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Abstract

The extensor apparatus of the knee consists of the quadriceps muscle and tendon, the patella, and patellar tendon. Patellar fractures are common injuries, and neglected patella fractures are exceptional, while quadriceps or patellar tendon tears may be misdiagnosed in emergency department. Patellar tendon and quadriceps tendon ruptures are serious injuries. The surgical management of chronic tears (greater than 6 weeks) may be highly demanding because of the retraction of the patella, the soft tissue retraction, and scar formation which create an irreducible gap. In these cases, primary repair is not possible. Many surgical techniques have been proposed for the treatment of neglected ruptures, but the optimal management is controversial. In this chapter two surgical techniques for reconstruction of the chronic ruptures of the quadriceps and patellar tendon are described.

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Reconstruction of Neglected Tears of the Extensor Apparatus of the Knee

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Abstract

The extensor apparatus of the knee consists of the quadriceps muscle and tendon, the patella, and patellar tendon. Patellar fractures are common injuries, and neglected patella fractures are exceptional, while quadriceps or patellar tendon tears may be misdiagnosed in emergency department. Patellar tendon and quadriceps tendon ruptures are serious injuries. The surgical management of chronic tears (greater than 6 weeks) may be highly demanding because of the retraction of the patella, the soft tissue retraction, and scar formation which create an irreducible gap. In these cases, primary repair is not possible. Many surgical techniques have been proposed for the treatment of neglected ruptures, but the optimal management is controversial. In this chapter two surgical techniques for reconstruction of the chronic ruptures of the quadriceps and patellar tendon are described.

Introduction

The knee extensor apparatus consists of the quadriceps muscle and tendon, the patella and patellar tendon. The quadriceps tendon (QT) is formed by the confluence of the rectus femoris, vastus intermedius, vastus lateralis, and vastus medialis tendons. It inserts in the proximal pole and on the dorsal, medial, and lateral surfaces of the patella. QT is composed of three different sheets. The rectus femoris forms the superficial sheet, the vastus medialis and lateralis tendon form the middle sheet, and the vastus intermedius forms the deeper sheet. The synovial membrane lies just below the vastus intermedius tendon. The patellar tendon (PT) is the distal continuation of the QT, and it extends from the inferior pole of the patella to the tibial tubercle. The extensor apparatus transmits force from quadriceps to the leg, and the patella acts as a fulcrum to increase the lever moment arm of the quadriceps, increasing the efficiency of extensor apparatus of 1.5 times (Amis 2007).

Patellar fractures are six times more frequent than tendon ruptures, but while neglected patella fractures are exceptional, quadriceps or patellar tendon tears may be misdiagnosed (Saragaglia et al. 2013). In this chapter, the treatment of chronic patellar and quadriceps tendon tears will be discussed.

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Chronic Patellar Tendon Rupture

Patellar tendon (PT) rupture is a serious injury. It accounts for approximately 3 % of all injuries to the tendon–ligament complex of the knee (Wiegand et al. 2013). Since most of these injuries occur in tendons with degenerative changes, such lesions are increasingly considered as evolving from asymptomatic tendinopathy (Loppini and Maffulli 2012).

In acute injuries, the tendon is typically sutured to the inferior pole of the patella or simply repaired in a tendon to tendon configuration (Enad 1999). After 2 weeks, the patella is retracted proximally, and scarring of the surrounding soft tissues makes primary repair increasingly more difficult (Maffulli et al. 2013).

The management of chronic ruptures (>6 weeks) is controversial. To deal with small gaps (2 cm or less), distal release of the quadriceps or a proximal transposition of the tibial tuberosity has been performed with good results (Casey and Tietjens 2001). Larger gaps are technically more demanding, as the debridement of the scar and degenerated tendon ends do not allow to juxtapose the tendon stumps to each other. This usually results from adhesions and quadriceps contracture or atrophy, and achieving the correct patellar height may be difficult. Some authors recommended a Z lengthening of the quadriceps tendon to adequately mobilize the patella and relocate it to its anatomical position (Mandelbaum et al. 1988). To strengthen the construct and allow earlier return to motion, tendon augmentations have been described. Autologous semitendinosus and gracilis tendon grafts, contralateral bone–patellar tendon–bone, turndown of the quadriceps tendon, lateral gastrocnemius muscle belly and part of an Achilles tendon, extensor mechanism allograft using bone–patellar tendon–bone allograft and Achilles tendon, and artificial materials have been used (Scuderi 1958; Cadambi 1992; Chiou 1997; Fukuta 2003; Milankov 2007; Lewis 2008). However, the optimal management of these lesions is still controversial.

Distal transposition of the sartorius muscle has been proposed, but the development of scar and degenerated tissue within and around the muscle fibers could impair the strength and biomechanics of the construct (Hess and Reinders 1986). The reverse gastrocnemius flap may be considered for large gaps, but its large volumes, later degeneration, and some loss in range of motion may limit its use.

Dejour et al. proposed the use of a contralateral autograft composed of a block of tibial tuberosity, middle third of the patellar tendon, patella, and quadriceps tendon (Dejour et al. 1992). Recently, a reconstruction with a Y-shaped, folded back vastus lateralis fascia flap has been successfully proposed, being able to restore quadriceps function and the anatomic position of the patella and allow early mobilization postoperatively (Amis 2007). The use of semitendinosus tendon to bridge the patellar tendon gap was first described by Kelikian et al. in 1957 (Wiegand et al. 2013).

Recently, the reconstruction of the chronic ruptures of PT with ipsilateral hamstrings tendon leaving the distal insertion in situ has been proposed (Maffulli et al. 2013). This procedure offers several advantages. First, the hamstring tendons are stronger than the distal iliotibial tract, fascia lata, or quadriceps–patellar retinaculum (Tashiro et al. 2003) and ensure a strong integration to the tendon–bone interface (Chen et al. 2012). Harvesting of the tendons is relatively easy; they are strong and they are routinely used for other surgical procedures (Charalambous and Kwaees 2013). Their blood supply is at least partially maintained by preserving the distal insertion of hamstring tendons, and it could promote better tendon healing. In ACL reconstruction with semitendinosus tendon autograft with or without maintaining the tibial insertion using an animal model, Papachristou et al. showed that harvesting the semitendinosus tendon without the detachment of the tibial attachment could preserve a sufficient blood supply to keep it viable (Papachristou et al. 2007).

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Fig. 1 Chronic patellar tendon rupture

Surgical Technique

Under general anesthesia and with the patient supine, the knee is prepped and draped in the usual sterile fashion. With the knee flexed to 90°, a midline incision is performed from the proximal pole of the patella to approximately 3 cm distal to the tibial tuberosity. The PT ends are exposed, freeing them from surrounding fibrotic and scar tissue (Fig. 1). Through the same incision, the fascia is dissected and the pes anserinus is identified. The tendons of gracilis and semitendinosus are freed of surrounding tissues and vincula. Each tendon is passed through an open tendon stripper, and it is gently advanced proximally, taking care to follow the anatomical course of the tendons. Once the proximal tendon edges of both tendons have been harvested, the proximal ends are prepared in the usual fashion using five continuous two-sided number one resorbable stitches. The distal tendon ends are left in situ, attached to the tibia, and sutured in the same way. With the knee extended, the patella is mobilized, and its distal half exposed. A tunnel in the midportion of the patella is drilled transversely with a cannulated burr over a Kirschner wire (Fig. 2), and another transverse tunnel is drilled at least 2 cm posterior to the tibial tuberosity. Both tunnels are drilled lateral to medial, and they are of equal diameter, usually 7 mm. A guidewire and a fiber wire suture are inserted into the hole to pass the tendon graft through the patellar tunnel from lateral to medial. Once the tendon ends are crossed over in a figure of eight fashion, in the same way, the graft is switched through the lower tunnel, behind the tibial tuberosity (Fig. 3). Traction is applied to the patella to try and relocate it as close as possible to its physiological position, without attempting to release the quadriceps tendon or further dissect the peripatellar tissues. The graft is secured to the patella tunnel exit holes with absorbable tendon to periosteum sutures and in the distal tunnel using a bioabsorbable 7 mm diameter interference screw. The subcutaneous fat is juxtaposed using fine absorbable sutures, the skin closed with subcuticular absorbable sutures. The leg is immobilized in full extension using a cylinder cast leaving the ankle free.

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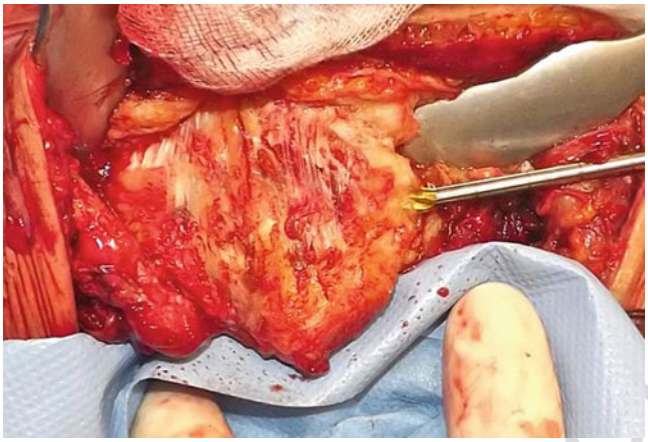

Fig. 2 Transverse tunnel in the midportion of the patella

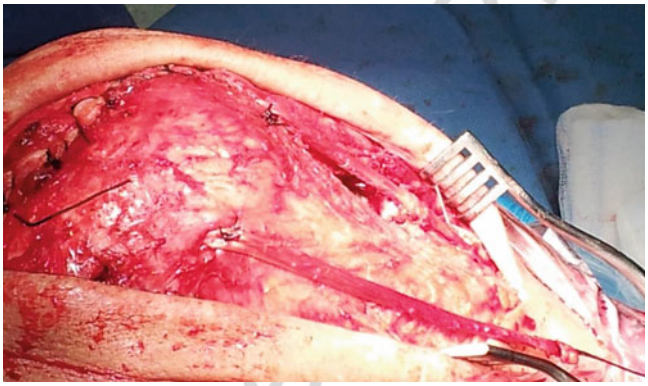

Fig. 3 Graft positioning

Postoperative Rehabilitation

Postoperative mobilization with crutches is recommended immediately, weight bearing is allowed as tolerated, and isometric exercises of the quadriceps muscles are encouraged as soon as patients can tolerate them. Active ankle flexion–extension mobilization is started immediately, and the patients are encouraged to try straight leg raise. At 2 weeks from surgery, the cylinder cast and the dressings are removed, and a removable splint is applied for another 2 weeks. Active mobilization is started at 4 weeks. Concentric exercises are started at 6 weeks, if full active and passive motions have been regained, and eccentric exercises are started after 12 weeks. Running, if desired, can be started gradually after 6 months, with the advice to progress to gentle training according to their own progress. Patients are allowed to resume sport activities at 9 months and discharged at 12 months if asymptomatic.

Complications

This technique is not without risks. Patellar fracture, tibial tuberosity fracture, infections, and hypoesthesia over the anterior aspect of the knee have been described (Tompkins 2012; Maffulli 2013). Persistent anterior knee pain has also been reported, probably related to degenerative changes to the patella.

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Fig. 4 Clinical examination 6 months following quadriceps tendon injury: a palpable gap proximal to the upper pole of the patella was evident

Table 1 Causes of quadriceps tendon rupture

Mechanisms of injury	Rate
Simple fall	61.5 %
Fall from stairs	23.4 %
Sport activities	6 %
Spontaneous ruptures	3.2 %
Agricultural injuries (penetrating trauma)	2.3 %
Car accident	3.2 %
Non-penetrating trauma	0.4 %

Quadriceps Tendon Rupture

Quadriceps tendon rupture is a relative uncommon injury with an incidence of 1.37/100,000 patients per year (Clayton and Court-Brown 2008) (Fig. 4). While PT rupture occurs more frequently in patients younger than 40 years, QT injuries are more common in males older than 40 years (Siwek and Rao 1981).

QT injuries may be caused by a direct trauma, or more frequently, they are associated to degenerative tendon changes. Violent eccentric contraction is the most common mechanism of injury (Scuderi 1958), but spontaneous ruptures may also occur (Table 1). Spontaneous ruptures affect people with predisposing conditions such as chronic renal failure, rheumatoid arthritis, diabetes, gout, and steroids abuse (Ciriello et al. 2012). Dobbs et al. reported a 0.1 % incidence of QT rupture after TKA (Dobbs et al. 2005). Spontaneous bilateral QT rupture is not exceptional, and it has also been reported from 6 % to 12 % of cases (Shah 2002; Ciriello 2012). A recent review reported that in more than 70 % of cases, ruptures occur at the distal portion of the QT, within 2 cm from the superior pole of the patella, while in about 12 % of cases, it involves the proximal part (Ciriello et al. 2012). Rasoul et al. found a correlation between the site of rupture and the age of patient (Rasul and Fischer 1993). In patients older than 40, ruptures occur more frequently at the tendon–bone junction, whereas in patients younger than 40 years, tears involve the mid-tendinous area.

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Diagnosis is based on the triad of acute pain, sometimes accompanied by a cracking sensation, failure of active knee extension, and palpable suprapatellar gap. The inability to maintain the passively extended knee against gravity suggests an extensor mechanism injury. But despite this clinical presentation, the diagnosis of QT tears may be difficult, and a delay in diagnosis is not uncommon. This probably results from the lack of a specific test for QT rupture (Jolles et al. 2007) and because often the patient refuses to extend the knee actively because of the associated pain, causing confusing diagnosis. Missing diagnosis in the emergency department has been reported in 40–67 % of cases (Jolles 2007; Saragaglia 2013).

Anteroposterior and lateral radiographs of the knee are the initial imaging. They allow assessment of bony injury, and they can provide indirect evidence of QT rupture. Ultrasound and MRI are useful for diagnosis of QT rupture and are recommended in doubtful cases, but their use did not decrease the high rate of misdiagnosis in emergency department (Jolles et al. 2007). However, in patients with clear clinical signs, a palpable gap, and an extensor mechanism deficit, MRI is not necessary (Lee et al. 2013).

Many different surgical techniques have been described to repair a QT rupture, and as in the patellar tendon, timing was identified as the determining factor in the functional outcome. Repair should be done in the first 48–72 h post injury to achieve a successful outcome (Scuderi 1958). Patients who had delay repair had poorer functional outcomes and decreased self-reported satisfaction (Rougraff et al. 1996). Furthermore, surgical technique did not affect outcome, but delayed surgery results in poorer results (Ciriello et al. 2012). Repair of chronic ruptures is more demanding because of soft tissue retraction, muscle contraction, and scar formation which can create an irreducible gap. In these cases, a primary repair is not possible, and lengthening procedures and extensor mechanism reconstruction are needed. The Codivilla techniques are well accepted (Saragaglia et al. 2013). An inverted V full-thickness flap is made in the QT, 1.5–2 cm from the proximal edge of the tear. The edges are then sutured with several stitches of thick non-resorbable suture, the triangular tendon flap is pulled back distally as reinforcement, and the open proximal portion of the inverted V is sutured longitudinally in side-to-side fashion. Rizio and Jarmon reported good results in three cases treated with a V-Y plasty (Rizio and Jarmon 2008). They performed a V-Y lengthening without augmentation or cerclage wire for gaps smaller than 20 mm. Three locking sutures were passed through three bone tunnels into the patella and tied distally over the patella. The authors did not use additional turndown flap to avoid further compromise of the tendon. Reconstruction of chronic QT tear with ipsilateral hamstring tendons has been also described (Leopardi 2006; Nguene-Nyemb 2011; McCormick 2013).

Surgical Technique

A longitudinal 3 cm skin incision is made over the pes anserinus, and the hamstring tendons are harvested in the usual fashion. A longitudinal midline incision is made overlying the quadriceps tendon and the proximal patella to expose quadriceps tendon (Fig. 5). A 5 mm transverse tunnel is drilled through the midportion of the patella, and the graft is pulled into the patellar tunnel, leaving free the distal parts of the tendons. The free ends of the tendons are then passed through the quadriceps tendon several times to bridge the defect (Fig. 6). After the operation, patients are placed in a long-leg cast or a knee brace for 6 weeks, before starting physical therapy. Early weight bearing is usually allowed with crutch support.

Complications

The most common complications after QT repair are quadriceps atrophy and decreased muscular strength (Lee et al. 2013). They occur in 20–30 % of cases, but this does not influence patient's

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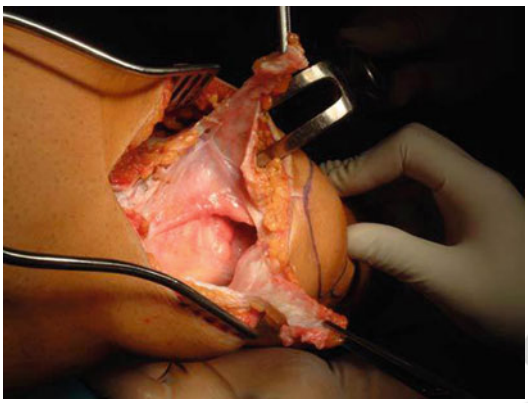

Fig. 5 Intraoperative appearance of the full-thickness defect of 10·4 cm produced after debridement

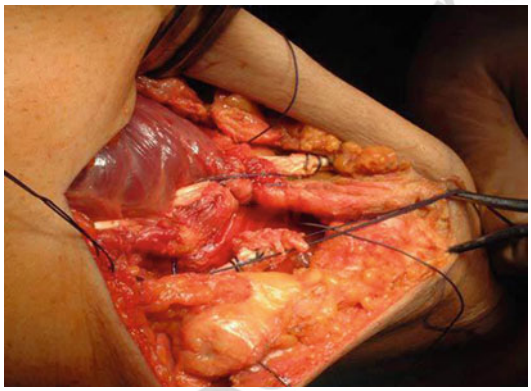

Fig. 6 Final intraoperative appearance. The free gracilis and semitendinosus graft was passed through a transverse patellar tunnel, leaving free the distal parts of the tendons, which were then passed through the quadriceps tendon several times to bridge the defect

satisfaction (Ciriello et al. 2012). Patella baja is a frequent consequence of chronic QT rupture (Rizio and Jarmon 2008). Recently 6.9 % incidence of heterotopic ossifications, 2.5 % of pulmonary embolism, 1.2 % of superficial infection, and 1.1 % of deep infection have been reported (Ciriello et al. 2012). Reruptures (2 % of cases) and anterior knee pain may also occur (Ciriello et al. 2012).

Conclusion

Neglected rupture of the PT is a debilitating problem. Reconstruction of chronic tears of PT reconstruction using the ipsilateral hamstring gracilis and semitendinosus tendon graft leaving their distal insertion in situ is safe and effective. It allows early mobilization of the knee and patients to return to preinjury daily activities with satisfactory outcomes.

Few case report and case series are reported regarding surgical management of chronic QT ruptures. No high-quality studies are available. It is therefore difficult to choose the best evidence-based treatment. The infrequence of QT rupture is another limiting factor for well-conducted studies. Timing of surgery, more than surgical technique, seems to be the determining factor for functional outcome. For this reason, improving diagnosis and more attention in emergency department is demanding in order to decrease the high rate of misdiagnosis and improve clinical outcome.

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Cross-References

▶ Anatomy and Biomechanics of the Knee

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