendon along the medial tibial tubercle in order to avoid a transverse tear of the patellar tendon [1]; (2) extend the medial arthrotomy proximally and perform a quadriceps snip for a more extensile exposure, relieving tension on the patella tendon [2]; and (3) perform a tibial tubercle osteotomy if the prior procedure still does not afford adequate exposure and there is a risk of avulsion of the patella tendon [3].

The timing and location of the injury may have an impact on the chosen surgical management. Several surgical techniques have seen described but none has yet to be considered the gold standard. Reconstruction options include direct repair, repair with autogenous graft [4], various allografts [5], and synthetic grafts [6]. Complete acute tears may be managed with direct repair, usually with autogenous graft augmentation, such as the semitendinosus tendon. Bone avulsion of the patella

G.R. Scuderi, MD
Northwell Health Orthopedic Institute, New York, NY, USA

N.B. Frisch, MD, MBA • R.A. Berger, MD
Department of Orthopedic Surgery, Rush University Medical Center, Chicago, IL, USA

J.A. Browne, MD (✉) • M.E. Mildren, MD
Adult Reconstruction, Department of Orthopaedics, University of Virginia, Charlottesville, VA, USA
e-mail: jab8hd@hscmail.mcc.virginia.edu

A. Baldini, MD, PhD (✉)
I.F.C.A. Institute, Florence, Italy
e-mail: drbaldiniandrea@yahoo.it

V. Franceschini, MD
Department of Orthopaedics and Traumatology, Sapienza University of Rome, Latina, Italy

M. D'Amato, MD
1st Orthopaedic and Traumatologic Clinic, Rizzoli Orthopaedic Institute, Bologna, Italy

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tendon from the inferior pole of the patella may be directly repaired to a bone trough at the site of the avulsion. Patella tendon avulsion from the tibial tubercle is a challenging repair since it is difficult to get secure fixation of the patella tendon into the tibial tubercle. In this scenario, the surgeon must choose between repair with autogenous augmentation and a reconstructive procedure with allograft or synthetic graft. The postoperative rehabilitation for all these procedures requires an extended period of immobilization with the knee locked in full extension, followed by gradual resumption of motion in a controlled dial flexion brace.

Late rupture of the patella tendon that may lead to chronic dysfunction of the extensor mechanism is a rare but devastating complication. Since the local tissue is compromised, the patella retracted proximally, and the patella tendon is atrophic and poor quality, a reconstruction of the patella tendon is necessary. The available options include Achilles tendon allograft, complete extensor mechanism allograft, and synthetic grafts. The chosen technique is dependent upon surgical experience and the quality of the local tissue. Clinical results with reconstruction of chronic ruptures of the patella tendon are variable and not always rewarding do to residual quadriceps weakness and extensor lag. The following case reports will review the surgical techniques available for the reconstruction of chronic ruptures of the patella tendon.

Option 1: Management of Patellar Tendon Rupture— Extensor Mechanism Allograft

Nicholas B. Frisch and Richard A. Berger

Case Presentation

History

A 54-year-old male presented to our office for a second opinion after a long history of left knee problems. He underwent a left total knee arthroplasty (TKA) 5 years earlier for degenerative arthritis at an outside hospital. He sustained a fracture of his left patella 2 years later during a motor vehicle accident requiring partial patellectomy with revision of the patellar component. He developed lateral subluxation of the patella with anterior knee pain and swelling. He subsequently underwent a patellar component resection with medial retinacular reefing for this lateral subluxation. His lateral subluxation worsened the recurrent anterior pain. Finally, this progressed to recurrent instability from his patella dislocation for which he was treated in a brace by his primary surgeon who recommended revision total knee arthroplasty.

Physical Examination

On physical examination, the patient was 6′4″ tall and weighed 215 pounds. He had physiologic valgus alignment of the knees in stance and an antalgic gait favoring his left side. Examination supine revealed full, painless passive range of motion of the left hip. There was a well-healed medial-based curved incision from a prior medial meniscectomy and a lateral midline incision over the left knee from the last few surgeries. Examination of the knee revealed a 30° extensor lag with full passive range of motion. He had 125° flexion. The patella tracked laterally, with passive motion. The patella was dislocating with resisted extension. There was no instability to varus/valgus stress at 0° and 30° of flexion. He had no anterior/posterior instability. He had a large effusion in the left knee. There were palpable pedal pulses and no sensory or motor deficits.

In cases of extensor mechanism failure, a proper physical examination is critical. Prior incisions over the knee must be inspected. Usually the more lateral incision is preferred due to the perfusion which comes from the medial side. The difference between the active and passive extension (extensor lag) must be measured as well as resisted extension which simulates climbing stairs and rising from a chair. A flexion contracture, inability to passively extend the knee, must be separated from an extensor lag. The tracking of the extensor mechanism during range of motion should be examined. A poorly tracking extensor mechanism is usually a result

of component malrotation and may be the cause of the extensor mechanism failure.

Radiographs and Advanced Diagnostics

Radiographs are evaluated for component alignment and fixation. Patellar position, tracking, and presence of heterotopic ossification are also evaluated. If there is any concern about malrotation of the components, an axial CT scan of the femoral and tibial components should be obtained to evaluate for component internal rotation [7].

In review of this patient, plain radiographs revealed a well-fixed cemented TKA. The patella was sclerotic, and there was no evidence of a patellar component, suggesting that the remnant of the patella which is present is osteonecrotic. Furthermore, the skyline view shows that the patella is subluxed laterally (Fig. 16.1). CT scans were also reviewed and demonstrated that the

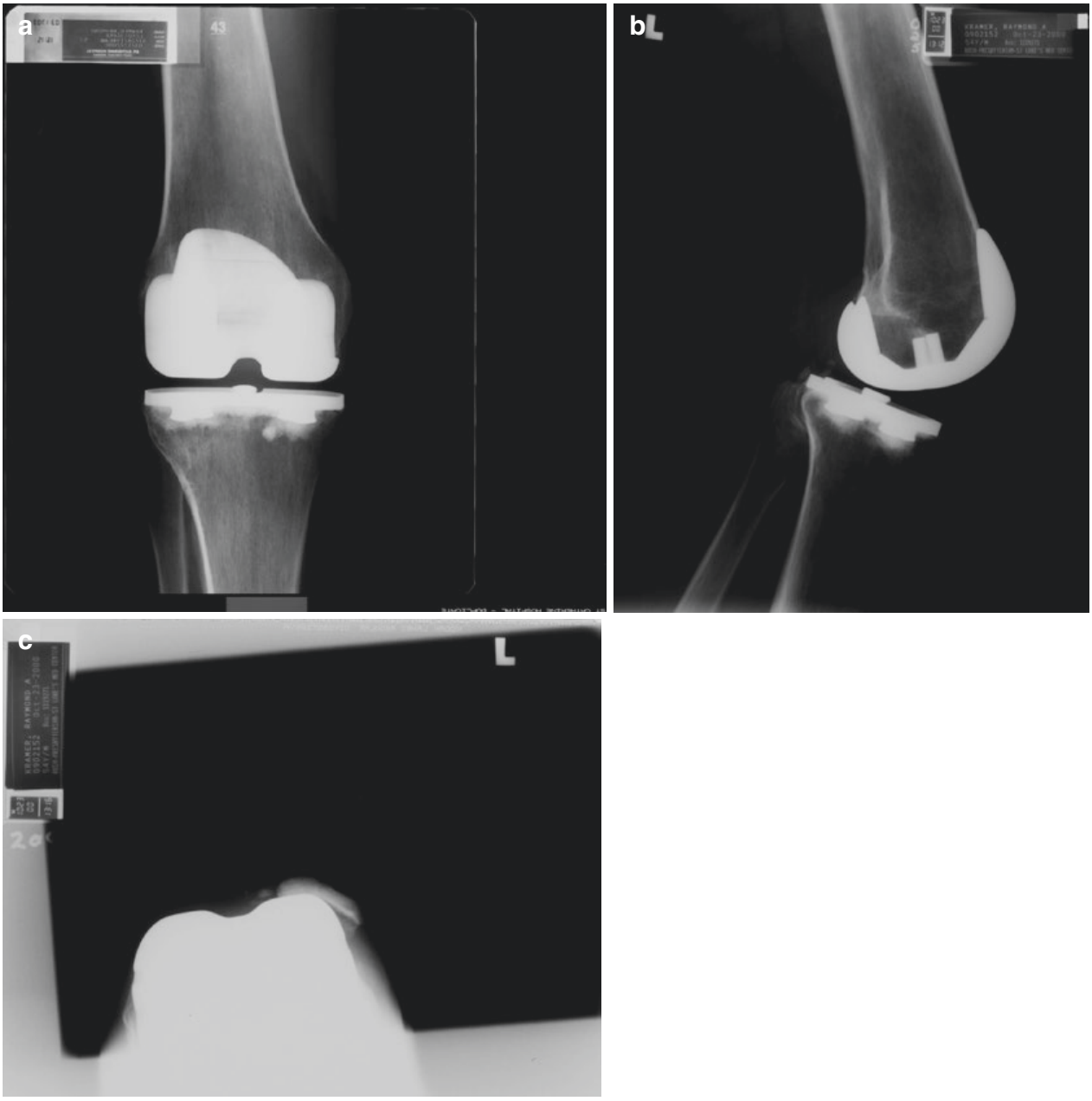

Fig. 16.1 Plain radiographs of the knee, including (**a**) anteroposterior, (**b**) lateral, (**c**) and skyline views, revealed a well-fixed cemented total knee arthroplasty. The patella was sclerotic, and there was no evidence of a patellar component, suggesting that the remnant of the patella which is present is osteonecrotic. The skyline view shows that the patella is subluxed laterally

femoral component as well as the tibial component was excessively internally rotated.

It is critical to evaluate the patient for infection. Investigation starts with an ESR and CRP. If these values are elevated, a knee aspiration is mandatory. In this case infection was not present.

Surgical Approach

Allograft Extensor Mechanism

Extensor mechanism allografts are hard to obtain and advanced planning is need. We order a specimen consisting of a quadriceps tendon (at least 5 cm), patella, patella tendon, and tibial bone or a large portion of the proximal tibia (Fig. 16.2). It is critical that the appropriate sided graft be ordered since a graft from the contralateral side will result in patellar maltracking and early failure. The allograft must be fresh frozen and non-irradiated. Freeze-dried allografts may be weakened leading to complications and failure [8, 9]. The authors have found that the best specimens are whole knee allografts, which allow us to fashion the extensor mechanism allograft as we see fit in the operating room.

Exposure of the Knee

The patient is positioned supine on the operating table with a non-sterile pneumatic tourniquet around the thigh. The leg is prepped and draped. The pneumatic tourniquet is inflated with the knee in flexion. For short legs, a sterile tourniquet is used so that it may be removed to obtain proximal access. Previous incisions are noted, and if possible, a midline skin incision is used. If multiple incisions are present, we use the most lateral incision closest to the midline in order to preserve the blood supply to the skin. This is important, as these are often multiple operated knees and wound healing may be compromised.

After choosing the appropriate incision, dissection is continued, keeping skin and subcutaneous flaps as thick as possible, and expose the retinaculum and extensor mechanism. A midline incision is preformed through the remaining extensor mechanism (quadriceps tendon, patella, and patellar tendon including over the tibial tubercle), creating medial and lateral flaps of the entire extensor and exposing the joint. It is recommended that appropriate cultures and a cell count be done at this point. The midline incision is started proximally into the host quadriceps, maintaining a medial and lateral sleeve of tissue for later closure. The incision is carried over the patella, if present. The native patella, if present, it is osteotomized longitudinally, in line with the midline soft tissue retinacular incision (Fig. 16.3). This allows the patellar bone to be shelled out and removed, preserving the soft tissue continuity with the medial and lateral flaps (Fig. 16.4). Finally, the midline incision is then carried through the patellar tendon and over the host tib-

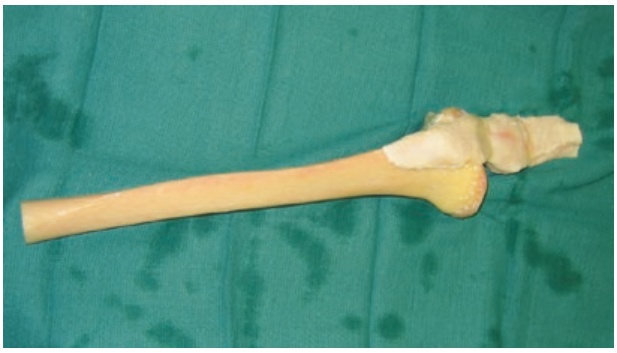

Fig. 16.2 Extensor mechanism allograft specimen consisting of a quadriceps tendon (at least 5 cm), patella, patella tendon, and tibial bone or large portion of the proximal tibia

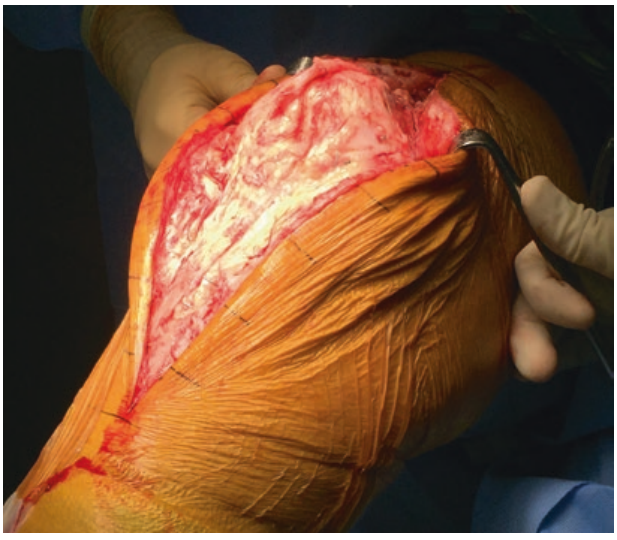

Fig. 16.3 The midline incision is carried over the patella, and if present, the native patella is osteotomized longitudinally, in line with the midline soft tissue retinacular incision

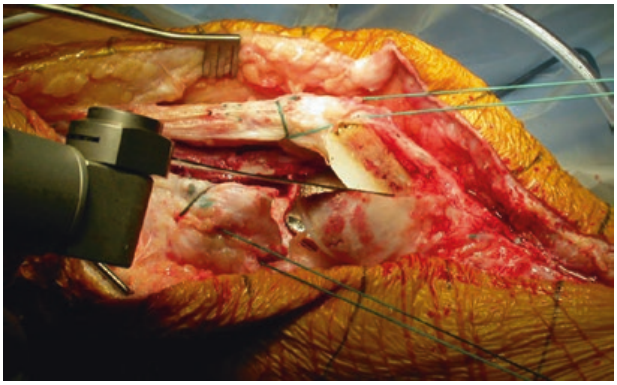

Fig. 16.4 After osteotomy, the native patellar bone is shelled out and removed, preserving the soft tissue continuity with the medial and lateral flaps

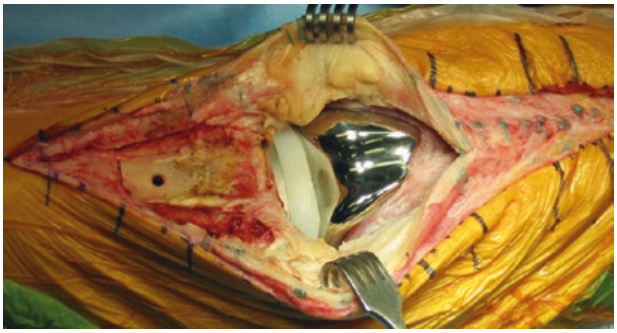

Fig. 16.5 The midline incision is then carried through the patellar tendon and over the host tibial tubercle, elevating the patella tendon from the tubercle both medially and laterally to expose the tibial tubercle, opening up like a book

ial tubercle, elevating the patella tendon from the tubercle both medially and laterally to expose the tibial tubercle, opening up like a book (Fig. 16.5).

TKA Component Revision

We have successfully performed extensor mechanism allografts with cruciate retaining, posterior stabilized, condylar constrained, and constrained hinge knee designs. Regardless of the implant, any malrotation of the femoral and tibial components must be adequately addressed as many extensor mechanism disruptions are the direct result of component malrotation. Similarly, flexion and extension gaps must be assessed and balanced properly. If necessary, revision of the components is performed at this time. In the event that stemmed components are to be introduced, the wires through the tibial bone can be placed posterior to the stem prior to tibial component insertion in order to provide additional fixation. The final polyethylene liner is inserted prior to performing the extensor mechanism allograft reconstruction.

Allograft Preparation

When preparing the extensor mechanism allograft, begin by cutting the allograft tibial tubercle on either side of the patellar tendon. Next, cut the allograft tibial tubercle 1 cm proximal to the insertion of the patellar tendon and distally at the end of the patellar tendon. The result is an allograft tibial tubercle that is roughly 6–8 cm long and 1.5–2 cm wide. Trim the depth of the allograft tibial tubercle to 1.5 cm proximally, tapering down to 1 cm distally (Fig. 16.6).

Now prepare the dovetail on the proximal aspect of the allograft tibial tubercle. The dovetail locks the allograft tibial tubercle into to the native tibial trough and resists proximal graft escape. In addition, the dovetail allows a press fit of the allograft tibial tubercle into the native tibia. The dovetail is marked into the allograft tibial tubercle by drawing an angle of 45°, starting at the insertion of the patellar tendon onto the allograft tibial tubercle and going proximal as the bevel goes posterior. After marking, the bevel is cut with a thin saw blade (Fig. 16.7). The longitudinal length of the bevel is approximately 15–20 mm (Fig. 16.8).

Upon completion of allograft tibial tubercle, attention is turned to the proximal end of the allograft. Two, #5 nonabsorbable sutures are placed along the medial and lateral aspect of the allograft quadriceps tendon using a Krackow locking stitch. The proximal ends of the suture will exit proximally and will be used to tension the allograft tightly once appropriately secured distally in the host tibia.

Proximal Tibia Trough Preparation

Using a marking pen, the host proximal tibial trough is marked out to perfectly match the allograft tibial tubercle, which has already been prepared. The proximal-distal location of the trough is critical to determine where the patella will articulate with the trochlear. With the leg in full extension, the allograft patella is placed at the top of the trochlea so that it fully articulates, and

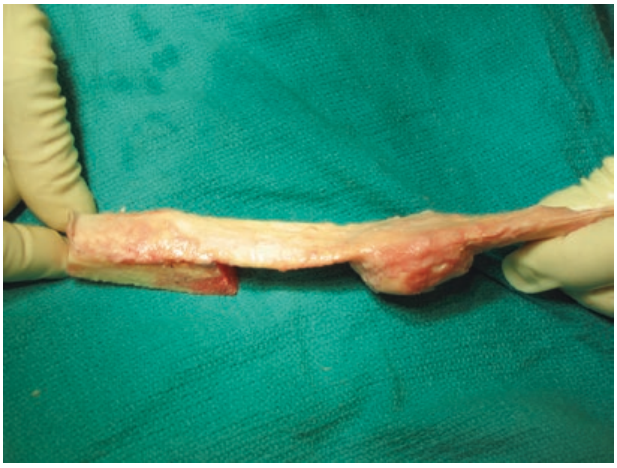

Fig. 16.6 Begin by cutting the allograft tibial tubercle on either side of the patellar tendon. Next, cut the allograft tibial tubercle 1 cm proximal to the insertion of the patellar tendon and distally at the end of the patellar tendon

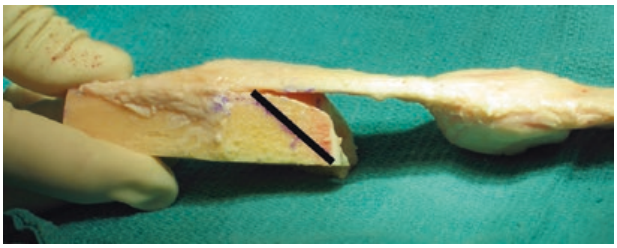

Fig. 16.7 Prepare the dovetail on the proximal aspect of the allograft tibial tubercle. The dovetail is marked into the allograft tibial tubercle by drawing an angle of 45°, starting at the insertion of the patellar tendon onto the allograft tibial tubercle and going proximal as the bevel goes posterior. After marking, the bevel is cut with a thin saw blade

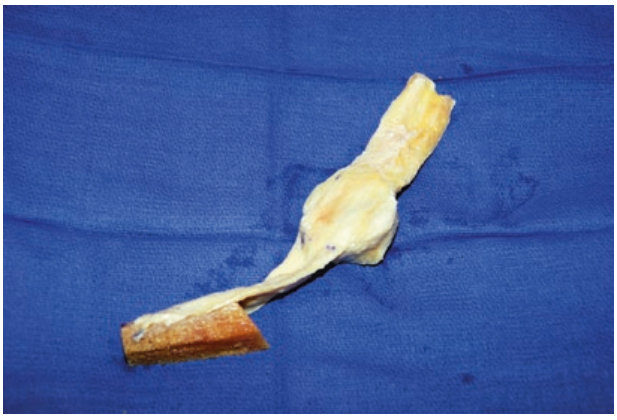

Fig. 16.8 The longitudinal length of the bevel is approximately 15–20 mm

the location of the junction of the allograft tibial tubercle and allograft patellar tendon is marked on the native tibial tubercle.

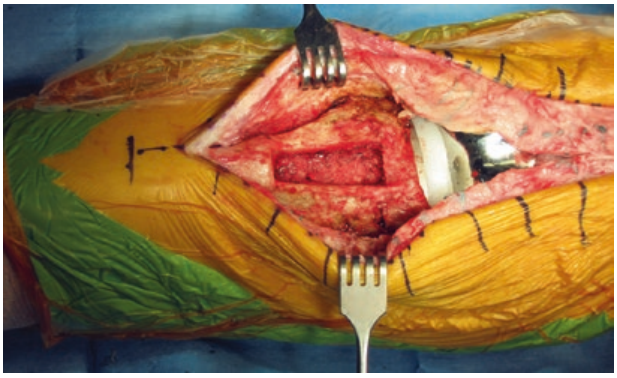

Fig. 16.9 The rectangular tibial trough is then cut into the host tibial tubercle such that the allograft tibial tubercle remains 1 mm wider than the host trough to ensure a press fit

The rectangular tibial trough is then cut into the host tibial tubercle such that the allograft tibial tubercle remains 1 mm wider than the host trough to ensure a press fit. Great care is taken to make sure that the medial and lateral walls of the host tibial tubercle remain intact for stability of the allograft tibial tubercle. Proximally, the host bone is beveled, to accept a press fit of the dovetailed allograft tibial tubercle (Fig. 16.9).

The final preparation of the trough is to pass two or three 18 gauge stainless steel wires through drill holes in the tibia from medial to lateral. These wires pass deep to the tibial trough and can be placed around a stemmed tibial component for additional fixation as noted above. At this point, the allograft tibial tubercle is press fit into the trough. First the dovetail of the allograft tibial tubercle is inserted in the bevel of the host tibial tubercle. The allograft extensor mechanism is gently press fit in with a bone tamp or punch, with an up and in displacement of the allograft tibial tubercle to lock the dovetail of the allograft tibial tubercle in place. Once the allograft tibial tubercle is fully seated proximally, the distal aspect is seated, removing any excess allograft tibial tubercle that extends past the distal end of the trough with a saw or motorized burr (Fig. 16.10).

The allograft tibial tubercle is held in place with the two or three wires. The wires are tightened on the lateral aspect of the host tibial tubercle so that they are under the muscle of the calf and not directly under the skin (Fig. 16.11).

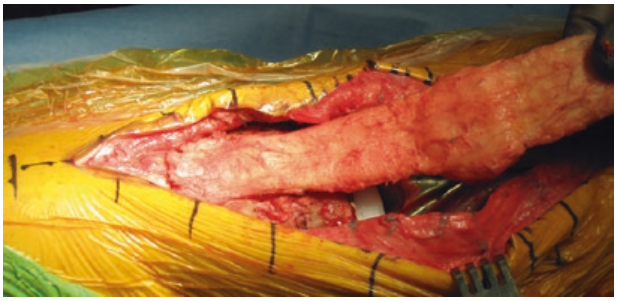

Fig. 16.10 Once the allograft tibial tubercle is fully seated proximally, the distal aspect is seated, removing any excess allograft tibial tubercle that extends past the distal end of the trough with a saw or motorized burr

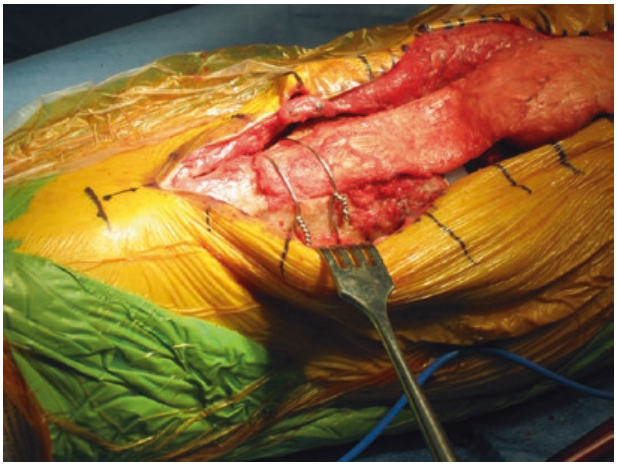

Fig. 16.11 The allograft tibial tubercle is held in place with the two or three wires. The wires are tightened on the lateral aspect of the host tibial tubercle so that they are under the muscle of the calf and not directly under the skin

Alternatively, a cancellous screw with washer may be added for additional fixation, taking care not to overtighten the screw and fracture the allograft tibial tubercle.

Host Distal Quadriceps Preparation, Tensioning, and Closure

A single retention suture is placed in the host distal quadriceps medially and laterally which allows the host quadriceps to the pulled distally. With the knee in full extension, the two sutures in the allograft quadriceps are pulled proximally as the host quadriceps is pulled distally (Fig. 16.12). The sutures in the allograft quadriceps are pulled from distal to proximal, out and up through the more proximal host quadriceps. The two ends of the allograft quadriceps sutures are tied together to hold it in place (Fig. 16.13). With this tension

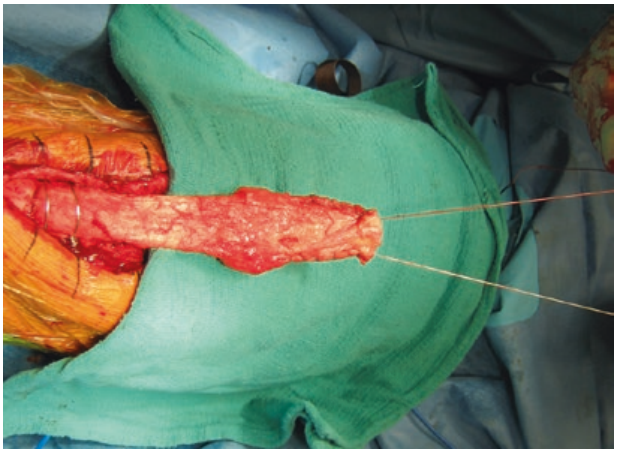

Fig. 16.12 A single retention suture is placed in the host distal quadriceps medially and laterally which allows the host quadriceps to the pulled distally. With the knee in full extension, the two sutures in the allograft quadriceps are pulled proximally as the host quadriceps is pulled distally

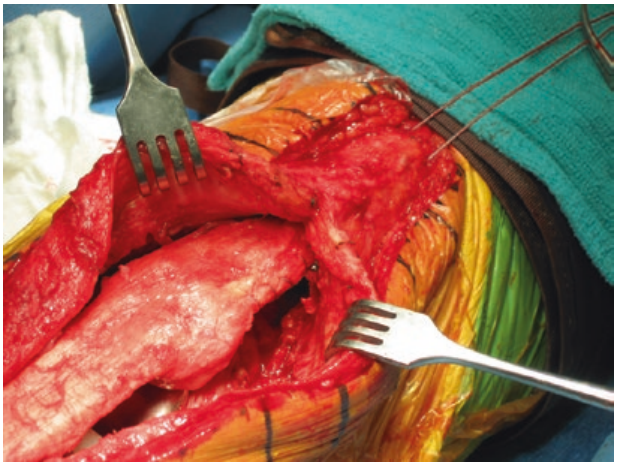

Fig. 16.13 The sutures in the allograft quadriceps are pulled from distal to proximal, out and up through the more proximal host quadriceps. The two ends of the allograft quadriceps sutures are tied together to hold it in place

maintained, the allograft quadriceps is sutured beneath the host quadriceps with #2 nonabsorbable suture, in a vest-over-pants fashion (Fig. 16.14). Maintain constant distal tension on the host quadriceps in order to maximize tension with the knee in the extended position.

Once the proximal aspect of the allograft is secured, the repair is continued along the medial and lateral sides trying to leave enough of the host retinaculum so that it may be brought over top of the allograft to completely cover it. After the allograft is fully sutured in place down to the

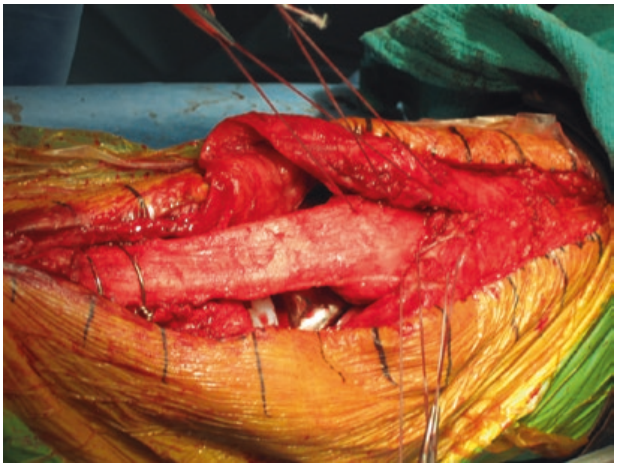

Fig. 16.14 With this tension maintained, the allograft quadriceps is sutured beneath the host quadriceps with #2 nonabsorbable suture, in a vest-over-pants fashion

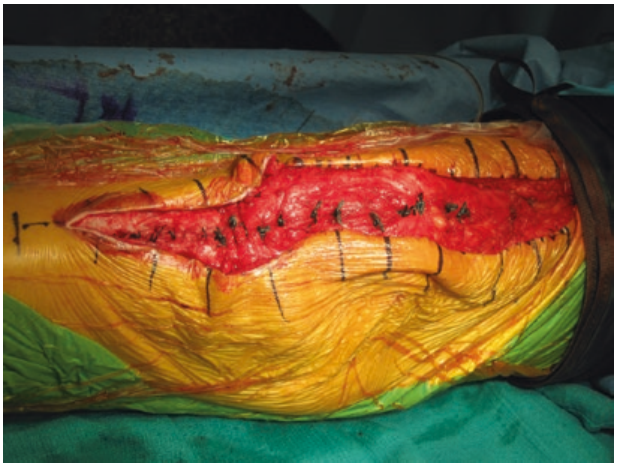

Fig. 16.15 The repair is continued along the medial and lateral sides trying to leave enough of the host retinaculum so that it may be brought over top of the allograft to completely cover it. After the allograft is fully sutured in place down to the patellar tendon, the host quadriceps is closed over the top of the allograft with sutures

patellar tendon, the host quadriceps is closed over the top of the allograft with sutures (Fig. 16.15).

We do not routinely flex the knee to test our repair. In the event that the repair is to be tested, the knee should not flex beyond 30° due to the tightness of the allograft. At this point the subcutaneous tissues are closed in a routine fashion and the skin is closed with staples or a nonabsorbable suture.

Postoperative Protocol, Rehabilitation, and Results

The knee is placed in full extension in a brace in the operating room. Wound healing is a major concern in these patients and it is important to use a brace that allows for complete immobilization of the knee in full extension but permits access to the wound postoperatively.

Patients are maintained in full extension for 8 weeks after surgery. During this period, we allow weight bearing as tolerated, but we do not allow any flexion. We encourage isometric static quadriceps contractions. After 8 weeks, active flexion is permitted with supervised physical therapy. Initially, the patient only achieves about 30–40°, but this slowing improves with time. We allow active extension in the brace to begin at 8 weeks too. During this time, the patients continue weight bearing with the brace locked in full extension. At 12 weeks, we remove the brace allowing further active flexion as tolerated and ambulation without the brace.

This patient followed the aforementioned protocol and has done well postoperatively. At his 3.5-year follow-up visit, he did have some residual swelling but had near full active extension to −10° and flexion to 120°. At 10-year follow-up, he had 7° extensor lag but full extension with passive range of motion and 120° flexion. Radiographs demonstrated well-fixed stemmed tibial and femoral components with intact extensor mechanism allograft. Alignment was maintained and there was no evidence of component loosening. Of note there was evidence of some resorption of the patella on radiographs (Fig. 16.16). There has been some controversy over whether or not to resurface the patella during this procedure. While historically we have not performed a patellar resurfacing, with improved long-term survival of the graft as in this patient, increased patellar resorption may suggest that resurfacing could prove to be beneficial.

Clinical Results

Extensor mechanism disruption is arguably the most devastating complication of total knee arthroplasty. Multiple techniques for repair or reconstruction of a deficient extensor mechanism have been described in association with total knee arthroplasty, but few have been able to reliably restore the extensor mechanism [10]. While direct repair in native knees usually yield good

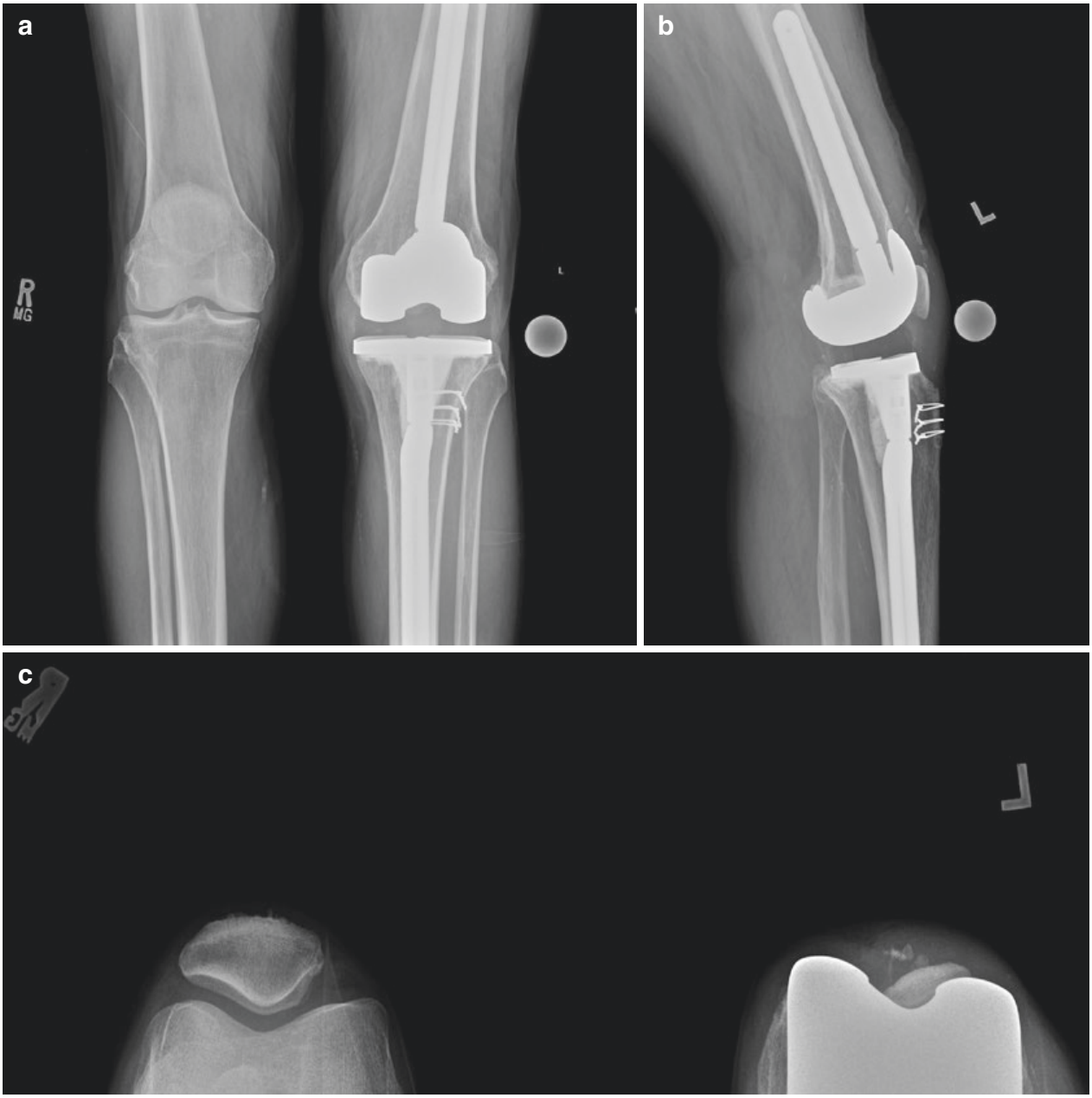

Fig. 16.16 Radiographs including (**a**) anteroposterior, (**b**) lateral, and (**c**) skyline views demonstrated well-fixed stemmed tibial and femoral components with intact extensor mechanism allograft. Alignment was maintained, and there was no evidence of component loosening. Of note there was evidence of some resorption of the patella on radiographs

results, the same technique following a total knee arthroplasty resulted in high failure rates [11]. Emerson et al. have reported on the use of an extensor mechanism allograft in TKA with reported good short-term results; however persistent extensor lag developed over time [8, 9]. Nazarian and Booth modified the original technique and recommended that allograft be tightly tensioned in full extension, yielding encouraging short- and midterm results [5]. We have reported a comparison study which demonstrated tightly tensioning in full extension yielded excellent results and an average postoperative extensor lag of 4.3°, while not tightly tensioning the allograft resulted in a 100% failure rate [12].

Key Points

- The appropriate allograft for an extensor mechanism reconstruction can be very difficult

to obtain. It is important to contact the tissue bank several weeks prior to the surgical date and verify that the appropriate side has been ordered. It is also helpful for the allograft to be a similar size to the patient. The allograft must be a fresh frozen, non-irradiated allograft specimen consisting of a quadriceps tendon, patella, patella tendon, and tibial bone. It must have at least 3–5 cm of quadriceps tendon attached to the patella.

- It is imperative that full thickness flaps are created during the surgical exposure and that a midline incision, which utilizes the most lateral previous approach, is chosen. Wound healing is the primary concern with this surgical procedure as patients have usually had many prior surgical procedures. The skin of these patients is already tenuous, and the bulk of both allograft tissue and prosthetic component places more tension on the skin.
- Revise existing components if needed. Both the tibial and femoral components need to be assessed critically for malrotated or instability. If present, these problems were like a contributing factor in the extensor mechanism disruption, and failure to address suboptimal component positioning, rotation, or instability may result in premature graft failure.
- The allograft tibial tubercle bone block must be prepared and press fit into the native tibial trough to provide intrinsic stability to the graft. Failure to provide this mechanical stability may result in graft migration or failure of bone union.
- The proximal-distal location of the trough is critical to determine where the patella will articulate with the trochlear. With the leg in full extension, the allograft patella is placed at the top of the trochlea so that it fully articulates, and the location of the junction of the allograft tibial tubercle and allograft patellar tendon is marked on the native tibial tubercle.
- The allograft must be sutured into place as tight as possible with the knee in fully extended. While the extensor mechanism may appear overly tight, it is not. Failure to provide maximal tension on the graft will result in subsequent extensor lag.
- The host medial and lateral retinacular flaps are sewn over the allograft as much as possible in order to cover the allograft. Leaving the allograft under the skin usually results in a persistent subcutaneous skin reaction.

Option 2: Management of Extensor Mechanism Deficiency Using Knitted Polypropylene Graft

James A. Browne and Mark E. Mildren

Case Presentation

Case History

A 65-year-old male presented to our clinic with increasing pain and disability in his left knee 12 years following primary total knee arthroplasty by an outside surgeon. The patient had experienced a quadriceps tendon rupture, 4 years prior to presentation, and underwent primary repair without augmentation again by an outside surgeon, which failed almost immediately following this procedure. Upon presentation to our clinic, the patient was found to have complete extensor mechanism deficit as well as component loosening and active periprosthetic infection. He could not ambulate without a walker and failed an attempt at bracing. Given the failure of conservative management, he underwent two-stage revision, with the first procedure being static antibiotic spacer placement and patellectomy for a frankly necrotic patella in an attempt to eradicate his chronic infection. He represented after normalization of his inflammatory markers for the second-stage procedure.

Physical Examination

The patient was well nourished with a body mass index (BMI) of 34. He had been maintained in a cast given his static spacer. The knee showed a well-healed linear scar on the anterior aspect, without surrounding warmth or erythema. The knee was in anatomic alignment and, however, had no motion due to the static spacer. Ankle

plantar and dorsiflexion were all 5/5 strength. Distal sensation to the extremity was intact.

To rule out infection, blood work including erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) were drawn as well as the knee aspirated and sent for cell count and culture. The lab work and aspirate were without signs of infection.

Radiographs and Advanced Imaging

Standing anteroposterior and true lateral views were obtained of the knee. These were consistent with static spacer placement with bone loss on the distal femur and proximal tibia.

Surgical Approach

After tourniquet placement, the supine patient is prepped and draped in the fashion typical for total knee arthroplasty. A standard midline incision utilizing the previous incision is made with typical dissection to the extensor mechanism as in revision knee arthroplasty, being cognizant to retain full thickness flaps on both the medial and lateral sides (Fig. 16.17). Both vastus medialis and vastus lateralis are mobilized to allow for excursion. This can be aided with placing a heavy tag stitch in each. In our patient, antibiotic cement needed to be removed prior to reimplantation (Fig. 16.18).

The knee is first prepared for revision knee arthroplasty components using standard techniques. Trial components are placed to confirm appropriate implant size and position as well as collateral ligament tension and stability. We recommend the use of a varus/valgus constrained prosthesis or hinge in the setting of extensor mechanism deficiency. Once satisfied with trial implants, attention is turned to preparing the knee for the extensor mechanism reconstruction. The synthetic mesh graft (Marlex mesh, CR Bard, Murray Hill NJ, USA) is prepared on the back table by rolling a single 25 × 35.5 cm sheet over on itself multiple times (Fig. 16.19), causing it to form the shape of a tube approximately eight to ten layers thick and 2–2.5 cm wide. This is then secured in place with a running #5 Ethibond or other heavy non-absorbable sutures (Fig. 16.20).

The synthetic mesh graft is always secured to the tibia in an intramedullary position. The exact technique to prepare the tibia depends upon whether or not the tibial component is being revised. In this case, a burr is used to create a trough on the anteromedial aspect of the tibia for

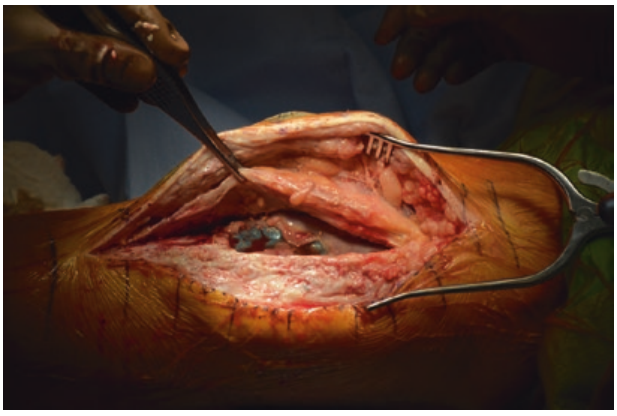

Fig. 16.17 Exposure of the antibiotic spacer with creation of full thickness medial and lateral tissue flaps

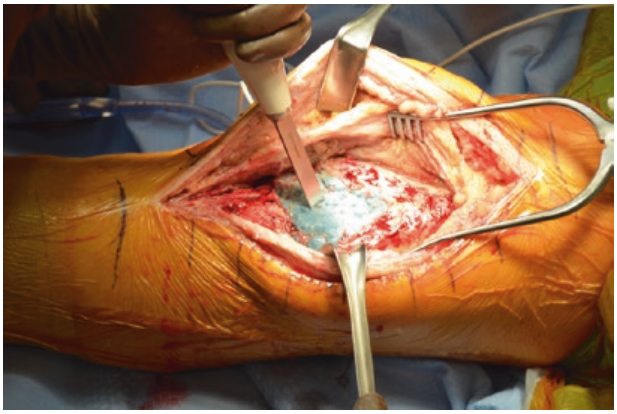

Fig. 16.18 Removal of the static antibiotic spacer

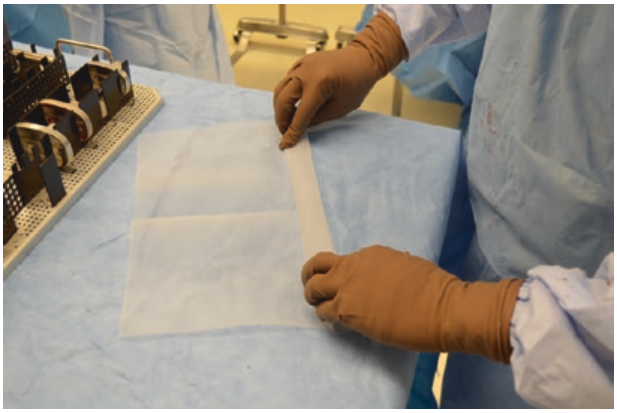

Fig. 16.19 The mesh is rolled over on itself to create a tubular structure approximately eight layers thick

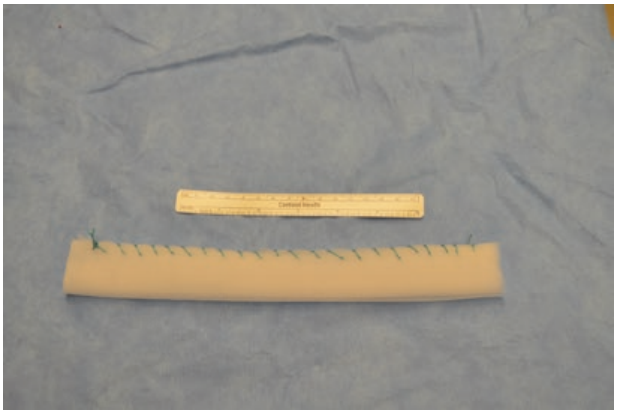

Fig. 16.20 The mesh is sutured in a running fashion with a heavy nonabsorbable suture

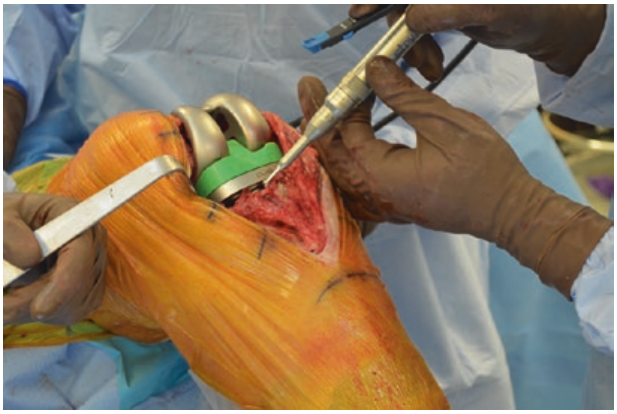

Fig. 16.21 Creation of an anteromedial trough in the tibia using a burr for placement of the mesh. The trials components are in place but can be removed to help facilitate this process

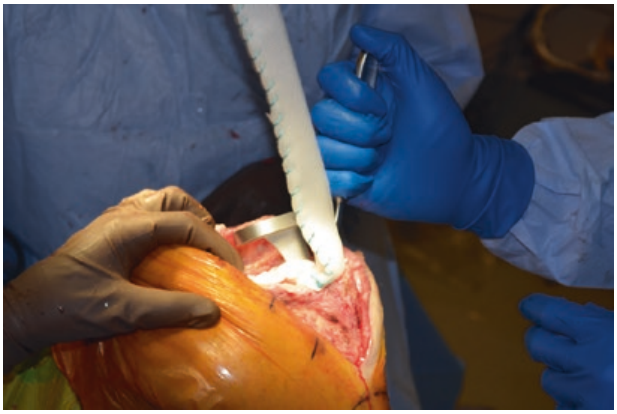

Fig. 16.22 The mesh is inserted anterior to the tibial stem in an intramedullary position during tibial cementation, exiting out through the previously created trough. Care must be taken to ensure that several centimeters of graft are cemented into the canal

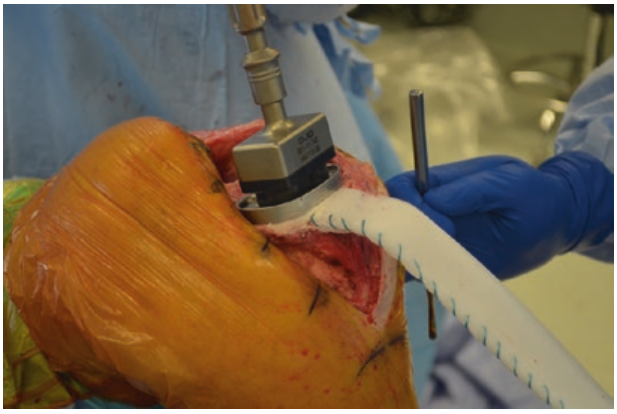

Fig. 16.23 The mesh exiting underneath the tibial baseplate

the graft to exit (Fig. 16.21). The graft is placed anterior to the tibial trial and exits the intramedullary canal in an anteromedial direction (Fig. 16.22). Care must be taken to ensure that several centimeters of the graft can be inserted into the canal to ensure adequate fixation. The graft is inserted prior to cementation of the tibial implant. The tibial prosthesis is then cemented into place using methyl methacrylate with the mesh adjacent to the tibial stem (Fig. 16.23). A periosteal elevator or freer can be used to be certain the graft remains in the canal and securely surrounded by cement. We choose a tibial stem that is at least 4–6 cm distal to the graft fixation to ensure tibial component fixation.

If the tibial prosthesis is to be retained, a burr is used to open up the anteromedial cortex of the tibia in a trough-like fashion. This trough is distal to the tibial tray, but proximal to the tibial tubercle, optimally placed slightly medial to the anterior tibial crest. Methyl methacrylate is used for fixation, with an additional screw and washer often placed for augmentation if there is adequate room for the screw in the metaphysis. The screw must be directed either medially or laterally to avoid the tibial keel/stem.

Once the methyl methacrylate has polymerized and the final implants are in place, a sleeve of scar or retinaculum is used as an interposition between tibial baseplate and the mesh to avoid abrasion of the graft on the polyethylene. This is accomplished by taking a sleeve of lateral tissue, passing it deep to the mesh and anterior to the tibial baseplate so that it lies between the graft and the polyethylene (Fig. 16.24). The tissue is

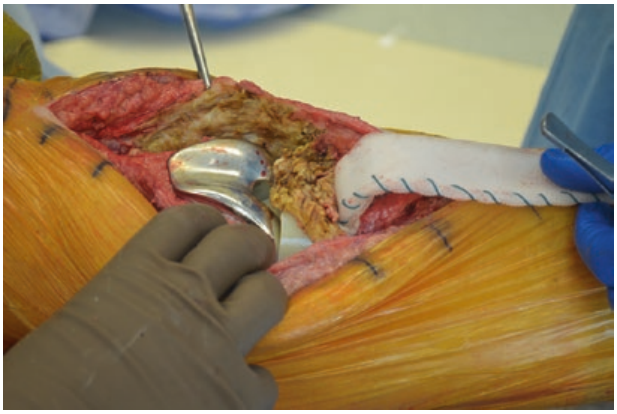

Fig. 16.24 A flap of lateral scar tissue or retinaculum is advanced to lie between the mesh and the polyethylene tibial insert, preventing abrasion of the graft

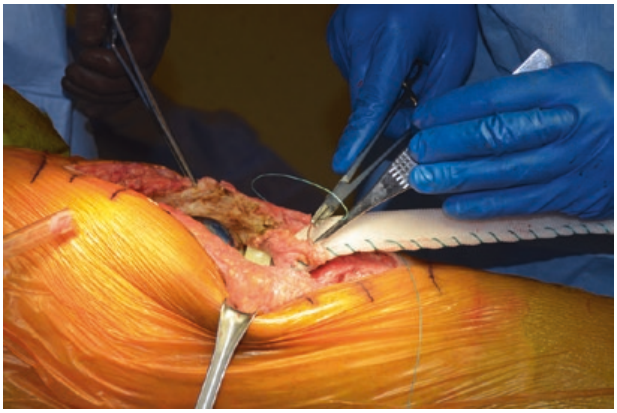

Fig. 16.25 This tissue flap is sutured to the deep surface of the mesh

then sutured to the undersurface of the mesh using nonabsorbable sutures (Fig. 16.25). The mesh graft is then advanced from deep to superficial through a rent in the lateral patellar tendon scar or retinaculum (Figs. 16.26 and 16.27). Again, the vastus medialis and lateralis are extensively mobilized with blunt dissection to release adhesions. The knee is brought into extension, and the quadriceps muscles are pulled distally to restore patellar height (if the patella is present). The mesh is then brought proximally and laid superficially to the vastus lateralis so that the medial edge of the mesh lines up with the medial edge of the lateralis (Fig. 16.28). The mesh is secured to the lateral retinaculum, vastus lateralis, and remaining quadriceps tendon using multiple #5 nonabsorbable sutures with the graft and lateral quadriceps under tension (Fig. 16.29).

With the knee in extension, the vastus medialis is then further mobilized to allow its

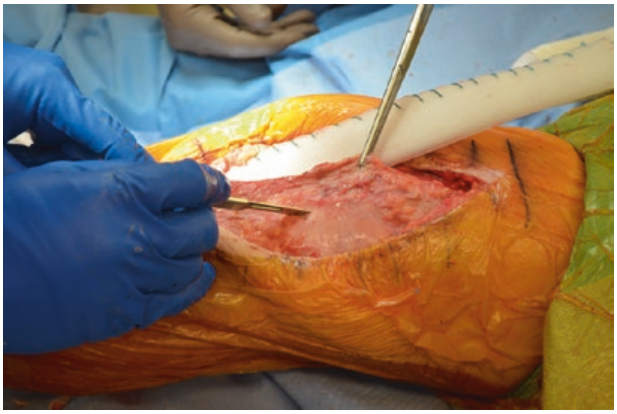

Fig. 16.26 A scalpel is used to create a rent in the lateral retinaculum to allow passage of the mesh from deep to superficial

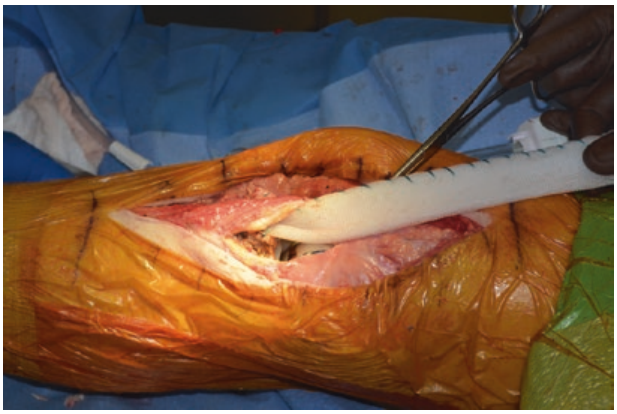

Fig. 16.27 The mesh is passed from deep to superficial through the created rent

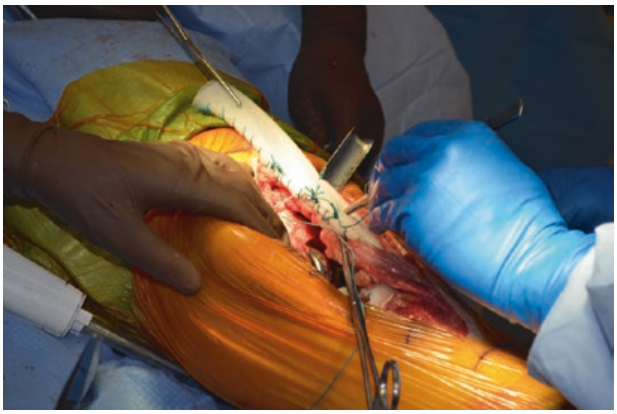

Fig. 16.28 With the lateralis mobilized and advanced, the mesh is laid so that it up with the lateral aspect of the quadriceps tendon and vastus lateralis. This is then secured in place under tension with multiple heavy nonabsorbable sutures

advancement over top of the graft in a lateral and distal direction (Fig. 16.30). This allows for a closure in a "pants-over-vest" fashion,

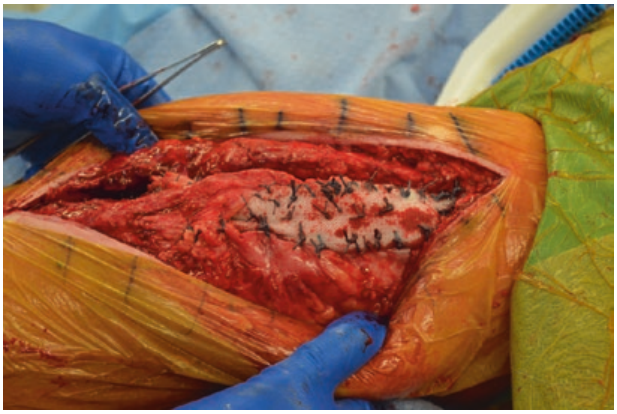

Fig. 16.29 Multiple nonabsorbable sutures are used to secure the mesh graft to the lateral retinaculum, vastus lateralis, and lateral split of the quadriceps tendon. Redundant mesh may be removed proximally

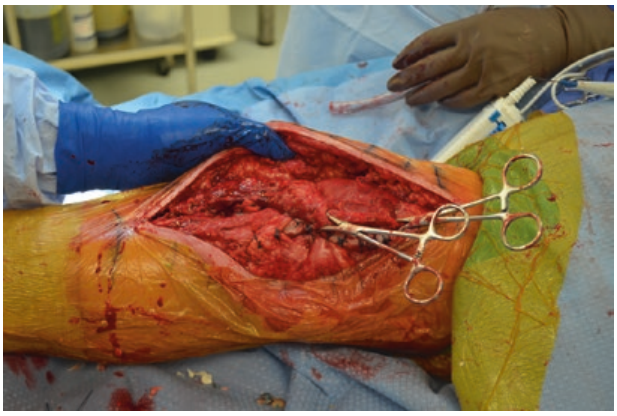

Fig. 16.30 The vastus medialis is sufficiently mobilized laterally and distally to cover the lateral edge of the mesh. This is brought over top of the mesh and is secured with multiple heavy sutures

sandwiching the mesh between the deeper vastus lateralis and the now more superficial medialis, completely covering the mesh with host tissue. The medialis is secured to the mesh-lateralis construct with more #5 nonabsorbable sutures. This should be done in a manner so that no mesh is visible and completely covered by soft tissue (Fig. 16.31).

It is important to emphasize that this reconstruction is accomplished with the knee in extension and extensive mobilization distally of the quadriceps, especially the medialis, is required. It is also important to note that both the quadriceps and graft are secured under tension [13]. The repair should not be tested by bringing the knee into flexion following final suture placement.

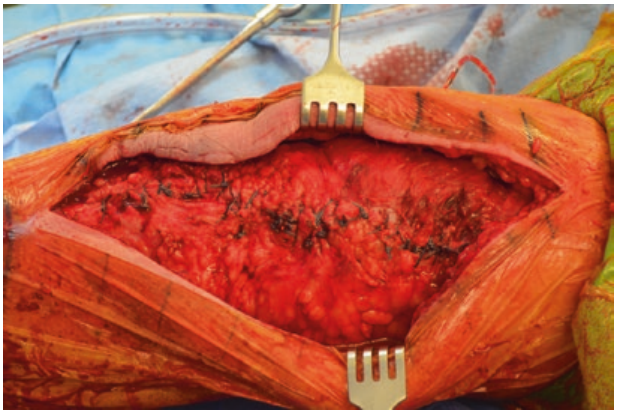

Fig. 16.31 The mesh is successfully covered in a "pants-over-vest" fashion so that no mesh is uncovered by soft tissue

Drains are placed deep to the reconstruction and the wound is closed in a layered fashion. Following wound closure, the patient is placed in a long leg splint and transitioned to a long leg cylinder cast prior to leaving the hospital.

Patients are immobilized in a long leg cast for 12 weeks and are allowed to be touchdown weight bearing during this time. We then gradually transition the patient to full weight bearing following cast removal using a hinged knee brace. They undergo a gentle increase in knee flexion over time. We progressively increase range of motion over the following 3 months: 0–30° during the first month, 0–60° the second month, and 0–90° during the third month [14].

Postoperative Result

Our patient experienced a rather uneventful recovery, with sutures removed 3 weeks postoperatively. He was transitioned out of the cast at 12 weeks following surgery. He was kept toe-touch weight bearing until cast removal, at which time he was transitioned to a hinged knee brace and made full weight bearing. The brace was continued for an additional 3 months following cast removal, with progressive knee flexion and strengthening with physical therapy. He obtained 90° of knee flexion at approximately 6 months post mesh reconstruction. Although he had a 10° extensor lag, he had a functional extensor mechanism and could ambulate with a cane. He had minimal pain and no signs of recurrent infection.

Clinical Results

As expected with this type of specialized procedure, no large trials exist confirming its results postoperatively. Browne and Hanssen produced the largest follow-up in patients with a mesh reconstruction for isolated patellar tendon disruption following total knee arthroplasty [15, 16]. Mean Knee Society pain and function both improved significantly. Excluding complications, the mean extensor lag for patients measured 2.8°. Of note, the ambulatory status of the patients faired extremely well with 10 of 12 patients being able to use stairs. Furthermore, the cost of the mesh is approximately one tenth of that compared to Achilles tendon allograft. The results of extensor mechanism reconstruction can be expected to be worse in those patients with periprosthetic joint infection when compared to those with aseptic failure.

Key Points

- Patients should be counseled that this is a procedure that necessitates extensive and protracted recovery period including 3 months in a cast following surgery.
- Infection must be ruled out in a patient with extensor mechanism disruption prior to undertaking a reconstruction.
- During the surgical approach, the quadriceps musculature must be extensively mobilized and advanced to secure the mesh graft under tension.
- The mesh must be fully covered in a "pants-over-vest" fashion, with the mesh laying between the medialis and the lateralis, so as to avoid irritation of the subcutaneous tissues and prevent wound complications
- The knee should *not* be taken though a range of motion following the mesh placement.

Option 3: Structural Proximal Tibia and Patellar Tendon for Chronic Rupture

Andrea BaldiniVincenzo Franceschini, and Michele D'Amato

Case Presentation

History and Physical Examination

The patient is a 60-year-old male with a BMI of 31. At the age of 54, he sustained an open tibial plateau fracture on the right knee with an associated external popliteal sciatic nerve palsy. The fracture was treated with an external fixator, but 6 months later, he underwent a total knee arthroplasty (TKA) because of malunion. Six months after surgery, the patient developed a sinus tract on the operated knee which was treated with antibiotic therapy with temporary relief of symptoms. After 3 years of intermittent antibiotic suppression therapy, he finally underwent a two-stage revision procedure with a static spacer followed by a semi-constrained stemmed TKA (Fig. 16.32).

When the patient came at our observation, the knee was swollen, painful, and with an evident sinus tract with purulent discharge on the anteromedial aspect of the proximal tibia. The knee had a range of motion from 0° to 100° and an extension lag of 20° with a palpable gap at the patellar tendon

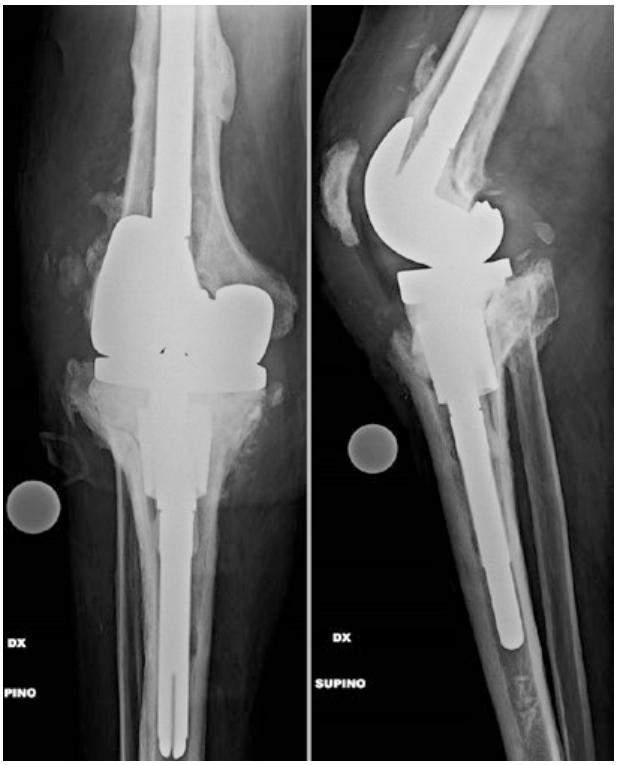

Fig. 16.32 Radiographs of the patient at the moment he was referred to our service. It showed mobilization of the constrained implant

level. The knee was also unstable anteroposteriorly and at varus valgus stress, despite the semi-constrained articulation. Aspiration was positive to *Enterococcus faecalis* ampicillin-resistant.

At this time an antibiotic-loaded articulated cemented spacer was attempted but the fistula immediately recurred. Intraoperative culture at the time of the spacer was positive for *Klebsiella pneumoniae.* The spacer was explanted, and a resection arthroplasty was performed due to the high aggressiveness of the infection. Antibiotic therapy with meropenem and colistin was introduced. After 5 months the joint aspiration was negative for bacteria, but the cell count was still high. A cemented static spacer added with 10 g of vancomycin and 80 mg of gentamycin was performed. During this procedure the incompetent patellar tendon was reinforced with a synthetic hernia mesh (Prolene, Ethicon, Somerville NJ, USA) fixed on the tibia with the technique described by Hanssen et al. [15], as an attempt to solve the extensor mechanism insufficiency and to avoid another complex surgical step in the final procedure.

The patient has been casted for 2 months, and during the following months, he developed a progressive extension lag of approximately 40°, suggesting that the hernia mesh repair was not completely efficient. The knee was dry, the skin was well healed, and all the clinical signs and the lab exams were negative for infection. A revision total knee arthroplasty with a hinged implant (Rotating Hinge Knee, RHK, Zimmer Biomet, Warsaw IN, USA) and with the use of a segmental proximal tibial graft inclusive of extensor mechanism was then planned.

Radiographs and Advanced Imaging

The preoperative x-rays are shown in Fig. 16.33. The anteroposterior and lateral x-ray views of the static spacer show a massive bone loss of the proximal tibia and patella lysis. The external fixator femoral pin, utilized as reinforcement of the static spacer, has been broken. The two screws that were used to fix the hernia mesh to the tibia are also evident.

Surgical Approach

Surgical exposure was performed extending the previous incision proximally and distally. The capsule, which was sutured in the previous surgery with the augmentation of a hernia mesh, was found intact. However, the patellar tendon was clearly still not competent. As a complete extensor mechanism graft was planned, a central

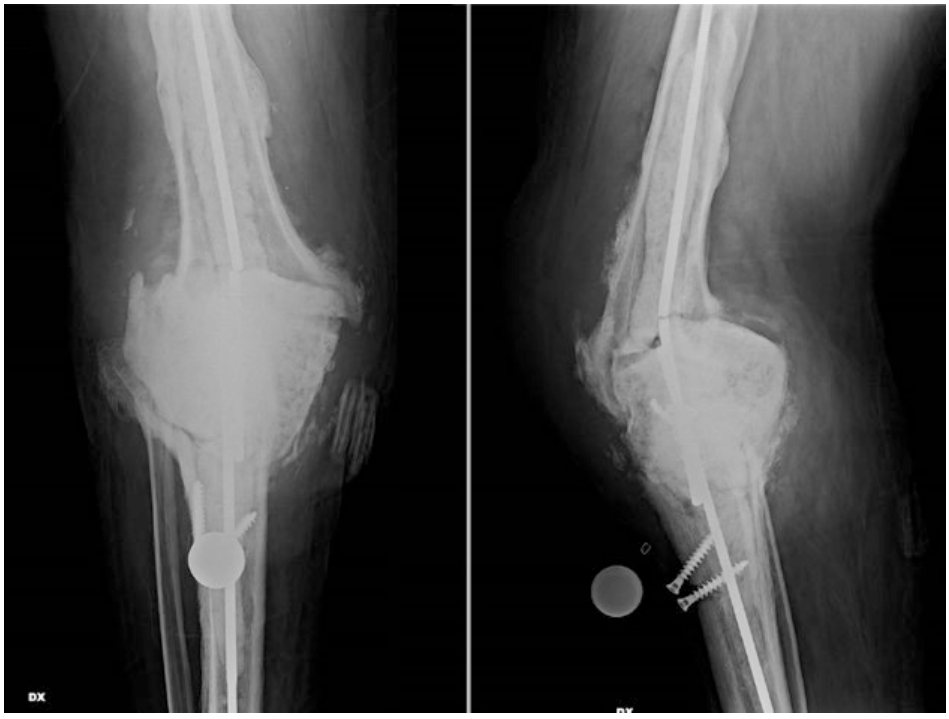

Fig. 16.33 Preoperative x-rays of the patient showing the rupture of the cemented static spacer and the two screws that were used to fix the hernia mesh

median arthrotomy was performed and the remnants of the patella were subperiosteally enucleated. The lateral and medial femoral gutters were cleared as well as all the adhesions in the suprapatellar pouch and on the rectus femoris in order to obtain sufficient exposure to the joint. Careful attention was paid in the removal of the broken cement spacer to avoid any additional bone loss on the tibial and femoral side. Gentle manipulation of flexion was performed after the spacer removal to gain some flexibility.

Bone loss according to Anderson Orthopaedic Research Institute (AORI) classification was 2B on the femur and 3 on the tibia. As a hinged implant was planned, the distal femur was reshaped and reduced in M-L size with a medial and lateral epicondylectomy in order to reduce the soft tissue tension and to help joint capsule closure.

The femoral side was prepared for a hybrid fixation: a cementless fixation with trabecular metal (TM) augments and cones was chosen for zones of sclerotic bone, while a cemented fixation was used in presence of medullary bone. According to that, epiphyseal fixation was enhanced with cementless TM augments (10 mm distal augments, 10 mm posteromedial and posterolateral augments) and a TM cone (size small 30 mm) was placed in the metaphysis. The definitive femoral component was then cemented on the epiphyseal and metaphyseal area, while a diaphyseal filling 17 × 130 mm stem was used.

The femoral distal joint line has been built up taking into account both the joint space in extension referring to the remnants of the lateral tibia and to the tension of the residual part of the extensor mechanism in flexion. Attention has been paid not to distalize the joint line more than 45 mm from the adductor tubercle as a hinged implant with an anti-recurvatum locking mechanism was used.

The tibial bone defect extended more widely on the medial side than the lateral one measuring 7 cm in depth from the tip of the fibula (Fig. 16.34). The stepped shape was then refined to the bone defect with the use of a saw blade in order to increase the stability of the graft/host bone construct (Fig. 16.35). The same shape was

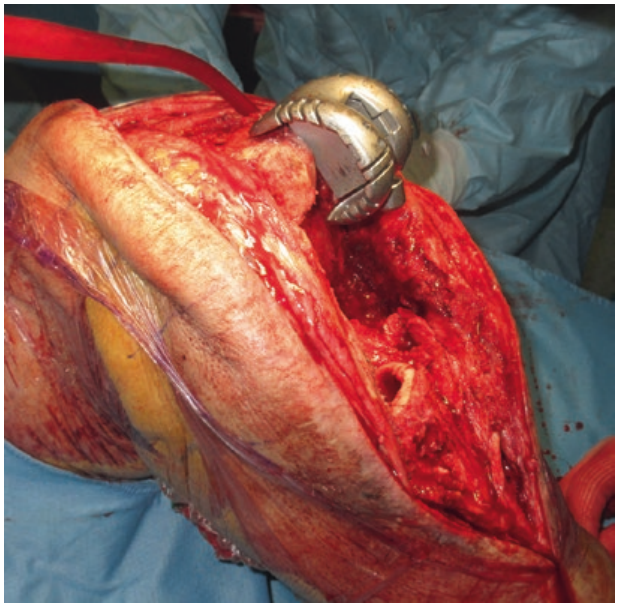

Fig. 16.34 Reconstruction of flexion and extension gaps was challenging as the tibial bone defect was severe measuring 7 cm in depth from the tip of the fibula

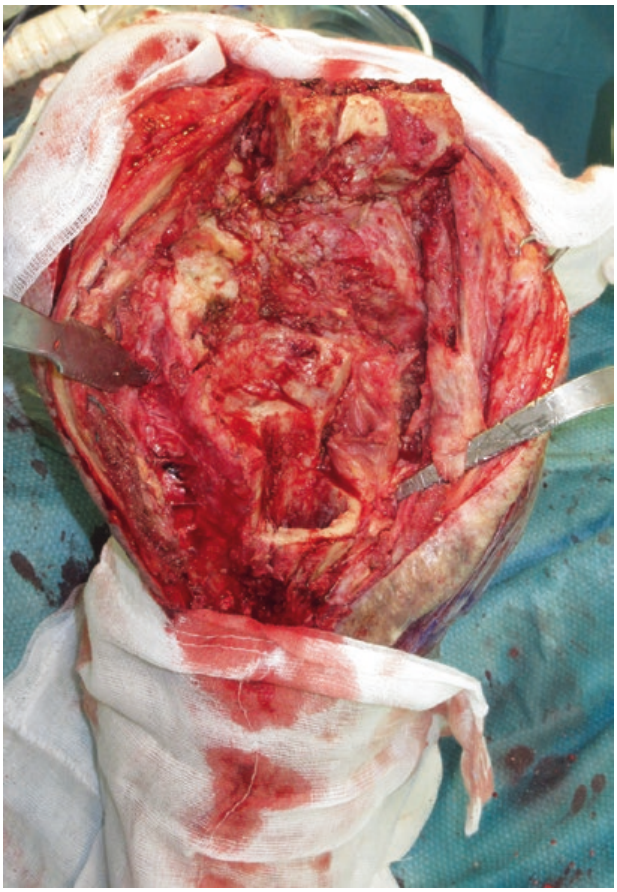

Fig. 16.35 The tibial bone defect was modeled to acquire a stepped shape in order to increase the stability of the graft. The defect extended more widely on the medial than the lateral side

reproduced over the graft. The graft was then positioned on the tibia, and the residual space in extension was checked under traction. The graft was modeled using intramedullary instrumentation to receive an RHK tibial component with a TM femoral cone (size small 30 mm off-label use) (Figs. 16.36 and 16.37). The TM cone was used an intramedullary temporary fixation device with its distal half portion inserted in the graft and its proximal half portion inserted in the host bone of the patient. Fixation in this zone would also provide long-term fixation of the tibia against subsidence and rotational forces in case of allograft resorption.

Tibial fixation was obtained with a hybrid technique. The proximal part of the tibial component was cemented to the proximal portion of the graft, and a diaphyseal filling 15 × 130 mm cementless stem was used to obtain fixation in the host tibial diaphysis. After the cement was hardened, a 14 mm hinged polyethylene liner was inserted.

Once the tibiofemoral joint was restored, the extensor mechanism insufficiency was then addressed by proximally suturing the quadriceps tendon of the tibial graft with the remnants of the host quadriceps. Both the graft and the host quadriceps remnants were tightly tensioned in full extension with nonabsorbable #5 Krackow sutures, and the overlapping portions of autologous and graft tissues were sutured with nonabsorbable #5 and #2 sutures (Ethibond, Ethicon, Somerville NJ, USA), covering the graft as much as possible with the autologous tissue (Fig. 16.38). The correct patella height was chosen so that the proximal pole of the patella would have rested immediately proximal to the tip of the trochlea in full extension. A thorough washout and a meticulous wound closure were performed. After surgery the patient was placed into a long **leg plaster cast** in order to avoid any tension on the quadriceps tendon before its healing. The postoperative x-rays are shown in Fig. 16.39.

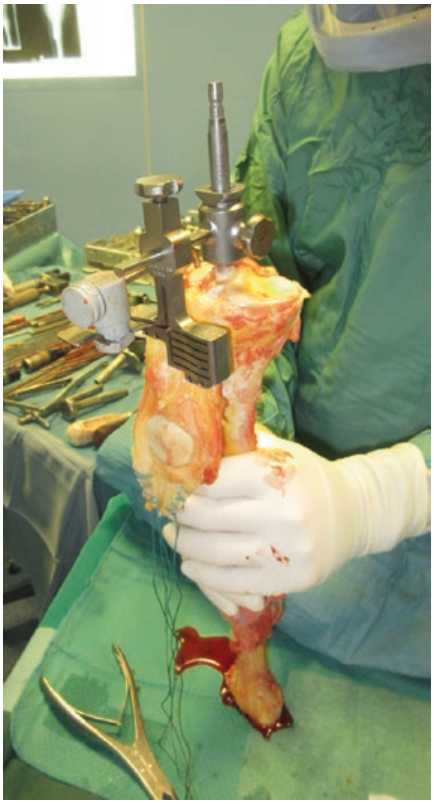

Fig. 16.36 The use of intramedullary instrumentation represents an easy and stable technique to remodel the tibial graft

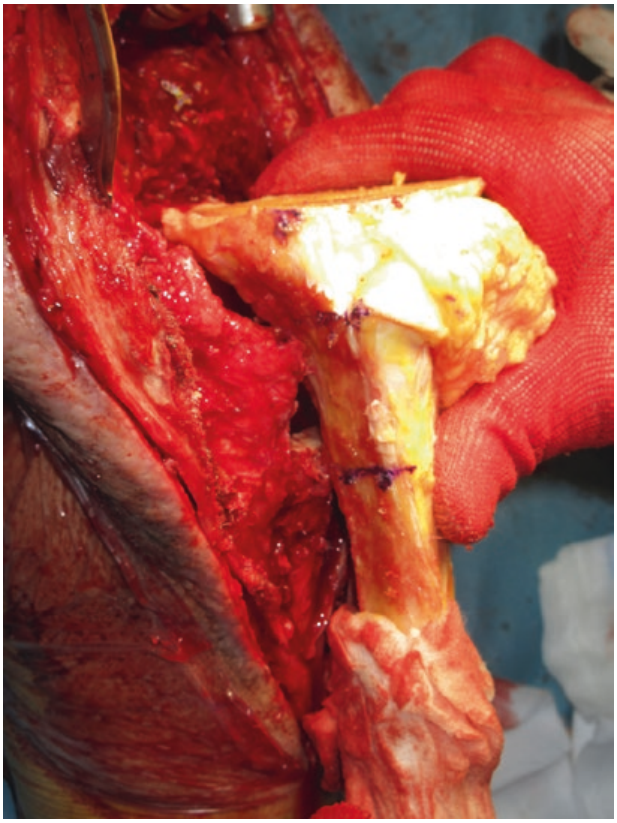

Fig. 16.37 The tibial graft was remodeled to obtain the same size and shape of the native tibial bone defect

Postoperative Result

The plaster cast was maintained in full extension for 2 months, with partial weight bearing allowed from the second postoperative week after the wound has been healed. After 2 months the plaster cast was removed and physiotherapy began

allowing a slow progression of flexion (0–40° and then 15° every week). An extension brace was utilized for additional 2 months while walking. At 6 months postoperatively, the patient did not show any recurrent sign of infection, was able to walk with one can for three blocks, and had 5° of extension lag and 90° of maximum flexion. The patient had no pain under weight-bearing activities and at rest. He still had to manage stairs with rail and one cane. His final level of satisfaction was high particularly because the authors proposed him an arthrodesis as the most valid salvage procedure alternative. The patient did not accept arthrodesis at that stage, and he was informed about the possible risks, including above-the-knee amputation. At 3-month follow-up, he stopped oral antibiotics (ciprofloxacin and amoxicillin) with a normal C-reactive protein (CRP) value. Close follow-up to detect a possible infection recurrence was undertaken and continued up to the midterm.

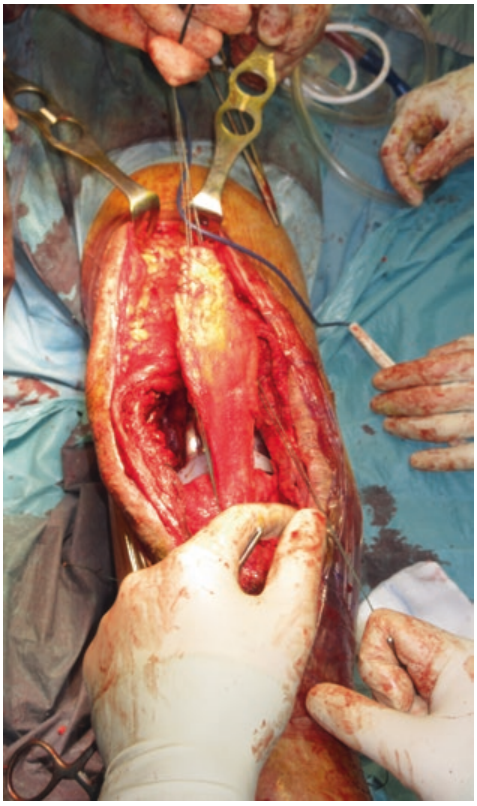

Fig. 16.38 The extensor apparatus was proximally sutured to the host quadriceps remnants while being tightly tensioned in full extension

Discussion

Severe tibial bone loss represents a technical challenge for surgeons performing revision knee arthroplasty. AORI type 3 tibial defects are characterized by extensive loss of metaphyseal bone with possible damage to the collateral ligaments and, as in our case, of the extensor mechanism (EM) [17]. The remaining metaphyseal bone is usually sclerotic or fragile and do not provide an adequate surface for cement fixation.

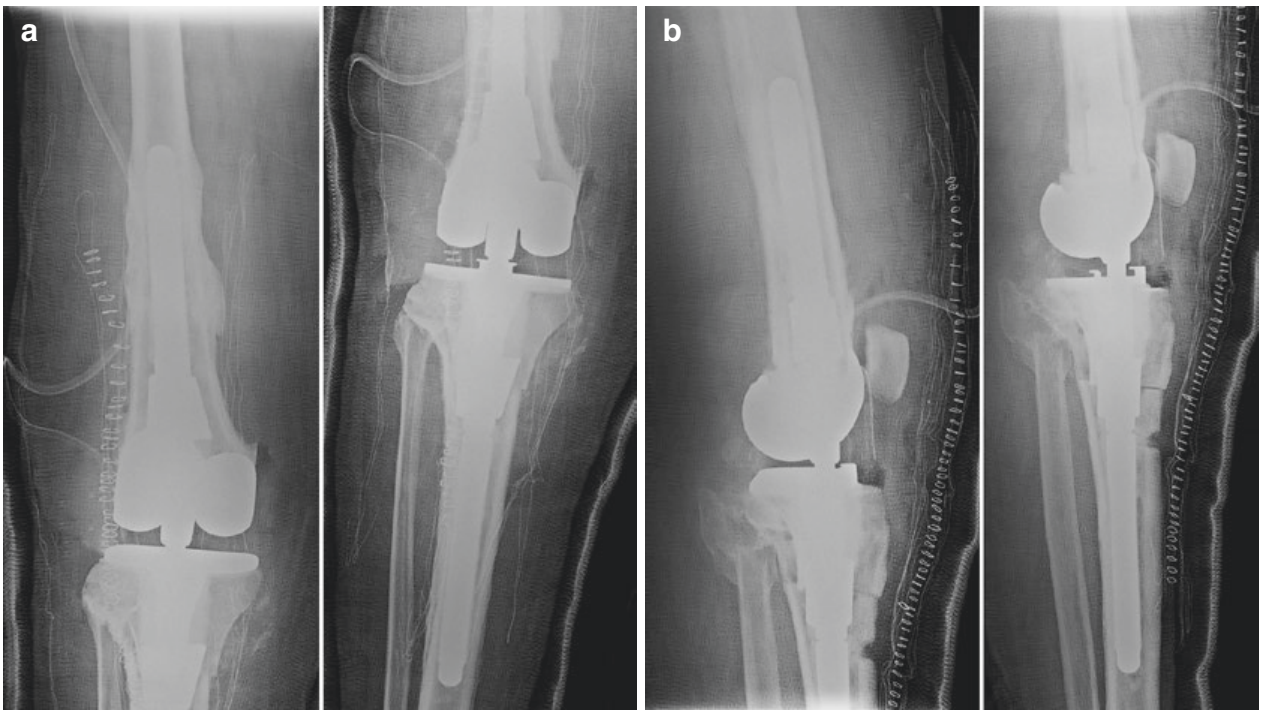

Fig. 16.39 (**a**, **b**) Postoperative x-rays of the patient

Surgical options for large uncontained type 3 tibial defects include reconstruction with structural allograft, metaphyseal sleeves or cones, and megaprosthesis.

According to Dorr et al., structural allograft reconstruction is indicated in the presence of tibial defects involving >50% of the osseous support of either tibial plateau [18]. However, in the current case, the choice of a segmental proximal tibial allograft for reconstructing the metaphysis was inevitable as the EM was insufficient and there was no tibial bone available to fix a tendon graft or even a full EM allograft alone. In addition to that, the synthetic hernia mesh that was used in the previous surgery to reinforce the patellar tendon failed as demonstrated by the significant extension lag (40°) experienced by the patient. For these reasons, a segmental proximal tibial allograft that included the EM was performed.

Advantages of structural allograft reconstruction include the ability to create any shape or size of construct according to the bone defect, excellent support of the revision implant, and the biologic potential for bone stock restoration. Disadvantages include a minimal risk of disease transmission and risks of allograft nonunion, malunion, collapse, or resorption. This reconstructive approach requires careful preoperative preparation and a meticulous operative technique in order to (1) match the specimen with the host defect size; (2) develop a healthy, bleeding host recipient site; (3) maximize surface contact between the allograft and the host bone; (4) optimize mechanical interlock between graft and host; and (5) guarantee strong implant fixation without instability or malalignment.

In the current case, the interlock between graft and host was obtained by using a TM cone that was also useful to enhance long-term fixation of the tibia against subsidence and rotational forces. Tibial fixation was performed according to hybrid technique with cemented proximal portion in the graft and cementless fluted stem in the tibial diaphysis. The use of stem extension is critical to offload the structural allograft during incorporation.

Although it is difficult to compare the results of published series as they differ in type of graft fixation, length and type of stem fixation, and constraint of the implant, several studies have reported the long-term outcomes of structural allografts with an average 74% graft survivorship at 10 years [19–21].

Engh et al. in a series of 46 knees with an AORI type 3 defect reported an 87% good-to-excellent outcome at a mean follow-up of 4.2 years. They noted only four failed allografts, two of which were secondary to infection. No allograft collapse or aseptic loosening was observed at a mean of 7.9 years [17].

However, Clatworthy et al. reported a less favorable allograft survival rate of 72% at 10 years in a series of 52 revision procedures for patients with large, uncontained osseous defects treated with structural allografts. They reported 11 failures because of infection (four), graft resorption (five), and allograft nonunion (two) [20].

Bauman et al. reviewed 70 revision TKA cases treated with structural allograft reconstruction and followed for a minimum of 5 years. Eight failures related to the allograft were found, and a revision-free survival rate of 75.9% at 10 years was reported [19].

Finally, a recent systematic review involving 551 structural allografts with a mean follow-up of 5.9 years described a 6.5% rate of graft failure, a 3.4% rate of aseptic loosening, and a 5.5% rate of infection [22].

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