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Case Studies

Rehabilitation exercise program after surgical treatment of quadriceps tendon rupture: A case report

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ABSTRACT

Objectives: This case report describes in detail the rehabilitation exercise program, provide post-operative therapeutic objectives/recommendations and to facilitate the return to a possible schedule of ADL and participation in sports after the surgical treatment of quadriceps tendon rupture. Also, the exact surgical technique is described.
Design: A single case report.
Participant: The patient was an active 53-year-old man who sustained this injury as a result of a sudden misstep with his left foot into a hole, while he was trekking across muddy countryside. Clinical examination of the knee revealed skin ecchymosis, swelling and tenderness over the distal thigh. Plain radiographs showed patella baja, and the scheduled magnetic resonance imaging (MRI) showed interrupted continuity of the quadriceps tendon and the patella. A diagnosis of quadriceps tendon rupture was made and the patient was scheduled to undergo surgical intervention the following day.
Rehabilitation exercise program: A well-structured rehabilitation exercise program was followed in order to ensure rapid recovery and good functional outcomes. His postoperative course progressed normally, demonstrating a return to the normal activities of daily living at 6 weeks, full active range of motion at 16 weeks, and return to sports recreational activities at 5 months.
Conclusions: An early surgical treatment and subsequently a well-structured rehabilitation exercise program have contributed to maximize the functional outcomes of the patient and provide a rapid and safe return to the activities of daily living (7th week) with participation in non-contact sports after the 18th week.

1. Introduction

Quadriceps tendon rupture is an uncommon injury (1.37/100,000) that predominantly affects middle-aged men (>50 years of age), often with a history of degenerative changes or systemic diseases and was first reported by Galen in the 2nd century B.C.E. (Yan, 2012; Zuke, Go, Weber, & Forsythe, 2017). Ruptures are most commonly transverse, unilateral and occur in the tendo-osseous junction in the superior pole of the patella (De Baere, Geulette, Manche, & Barras, 2002). The mechanism of injury is a combination of a sudden violent eccentric contraction of the quadriceps muscle with the foot planted on the ground and the knee partially bent (Zuke et al., 2017). Prompt diagnosis and surgical treatment of quadriceps tendon ruptures is recommended in order to achieve optimal functional outcomes, thereby avoiding the tendon retraction and quadriceps muscle atrophy that may occur with delayed repair (Pocock, Trikha, & Bell, 2008).

Several surgical repaired techniques have been described as the treatment of choice: from direct repair using Bunnel or Krackow sutures and suture anchors in acute cases, to repair via lengthening procedures using grafts in chronic cases, with the preferred treatment of choice is still up for debate (De Baere et al., 2002; Gao, Shao, Liu, & Xiang, 2017, Grecomoro, Camarda, & Martorana, 2008). A rehabilitation exercise program after surgical repair of quadriceps tendon rupture is also of great importance in order to ensure a good functional outcome and a rapid return to the functional activities of daily living (ADL) (De Baere et al., 2002). In the literature, only three studies exist providing some suggestions about the post-operative

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recovery phase (Pocock et al., 2008; Saito et al., 2015; Zuke et al., 2017), without, however, presenting the main therapeutic goals in a post-operative rehabilitation exercise program. Thus, the main purpose of this case report is to describe in detail the rehabilitation exercise program, provide post-operative therapeutic objectives/recommendations and to facilitate the return to a possible schedule of ADL and participation in sports after the surgical treatment of quadriceps tendon rupture. Also, the exact surgical technique is described.

2. Methods and results

2.1. Case presentation

The patient was an active 53-year-old man (weight 88 kg, height 186 cm and body mass index of 25,4), with no significant prior surgical or medical history (no history of previous trauma or long-term steroid usage at a local site and an active lifestyle, going trekking twice per week). He was brought to the emergency department within 3 h, assisted by two people in order to walk normally. The injury occurred while he was trekking in muddy countryside. After a sudden misstep with his left foot into a hole (approximately 50 cm deep) while walking; he reported hearing a "popping" in his left knee and he felt immediate pain in the suprapatellar region over the lateral aspect of his left thigh. Clinical examination of the knee revealed skin ecchymosis, swelling and tenderness over the distal thigh. A palpable defect was felt immediately proximal to the patella, which is called the "sulcus sign" (Fig. 1). The patient was unable to perform an active straight leg raise and the extension lag sign was positive. A high clinical awareness of a quadriceps tendon rupture was made at this point. An aspiration was notable for 40 mL of bloody fluid, confirming the presence of a hematoma and reducing pain.

Plain radiographs were negative for fractures, but they showed patella baja and signs of left suprapatellar swelling (Fig. 2). At that time, an above-knee back-slab cast (Z-shaped) was placed in the emergency department, in order to support the thigh and the back of the knee and also to control pain. The patient was admitted and scheduled for a magnetic resonance imaging (MRI). MRI showed interrupted continuity of the quadriceps tendon and the patella with a gap of 1.2 cm (Fig. 3). A partial rupture of the medial and lateral patellar retinacula was also revealed. Based on the clinical examination and MRI findings, a diagnosis of quadriceps tendon rupture was made and the patient was scheduled to undergo surgical intervention the following day (within 4 days of the injury). Subsequently, to the operative treatment, a rehabilitation exercise program was scheduled to restore the individual to his previous level of functioning (Fig. 4). The rehabilitation program was divided into five different phases: control of pain, protect surgical repair and maintain cardiovascular fitness (phase 1); start mobilization and begin muscle strengthening (phase 2); regain independence in ADLs (phase 3); normalize gait on all surfaces (phase 4); and return to sport (phase 5) (Table 1). During the rehabilitation, the patient was monitored by a physiotherapist and one orthopaedic surgeon. The patient's progress was evaluated by the physiotherapist on a weekly basis. The subject was scheduled to receive physical therapy intervention five times per week for 22 weeks.

2.2. Surgical treatment

Surgical repair was done through a longitudinal midline incision of 8 cm, above the patella and extending proximally, in order to expose the ruptured tendon and the patella (Fig. 5). Surgical dissection and removal of the hematoma revealed a complete quadriceps tendon ruptured at the tendo-osseous junction of the patella. The Krackow suture technique was used as it is an invaluable grasping suture for large tendon repair, such as Achilles tendon, patella tendon and quadriceps tendon (Krackow, Thomas, & Jones, 1988; Sherman, 2018). Despite its first introduction being over three decades ago, it still provides a secure, biomechanically strong and stable fixation of soft tissue repair (Sherman, 2018). Previous studies have shown that increasing the number of sutures is more important than increasing the number of locking loops, according to risk of failure analyses (McKeon, Herning, Fulkerson, &

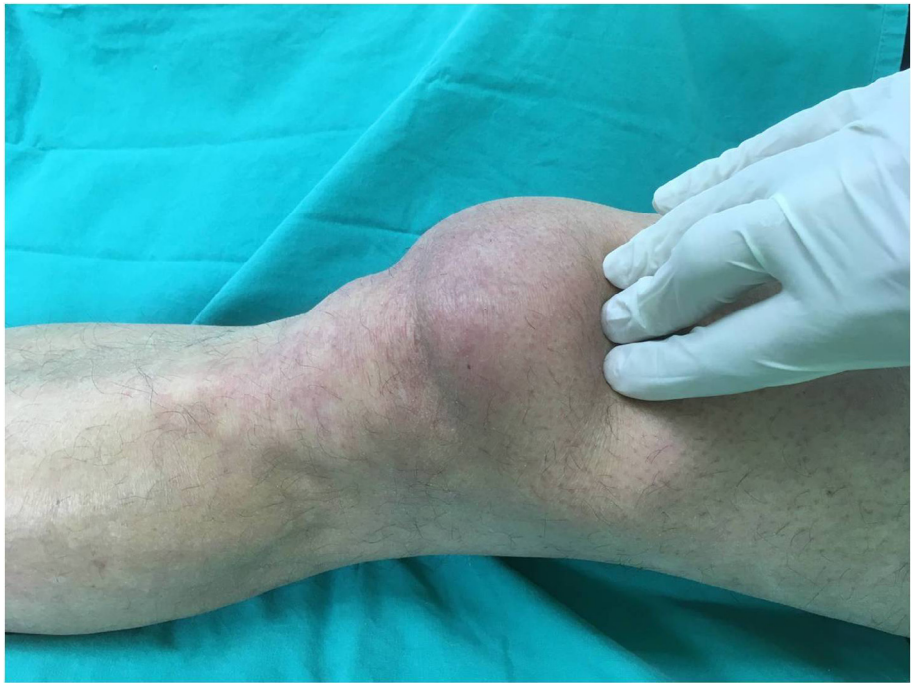

Fig. 1. Knee examination showing obvious swelling with an accompanying palpable defect in the suprapatellar area and a low-lying patella.

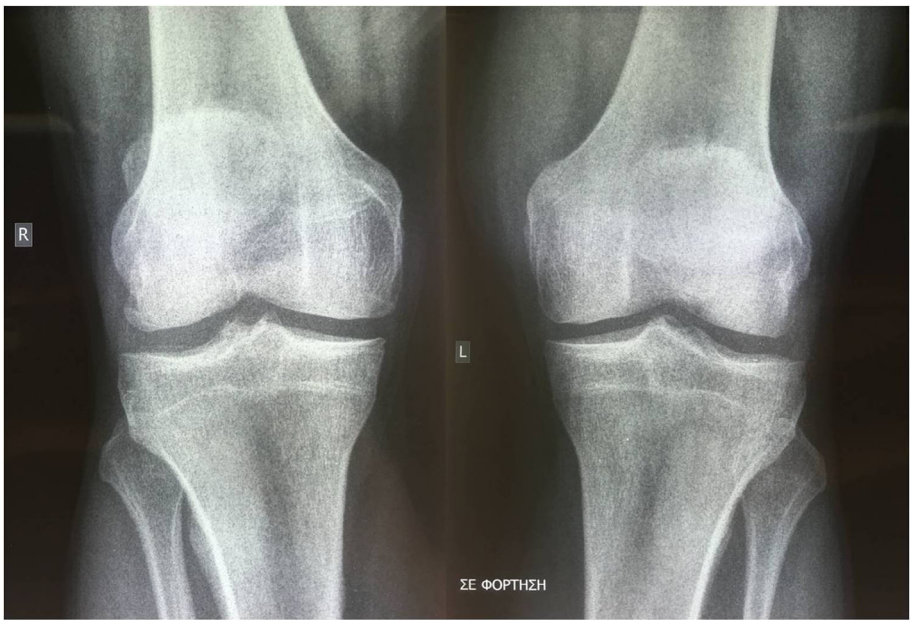

Fig. 2. Antero-posterior weight-bearing radiography of knee showing the low position of the patella (left knee) associated with quadriceps tendon rupture.

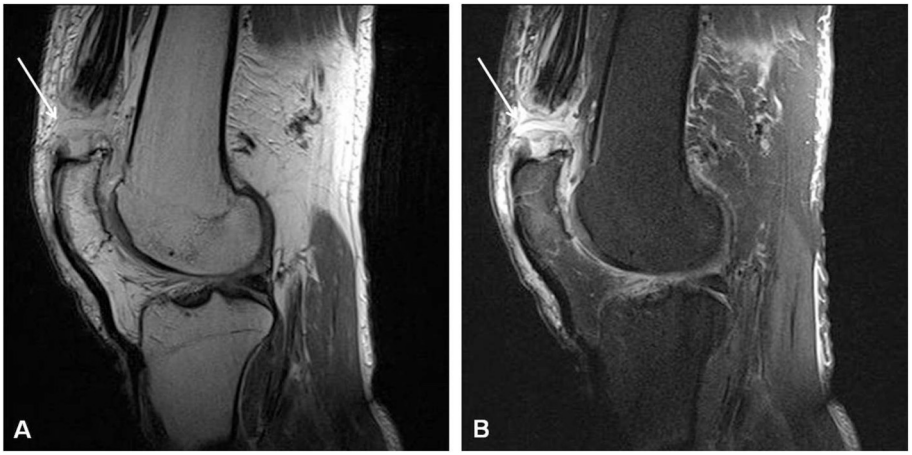

Fig. 3. Sagittal T1-weighted (A) and sagittal T2-weighted (B) MRI images demonstrating a complete quadriceps tendon rupture (white arrows) at the osteotendinous junction.

Langeland, 2006; Sherman, 2018).

For this reason, three non-absorbable coated braided polyester sutures (№ 5, Ti-Crom™, Covidien, Masfield, MA) were placed in three parallel lines in the avulsed tendon end with a Krackow-type whipstitch (Fig. 5). Each bite of tendon was passed through the loop of the previous bite, in order to lock the suture and reduce the risk of it tearing out. After five bites, a transverse bite takes the needle to the other side of the tendon and a second/third line of locked sutures is placed running distally. Five locking loops for each suture along the side of the quadriceps tendon were performed. Three parallel 2.5 mm holes were drilled, placed longitudinally through the patella (Fig. 5). A suture passer was used to draw the suture ends through the drill holes. The two lateral suture ends and one central suture end were drawn tight and tied firmly laterally (inferior pole of patella). In addition, the two medial suture ends and one central suture end were drawn tight and tied firmly medially (inferior pole of patella). The lateral and medial retinaculum ligaments were also repaired using absorbable coated vicryl sutures (№ 2-0, Ethicon, Somerville, NJ) (Fig. 5). The knee range of motion (ROM), patella tracking and degree of knee flexion were checked and assessed intraoperatively. Vicryl sutures (№ 2-0, Ethicon, Somerville, NJ) were used to close the incision and surgical staples were used to close the skin incision (Fig. 5).

2.3. Post-surgical rehabilitation exercise program

In our case report, the patient was a healthy and active individual. As result, regarding post-operative rehabilitation exercise program, some of the tasks were to guide the patient to a quick and safe recovery, achieve a return to his previous physical active level and to address his expectations appropriately. The specific goals were determined by the physiotherapist based on the initial examination findings and subject to the physician's agreement, according to the specific patient's needs and preferences. The rehabilitation goals were: i) control pain, protect surgical repair, maintain cardiovascular fitness, and start mobilization (phase 1 and 2), ii) muscle strengthening, normalize gait, and regain independence in basic ADLs (phase 3 and 4), and iii) return to sports (phase

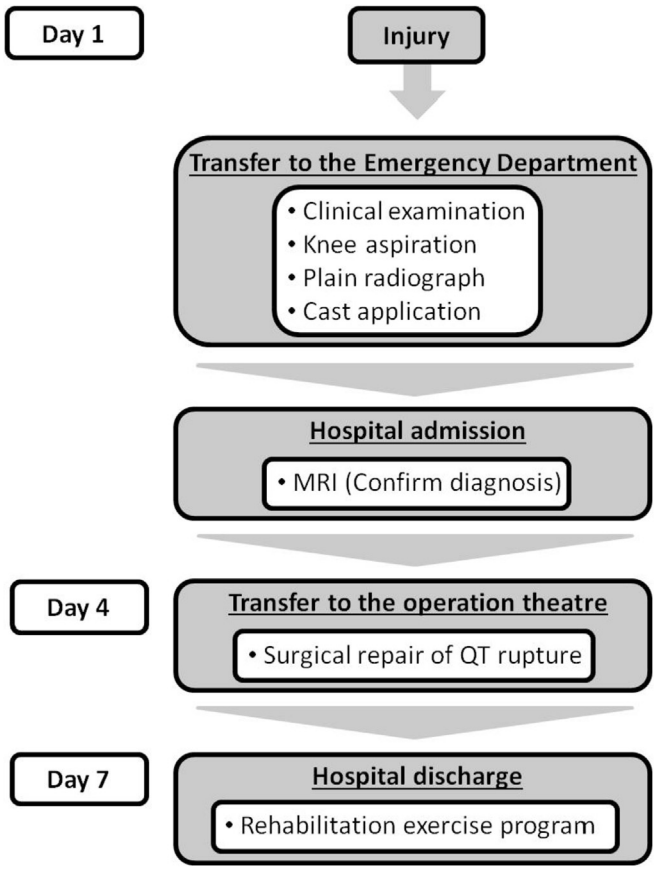

Fig. 4. The overall flow-chart from injury to rehabilitation exercise program.

5) (Table 1). The patient's goals were: i) complete recovery with full unrestricted function, ii) return to all ADLs and work environment, and iii) return to previous sports activities. The intervention was designed on a weekly improvement basis and the clinical progress of the patient was tested every week. Each treatment session lasted from 30 min during the first week, to 90 min during the last week.

2.3.1. Control of pain and wound healing – protect surgical repair, maintain cardiovascular fitness and start mobilization (phase 1 & 2)

The Hemovac drain was removed 1 day after the surgical treatment and the patient was allowed to walk with two crutches and weight bearing as much as could be tolerated. The initial post-operative phase (1st to 6th week) was necessitated by the use of crutches to facilitate rest and ensure the immobilization of the quadriceps (Table 1). In the post-operative period (1st week), patient started an upper body strengthening exercise program three times per week to maintain fitness and minimize the risk of long-term health complications. During the 3rd week, new therapeutic exercises were started, including stretching, isometric exercises of the lower extremity (quadriceps, hamstring, gluteal) and strengthening of the knee musculature (standing toe raise, straight leg exercise, hip abduction/adduction, knee extension through a short arc of motion) (Table 1). Hamstring and gluteal play synergistic roles and isometric exercises of these muscles were performed in order to strengthen, build up stability and improve the balance of the legs. Gradually, weight bearing was assisted with the use of a single crutch, as needed for the 3rd to 6th weeks post-operatively, while the knee was immobilized in a functional knee brace for 12 weeks, with a gradually increasing range of motion. The patient had an initial post-operative period (1st to 6th week) with continuous passive movement (CPM) of 0°–45° (Table 1 & Fig. 6). A CPM device was used to improve the ROM in the knee joint and also eliminate the problem of stiffness. CPM was applied one week post-operatively until the end of 10th week. During that period, the patient received 2 h of CPM application five days per week. CPM was used for 1 h, twice daily; and was performed with increasing flexion, depending on tolerance, every week. The CPM machine used was an Artromot®-K1 classic (Ormed GmbH & Co., Freiburg, Germany) with maximal possible flexion angles of 115° (hip) and 120° (knee). The patient was instructed not to resist or actively support the motion of the device.

2.3.2. Main rehabilitation exercise program (phase 3 & 4)

The muscle strengthening exercises were based on a progression program starting with bodyweight exercises and continuing with elastic resistance exercises (7th week) and machine resistance exercises (12th week) (Fig. 6 & Table 1). Closed kinetic chain (CKC) and opened kinetic chain (OKC) exercises on the muscle strength and muscle activity of the joint were used. Open kinetic-chain exercises were utilized later in rehabilitation (10th week) (Table 1). The knee brace was removed at the 12th week after a clinical examination by the physician, and free ambulation was enforced. At this time-point the patient could actively flex the knee to 110° and underwent a program of quadriceps-strengthening exercises with weight machines to ensure full recovery (Table 1 & Fig. 6). Quadriceps and hamstring exercises were employed in order to improve the hamstring/quadriceps strength ratio, providing muscular stability at the knee joint and reducing the risk of re-injury.

Re-education of the knee joint movement for control of balance is an important factor in remedying gait or balance problems. Therefore, proprioceptive exercises were induced for improving the static/dynamic balance and gait (7th week). Treadmill-walking exercise (12-min, three times per week) commenced in the 10th week to improve balance, gait ability, skeletal muscle strength and to promote cardiovascular and general fitness. For the treadmill, the patient was instructed to walk at a walking-speed of 3 km/h (10th week) to 5.5 km/h (18th week). All walking trials were performed on a treadmill (Cateye EC-T220, Osaka, Japan). Stationary bike and aquatic exercises were used at the 11th and 14th weeks, respectively (Fig. 6). The use of a stationary bike for 20 min with no-resistance is suggested at the end of CPM application, as well as an active ROM exercise (0°–130° from the 8th to 16th week) in order to increase, and eventually reach, the full range of motion of knee joint (130°) by actively using the muscles at the 16th week (Table 1). In addition, the use of stationary bike for 5–10 min with no-resistance is proposed as an active warm-up. The use of aquatic exercises has a positive effect on function and pain, is beneficial to maintaining physical stamina and is the essential initial step to becoming comfortable in the water environment and to prepare for the next step in swimming protocols.

2.3.3. Return to sport – final clinical examination (phase 5)

Sports recreational activities, such as swimming, cycling and running were allowed after physician's clinical examination at 5-months post-operatively (Table 1). At the 6-months follow-up, the patient was almost pain-free during activities of daily living apart from some occasional slight pain when ascending and descending stairs. At this time point, in order to evaluate the effectiveness of the reconstruction, the Lysholm Knee Score and Kujala Anterior Knee Pain Scale were applied, with 90 and 87 scores, respectively. The recovery in strength of the quadriceps was clinically assessed by Medical Research Council (MRC) grading of power of knee flexion/extension and found to be of grade 5/5 in the patient. At the twelve month follow-up, the patient was pain-free in daily life except for an occasional mild discomfort in athletic

Table 1
Progression of rehabilitation exercise program after surgical treatment of quadriceps tendon rupture.

Phases	Goals	ROM	Weight bearing	Physiotherapy
Phase 1 (1–2 weeks)	• Control pain/swelling and wound healing • Protect surgical repair (knee brace locked in full extension) • Maintain cardiovascular fitness	Knee ROM from 0° to 30° (only passive knee motion)	Partial weight bearing on crutches in extension knee brace	• Ice therapy • Isometric quadriceps, hamstring and gluteal sets • Ankle pumps (stimulate circulation in the leg) • Maintaining fitness through upper extremity cardiovascular exercises
Phase 2 (3–6 weeks)	• Protect surgical repair (knee brace locked in full extension until 5th week) • Regain knee motion • Begin muscle strengthening • Maintain cardiovascular fitness • Normalize gait	Knee ROM from 0° to 45° (only passive knee motion)	Weight bearing on crutches in extension knee brace: - week 5: open to 30°	• Suggested therapeutic exercises: - ankle pumps - patellar mobilizations - heel drop/slides - hip abduction/adduction - short arc lift - standing toe raises - straight leg exercise - hamstring/calf stretch • Isometric quadriceps, hamstring and gluteal sets • Maintaining fitness through upper extremity cardiovascular exercises
Phase 3 (7–12 weeks)	• Regain independence in basic ADLs tasks and return to work • Regain and improve knee ROM • Muscle strengthening • Normalize gait	• Passive knee ROM from 0° to 90° • Active knee ROM from 0° to 90°: - week 7–8: 20° - week 9–10: 45° - week 11–12: 90°	Weight bearing without crutches and with knee brace open to 90°: - week 8: open to 45° - week 10: open to 60° - week 12: open to 90°	• Suggested therapeutic exercises (use of elastic resistance bands, continue as above - add below): - flamingo stands - side leg raises - wall squat with a ball - quadriceps stretch - stairs (9th week) - treadmill walking (10th week) - stationary bike (11th week) • Closed chain (8th week): - light squats (0° - 40°) - leg press (optional) • Open chain (10th week): - leg extension (machine) - hamstring curl (machine) • Lower body balance and proprioceptive exercises (balance board): - backward walking - walking on heels/toes - one leg standing - side stepping - bipodal/unipodal balance (board) - squat (board) - passing/throwing ball as distraction (board) • Maintaining fitness through upper extremity cardiovascular exercises
Phase 4 (13–18 weeks)	• Normalize gait on all surfaces • Muscle strengthening	Active knee ROM from 0° to 130°: - week 13: 110° - week 16: 130°	Weight bearing without crutches and knee brace	• Suggested therapeutic exercises (continue as above - add below): - squats (up to 70°) - step up - leg press - single leg squat • Aquatic exercises that stimulate freestyle and breaststroke leg kicks with the use also of large fins (14th week) • Lower body balance and proprioceptive exercises (balance board) as above • Maintaining fitness: - Upper extremity cardiovascular exercises - week 18: jogging - week 18: swimming
Phase 5 (19–22 weeks)	• Muscle strengthening • Return to sports activities (non-contact sports)	Full knee ROM	Weight bearing without crutches and knee brace	• Suggested therapeutic exercises (continue as above - add below): - walking lunge - pistol squat (optional) • Lower body balance and proprioceptive exercises (balance board) as above • Maintaining fitness: - week 20: road bike - week 22: running

Abbreviations: ROM = range of motion; ADLs = activities of daily living.
Note: The choice of each exercise and progression depends on the individual desired outcome at each phase, according to clinical examination/evaluation by the physician and physiotherapist.

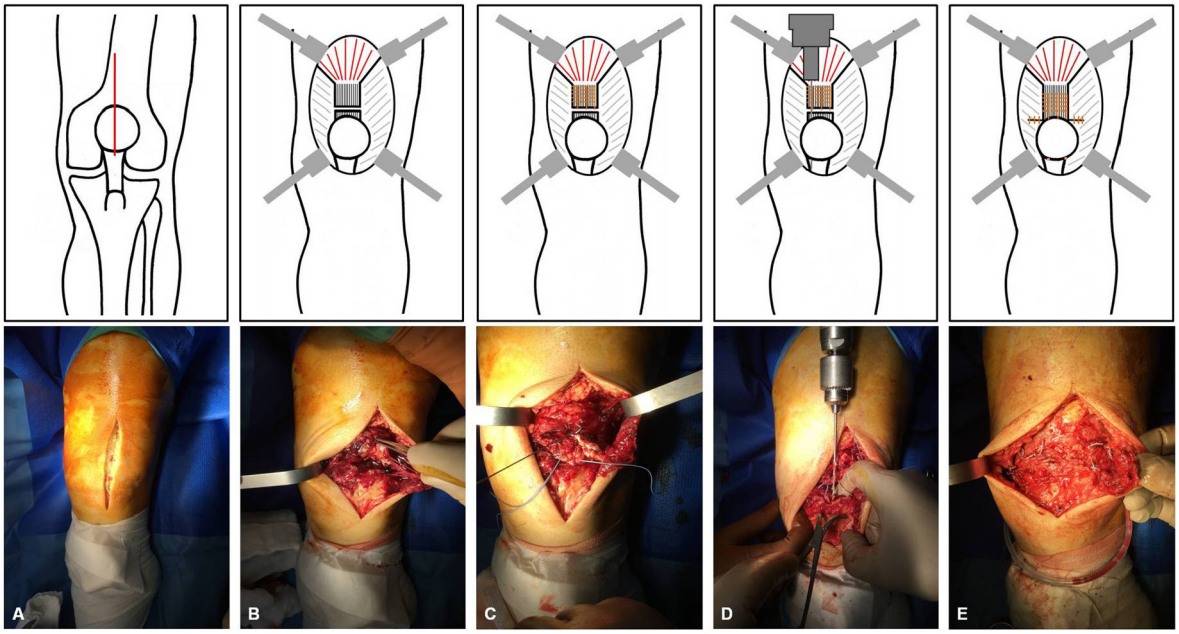

Fig. 5. The drawings illustrate operative repair of the quadriceps tendon rupture (upper row). Intraoperative pictures showing step-by-step the general surgical procedure (bottom row). **A,** Longitudinal mid-axial incision for exposure of the quadriceps tendon rupture; **B,** Hematoma is evacuated to allow visualization of the free ruptured tendon ends; **C,** Three No. 5 non-absorbable sutures are placed along the medial, middle and lateral borders of the quadriceps tendon (Krackow type whipstitch); **D,** Three parallel longitudinal holes drilled through the patella in order to pass the suture; **E,** The central two suture ends are passed through middle hole and each one are tied with the suture ends of medial and lateral two suture ends in medial and lateral hole. The medial and lateral retinaculum are closed.

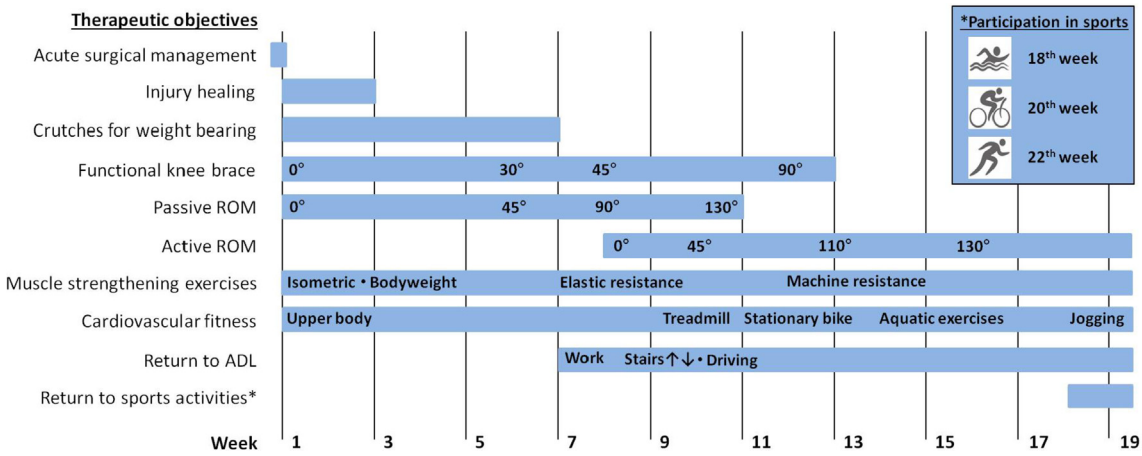

Fig. 6. Summary of the therapeutic objectives presented week by week and possible recommendations to return to activities of daily living (ADL) and participation in sports. Rehabilitation phases were overlapped according to the patient's progress.

activities, such as basketball and soccer. One year after surgery and the rehabilitation exercise program, the Lysholm Knee Score and Kujala Anterior Knee Pain Scale were 100 and 97, respectively.

3. Discussion

To the best of our knowledge, our study is the first to describe a detailed rehabilitation exercise program, provide post-operative therapeutic objectives/recommendations and to facilitate the return to a possible schedule of ADL and participation in sports after the surgical treatment of quadriceps tendon rupture. Surprisingly, our patient revealed an early return to activities of daily living (returned to work in the 7th week and started driving in the 10th week after surgery); more rapid compared to other case reports (Gao et al., 2017).

Rupture of the quadriceps tendon usually occurs in males over 40 years of age and is associated with chronic systemic medical conditions, such as diabetes, gout, rheumatoid arthritis (Zuke et al., 2017) or with anabolic steroid use (De Baere et al., 2002; Pocock et al., 2008). In our study, a 53-year-old healthy and active male, with no surgical or medical history, sustained an acute quadriceps tendon rupture. The tendon most commonly ruptures transversely about 2 cm from the superior pole of the patella in a degenerative area of the tendon (Grecomoro et al., 2008). The diagnosis of rupture is based on clinical findings. When in doubt, diagnosis is confirmed by magnetic resonance imaging (MRI). Although MRI is a more expensive method in diagnosing tendon ruptures, MRI is considered the imaging gold standard, providing an anatomic overview and excellent soft tissue contrast and is particularly useful for preoperative planning (Shah & Jooma, 2002; Yan, 2012).

Direct surgical treatment of the quadriceps tendon to the patella is recommended for most acute ruptures to ensure the optimization of a full return of strength and function (Saito et al., 2015). Delay in surgical treatment is an important reason for poor functional outcomes and a significant contributor to the associated increased risk of complications (Saito et al., 2015; Shah & Jooma, 2002; Yan, 2012). In our patient, the surgical repair was performed within 4 days of the injury, in order to reduce the overall post-operative complications and to provide a far better prognosis. Several techniques and various sutures types, including the Krackow, Bunnell and Kessler, can be used for treating a ruptured tendon. Biomechanical studies have shown that, according to the tendon repair strength, the Krackow and the Bunnel sutures are superior in endurance, strength of failure and durability to the Kessler sutures (Manent et al., 2017; McKeon et al., 2006). Although the use of the Krackow suture is technically more demanding than the two other suture types, Krackow sutures have been shown to present greater axial resistance than both the Bunnell and Kessler sutures (Ortiz et al., 2012).

Early post-operative rehabilitation exercise program is of great importance in order to obtain and maintain rapid recovery and good functional outcomes (Fanchini et al., 2018). In the present case report, the patient attended a well-structured rehabilitation exercise program 5 times weekly for a period of 22 weeks. As recently suggested, patients with an excellent functional outcome had significantly more therapy sessions than those with good, fair, or/and pair functional outcome (Toker, Oak, Williams, Ipaktchi, & Ozer, 2014). In addition, a successful return to a previous competitive level is described with a comprehensive goal-oriented rehabilitation program, with daily physiotherapy treatments and gym activities (Fanchini et al., 2018). Therefore, physicians and physiotherapists should pose attainable and comprehensive goals tailored to the patient's needs. It seems that as number of sessions is increased, patient's functional outcomes are also improved.

Regarding post-operative rehabilitation, it has been reported that knee joint immobilization in full extension for 4–6 weeks after surgical treatment is necessary to protect tendon repair and allow complete healing (De Baere et al., 2002; Saito et al., 2015). In our case, the patient's knee was immobilized in a functional brace for five weeks in full extension with gradually increase of the degrees of flexion of the brace until the 12th week, when the knee brace was removed. It is suggested from the literature that a safe period for knee immobilization in a brace is between two to three months, until the patient regains muscle control and discomfort decreases (Yan, 2012). In addition, the literature advocates the use of brace immobilization according the type of injury, partial or complete tears (Gao et al., 2017; Yan, 2012). We preferred to protect the suture repair because a re-rupture irremediably affects the final prognosis. A second operative treatment is usually more demanding as there is more damage to the soft tissues and tendon, resulting in the need for a graft in order to re-build the destroyed anatomical construction (Krahe & Berlet, 2009). Most patients that sustain a re-rupture of a tendon and are treated surgically have a prolonged recovery period, with function deficits on the injured side and a negative effect on both work and leisure activities (Westin et al., 2018).

The emphasis in rehabilitation should be focused on regaining the full range of motion and gradually increasing the weight bearing on the knee. The goals of the rehabilitation exercise program are to regain full flexion and extension of the knee joint and also build balance and strength. For this to be accomplished, attention must be focused on restoring ROM and flexibility at the injured knee. The range of motion exercises may begin within one week post-operatively when pain is much less evident, initially with CPM then followed by active ROM exercises (Saito et al., 2015; Zuke et al., 2017). Pocock et al. (2008) have shown successful restoration of the extensor mechanism of the knee involving an initial post-operative period of CPM use. The same functional gains have also been reported in obese patient after early CPM application (Kelly, Rao, Louis, Kostes, & Smith, 2001). It is well supported from the literature that the CPM has become an adjunct for the early post-operative phase after surgical treatment of quadriceps tendon ruptures, reducing the problems associated with joint immobilization (Howard, Mattacola, Romina, & Lattermann, 2010; Kelly et al., 2001; Plesser et al., 2018). Early and progressive ROM exercises following operative treatment of quadriceps tendon rupture seem to decrease post-operative joint stiffness and improve functionality (West, Keene, & Kaplan, 2008). A gradually increase of ROM exercises, based on the level of knee joint function and pain as tolerated by the patient in order to protect the integrity of the tendon, is always crucial (Pocock et al., 2008; Zuke et al., 2017).

Therapeutic exercises, as part of a rehabilitation exercise program, can improve joint mobility, muscle strength and overall physical conditioning, and help the patient so as to promote optimal health. Kinetic chain exercises are useful for isolating muscles in order to strengthen them. Kinetic chain-based rehabilitation exercises have been grouped into closed and open chain. In general, CKC exercises are multi-joint movements where the distal aspect of the extremity is fixed to an object that is stationary. In contrast, OKC exercises are single joint movements where the distal aspect of the extremity is free to move through space. From a biomechanical prospective, it is likely that OKC knee exercise increase quadriceps and patellar tendon tension, producing more strain on the tibiofemoral joint surfaces (Stensdotter, Hodges, Mellor, Sundelin, & Häger-Ross, 2003). The literature indicates that CKC exercises are recommended for use earlier in rehabilitation than OKC exercises. CKC exercises have been preferred because of the belief that they provide greater joint compressive forces, reduce shear forces on the knee, exercise multiple joints through weight bearing and muscular contractions, control velocity/torque and facilitate postural/dynamic stabilization mechanics (Glass, Waddell, & Hoogenboom, 2010; Witvrow, Danneels, Van Tiggelen, Willems, & Cambier, 2004). A combination of CKC and OKC exercises is the ideal approach to musculoskeletal and sports rehabilitation programs of the lower extremities and lead to greater quadriceps torque return and a quicker return to sport than CKC alone (Glass et al., 2010).

Muscle strength progression is based on the intensity of exercise being undertaken, which can be defined as a given percentage of the maximal muscle contraction strength (Lorenz & Reiman, 2011). In our study, following surgical treatment of the ruptured quadriceps tendon and the post-operative immobilization of the knee joint, gradually muscle strengthening exercises are important for the rehabilitation of knee instability. The primary muscles that cross the knee joint are the quadriceps, hamstrings and gastrocnemius, which comprise the main muscles of a post-operative rehabilitation strengthening program.

Electromyography (EMG) is commonly used to measure the level of muscle activation and provides a rough estimate of exercise intensity for specific muscles involved in the movement (Andersen et al., 2006). According to the scientific literature, the rectus femoris is maximally activated with the leg extension exercises, although with the least amount of co-activation of the hamstrings (Ebben et al., 2009). In the same study, the vastus lateralis activation was the greatest during exercises such as lunge and squat. In a recent study, EMG activity for the biceps femoris was similar for the leg curl and Romanian dead lift (McAllister et al., 2014). The squats exercise found to be superior in the activation of the vastus lateralis and vastus medialis with EMG compared it with knee extension

(Signorile, Webwe, Roll, Carusi, Lowensteyn, & Perry, 1994). Multiple-joint exercises, such as leg press and squat, require more complex neural responses and activate multiple muscle groups around the knee joint (Da Silva, Brentano, Cadore, De Almeida, & Kruel, 2008). These types of exercises can be used in the late rehabilitation phase. It is obvious that a rehabilitation program with varied exercises is more effective in producing strength gains in the knee musculature.

4. Conclusions

In conclusion, complete quadriceps tendon rupture is an uncommon injury of the knee and a prompt diagnosis always requires a high degree of clinical awareness. Early surgical treatment and a subsequent well-structured rehabilitation exercise program that focuses on ROM, muscle strengthening, gait ability and cardiovascular fitness, maximizes the functional outcomes for the patient and provides a rapid and safe return to all activities of daily living, as well as sports activities. The present case report describes a more comprehensive and detailed post-operative rehabilitation exercise program and attempts to fill the gap apparent in the current literature. A possible timescale for a return to the activities of daily living is the 7th week with participation in non-contact sports after the 18th week.

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None declared.

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