

Quadriceps and patellar tendon rupture

Overview

EPIDEMIOLOGY AND PATHOANATOMY

- Patellar or quadriceps tendinopathy occurs in active individuals who engage in activities involving forceful, eccentric contraction of the knee extensor mechanism, particularly jumping sports [2].
- Harder playing surfaces and increased frequency of practices are associated with increased rates of tendinopathy [2].
- Patellar tendinopathy, or jumper's knee, occurs most frequently in adolescents and young adults [2].
- Quadriceps tendinopathy occurs in middle-aged and older adults [2].
- Patellar tendinopathy tends to occur at the deep fibers of the patellar attachment of the tendon [2].
- The deep fibers of the patellar tendon attachment have a tenuous blood supply [2].
- Affected tissue in patellar tendinopathy may demonstrate fibrinoid necrosis, angiofibroblastic change, or mucoid degeneration and disorganized collagen structure [2].
- Metaplasia of adjacent fibrocartilage may be present in patellar tendinopathy [2].
- The medial portion of the patellar tendon often demonstrates thickening compared with the rest of the tendon [2].
- The pathoanatomy of quadriceps tendinopathy is similar to that of patellar tendinopathy [2].

CLINICAL EVALUATION

- Patients with patellar or quadriceps tendinopathy describe an insidious onset of pain and swelling of the affected tendon [2].
- Symptoms initially develop after activity, gradually start to bother the individual both during and after activity, and eventually limit athletic performance during the activity [2].
- Patients may report buckling of the knee, which represents reflex quadriceps inhibition due to pain [2].
- Physical examination reveals tenderness and soft-tissue swelling, usually in the area where the tendon attaches to the patellar bone [2].
- Patients often have discomfort with resisted extension of the knee [2].

- Plain radiographs of the knee may demonstrate degenerative spurring where the affected tendon attaches to bone [2].
- MRI usually shows thickening in the affected portion of the tendon and may demonstrate intrasubstance signal abnormalities [2].
- Thickening is much more diagnostic than signal changes when identifying abnormal tendon on MRI [2].

CLASSIFICATION

- The three stages of tendinopathy according to Blazina are: Stage 1 (pain after activity), Stage 2 (pain during and after activity), and Stage 3 (pain that limits function during an activity) [2].

TREATMENT

- Nonsurgical intervention is the mainstay of treatment for patellar or quadriceps tendinopathy [2].
- Initial treatment for tendinopathy consists of activity modification [2].
- Progressive flexibility and eccentric strengthening exercises follow initial activity modification [2].
- Taping to aid proprioception and patellar tracking or using an infrapatellar strap can be helpful [2].
- NSAIDs can be beneficial for tendinopathy [2].
- Corticosteroid injection is contraindicated for tendinopathy because of the increased risk of tendon rupture [2].
- No recommendation can be made currently regarding prolotherapy injections using a local irritant to elicit an inflammatory healing response [2].
- No recommendation can be made currently regarding platelet-rich plasma injection [2].
- Surgery for tendinopathy is reserved for patients who continue to have pain and swelling of the tendon after a nonsurgical treatment regimen has been attempted [2].
- Surgical procedures for tendinopathy are performed according to the surgeon's preference [2].
- Surgical options for tendinopathy include various methods of debriding diseased tissue and stimulating a vigorous healing response [2].
- Simple longitudinal excision of the diseased portion of tendon followed by abrasion of the bone to provide a bleeding surface for tendon healing is a surgical option for tendinopathy [2].
- Finishing with the application of side-to-side sutures or suture anchors as needed is part of the surgical procedure for tendinopathy [2].
- Variations of the surgical procedure for tendinopathy include drilling of the bone to stimulate a healing response [2].
- Variations of the surgical procedure for tendinopathy include multiple tendon perforations ("pie crusting") to stimulate healing of the tendon tissue [2].
- All surgical procedures for tendinopathy can be performed using a standard anterior midline incision to expose the diseased tendon and its attachment to the patella [2].

- Operative treatment is indicated for all extensor tendon ruptures in which extensor mechanism function is compromised, the soft tissues are adequate for healing, and the patient is fit for surgery [1].
- Many different repair techniques have been described for extensor tendon ruptures with no single technique demonstrating superiority [1].
- The patient is positioned supine on a standard operating table for extensor tendon repair [1].
- A small bump under the hip is often useful for controlling external rotation of the limb during extensor tendon repair [1].
- A small bump of towels that can be moved from beneath the knee and ankle helps in providing slight knee flexion and extension, respectively, during the case [1].
- A tourniquet is rarely needed for extensor tendon repair but may be placed in a nonsterile fashion and only inflated if uncontrollable bleeding is encountered [1].
- An extensile straight midline incision is most often employed to expose the knee from the inferior patella to 5 cm proximal to the quadriceps tendon rupture [1].
- For patellar tendon ruptures, the incision extends from the superior patella to the tibial tubercle [1].
- Full-thickness flaps are elevated medially and laterally to identify the apex of the retinacular tears, if present [1].
- The joint is irrigated to remove hematoma, allow identification and assessment of the tear, and examination of the patella and distal femoral articular surfaces [1].
- Key surgical steps for acute extensor tendon rupture include an anterior longitudinal midline incision [1].
- Key surgical steps for acute extensor tendon rupture include exposing the tendon rupture [1].
- Key surgical steps for acute extensor tendon rupture include removing nonviable tendon edges [1].
- Key surgical steps for acute extensor tendon rupture include placing grasping stitches in the tendon [1].
- Key surgical steps for acute extensor tendon rupture include reattaching the patellar or quadriceps tendon through three parallel longitudinal drill holes in the patella [1].
- Key surgical steps for acute extensor tendon rupture include securing sutures over bone bridges in full extension [1].
- Key surgical steps for acute extensor tendon rupture include assessing strength of repair with controlled flexion [1].
- Key surgical steps for acute extensor tendon rupture include considering adding a cerclage wire from quadriceps tendon to tibial tubercle for patellar tendon injury [1].
- Key surgical steps for acute extensor tendon rupture include performing multilayer closure [1].
- Avulsion of the quadriceps tendon from the superior pole of the patella can be treated by debridement of the tendon, followed by the passage of two heavy nonabsorbable sutures into the tendon [1].
- Three parallel drill holes are created from superior to inferior through the patella for quadriceps tendon avulsion repair [1].
- Sutures are passed through the drill holes and tied at the inferior patella for quadriceps tendon avulsion repair [1].

- The retinacular tissue is repaired during quadriceps tendon avulsion repair [1].
- A midsustance rupture can be repaired with end-to-end approximation of the tendon rupture [1].
- If the repair is tenuous, the Scuderi technique or quadriceps turndown flap has been described as a method to reinforce the surgical repair [1].
- A partial-thickness triangular flap is developed from the anterior surface of the proximal tendon that is 2 in along the base and 3 in along each side for the quadriceps turndown flap [1].
- The flap is folded distally over the rupture/repair and sutured into place [1].
- Several authors have suggested techniques for reinforcing the repair using wire, Dacron tape, or suture [1].
- No complications and 100% good and excellent results were reported with use of a braided nonabsorbable relaxing suture tensioned at 30 degrees of flexion in 20 quadriceps repairs [1].
- The authors felt the relaxing suture reinforced the repair and allowed early active motion and brace-free ambulation at 6 weeks [1].
- Most repairs for tendon avulsions are sufficiently strong that secondary stress-relieving devices are not required [1].

Anatomy & Pathophysiology

EXTENSOR MECHANISM ANATOMY

- The extensor mechanism collectively refers to the quadriceps tendon, medial and lateral retinacula, patella, and patellar tendon [43].
- The quadriceps muscle complex is composed of the vastus lateralis, vastus medialis, rectus femoris, and vastus intermedius [43].
- The vastus lateralis inserts on the patella at an approximately 30-degree angle relative to the longitudinal axis of the femur [43].
- The most medial fibers of the vastus lateralis insert on the superolateral patella, while its most lateral fibers run lateral to the patella to insert into the lateral retinaculum and iliotibial tract [43].
- The vastus medialis consists of two distinct portions separated by fascia and innervated by distinct branches of the femoral nerve [43].
- The vastus medialis longus inserts on the patella proximally at an angle of 15 to 18 degrees relative to the long axis of the femur [43].
- The vastus medialis obliquus inserts more distally on the patella at an angle of 50 to 55 degrees relative to the long axis of the femur [43].
- The rectus femoris fibers run 7 to 10 degrees medially relative to the long axis of the femur in the coronal plane [43].
- The vastus intermedius lies deep to the rectus femoris and inserts directly into the superior base of the patella [43].

- The quadriceps tendon insertion reflects an intricate blending of all tendon fibers at the insertion into the superior patella [43].
- The quadriceps tendon has been described as having two to four distinct layers [3].
- The patellar retinaculum and iliotibial band function as secondary extensors of the knee [43].
- The retinaculum is formed by the continuation of the deep investing fascia lata in the thigh and is reinforced by inserting aponeurotic fibers from both the vastus medialis and lateralis [43].
- Both the medial and lateral retinacula insert directly into the proximal tibia [43].
- The medial patellofemoral ligament is an extracapsular continuation of the deep retinacular surface of the VMO [43].
- The medial patellofemoral ligament extends from the superior medial border of the patella and attaches to bone just anterior to the medial collateral ligament on the medial epicondyle [43].
- The medial patellofemoral ligament contributes 50% to 60% of the total restraining force of the medial patellar stabilizers [43].
- The medial patellofemoral ligament has a fan-shaped configuration running from the upper medial margin of the patella to a femoral insertion posterosuperior to the epicondyle and just distal to the adductor tubercle [43].
- Cadaveric dissections reveal the medial patellofemoral ligament to be 58.8 ± 4.7 mm in length, 12 ± 3.1 mm in width, and inclined 15.9 ± 5.6 degrees proximally [43].
- The patellar tendon originates from the apex of the patella proximally and inserts into the tibial tubercle distally [43].
- The average length of the patellar tendon is 5 cm [43].
- The patellar tendon is formed primarily from a continuation of the central fibers of the rectus femoris tendon [43].
- The patellar tendon is reinforced at its tibial insertion medially and laterally by the extensor retinaculum and the iliotibial tract [43].
- The patellar tendon receives its blood supply from the infrapatellar fat pad and from the retinaculum through the medial and lateral inferior geniculate arteries [15].

PATHOPHYSIOLOGY OF RUPTURE

- Under normal conditions, tensile overload of the extensor mechanism usually leads to fracture of the patella, which is considered the weakest link in the extensor mechanism [37].
- Between 50% and 75% of tendon fibers must be transected to result in a rupture under forces greater than those seen under physiologic conditions [37].
- Patellar tendon ruptures secondary to indirect trauma have been considered the end stage of long-standing chronic tendon degeneration secondary to repetitive microtrauma [37].
- Biopsy specimens of spontaneously ruptured tendons reveal pathologic findings that are degenerative in nature, including hypoxic tendinopathy, mucoid degeneration, tendolipomatosis, and calcifying tendinopathy [37].

- Ruptures may occur in the absence of pathologic tendon degeneration [37].
- Prodromal symptoms were present in 46% of professional football players prior to patellar tendon rupture [37].
- In a series of 13 athletes with chronic jumper's knee that resulted in tendon rupture, younger patients had more severe symptoms than older patients [37].
- Kelly et al. concluded that more advanced degeneration is required to weaken younger healthier tendons [37].
- Rupture of the patellar tendon or quadriceps tendon generally occurs with eccentric loading of the knee extensor mechanism, often when the foot is planted and the knee is slightly bent [3].
- Less commonly, these injuries can occur with a direct blow to the tendon when the extensor mechanism is under tension [3].
- The mechanism of injury for patellar tendon rupture is tensile overload of the extensor mechanism [15].
- Most patellar tendon ruptures occur with the knee in a flexed position [15].
- The most common injury pattern for patellar tendon rupture is a proximal sided rupture [15].
- Midsubstance ruptures or distal avulsions of the patellar tendon are also possible [15].
- Both patellar tendon and quadriceps tendon ruptures typically occur at the tendon attachment to the patella [3].
- Underlying chronic degeneration often is present in ruptures and is characterized by angiofibroblastic tendinosis, mucoid degeneration, and pseudocyst formation at the attachment of tendon to bone [3].
- The patellar tendon routinely sees forces of 3 times body weight when ascending stairs [15].
- It takes over 17 times body weight to rupture a normal patellar tendon [15].

PATHOANATOMY OF TENDINOPATHY

Classification

- The Blazina classification defines three stages of patellar or quadriceps tendinopathy [2].
- Stage 1 of the Blazina classification is characterized by pain after activity [2].
- Stage 2 of the Blazina classification is characterized by pain during and after activity [2].
- Stage 3 of the Blazina classification is characterized by pain that limits function during an activity [2].

Clinical Presentation

MECHANISM AND EPIDEMIOLOGY

- Rupture of the patellar tendon is most common in patients younger than 40 years [3, 5].
- Rupture of the quadriceps tendon is most common in patients older than 40 years [3, 5].

- Patients who sustain quadriceps tendon ruptures may have underlying conditions that predispose them to injury, such as obesity, diabetes mellitus, hyperparathyroidism, rheumatoid arthritis, systemic lupus erythematosus, hyperbetalipoproteinemia, hemangioendothelioma, chronic renal failure, or gout [3].
- Anabolic steroid use and local corticosteroid injection into the tendon are associated with both patellar and quadriceps tendon ruptures [3].
- Quadriceps and patellar tendon injuries most often occur as low-energy injuries in isolation [5].
- ACL tears have accompanied up to 12.5% of high-level sporting injuries resulting in patellar tendon rupture [5].
- Numerous reports of simultaneous bilateral quadriceps tendon rupture include patients with systemic illness and obesity [5].
- Bilateral rupture of the patellar tendon can occur but is less frequent than bilateral quadriceps rupture [5].

HISTORY AND SYMPTOMS

- Patients with a rupture of the patellar tendon or quadriceps tendon often report a history of pain consistent with underlying tendon degeneration [3].
- Patellar tendon rupture has been reported after midthird tendon harvest for knee ligament reconstruction [3].
- The rupture typically occurs during an eccentric load on a flexed knee, such as landing from a jump or taking a forceful step while descending stairs [3].
- Less commonly, a rupture can occur during a forceful quadriceps contraction when taking off for a jump [3].
- Patients may note prodromal signs and symptoms including pain, atrophy, and tenderness around the distal or proximal patellar pole [5].
- A history of Osgood–Schlatter disease or jumper’s knee may be present in patients with extensor mechanism injuries [5].
- Pain with an associated tearing or popping sensation is typical of extensor mechanism injuries [5].
- Inability to bear weight is a typical symptom following extensor mechanism injury [5].
- A traumatic hemarthrosis is common after extensor mechanism injuries [5].

PHYSICAL EXAMINATION

- Physical examination for a complete rupture of either the patellar tendon or the quadriceps tendon demonstrates tenderness at the site of the injury [3].
- Physical examination for a complete rupture of either the patellar tendon or the quadriceps tendon demonstrates hematoma [3].
- Physical examination for a complete rupture of either the patellar tendon or the quadriceps tendon demonstrates a palpable defect in the tendon [3].
- Patients with a complete rupture of either tendon cannot extend the knee against resistance [3].

- Patients with a complete rupture of either tendon cannot perform a straight leg raise [3].
- In incomplete ruptures or in patients with a complete rupture of the quadriceps tendon but an intact retinaculum, the ability to perform a straight leg raise against gravity may be uncompromised [3].
- The key to diagnosing an extensor mechanism injury is the lack of active knee extension or the inability to maintain the passively extended knee against gravity [5].
- Most commonly, patellar tendon ruptures extend completely through the retinacular tissue resulting in complete loss of knee extension [5].
- Quadriceps tendon ruptures may not involve as much of the retinacular tissue, and as a result some extension still may be possible [5].
- Typically, some degree of extensor lag is almost always present when compared with the uninjured limb [5].
- Immediately after injury, a defect may be palpable at the level of the rupture [5].
- When the diagnosis is delayed, the tendon defect may not be palpable secondary to consolidation of the hematoma and early scar formation [5].

IMAGING

- Radiographs of the knee after patellar tendon rupture demonstrate patella alta, particularly with the knee flexed [3].
- Radiographs obtained after quadriceps tendon rupture demonstrate patella baja [3].
- Radiographs obtained after quadriceps tendon rupture sometimes show bony fragments in the region of the rupture [3].
- MRI can be helpful when the diagnosis is uncertain, particularly when differentiating between a partial and a complete rupture of a tendon [3].

Investigations

RADIOGRAPHY

- Weight-bearing AP and lateral views are standard for initial evaluation of knee pathology [11].
- A view of the weight-bearing knee flexed at 45-degree angle, imaged posterior to anterior, is included in standard radiographic evaluation [11].
- The sunrise view (Merchant view) is included in standard radiographic evaluation [11].
- Extension and flexion lateral views are included in standard radiographic evaluation [11].
- A standing full-length AP radiograph from hip joint to ankle joint is used to evaluate limb alignment and knee deformity [11].
- The Kellgren-Lawrence (KL) rating grades the extent of osteoarthritis based on review of the AP knee radiograph [11].

- Primary features used for KL rating include osteophytes, joint space narrowing, subchondral sclerosis with or without subchondral cysts, and altered shape of periarticular bones [11].
- KL Grade 0 indicates normal knee features with no osteoarthritis [11].
- KL Grade 1 indicates osteoarthritis possibly present [11].
- KL Grade 2 indicates minimal severity osteoarthritis [11].
- KL Grade 3 indicates moderate severity osteoarthritis [11].
- KL Grade 4 indicates severe osteoarthritis [11].
- Knee arthroplasty is recommended when KL Grade 4 findings are present [11].

MRI

- MRI is considered grossly overused in the arthritic patient population [11].
- MRI is not indicated if the joint space is significantly narrowed on radiograph [11].
- MRI is used when osteonecrosis is suspected [11].
- MRI has been found to underestimate the size of articular cartilage defects in approximately 75% of cases [34].
- The reliability of clinical findings and magnetic resonance imaging for the diagnosis of chondromalacia patellae has been evaluated [29].
- Quantitative MRI analysis has been used to assess the association of patellofemoral joint morphology with chondromalacia patella [29].
- T2 mapping has been investigated for its role in MRI for patellofemoral chondromalacia [29].
- MRI findings have been documented in cases of symptomatic bilateral dorsal patellar defects presenting with cartilage involvement and bone marrow edema [29].
- The accuracy and reproducibility of identifying cruciate and collateral ligament insertions using MRI have been evaluated [35].
- Current concepts on MRI evaluation of postoperative knee ligaments have been reviewed [35].
- The sensitivity and specificity of 1.5 Tesla MRI for diagnosing injuries in patients with knee dislocation have been evaluated [22].
- The visibility of anterolateral ligament tears in anterior cruciate ligament-deficient knees has been assessed using standard 1.5-Tesla magnetic resonance imaging [8].
- MRI features of the anterolateral ligament of the knee have been described [8].
- The MRI appearance of the anterolateral ligament of the knee and its association with the Segond fracture have been reviewed [8].

CT

- Three-dimensional CT with remodeling is used for preoperative planning for reconstruction associated with dysplasia, post-trauma planning, and complex total knee arthroplasty planning [11].

- CT and MRI measurements of tibial tubercle–trochlear groove distances are not equivalent in patients with patellar instability [4].
- Computed tomography has been used to confirm acute traumatic proximal tibiofibular joint dislocation [10].
- The role of radiography and computed tomography in the diagnosis of acute dislocation of the proximal tibiofibular joint has been described [10].

ULTRASOUND

- Dynamic sonography has been used for the diagnosis of medial plica syndrome of the knee [31].
- Sonographic examination of knee ligaments has been described [35].

Treatment

NON-OPERATIVE MANAGEMENT

- Progressive flexibility and eccentric strengthening exercises follow initial activity modification for tendinopathy [2].
- Taping to aid proprioception and patellar tracking or using an infrapatellar strap can be helpful in treating tendinopathy [2].
- NSAIDs can be beneficial in the treatment of tendinopathy [2].
- No recommendation can currently be made regarding prolotherapy injections or platelet-rich plasma injection for tendinopathy [2].
- Nonsurgical treatment is indicated for partial rupture of the patellar or quadriceps tendon when no disruption of the extensor mechanism is present [3].
- Nonsurgical treatment is indicated for patients who are unable to tolerate surgery because of poor overall medical condition [3].
- Nonsurgical management of a complete quadriceps or patellar tendon rupture generally yields poor results with long-term disability in gait and weakness [45].
- Untreated complete ruptures will result in ambulation with a stiff-knee gait or circumduction to allow the foot to clear the ground during the swing phase of gait [45].
- Patients with untreated complete ruptures will complain of knee buckling and difficulty in climbing stairs [45].
- Incomplete ruptures are usually managed conservatively without surgical intervention if full active extension is present on physical examination [45].
- The limb is initially immobilized with the knee in full extension for 4 to 6 weeks for nonoperative treatment of extensor tendon rupture [45].
- Protected range of motion and strengthening are begun after the initial immobilization period for nonoperative treatment [45].

- Flexion of greater than 90 degrees is initially avoided to reduce stress on the tendon during nonoperative rehabilitation [45].
- Restrictions on flexion are removed once the patient achieves good quadriceps muscle control and is able to perform a straight-leg raise without discomfort [45].
- Partial tears with an intact extensor mechanism may be managed conservatively with immobilization in full extension, followed by progressive weight bearing and range of motion [15].
- Treatment of patellar tendinosis includes nonsteroidal anti-inflammatory drugs, physical therapy including strengthening and eccentric exercise, and orthoses such as a patella tendon strap [41].
- Surgery involving excision of necrotic tendon fibers is rarely indicated for patellar tendinosis [41].

OPERATIVE MANAGEMENT: INDICATIONS

- Surgery is indicated for a complete rupture of the patellar or quadriceps tendon [3].
- Early surgery within the first 2 weeks after injury is recommended for complete ruptures [3].
- Loss of extensor mechanism function is an indication for surgery in all but the most unhealthy and nonambulatory patients [45].
- Surgery is reserved for patients who continue to have pain and swelling of the tendon after a nonsurgical treatment regimen has been attempted for tendinopathy [2].
- In cases of complete ruptures with dysfunction of the extensor mechanism, surgery is indicated [15].

OPERATIVE MANAGEMENT: TECHNIQUE

- An extensile straight midline incision is most often employed to expose the knee for extensor tendon repair [1].
- Nonviable tendon edges are removed during repair of acute extensor tendon rupture [1].
- Grasping stitches are placed in the tendon during repair of acute extensor tendon rupture [1].
- The patellar or quadriceps tendon is reattached through three parallel longitudinal drill holes in the patella [1].
- Sutures are secured over bone bridges in full extension during repair of acute extensor tendon rupture [1].
- The strength of the repair is assessed with controlled flexion [1].
- A cerclage wire from quadriceps tendon to tibial tubercle may be added for patellar tendon injury [1].
- Multilayer closure is performed after repair of acute extensor tendon rupture [1].
- The Scuderi technique or quadriceps turndown flap has been described as a method to reinforce the surgical repair if the repair is tenuous [1].
- Techniques for reinforcing the repair using wire, Dacron tape, or suture have been suggested by several authors [1].
- A braided nonabsorbable relaxing suture tensioned at 30 degrees of flexion has been reported to result in no complications and 100% good and excellent results in 20 quadriceps repairs [1].

- The relaxing suture reinforced the repair and allowed early active motion and brace-free ambulation at 6 weeks in the reported quadriceps repairs [1].
- Nonabsorbable sutures are placed in the patellar tendon using a running locking stitch and passed through longitudinal drill holes in the patella [3].
- The retinaculum is repaired with a heavy absorbable suture during patellar tendon rupture repair [3].
- The paratenon is repaired if possible during patellar tendon rupture repair [3].
- Ideally, the knee should flex to 90° after patellar tendon rupture repair [3].
- Quadriceps tendon repair is performed via a midline incision [3].
- Longitudinal drill holes are placed in the patella for quadriceps tendon repair [3].
- The quadriceps tendon is sutured using a heavy nonabsorbable suture in a running locking pattern [3].
- The retinaculum is sutured using a heavy absorbable suture during quadriceps tendon repair [3].
- Reinforcement for quadriceps tendon repair can be performed using a quadriceps turndown, a pull-out wire, or a fascia lata or hamstrings autograft if necessary [3].
- Ideally, the knee should flex to 90° after quadriceps tendon repair [3].
- Options for surgical treatment of tendinopathy include various methods of débriding diseased tissue and stimulating a vigorous healing response [2].
- Side-to-side sutures or suture anchors are applied as needed after excision and abrasion for tendinopathy [2].
- Drilling of the bone to stimulate a healing response is a variation of the surgical procedure for tendinopathy [2].
- Multiple tendon perforations (“pie crusting”) to stimulate healing of the tendon tissue is a variation of the surgical procedure for tendinopathy [2].
- The site of the tear (proximal, midsustance, or distal) will dictate the preferred surgical repair technique for patellar tendon rupture [38].
- Avulsion of the patellar tendon from the inferior pole of the patella can be treated by debridement of the tendon, followed by the passage of two heavy nonabsorbable sutures into the tendon [38].
- Three parallel drill holes are created from inferior to superior in the patella for patellar tendon avulsion repair [38].
- Sutures are passed through the drill holes and tied at the superior pole of the patella for patellar tendon avulsion repair [38].
- The medial and lateral retinacular tears are identified and repaired during patellar tendon avulsion repair [38].
- A cerclage or reinforcement suture or wire is recommended for most cases of patellar tendon avulsion repair [38].
- A transverse tunnel 1 cm posterior to the tibial tubercle is drilled for the cerclage or reinforcement suture or wire [38].
- Heavy nonabsorbable suture or wire is passed through the transverse tunnel in the tibial tubercle [38].

- The wire or suture is brought proximally and passed under the quadriceps tendon close to the superior border of the patella [38].
- The cerclage or reinforcement suture or wire is tensioned at 30 degrees of flexion [38].
- The knee is flexed to 90 degrees to test the integrity of the repair after patellar tendon avulsion repair [38].
- No complications and 100% good and excellent results were reported in 30 patients with patellar tendon rupture treated with transosseous sutures and a braided nonabsorbable relaxing suture [38].
- The braided nonabsorbable relaxing suture was placed through the quadriceps tendon and retinaculum and around the distal patella tensioned at 30 degrees of flexion [38].
- Range of motion from 0 to 55 degrees was instituted at 7 days and patients were weaned to brace-free ambulation at 6 weeks in the reported patellar tendon repairs [38].
- Hamstring autograft can be utilized for patellar tendon repair [38].
- The semitendinosus tendon is harvested with an open tendon stripper leaving the insertion intact for hamstring autograft repair [38].
- The proximal aspect of the semitendinosus tendon is passed through a transverse drill hole in the patella and sutured to the distal lateral retinaculum or patellar tendon [38].
- The use of hamstring tendons has been shown to lead to less gap formation at the repair in biomechanical studies [38].
- The patellar tendon suture line is reinforced with absorbable sutures after hamstring autograft repair [38].
- A hinged knee brace is applied with the knee in full extension after patellar tendon repair [38].
- A midsustance tear of the patellar tendon is more difficult to repair as the quality of tissue may be compromised [38].
- Caution should be observed to prevent shortening of the tendon and creating patella baja with placement of the sutures for midsustance tears [38].
- The most common method of repair for midsustance patellar tendon tears involves simple end-to-end repair, with or without a reinforcing cerclage suture of wire or nonabsorbable suture material or tape [38].
- A distal patellar tendon rupture from the tibial tubercle is the least common pattern [38].
- A suture repair through bone tunnels with semitendinosus and gracilis augmentation is recommended for distal patellar tendon ruptures [38].
- A midline longitudinal incision 15 to 20 cm long is made to expose the rupture for quadriceps tendon repair [14].
- The hematoma is irrigated and the tendon ends are freshened during quadriceps tendon repair [14].
- If sufficient tendon is left distally, an end-to-end repair is made using multiple No. 2 or No. 5 nonabsorbable mattress sutures through the tendon [14].
- No. 0 absorbable sutures are used to repair the retinaculum during quadriceps tendon repair [14].
- A circumferential wire or suture is used for protection of the repair during quadriceps tendon repair [14].
- In ruptures at the osteotendinous junction, an 8- to 10-mm stump of vastus intermedius often is left attached to the patella [14].

- No. 0 nonabsorbable sutures are placed through the vastus intermedius stump and laid aside for later use [14].
- A small trough is made in the superior pole of the patella with a rongeur [14].
- Three longitudinal holes about 1 cm apart are drilled centered over the anticipated area of attachment of the quadriceps tendon [14].
- A No. 5 nonabsorbable suture is passed proximally through the quadriceps tendon using a running interlocking suture for a distance of about 2.5 cm until normal-appearing tendon is reached [14].
- The suture is passed distally in a similar manner, ending just lateral to the midline of the ruptured tendon [14].
- Similar sutures are passed along the medial side of the tendon and distally [14].
- The suture is passed distally with a suture retriever or Beath pin, a single throw is made in the suture, and it is secured with a hemostat [14].
- The knee is moved through a range of motion to check patellar tracking and position [14].
- The sutures in the vastus intermedius stump are brought anteriorly and secured through the quadriceps tendon while maintaining anatomic position [14].
- The sutures are tied distally, drawing the tendon into the bony trough [14].
- The retinaculum is repaired with interrupted absorbable sutures [14].
- A cylinder cast or locked brace with the knee in extension is applied after quadriceps tendon repair [14].
- Repair is performed through a midline incision using sutures end to end, sutures into bone tunnels, or suture anchors for patellar tendon rupture [15].
- In cases with poor tissue quality or chronic tears, augmentation with autograft or allograft tissue may be necessary for patellar tendon rupture repair [15].
- The tendon, along with the medial and lateral retinaculum, should be sewn end to end for patellar tendon rupture repair [13].
- A stress-relieving wire may be placed around the patella and through the tibial tubercle for patellar tendon rupture repair [13].
- The stress-relieving wire should be removed in 6–8 weeks [13].
- The quadriceps must be freed up from the femur and the patella pulled down to the proper location for chronic patellar tendon ruptures [13].
- The gracilis and semitendinosus tendons can be used to substitute for the patellar tendon in chronic ruptures [13].
- Reestablishment of an intact extensor mechanism is necessary for sleeve fractures of the patella [13].
- Open reduction and internal fixation with tension band wiring are recommended for displaced sleeve fractures of the patella [13].

OPERATIVE MANAGEMENT: POSTOPERATIVE CARE AND REHABILITATION

- The cylinder cast or locked brace is worn for 6 weeks after quadriceps tendon repair [14].

- Weight bearing with crutches is allowed at 3 weeks after quadriceps tendon repair [14].
- Cast removal and a dial-locked brace are fitted, allowing a range of knee motion from 0 to 60 degrees after quadriceps tendon repair [14].
- The range of motion is increased 10 to 15 degrees each week after quadriceps tendon repair [14].
- An aggressive strengthening program is essential for good functional recovery after quadriceps tendon repair [14].
- Postoperatively, the patient may bear weight, but the limb should be protected initially in a cylinder cast or a brace after patellar tendon rupture repair [3].
- Postoperative care for quadriceps tendon rupture repair involves a period of immobilization in a cylinder cast or splint followed by progressive flexibility exercises [3].
- Postoperative rehabilitation for patellar tendon rupture includes early weight bearing with the knee braced in extension [15].
- Exercises to optimize range of motion with passive extension, active closed chain flexion, and prone open chain flexion are part of postoperative rehabilitation for patellar tendon rupture [15].
- Full return to sports is usually achieved at 6 months after patellar tendon rupture repair [15].
- The outcome largely depends on the timing of the surgery, as acute repairs often do better than those performed in the chronic setting [15].
- Complications of patellar tendon rupture repair include arthrofibrosis, decreased quadriceps strength, and quadriceps atrophy [15].
- Repair of chronic patellar tendon rupture can be complicated by proximal retraction of the patella and by insufficient tissue for repair [3].
- Retraction can be addressed by surgical dissection and mobilization of the quadriceps tendon [3].
- Tendon augmentation can be performed with a hamstring autograft passed through tibial and patellar drill holes, a central quadriceps tendon–patellar bone autograft, a contralateral bone–patellar tendon–bone autograft, or an allograft [3].
- Augmentation with wire, nonabsorbable tape, or heavy suture also can be considered for chronic patellar tendon rupture repair [3].
- Chronic quadriceps tendon ruptures can be complicated by proximal migration of the tendon stump, which requires débridement and mobilization of the tendon [

ACUTE REPAIR OUTCOMES AND COMPLICATIONS

- Most series have reported between 70% and 100% good to excellent results following acute patellar tendon repair [7].
- Persistent quadriceps muscle atrophy commonly occurs after acute patellar tendon repair but has not been correlated with loss of strength [7].
- No relationship has been demonstrated between the configuration of the rupture, the method of repair, and clinical outcome for acute patellar tendon ruptures [7].

- Early repair within 2 to 3 weeks of injury is the only factor associated with better outcomes for acute patellar tendon ruptures [7].
- In a review of 25 patients treated within 7 days, 96% had good to excellent results, while only two of six patients with delayed repair had excellent results [7].
- A greater degree of persistent quadriceps atrophy was noted in patients treated with delayed repair compared to early repair [7].
- In a series of 35 traumatic patellar tendon ruptures treated acutely with primary repair and a neutralization wire, 57% had excellent results and 29% had good results [7].
- In a radiographic analysis of 10 patients who underwent operative repair of acute patellar tendon ruptures, 7 demonstrated incongruity on Merchant and lateral radiographs [7].
- Patients with residual patellofemoral symptoms after acute patellar tendon repair all had articular incongruity, but the majority of patients were asymptomatic [7].
- Articular incongruity may not be the only cause of persistent knee pain in patients who undergo patellar tendon repair [7].
- No complications and excellent results were reported in 30 patellar tendon ruptures treated with transosseous sutures and a braided nonabsorbable relaxing suture tensioned at 30 degrees of flexion [7].

CHRONIC OR NEGLECTED RUPTURE COMPLICATIONS

- Chronic or neglected patellar tendon ruptures present significant operative challenges due to the unopposed pull of the quadriceps muscles, which can result in significant contraction of the extensor mechanism [7].
- Proximal retraction in chronic patellar tendon rupture can be addressed by surgical dissection and mobilization of the quadriceps tendon [3].
- Results for reconstruction of chronic patellar tendon rupture have generally been less satisfactory compared to acute repair [7].

Recovery

- Most series have reported between 70% and 100% good to excellent results for acute patellar tendon repair [7].
- The majority of patients who undergo early primary repair achieve a functional range of motion and normal quadriceps strength [7].
- No relationship has been demonstrated between the configuration of the rupture, the method of repair, and clinical outcome [7].
- Early repair within 2 to 3 weeks of injury is the only factor associated with better outcomes [7].
- Siwek and Rao reviewed 25 patients treated within 7 days and found that 96% had good to excellent results [7].
- Only two of the six patients with a delayed repair in the Siwek and Rao series had excellent results [7].

- Siwek and Rao noted a greater degree of persistent quadriceps atrophy in patients treated with delayed repair [7].
- Hsu et al. reviewed 35 traumatic patellar tendon ruptures treated acutely with primary repair and a neutralization wire [7].
- Hsu et al. reported 20 excellent (57%) and 10 (29%) good results in their series of 35 patients [7].
- The majority of patients in the Hsu et al. series sustained the injury on a motorcycle [7].
- One-third of the patients in the Hsu et al. series had multiple injuries, which the authors concluded may have contributed to the slightly lower success rate observed [7].
- Larsen and Lund performed a radiographic analysis of patellar congruence in patients who underwent operative repair of acute patellar tendon ruptures [7].
- Seven of 10 patients in the Larsen and Lund series demonstrated incongruity on Merchant and lateral radiographs [7].
- Patients with residual patellofemoral symptoms in the Larsen and Lund series all had incongruity, but the majority were asymptomatic [7].
- Larsen and Lund concluded that articular incongruity may not be the only cause of persistent knee pain in patients who undergo patellar tendon repair [7].
- West et al. demonstrated no complications and excellent results in 30 patellar tendon ruptures treated with transosseous sutures and a braided nonabsorbable relaxing suture [7].
- In the West et al. protocol, the relaxing suture was placed through the quadriceps tendon and retinaculum and around the distal patella tensioned at 30 degrees of flexion [7].
- West et al. instituted range of motion from 0 to 55 degrees at 7 days postoperatively [7].
- West et al. weaned patients to brace-free ambulation at 6 weeks postoperatively [7].
- Chronic or neglected patellar tendon ruptures present significant operative challenges [7].
- The unopposed pull of the quadriceps muscles can result in significant contraction of the extensor mechanism in chronic or neglected patellar tendon ruptures [7].
- Early series recommended preoperative traction to overcome the contracted quadriceps muscle so that the tendon ends could be reapproximated in chronic or neglected patellar tendon ruptures [7].
- There have been no large series evaluating the outcomes after reconstruction of a chronic patellar tendon rupture [7].
- Isolated case reports have described different techniques and grafts including autogenous or allogenic grafts when local tissue is unavailable for chronic patellar tendon rupture [7].
- Results for chronic or neglected patellar tendon rupture have generally been less satisfactory compared to acute repair [7].

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