




CASE REPORT

Repair of Bilateral Quadriceps Tendon Rupture Using a Modified Knotless Suture Anchor and Internal Brace Technique: Surgical Technique and Case Report

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Background: Quadriceps tendon rupture (QTR) is a rare clinical condition often caused by indirect injury in healthy people. In addition, spontaneous and bilateral ruptures can occur in patients with predisposing factors, such as endocrine or rheumatic disease. Currently, several QTR repair techniques have been proposed; however, no consensus exists about the best repair technique.

Case Presentations: A 55-year-old man with renal failure secondary to glomerulonephritis suffered from spontaneous bilateral quadriceps tendon ruptures. Based on a knotless suture anchor and internal brace, a novel double-row suture-bridge configuration surgical approach was used to treat the patient. At 11-month follow-up, the patient maintained excellent function, with a Lysholm score of 91 for both knees.

Conclusions: This technique may be an effective method for repairing ruptured quadriceps tendons.

Key words: internal brace; knotless repair; quadriceps tendon; rupture; simultaneous

Introduction

Quadriceps tendon rupture (QTR) is a rare injury affecting nearly 1.37 persons per 100,000 annually¹. This condition occurs as a consequence of direct or indirect trauma. Unprompted ruptures, which can be bilateral, are common in patients with certain disorders, such as chronic renal failure, gout, diabetes, rheumatoid arthritis, steroid abuse, etc. It also affects healthy people who participate in sporting activities². Due to extended life expectancy and increased physical activities among the elderly, the incidence of quadriceps tendon rupture has increased³. Despite being a rare pathology, QTR decreased the quality of life in patients and may cause disability if left untreated³. Currently, most healthcare professionals advocate surgical repair as the standard treatment for QTR. Several QTR repair techniques have

been proposed; however, no consensus exists about the optimal repair technique. This study optimized the method by designing a novel double-row suture-bridge configuration surgical method for QTRs using a knotless suture anchor and internal brace. Herein, we report a 55-year-old patient with spontaneous bilateral QTRs treated with this novel technique. This modified technique yielded excellent results.

Case Report

Medical History

The patient in this report was a 55-year-old Chinese man with renal failure secondary to glomerulonephritis. He has been on hemodialysis three times a week since 2016. The patient complained of acute pain in both knees following a

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Received 11 August 2021; accepted 20 May 2022

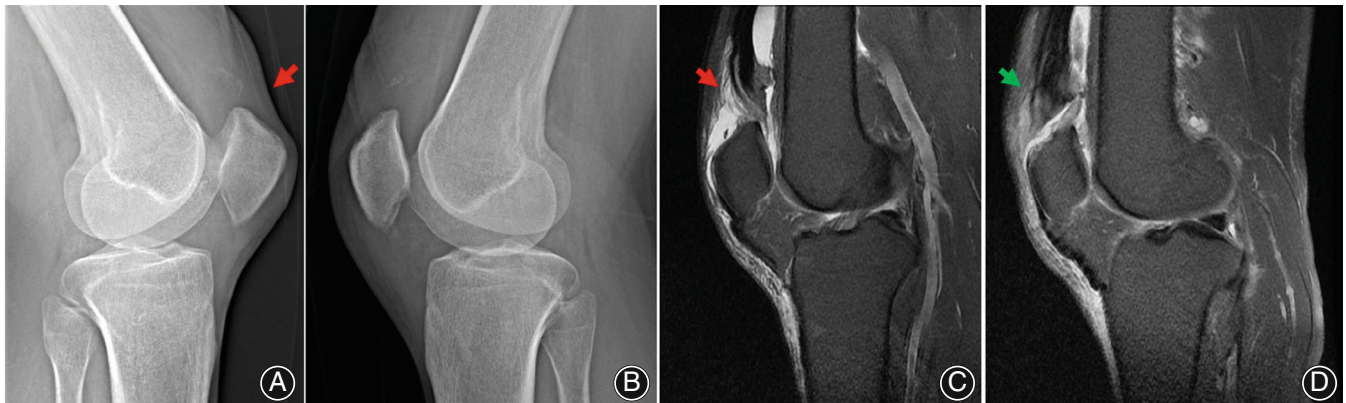


Fig. 1 Preoperative lateral radiograph of the left knee showing a downward and forward-tilted patella, red arrow in (A), slightly low-lying and forward-tilted patella on the right knee (B). Sagittal MRI reconstructions (T2 turbo spin echo sequence) of both knees showed the ruptures at the osteotendinous junction in (C) left and (D) right knee

fall due to a minor slip. His knees were swollen, preventing him from fully extending his legs and knees normally. Further examination of both knees revealed an edematous swelling, light ecchymosis in the suprapatellar region, and articular effusion. Bilateral suprapatellar gaps were suspected.

Plain radiographs revealed a downward and forward-tilted patella (red arrow, Figure 1(A)) on the left and a slightly low-lying and forward-tilted patella on the right (Figure 1(B)). Additionally, soft tissue swelling over the knees was observed. Magnetic resonance imaging (MRI) of knees revealed a full-thickness tear on the left quadriceps tendon at the patellar attachment (red arrow, Figure 1(C)) with 1.5 cm of tendon retraction and a complete tear of the right quadriceps tendon attachment (green arrow, Figure 1(D)) with 0.5 cm retraction and inferior traction from patellar tendons.

Exposure of Surgical Field

The patient received dialysis and then underwent bilateral tendon repair under general anesthesia on the next day. The surgical procedure was performed with the patient lying supine with bilateral thigh tourniquets and the knee in approximately 30° of flexion. A longitudinal incision (5–8 cm) was made over of quadriceps tendon area to the middle of the patella. A combination of sharp and blunt dissection was performed through the skin and subcutaneous tissues down to the extensor mechanism, revealing a complete quadriceps tendon ruptured at the tendon-osseous junction of the patella. Subsequently, the hematoma was debrided, and fibrotic tissue between the tendon and the patella's proximal pole was removed. The tendon ends were refreshed, and footprint on the patella's proximal pole was decorticated with a rongeur until active bone bleeding started.

Repairing Process

Two suture taps (2 mm wide) were obtained from two 4.75-mm SwiveLock® anchors loaded with FiberTape® Suture. Bunnell sutures were then placed in a proximal-to-distal direction for 4–6 throws in each direction within the medial and lateral 1/3 of the quadriceps tendon (Figure 2(A)), with the ends out distally. Following that, a #2 high-strength suture (FiberWire; Arthrex, Naples, FL) was placed in the same way in the middle 1/3 of the quadriceps tendon interlocking with two suture taps to strengthen the suture (Figure 2(B),(C)). The fiber taps and high-strength sutures were pulled to the patella, approximating the location of quadriceps tendon attachment, and marking the spots where they will enter into the patella. Two 2.4-mm guide pins were drilled into marked points on the superior aspect of the patella to a minimum depth of 25 mm, approximately 5 mm apart, nearly at the medial and lateral 1/3 of the proximal pole patella. Then, the 4.5-mm cannulated drill bit was drilled over the guide pin to a depth of 25 mm. The bone socket was tapped with the 4.75-mm SwiveLock Tap to breach the patella cortex for at least three turns (Figure 2(D)). The lateral suture tape, two limbs, and one high-strength suture tail were shortened to the patella by passing them through the eyelet of 4.75-mm SwiveLock® anchors. With a fully extended knee and maintained tension on the medial strand, the assistant antagonistically held and pushed up the patella. Subsequently, the anchor's eyelet was placed into the lateral drill hole, after which the lateral SwiveLock anchor was malleted and screwed into the patella to anchor the lateral quad tendon. This procedure was repeated with the remaining medial sutures on the tendon's opposite side (Figure 2(E)).

The suture tap limbs were then passed through the quadriceps tendon stump, with one ipsilateral and one contralateral suture tape limb advanced through the medial proximal patellar tendon and tied. The lateral side was

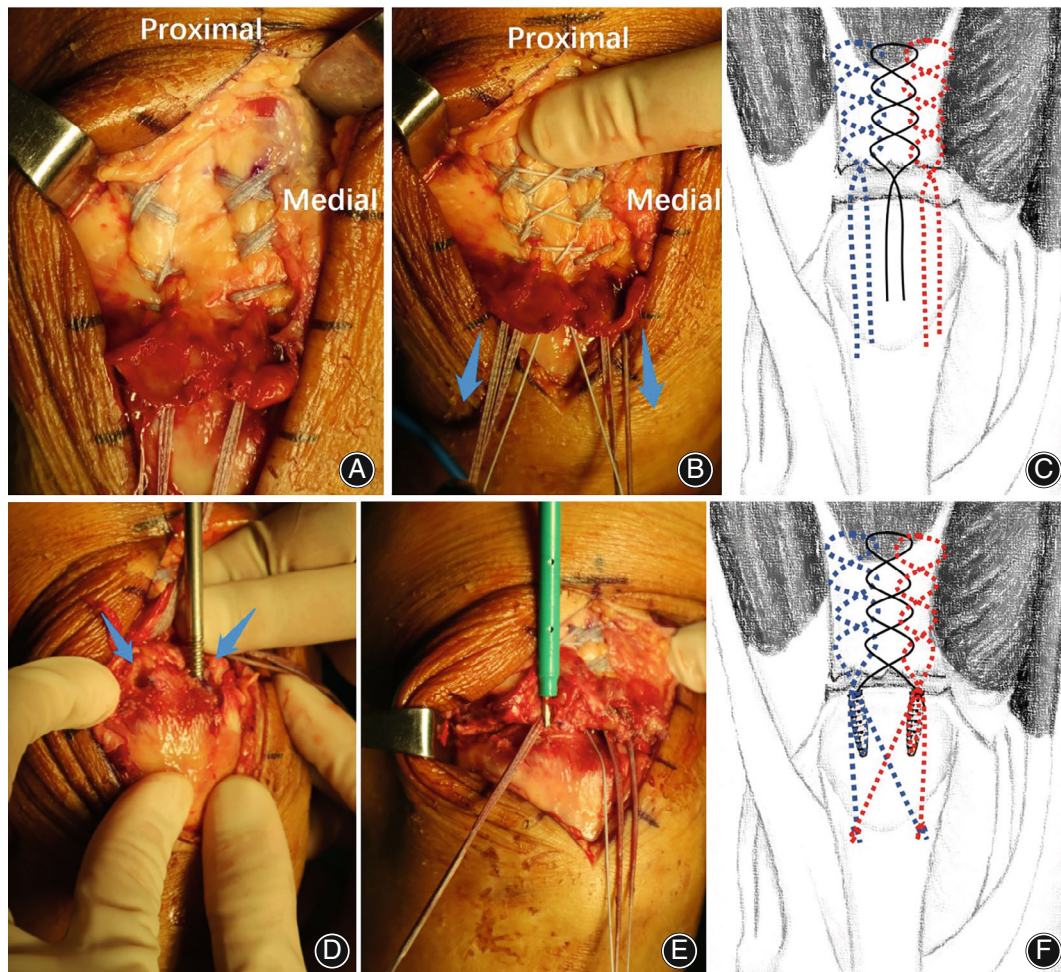


Fig. 2 (A) Bunnell sutures were placed with two suture taps in a proximal-to-distal direction in the medial and lateral 1/3 of the quadriceps tendon. (B) A #2 high-strength suture was applied inter-locking with two suture taps to strengthen the suture in the middle 1/3 of the quadriceps tendon. (C) Illustration of (A), (B). (D) Tapped the bone sockets on the superior aspect of the patella. (E) Passed the lateral suture tape two limbs and one high-strength limb into an eyelet of a 4.75-mm BioComposite SwiveLock[®] anchor. Screwed the SwiveLock anchor into the patella, anchoring the quad tendon. (F) Double-row suture-bridge repairment and augmentation with knotless suture anchor and internal brace for quadriceps tendon

similarly treated to form a “|X|” configuration (Figure 2(F)), which also served as a tension band in the front part of the patella. Following that, the tails were cut, knots were sutured, and buried into the proximal patellar tendon with 3/0 absorbable suture to prevent knot loosening and protuberance irritation. This effectively modified the double-row suture-bridge configuration, restored the quadriceps tendon footprint contact area, and increased the compression of tendon-to-bone site. FiberWire from 4.75-mm biocomposite knotless suture anchors was employed to repair medial and lateral retinacular ruptures. If the medial patellofemoral ligament (MPFL) or lateral patellofemoral ligament (LPFL) were completely detached from the patella, one or two 3.5-mm metal suture anchors were placed on the patella at MPFL or LPFL insertion sites to repair medial and lateral retinacular ruptures.

Postoperative Examination

After the repair was completed, the knee in a full range of motion (ROM) was performed to assess the degree of knee flexion, patella position and tracking, suture retention in the tendon, and repaired quadriceps tendon tension. Final fluoroscopy was employed to confirm the anchor location and patella height. The subcutaneous layer was then closed in one plane with a 3/0 absorbable suture, followed by a skin intermittent suture without drainage. The same procedure was performed on the contralateral knee. At the end of procedure, removable splints were placed on the knee.

Bilateral knees postoperative T2-weighted sagittal MRI revealed normal continuity of the repaired quadriceps tendon with the superior pole of the patella (Figure 3).

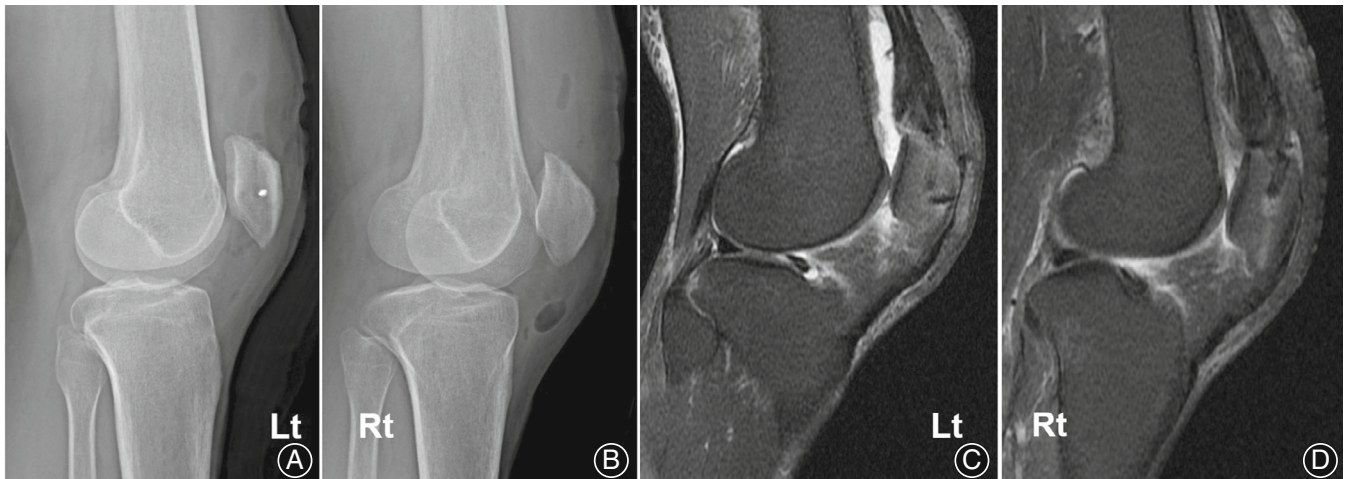


Fig. 3 (A, B) Postoperative radiograph shows restoration of vertical alignment of patella with one 3.5-mm metal anchor used to repair the MPFL on the left knee (A). (C, D) Sagittal T2-weighted MRIs of the knees revealed the normal continuity of the repaired quadriceps tendon with the superior pole of the patella

Rehabilitation Protocol

Isometric strengthening of quadriceps and ankle pump started immediately on the first day following surgery, including gradual passive flexion movements. With the hinged knee brace protection, knee ROM was allowed up to 30° in the first week and allowed to weight-bear as tolerated using crutches, then increased to 60° for weeks 2–4, with concurrent quadriceps femoris muscle power training, and then to 90° for weeks 4–6 postoperatively and use of crutches is tapered.

After 8–12 weeks, gradual and complete resumption of normal activities was encouraged. After 3 months, he could perform usual daily activities without pain except for slight pain when ascending or descending the stairs (Figure 4). At this time point, the reconstruction success was evaluated by applying Lysholm Knee Score, with 91 and 91 scores, respectively. Three months after surgery, a full knee extension and flexion physical examination was conducted. After 11 months after the operation, the patient was lost to follow-up.

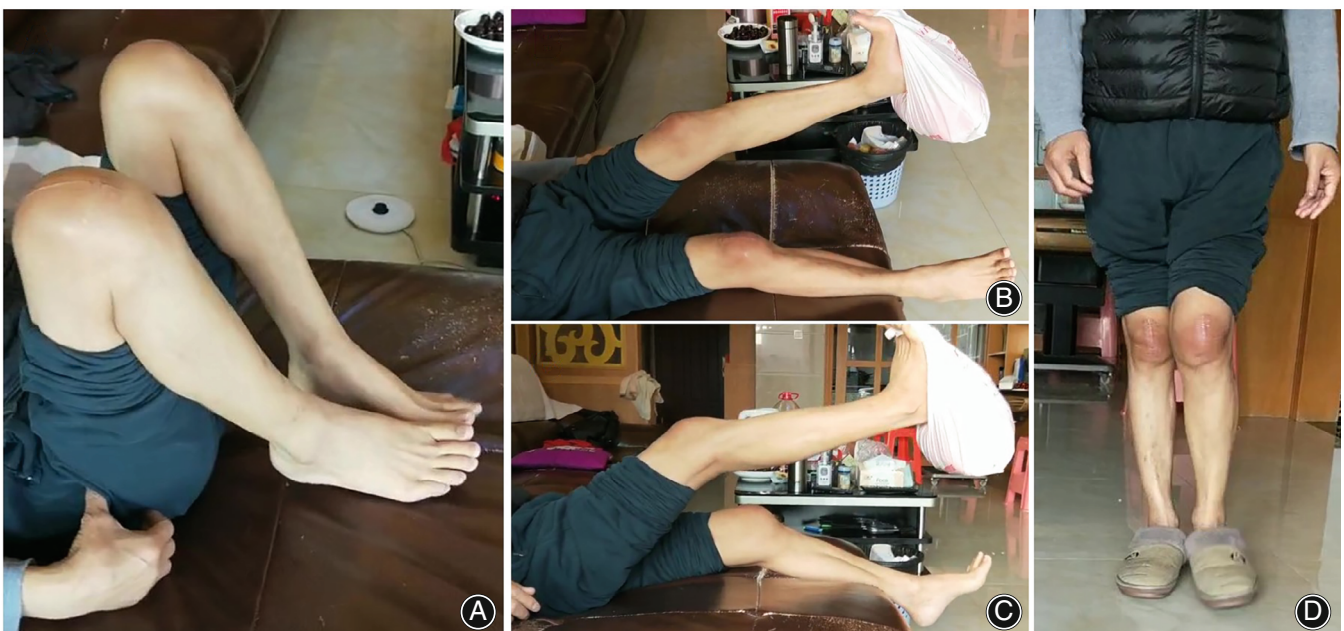


Fig. 4 The patient regained full active movement of both knee joints and was able to participate in his activities of daily living after recovery

Discussion

The Epidemiology and Treatments of QTR

QTR is a rare clinical condition that affects men between the ages of 50 and 60¹. Indirect trauma is the most common cause of rupture in healthy people, whereas ruptures can occur spontaneously and bilaterally in patients with predisposing factors, such as endocrine or rheumatic disease. More recently, Aleksy *et al.* reported that QTR occurs more often than reported previously, approximately a 4.1-fold overall increase, and the incidence is increasing rapidly³.

Surgical QTR repair provides adequate strength required for an early range of movements, improves function, and allows earlier return to normal physical or sporting activities. Numerous surgical techniques have been proposed for QTR treatment, but none of them is identified as the best³. Currently, nonabsorbable sutures are considered to yield good results. These sutures are passed *via* the patellar bone tunnels. Due to its excellent outcomes, this method has been highly effective for acute quadriceps tendon ruptures⁴. However, recent repair techniques with suture anchors have been advocated as less invasive alternatives that require shorter operative time, allow for early initiation of rehabilitation protocols, and reduce the risk of iatrogenic patella fracture or damage⁵.

The Idea and Advantages of the Novel Repair and Augmentation Approach

A sufficient tendon-to-bone anchorage enables increased compression across the quadriceps tendon footprint, resulting in maximal healing. A stronger repair would allow for accelerated rehabilitation. The modern double-row rotator cuff method exhibits superior biomechanical properties, such as strength, load to failure, stiffness, and gapping. These properties are based on a high load-to-failure ratio and improved tendon footprint restoration⁶. Internal brace ligament augmentation is based on the concept of ligament repair bridging, in which a high-tensile strength suture tape is employed to initiate early healing. In addition, the suture functions as a secondary stabilizer and serves as a check rein that is only loaded at the end of the range. This suture provides enough strength and permits early mobilization or acts as a scaffold for tissue ingrowth. Internal braces with ligament and tendon repairs provide extra stability in the anterior cruciate ligament and Achilles repairs^{7,8}. However, it is unclear whether these results can be applied to quadriceps tendon ruptures.

A recent cadaveric biomechanical study proposed a novel approach for QTR repair, which is biomechanically more effective than traditional fixation methods^{4,9}. However, this method does not reinforce the tendon at the tendon-to-bone site, and long suture tape utilized in this study is difficult to obtain. So far, few studies have explored restoring footprint contact area or increasing tendon-to-bone compression while avoiding retears or failure to heal following repair surgery.

In this study, we have described our preferred modified method for QTR repair using an internal brace constructed with a 4.75-mm biocomposite knotless suture anchor and suture tape. This method has several advantages. First, our method required minimal surgical exposure and less operative time than traditional transosseous repair techniques. Second, two wide suture taps from two 4.75-mm SwiveLock[®] anchors and a #2 high-strength suture in the interlocking Bunnell method are employed to repair QTRs by providing internal brace reconstruction. The suture method is easy to perform, and the strength of suture is equivalent or superior to that of locking Krackow stitch with a shorter operative time^{10,11}. It is cheaper than the suture anchor repair and avoids long suture tap. Third, the double-row suture-bridge lateral augmentation construct is developed with wider sutures, which prevent suture pull-through due to dissipation of applied forces across large surface areas of the tendon. Based on previous reports, we speculated that the modified double-row suture-bridge construct enhances the strength of repair construct of quadriceps tendon relative to other methods. Moreover, the double-row suture-bridge augmentation provides an extra fixation that prevents suture pullout in patients having poor bone stock, particularly those with osteoporosis. It improves the outcomes of these patients to a level that is comparable to that of patients with healthier bone stock. This fixation technique prevents possible knot protrusion, which is common in suture anchor repair methods. Finally, this efficient repair and augmentation allow the patient to start physical therapy earlier and aggressively. This might result in improved outcomes by alleviating quadriceps weakness and knee stiffness.

To our knowledge, there are no similar reports of using a double-row repairment and augmentation using a knotless suture anchor and internal brace to repair acute QTRs. The approach is reproducible and has demonstrated superior clinical outcomes.

Limitations

This study has the following limitations: (i) this study was conducted on a single case; (ii) we lacked a control group treated with a different repair method; (iii) no relevant cadaveric biomechanical tests were conducted on whether this double-row repair is superior to traditional fixation techniques. As a result, additional studies with a larger sample size, control groups, and cadaveric biomechanical analyses are required to confirm our findings.

Conclusion

Simultaneous bilateral quadriceps tendon rupture is a rare condition. Novel double-row repairment and augmentation technique for acute QTRs using knotless sutures and the internal brace is a practical approach and offers outstanding clinical results. This technique may be an effective method in repairing ruptured quadriceps tendons.

Ethical Approval

This case study, including its publication, was approved by the Ethics Committee of Xiaolan Affiliated Hospital of Southern Medical University, Zhongshan, Guangdong Province, China.

Informed Consent

Written informed consent was obtained from the patient for the publication of the case report and the accompanying images.

Acknowledgements

The authors are grateful to the patient for participating in this case report.

Authors' Contributions

The repair method was proposed by Xiaoping Wang and Yumin Tu, and the main surgical process was performed by Xiaoping Wang. The first draft of the manuscript was written by Daoqiang Huang and Weili Feng. The rehabilitative guidance and follow-up for the patient was performed by Weiwei Wu, Jian Huang, and Luyao Chen. All authors commented on previous versions of the manuscript and approved the final manuscript.

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