Surgical Treatment Options for Patella Tendon Rupture, Part I: Acute

PATRICK E. GREIS, MD; MICHAEL C. HOLMSTROM, MD; AMIT LAHAV, MD

**educational objectives**

After reading this article, physicians should be able to:

1. Explain the surgical treatments for acute patella tendon ruptures.
2. Describe the physical examination for the evaluation of acute patella tendon ruptures.
3. Discuss the historical treatment.
4. Analyze the current results of the acute repair/reconstruction of the ruptured patella tendon.

The patella tendon is an integral part of the extensor mechanism of the knee, and its rupture is a disabling injury. The peak incidence of injury occurs in the third and fourth decades and it is six times more common in males than females. In younger patients, rupture of the patella tendon tends to be the result of significant trauma or cumulative microtrauma, while in older patients it often is related to degenerative changes associated with aging. The injury also is associated with systemic diseases such as rheumatoid arthritis, systemic lupus erythematosus, chronic renal failure, diabetes, Paget’s disease, and hyperparathyroidism. Iatrogenic patella tendon rupture has been described as a complication of total knee arthroplasty, a late complication of a tibial nail, a result of steroid injections, and following removal of the central third of the tendon for anterior cruciate ligament (ACL) reconstruction. Bilateral simultaneous rupture is very rare and usually occurs in the setting of chronic systemic disease, although it has been reported in otherwise healthy people. Finally, direct causes of rupture such as laceration and direct blows have been described.

**MECHANISM OF INJURY**

Most often, the primary mechanism of injury involves a rapid contraction of the quadriceps muscle with a flexed knee. Patients with a patella tendon rupture usually present with a history of tripping or giving way of the knee associated with the sensation of a sudden pop and the acute onset of pain. The injury may occur with varying amounts of force, ranging from strenuous weight lifting to descending stairs, and if it is a complete rupture, there is the subsequent inability to extend the knee of the affected extremity.

McMaster first demonstrated that normal, healthy tendons usually do not rupture. Instead, a critical degree of tendon degeneration often occurs prior to rupture. Kannus and Józsa examined biopsy specimens from 891 spontaneously ruptured tendons and compared them with 445 age and sex-matched controls, with 9% in each group coming from the knee extensor mechanism. They demonstrated that while 34% of the control tendons had histopathologic changes, 100% of the ruptured tendons showed histopathological changes. Of these changes, 97% were degenerative, consisting of hypoxic degenerative tendinopathy, mucoid degeneration, tendinolipomatosis, or calcifying tendinopathy. Additionally, they found no signs of inflammatory cell infiltration in any of the studied tendons.

While the detailed etiology behind tendon degeneration is not fully understood, one factor is decreased arterial blood flow, with resulting local hypoxia and impaired metabolic activity. Aging also contributes...
to degeneration through decreased elasticity, decreased vascular supply, and degenerative changes in collagen.

These pathological studies showing histopathological changes in all ruptured tendons correlate clinically with findings described by Kelly et al. Patella tendon rupture in 10 athletes was shown in all cases to be the end-stage of jumper’s knee resulting from repetitive microtrauma. The patients often exhibited preexisting pain or aching in the infrapatellar region with running, jumping, climbing, or kicking activities, especially in patients aged <25 years at the time of rupture.

The amount of force transmitted through the patella tendon plays a role in ruptures, as does the patient’s underlying anatomy. Knee extensor forces through the patella tendon are greatest at 60° of flexion, and can equal 3.2 × body weight when ascending stairs.22

Yamaguchi and Zajac21 developed a computer model that suggests that a longer patella tendon may predispose one to patella tendon rupture by enhancing the transmission of quadriceps force to the tendon. Zernicke et al24 analyzed film of a weightlifter who ruptured his patella tendon during an event and calculated that patella tendon tension at the time of failure was 17.5 × the lifter’s body weight, thus representing an estimate of the strength of a healthy patella tendon. Tendons already weakened through the histopathological changes described above intuitively require an even lower force to fail.

When a patella tendon ruptures in an adult, it generally occurs at the patella bone-tendon junction. Biomechanically, the strain is greater at tendon insertion sites than in the body of the tendon itself. A midsubstance tear is more common with direct trauma or tendon laceration.2 In children, however, patella tendon rupture usually occurs at the distal end by an avulsion fracture of the tibial tuberosity apophysis (Figure 1), or at the proximal end by a patella sleeve fracture of the inferior patella pole. There are rare reports of both the proximal and the distal portions being simultaneously involved.25

**INDICATIONS AND CONTRAINDICATIONS**

Acute surgical repair of a patella tendon rupture is the standard of care. Significant proximal retraction of the patella with adhesions and quadriceps contractures can occur in injuries not treated within two weeks.

**Figure 1:** Lateral radiograph of patella tendon avulsion from the tibial tubercle in a skeletally immature patient. Note patella alta and defect at the tubercle.

**Figure 2:** Clinical photographs of a patella tendon rupture with proximal migration of the patella. Patella absent when viewed from above (A). Defect when viewed from the lateral side (B).

Contraindications for repair include acute infection, medical conditions that make the risk of surgery prohibitive, and massive injury with contamination that makes primary repair impossible and sec-
It is essential to test active knee extension in all cases where patella tendon disruption is suspected. Although the patient occasionally is able to contract the quadriceps and raise the leg in full extension through an intact extensor retinaculum, there usually is weakness when compared to the contralateral side and an extension lag.

While the clinical picture alone usually is adequate for diagnosis, additional diagnostic studies occasionally are used. On plain radiographs, degenerative changes in the patella tendon near its origin may cause a “tooth sign.” Patella alta also may be seen, being more readily apparent on a lateral view with the knee in flexion (Figure 3). The Insall-Salvati ratio is >1.2 and an avulsed bone fragment attached to the tendon may be seen. Ultrasonography and magnetic resonance imaging generally are unnecessary but may be useful in the few cases where the diagnosis is unclear or delayed (Figure 4).

**Surgical Technique**

Surgical technique of open patella tendon repair/reconstruction depends on several factors including the chronicity of the rupture, the site of the rupture, the relative skeletal maturity of the patient, and the quality of the tissue that is to be repaired. When planning the best technique for a particular patient, there are three general categories: acute repair, acute repair with augmentation, and chronic reconstruction. Skeletally mature patients with an acute rupture usually have adequate tissue for a primary repair. In acute ruptures secondary to a systemic process such as rheumatoid arthritis, or in the setting of a chronic rupture, the autogenous tissue alone may not be adequate and augmentation or reconstruction generally is required. Following are descriptions of various surgical alternatives to treat acute ruptures in both skeletally mature and immature patients.

**Acute Injuries**

Patients with acute patella tendon ruptures usually have adequate tissue for repair. The location of the rupture dictates the type of repair performed, and sometimes a combination of techniques must be used. While the preoperative exam and diagnostic studies often point to the site of rupture, the surgeon must be prepared for all possibilities. The basic sites of the patella tendon rupture include: 1) rupture of the tendon off the patella, 2) rupture of the tendon from the tibial tubercle±bony avulsion, 3) midsubstance rupture and, 4) complex pattern of rupture.

**Historical Treatment of Acute Injuries**

In 1947, McLaughlin described a technique in which the patella tendon was repaired primarily. To protect the repair, he recommended placing a stainless steel wire through the quadriceps tendon just proximal to the patella, and anchoring it to a bolt placed transversely through the tibial tubercle. The wire then was removed at 8 weeks.

Siwek and Rao reinforced their immediate repairs using external devices. These included Bunnell pullout wires, a pullout wire tied to a Steinmann’s pin through the tibia, or a pullout wire with Steinmann’s...
pins through both the patella and tibia. Their patients then were casted in extension for 6 to 11 weeks. Twenty-four of 26 patients subsequently had a good or excellent result, with one rerupture.

Miskew et al\textsuperscript{27} and Azur and Pickering\textsuperscript{28} have described repairing the patella tendon using Mersilene suture passed through bony tunnels either in the patella or the tibial tubercle.

Fujikawa et al\textsuperscript{29} describe reconstructing the patella tendon using a flexible open-weave polyester Leeds-Keio prosthetic ligament. Good results were described in 14 of 18 patients.

Kelly et al\textsuperscript{31} repaired the tendon with nonabsorbable sutures passed through drill holes in the patella. In 2 of 10 cases, they also augmented the repair with either a wire loop or umbilical tape. While Cybex strength testing showed good or excellent strength in only 4 of 9 patients, good or excellent clinical results were seen in 8 of 10 patients.

Levin\textsuperscript{30} first described the use of a Dacron vascular graft as a suture material in reconstruction of the patella tendon. Frazier and Clark\textsuperscript{31} described the use of a 5-mm Dacron vascular graft to repair acute ruptures, with good results at 4 months. Levy et al\textsuperscript{32} also recommend the use of a Dacron vascular graft to allow immediate mobilization of the knee.

Kelikian et al\textsuperscript{33} first described using the semitendinosus tendon in patella tendon reconstruction. They divided the tendon at the musculotendinous junction, passed it through drill holes in the tibial tubercle and the patella, and sewed it back on itself. They used a traction pin through the patella to mobilize the patella and then incorporated it into a cylindrical cast to help protect the repair. Larson and Simonian\textsuperscript{34} report excellent clinical results using semitendinosus augmentation with immediate postoperative mobilization in 4 of 4 patients.

Haas and Callaway\textsuperscript{2} determine the method of repair based on the location of the rupture and the time frame. For ruptures at the junction of the patella and the patella tendon identified within the first 2 weeks, they recommended primary repair with Kessler-type sutures in the tendon placed through holes in the patella. For midsubstance repairs, lacerations, or delayed repairs, they recommended augmentation of the primary repair with the gracilis and semitendinosus tendons.

Lindy et al\textsuperscript{35} describe a technique in which #5 braided polyester suture is used of the patella tendon the patient is placed in the supine position. A small bump is placed under the affected hip to allow the patella to point directly towards the ceiling. A tourniquet is not required, however its use can minimize blood loss. If used, the tourniquet is placed about the proximal thigh and the entire lower extremity is prepped free. For most acute injuries, only the involved extremity is prepped free. If tissue quality is suspect or if there are other concerns, the contralateral limb may also be prepped to allow for graft harvest should it be required. Following a sterile prep and drape of the limb, a midline approach to the patella tendon is made.

The incision is approximately 4 inches in length, starting just above the inferior pole of the patella and extending distally. This incision can be extended either superiorly or inferiorly if necessary. Standard dissection through skin and subcutaneous tissue is performed. In many acute ruptures, after the subcutaneous tissue is divided, the knee joint often is entered at the site of the rupture. Next, it is important to define the patella tendon and the site of the rupture. Avulsions from the patella are common, along with tearing of the medial and lateral retinacular tissue. The peritendon of the patella tendon is identified and can be incised to allow for dissection of the patella tendon itself. The joint is inspected for any concomitant damage to the condyles and the entire field is irrigated to remove old hematoma and clot. At this point the repair technique depends on the exact site of rupture.

\textit{Patella Insertion Ruptures.} For tears at the patella insertion, a total of three #5 braided polyester sutures are used. Sutures are used for both the medial and lateral borders of the patella tendon. A baseball-type stitch is used, initially working down one side of the tendon from proximal to distal, then back up within the substance of the tendon. Approximately one-third of the tendon width is incorporated into each stitch. In the central portion of the tendon, an additional #5 suture can then be woven.
in a modified Kessler-type fashion that will prevent the tendon from balling up (Figure 5). These sutures allow for excellent fixation of the patella tendon, and are marked with hemostats so that they can later be passed through drill holes.

Next, the inferior pole of the patella is debrided with a Rongeur and a small burr to provide a good bleeding surface for healing. A total of four holes then are made through the patella from inferior to superior. A 2-mm drill often is useful for this portion of the procedure. When drilling, the surgeon must take care to dissect down to the drill bit as it exits the bone at the superior border of the patella. Significant quadriceps tendon often is incorporated if this dissection is not performed. After each drill hole is made, a suture passer can be used to retrieve the sutures. The middle two holes accommodate two sutures each as seen in Figure 5. After passing these sutures through the patella, they can sequentially be tied with the knee flexed at 30°. The inferior pole of the patella should come in apposition with the patella tendon substance, but care must be taken not to over-tension the tendon and cause patella infera. The sutures are tied directly over the superior pole of the patella, again taking care not to incorporate quadriceps tendon. On occasion, these sutures will be prominent and palpable underneath the skin of a thin patient, however they rarely require removal.

When using transosseous sutures as described above, it generally is not necessary to use a stress relieving wire through the tibial tubercle and around the patella as initially described by McLaughlin.26 It may sometimes be necessary, though, if the tissue is of poor quality. Wires will frequently break at the time motion is initiated, necessitating removal, so we prefer to use a 5-mm Mersilene tape. This should be placed through a transosseous drill hole in the tibial tubercle and then up and over the patella through the quadriceps. It should be tied with the knee in at least 60° of flexion so that the joint is not overly constrained.

**Figure 6: Midsubstance repair with sutures.**

After repair of the patella tendon to bone, a repair of the medial and lateral retinacular tissue is required. This is a key portion of the procedure because it relieves much of the stress on the central repair. A #2-0 absorbable suture first is used to close any synovial tissue if two separate layers can be identified. A #1 absorbable suture then is used to close the medial and lateral retinacular tissues. At this point the wound is irrigated once again. A drain can be placed in the subcutaneous tissue if necessary, and the incision is closed using #0 absorbable suture in the deep subcutaneous tissue, #2-0 absorbable suture in the epidermis, and a running subcuticular stitch. A sterile dressing is applied and the patient is placed in a knee immobilizer in full extension. With a secure repair, motion can be initiated within the first few weeks with the goal of achieving 90° of flexion by 6 weeks.

**Tibial Tubercle Ruptures.**

In patients where the patella tendon rupture is at the tibial tubercle, a variation of previously described procedures is performed. The #5 braided polyester sutures similarly are placed using a running baseball-type of stitch on both the medial and lateral aspects of the tendon. A more central suture can likewise be used if possible. The bone at the site of the tibial tubercle attachment of the tendon should be roughened with a burr so that tendon to bone healing will occur. The sutures are placed through transosseous tunnels in the tibial tubercle and tied over bony bridges medially and laterally. Again, care must be taken to not over tension the ligament or move it too distally.

In this type of rupture, the retinacular tissue often is avulsed directly from the tibia. Suture anchors can be used to help augment the repair on the medial and lateral aspects of the tibia where this retinacular tissue attaches. Closure is identical to that as previously described.

**Midsubstance or Complex Ruptures.**

For patients who have the less common midsubstance or complex ruptures, a direct repair of tendon to tendon may be possible. In this situation, we also use #5 braided polyester suture in both the proximal and distal portions of the tendon, then tie the sutures to each other in the middle (Figure 6). If there is a complex tear, or a portion of the tendon is avulsed from the patella or the tibia, a combination repair is
performed with transosseous sutures used where possible. When repairing these complex injuries, augmentation with local tissue such as the semitendinosus or gracilis tendon can be considered.

**Ruptures in Skeletally Immature Patients.** In skeletally immature patients with a distal avulsion, one must consider potential damage to the tubercle apophysis during the repair. Several techniques have been described for repair including transosseous sutures, screw fixation, and pin fixation. With transosseous sutures, disturbance to the apophysis is unlikely. Careful follow-up is required, however, and if a progressive deformity is observed, then either a release of the sutures or bar excision may be required. Additionally, because these patients are skeletally immature and loss of motion is less of a concern, rehab can be somewhat slower. An above-knee cast in extension is therefore appropriate if fixation is tenuous.

**Acute Repair With Augmentation**
In situations when tissue quality is poor due either to an underlying disease process or to severity of injury, augmentation of the repair may be considered. The surgeon should attempt to repair native tissue as previously described, as long as this can be done without causing significant patella infera. If the tissue does not allow for an adequate repair, augmentation can be performed to provide more secure fixation.

The most common technique of augmentation involves the use of semitendinosus or gracilis tendons harvested from the medial aspect of the knee. Numerous authors have described techniques for using the semitendinosus to augment infrapatellar tendon ruptures,2,3,4,6

If hamstring augmentation is considered, the dissection is carried out slightly more distally and medially to identify the pes insertion. The semitendinosus and gracilis can be harvested using an open-ended tendon stripper without dissecting them free from their tibial insertion. This anatomic insertion can be left in continuity as long as the tendons are of good quality and adequate length is achieved (Figure 7). After the tendons are harvested, they are sized to determine the appropriate diameter hole to be made in the inferior pole of the patella.

Traditional technique dictates that the transosseous hole is made over a guide wire placed transversely through the inferior pole. This usually is done in the distal third, taking care to stay well anterior to the articular surface. If the hole is placed too far superior, there may be a deficiency in overall tendon length for the procedure. On the other hand, making the hole too far inferior can risk fracture of the inferior pole. The ACL aiming guides are very helpful in placing the guide wire, and the standard cannulated ACL drills can be used to make the hole through the patella.

The free ends of the tendons usually are secured with #5 braided polyester suture in a baseball-type stitch and passed through this transosseous hole. If there is ample tendon length, an additional transosseous hole within the tibial tubercle can be made to perform a complete circle graft. At times, however, tendon length often is not adequate and this is difficult. The suture can instead be tied distally to a post in the tibia, using a bicortical screw and washer. We prefer to use a 4.5-mm cortical shank screw with washer because it provides excellent bicortical fixation and the smooth shank minimizes the chance of suture breakage as it is tied.

An alternative means of routing the graft attempts to keep the fibers of the semitendinosus and gracilis tendons more in line with the natural patella tendon. This is done by leaving the tendons attached distally and placing them through a hole in the tibia running obliquely from just above the pes insertion to the lateral insertion of the patella tendon, similar to the technique described by Kelikian et al15 (Figure 8). The tendons then are passed through tunnels that start on the inferior pole of the patella at both the medial and lateral borders of the patella tendon, and which exit 2/3 of the way up the
Figure 8: Schematic (A) and clinical photograph (B) of reconstruction using the semitendinosus and gracilis tendons passed through transosseous tunnels.

patella on the anterior surface. If there is sufficient length, a final transosseous tunnel is placed through the tibia and the tendons are brought back down to the tibia.

It is rare in the acute setting that augmentation beyond the use of the semitendinosus or gracilis graft is required. If additional tissue or reconstruction is required, allograft tissue may be used.

RESULTS

Acute repair of patella tendon ruptures show promising results with good outcome. Larson and Simonian\(^{34}\) reported on four cases of acute midsubstance patella tendon rupture that were treated with primary surgical repair along with semitendinosus autograft augmentation. They concluded that all isolated patella tendon injuries in the study had excellent function at follow-up. Lindy et al\(^{35}\) reviewed the results in 24 patients who underwent acute primary repair of patella tendon ruptures augmented by a nonabsorbable polyester tape followed by immediate mobilization. Follow-up evaluations of 19 patients, performed at an average of 22.4 months showed active range of motion from 0° to 132° (contralateral knee, 0°-135°). All patients with isolated injuries have also returned to employment.\(^{36}\) Similarly, good results were found by Larsen and Lund\(^{18}\) in the functional results of 28 cases of rupture of the quadriceps and patella tendons. Excellent or good results were noted in 15 of 18 quadriceps and 7 of 10 patella tendons. Marder and Timmerman\(^{37}\) reported their experience with avulsion injuries as well as midsubstance ruptures, both treated with primary repair without augmentation, and early mobilization, in the athlete aged <40 years. At a mean follow-up of 2.6 years (range: 20-61 months), 12 patients had returned to their previous levels of activity. No loss of extension or extensor lag was noted. Patellofemoral symptoms and signs were present in five patients, but activity was limited in only two. Mean Lysholm score was 94. They concluded that primary repair with immediate, protected range of motion resulted in uniformly excellent results.\(^{37}\) Hsu et al\(^{38}\) also reported their retrospective review of 35 patients with traumatic patella tendon ruptures who were treated with primary repair and a neutralization wire. All the ruptures occurred in acute trauma;


