Rehabilitation of ruptured quadriceps tendon complicated by a post-operative wound infection and delayed surgical repair

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Abstract
Rupture of the quadriceps tendon is an uncommon but severe injury that has a long recovery period and risk of sequelae especially when repair is delayed. This article presents a case of ruptured quadriceps tendon complicated by a post-operative wound infection causing a six-month delay of definitive surgical treatment. This paper discusses therapy following resolution of the wound infection (to prepare the patient for definitive repair) and therapy following repair (to restore the subject to previous levels of competitive activity).

Introduction
Rupture of the quadriceps tendon superior to the patella is an uncommon but severe injury that has a long recovery period and risk of sequelae such as extension lag and limited flexion. Risk factors and surgical techniques are well described in the literature but rehabilitation that is critical to full recovery, has not been similarly discussed.

Rupture most commonly occurs because of a fall or sports injury, but can also be caused by lifting and non-penetrating blows to the quadriceps (Scuderi, 1958; Rasul and Fischer, 1993; Rougraff et al., 1996). The injury most commonly affects middle-aged men (average 59 years) (Scuderi, 1958; Rasul and Fischer, 1993; Rougraff et al., 1996; Konrath et al., 1998). The risk of quadriceps rupture is elevated in persons with systemic diseases (e.g., diabetes, renal disease, gout). In addition, approximately 20% of persons who rupture a quadriceps tendon will suffer a subsequent contralateral rupture (Rougraff et al., 1996).

Several surgical techniques give satisfactory results for primary repair of a ruptured quadriceps tendon (Scuderi, 1958; Olusola and Ahmad, 1985; Fujikawa et al., 1994; Rhomberg et al., 2000). Immediate repair (within 2 weeks) generally yields excellent results, while delayed repair is associated with poor prognosis (Scuderi, 1958; Rougraff et al., 1996).
The poor prognosis associated with delayed repair reflects technical operative difficulties and associated muscular contracture, atrophy, fibrosis, and anatomic defects of the rectus femoris. Optimal outcome involves recovering preoperative pain-free stability and range of motion (Rasul and Fischer, 1993; Rougraff et al., 1996). Functionally this can be measured by need for ambulatory aids, ability to climb stairs, maximum walking distance, and return to pre-injury activities.

Persons with a ruptured quadriceps tendon may delay several months before seeking medical attention, and misdiagnosis leading to delayed treatment is common (Rougraff et al., 1996). Delay may occur in patients evaluated in an emergency room for a “knee sprain”. A tendon defect may not be apparent immediately, due to hematoma formation, nor may there be an appreciable drop of patellar level (Scuderi, 1958). Furthermore, radiography is normal, so patients are sent home and advised to consult an orthopedic surgeon if symptoms persist. Considerable time may elapse before the patient realizes his/her symptoms are not improving. Thus, primary care providers should have a high index of suspicion when evaluating patients after acute knee injuries, especially those involving hyperflexion. Evaluation should ascertain the mechanism of injury and risk factors for quadriceps rupture (Table 1). Physical evaluation of such clients must assess the ability to actively extend the knee, a palpable suprapatellar defect, and visible patella-baja when the patient stands.

### Case report

The patient was a 58-year-old white male white-water boater running a class-V river. His past medical history was unremarkable, other than having ruptured his left quadriceps tendon 10 years previously. After approximately 4 h on the river, while portaging, he slipped and fell on a flexed knee. Following the fall, he had swelling, hemarthrosis, inability to extend the right knee, and a palpable suprapatellar defect. Surgery to repair the rupture occurred 2 days later. Ten days following surgery, the wound dehisced revealing an infected hematoma. Treatment involved six surgeries for irrigation and debridement over a 12-day period. Fixtures from the primary repair were removed.

The patient was discharged on IV antibiotics that were continued for 6 weeks. Home physical therapy began 1 week post-surgery and continued twice weekly for 6 months. Massage therapy began 3 months post-surgery and was continued twice weekly alternating with physical therapy. The patient underwent definitive surgical repair 6 months following discharge. Physical therapy twice weekly (for 2 months) was resumed 1 week following surgery. Massage therapy twice weekly (alternating with physical therapy) began 1 month post-operatively, and the patient began a daily training program in conjunction with massage therapy 2 months following the final surgery. One year following repair the patient had resumed all previous activities that include class-V whitewater boating, vertical and horizontal caving, and orienteering (albeit at a somewhat reduced efficiency).

### Therapy of untreated quadriceps rupture prior to definitive repair

In general, massage therapists do not treat patients prior to surgical repair of a ruptured muscle. However, in this case intensive therapy following treatment of the post-operative infection, prior to the final repair, was essential to attain an optimal outcome. The goal of this initial therapy program, coordinated by the orthopedic surgeon, was to reduce scar tissue and regain range of motion in the knee.

Physical therapy began immediately following surgery (phase-1 of rehabilitation). Intensive therapy began 3 months later during phase-2 when massage therapy was initiated and the patient began self-assisted motion using an ERMI Knee Flexionator (ERMI, Inc., Decatur, GA). The patient...
recorded range of motion four times a day following each session (Fig. 1) and documented an increase from 70° to 100° that plateaued during phase 3.

During phase 1, the patient was waking in pain at night and complained of a “dead meat” sensation in the lower thigh. Massage therapy focused on decreasing trigger points in retracted tissues and splinting muscles surrounding the joint. The knee was highly edematous and the surgical scar adhered to the anterior distal femur. Neuromuscular therapy was used to treat trigger points (Fig. 2). Aggressive deep transverse friction and myofascial release was performed over the anterior knee to loosen scarring. Emphasis was placed on the superior border of the patella that was difficult to palpate. Sessions also attempted to increase range of motion, increase blood flow to the area, and improve neurologic function. Techniques included proprioceptive neuromuscular facilitation, muscle energy techniques (Chaitow, 2001), active isolated-stretching (Mattes, 2000), positional release, traction, and assisted range of motion that yielded audible signs of scar tissue release.

By 90 days, the superior border of the patella was visible and readily palpable; trigger points in the upper thigh had decreased in number and sensitivity; and, the patient was no longer waking up in pain from the upper thigh. However, new trigger points that referred deep into the knee joint, appeared in the vastus medialis obliquus and medial border of the patella (Fig. 3). The patient still complained that his lower thigh just above the patella felt like “dead meat”.

Beginning at 90 days, therapy emphasized achieving maximum range of knee joint motion before final surgical repair. Therapy focused on range of motion involving tibia/fibula/femur, and patella/femoral glide. Flexion of the knee produced extreme pain in the anterior superior patellar region. Therapy utilized cross-fiber and myofascial techniques to mobilize scar tissue around the superior patella, followed by myofascial work along the anterior femoral scar line (which had started to loosen). Vastus medialis obliquus trigger points were treated with digital pressure followed by deep transverse friction around the entire patella. In addition, therapy at this stage alternated deep transverse friction with tractioning and mobilization of the patella.

Range of motion increased dramatically through phase 2 then began to plateau, marking the beginning of phase 3. Very few trigger remained and paraesthesia in the lower thigh had greatly improved (Fig. 4). A stationary bike was added to the program to facilitate blood flow to the area and inhibit atrophy of the muscles around the hip and
knee joints. Treatment of scar tissue remained aggressive and began to focus on active assisted techniques to enhance efficiency of muscles supporting the knee joint. Forced flexion was associated with increased pain in the suprapatellar area (due to a large ossified scar discovered during the subsequent surgery).

Because range of motion had plateaued and final surgery was imminent, the focus of therapy changed to loosen retracted and adhered tissue in the upper thigh. Myofascial mobilization, cross-fiber, and petrissage were employed to loosen muscle tissue; followed by deep compressive effleurage and stripping techniques to stretch the retracted tissue. The patient also began using a Thera Cane (Thera Cane Co., Denver, CO) for self-treatment to apply deep pressure on the remaining trigger points and to help strip and elongate retracted tissue. This therapy continued until day 184, when definitive reparative surgery was performed.

Definitive repair

Examination under anesthesia showed that the patient had no patella mobility and significant patella baja. The patella was surrounded by dense scar tissue with a palpable defect starting approximately 5 cm superior to the patella. The range of motion was approximately 0–80°. A mid-line incision was made extending from the quadriceps muscle to the tibial tubercle. The patella was released superiorly from the heterotopic bone and extended laterally down to the tibial tubercle. The dense scar tissue was painstakingly removed from the lateral and medial gutter. The patella tendon was then freed from dense fat pad scarring and the anterior interval (between the anterior tibia and patella tendon) was recreated. Next attention was directed to removing the heterotopic bone from the area superior to the patella and freeing the remaining quadriceps tendon and muscle from the femur. At this point patella mobility was good and range of motion was 0–120°. The surgeons next performed a V-Y plasty on the mid quadriceps tendon and placed large sutures through this portion on the tendon and also through the medial head of the quadriceps tendon. They were then tied to the patella through longitudinal drill holes in the patella. The illiotibial band was then split and transferred to the medial patella and fixed in a like manner. The V-Y plasty was then closed. The knee moved easily from 0° to 40° of flexion and maintained good patella mobility. With the leg at full extension, an Achilles tendon allograft was placed over the distal 6 cm of the quadriceps and the patella. This was anchored in place by approximately 40 individual sutures. The wound was then closed and the motion again tested and again found to move easily between 0° and 40° with good patellar mobility.

Therapy of quadriceps rupture following definitive repair

The primary objective was to return the patient to previous levels of competitive activity. To achieve full knee flexion, therapy addressed restoring the retracted quadriceps tissues to normal architecture. "The number of sarcomeres in theory determines the distance through which a muscle can shorten and the length at which it produces maximum force. Sarcomere number is not fixed and in adult muscle the number can increase or decrease. The stimulus for sarcomere length changes may be the amount of tension along the myofibril or the myotendon (musculo-tendinous) junction, with high tension leading to an addition of sarcomeres and low tension causing a decrease" (Hall and Brody, 1999). Rehabilitation following final repair followed three phases. Fig. 5 summarizes range of motion through the phases.

Phase 1 immediate post operation

Physical therapy began immediately post operatively, with the patient in a continuous passive motion machine. The patient used the machine...
24-hours a day for 1 week, then while asleep or lying in bed for another 2 weeks. Following discontinuation of the passive motion machine and throughout the remainder of this phase, the patient attended twice weekly physical therapy sessions that included electro-stimulation and level-1 exercises (hip extension, hip adduction, abduction, flexion, extension, patella mobilization, and ankle sets). The patient also practiced level-1 exercises on a daily basis at home.

**Massage therapy resumed at 8 weeks**

The scar was healing well, there was extensive inflammation of the knee joint and surrounding tissues, the skin was locked-down along the IT band and upper thigh and the patient reported extensive numbness of the lateral superior aspect of the knee joint line (Fig. 6). Stretching of the repaired area was contraindicated per instructions of the surgeon. Twice-weekly sessions during this phase focused on decreasing inflammation and scar tissue around the knee joint. In addition to deep transverse friction, and skin rolling to treat the patella, broad applications of myofascial treatment focused on the quadriceps and IT band, in conjunction with trigger point therapy.

**Phase 2 movement aspects of the tissue**

By 182 days post-surgery, inflammation around the knee had resolved, there was noticeable decrease in scar tissue and edema around the patella, and the surgeon approved light stretching on the repair. The skin and soft tissue on the medial side of knee were becoming mobile but tissues on the lateral patella remained locked-down, edematous, and numb. Trigger points in the upper thigh had decreased in number and intensity (Fig. 7).

Treatment procedures involved application of mild tensile stress that neither overloads nor under-loads the healing tissue. Overloading will have destructive consequences, while under loading elicits little or no effect. Procedures focused on: (1) scar and joint mobilization; (2) a combination of cross-fiber and myofascial mobilization; and, (3) deep transverse friction applied to the anterior quadriceps and around the knee joint. Trigger points in the upper thigh, where the tissue was retracted, also presented a problem and were treated with digital pressure followed by deep transverse friction. Each session concluded with 30 min of muscle energy techniques (Chaitow, 2001) and assisted active isolated-stretching (Mattes, 2000) to mobilize the knee joint and facilitate reeducation of muscle movement patterns. During phase 2, the patient increased his self-rehabilitation to include 1-hour daily of stairs walking, light weight training
(leg press, leg curl, leg extension, hip flexion/extension adduction abduction), and swimming. Weight training involved open kinetic-chain exercises that isolated specific muscle groups.

**Phase 3 strength training and final rehabilitation return to competitive activity**

By 270 days post operatively only minimum edema remained at the lateral patellar border, there was complete mobilization of the superficial scar, and soft tissue around the patella and the quadriceps had increased in strength and mass. The area of congested tissue in the upper thigh was noticeably reduced and although the trigger points had been decreased, a couple still remained (Fig. 8). The objective of phase 3 (remodeling and maturation of the tissues) is to continue to increase strength and regain the functional movement patterns and activities that the patient was performing before the injury. In this case, the primary concern was to establish strength and stability through a full range of motion. The major limiting factor was decreased quadriceps length caused by retraction and immobilization.

Massage therapy during phase 3 continued to utilize deep transverse friction on the repair site to reduce scar tissue and neuromuscular trigger point therapy to reduce pain and contracture in the retracted tissue of the upper thigh. Manipulation also included proprioceptive neuromuscular facilitation and assisted active isolated-stretches to facilitate the formation of a functional scar and to increase range of motion. Various stretches isolated three areas: (1) the muscle belly; (2) the origin of the rectus femoris at the hip joint; (3) and, its insertion at the patellar tendon. Progressively increased resistance exercise addressed the detrimental effects of the immobilization and associated retraction of the quadriceps muscle group. The patient continued daily open-chain kinetic exercises but increased the amount of weight and number of repetitions. The patient also practiced closed kinetic chain exercises. “Closed kinetic chain exercises use varying combinations of isometric, concentric, and eccentric contraction that must occur simultaneously in different muscle groups within the chain” (Prentice, 1994). Closed kinetic chain exercises included squats, modified static lunges, and lateral step-ups. Throughout phase-3 he also increased participation in previous recreational activities orienteering, class IV white-water boating (which included swimming rapids), and horizontal and vertical caving.

**Discussion**

The success of a complex rehabilitation program, such as that following rupture of the quadriceps tendon, requires a coordinated effort lead by an experienced orthopedic surgeon who has assembled a rehabilitation team. This team includes physical and massage therapists and must have complete patient compliance. The physical therapy component of the program attempts to develop strength and range of motion and return the injured tissue to activity. This was implemented by sessions of ultrasound/hydrocolater packs, forced range of motion, strength training, stationary bike, and electro-stimulation for 1 hour two days a week. The massage therapy component sought to identify and treat dysfunctional tissue and facilitate the formation of a functional scar, thus optimizing the potential for full rehabilitation (the patient’s return to previous competitive levels of activity). Dysfunctional tissue manifests as pain that diminishes in parallel with successful massage therapy. Massage therapy has three general goals (Fig. 9) that pose unique challenges, and are subjected to the different treatment modalities discussed in this case report.

**Restoration of the neuromuscular component**

Massage therapy to restore the neuromuscular component must identify trigger points that manifest as localized or referred pain patterns, and are treated with ischemic compression. Ischemic compression can involve flat palpation, pincer
palpation, or a mixture of both depending on the location of the trigger point. The intent is to blanche the compressed tissues that become hyperemic on release of the pressure (Simons et al., 1999). Ischemic compression increases blood flow to the area and facilitates return of normal neurological function. Ischemic compression should be employed in conjunction with muscle re-education through facilitated stretching.

Reduction of scar tissue

The second general goal is to reduce scar tissue. Massage therapy accomplishes this by first carefully palpating to identify adhesions between muscle fibers and areas of scar tissue around the surgically repaired area. Muscle fibers compromised by scarring cannot function at full capacity because scar tissue adheres to adjacent structures. Therapy to reduce scar tissue and create a functional scar includes myofascial techniques, deep transverse friction, and application of appropriate tensile stress to the affected area. Deep transverse friction alone is sufficient for tendons; it may be combined with passive movement for ligaments, and with active movement for muscles. Muscle movement should be accompanied by progressive resistance appropriate to the stage of healing (Cyriax, 1984).

Mobilization of femur/tibial joint hinge and glide of patellar/femoral joint

Finally, therapy must maintain the best possible mobility at the knee. Thus, the massage therapist identified and measured baseline range of motion, applied techniques to increase both flexion and extension, and monitored effectiveness of therapy by regularly documenting range of motion. Therapy of the femoral tibial joint included flexion/extension, anterior/posterior mobilization, rotation, and tractioning. Therapy of the patellar component of the joint utilized superior/inferior movement, lateral movement, and tractioning the patellar tendon. For this patient, the therapist also employed valgus/varus movement to apply tension on the excessive scar tissue surrounding the joint line (Alter, 1996).

In conclusion, the patient’s almost complete return to previous high-levels of athletic activity clearly indicates the success of the overall rehabilitation strategy described in this report. This successful strategy is based upon a team of orthopedic surgeons, physical, and massage therapists all with expertise in sports medicine. Each major section of the report reviewed how the team approached rehabilitation over time. The peer-reviewed sports medicine rehabilitation literature is sparse with respect to objectives and specifics of massage therapy and its contribution to a comprehensive rehabilitation program. Thus, the article focused on massage therapy.

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References


