Technical Note

Re-tensionable Quadriceps Tendon Repair Technique

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Abstract: Quadriceps tendon rupture is a devastating injury that has traditionally been repaired using bone tunnels and knot tying. Recent innovations seeking to address persistent weakness and gap formation of repairs have used suture anchors and knotless technology. Despite these innovations, the clinical outcomes of these repairs continue to be mixed. We describe a technique that leverages a pre-tied knotted high-tension suture construct to allow for a re-tensionable quadriceps repair.

Quadriceps tendon rupture is a rare devastating injury resulting in significant disability and pain. Prompt operative treatment of this injury is critical in nearly all cases because of the impact on the extensor mechanism function.[1,2] The optimal surgical technique is a source of much discussion and research, with the 2 most common techniques being repair via transosseous patellar tunnels with suture tied over bone bridges and the more recent suture anchor repair.[1] The historic standard has involved 3 bone tunnels with knots tied. Biomechanical studies on these techniques have shown promising characteristics of suture anchor techniques, including decreased gap formation on cyclic loading,[3,4] with at least 1 study also reporting increased stiffness and ultimate load to failure.[5] Suture anchor techniques capitalize on the reproducible and mechanically sound mechanism of the anchor to secure the tendon in contrast to the variability seen in knot tying. Despite these advantages, the suture anchor techniques described to date require application of a distal force vector on the patella to insert the anchors, which is the same force that the anchors are being used to counteract. In addition, one of the limitations of both of the aforementioned techniques is the inability to re-tension the constructs after they have been secured and cycled, raising the potential for gap formation with both. For this reason, we present a re-tensionable quadriceps tendon repair technique (Video 1). Table 1 presents some of the advantages and disadvantages of the technique.

Surgical Technique

The patient is positioned supine on the operating room table with the ipsilateral hip on a bump to allow for neutral orientation of the knee. We prefer to use a leg bump as well, such as a Ramp Leg Elevator (BoneFoam, Corcoran, MN). The leg is prepared and draped to the mid thigh with a nonsterile tourniquet placed under the draping.

With the leg exsanguinated and the tourniquet inflated, a standard midline incision is made over the quadriceps tendon defect, exposing the distal tendon

Table 1. Advantages and Disadvantages of Re-tensionable Quadriceps Tendon Repair Technique

Advantages
Mechanical advantage of pulley and screw mechanisms
Ability to perform re-tensioning multiple times after knee flexion
Pre-tied knot increases consistency of repair
Smaller drill hole diameter than repair with suture anchors
Securing construct Pulls patella to quadriceps as opposed to pushing it away
Potentially less expensive and less equipment required than repair with suture anchors
Disadvantages
Potentially prominent knot
Exposure of distal pole of patella required

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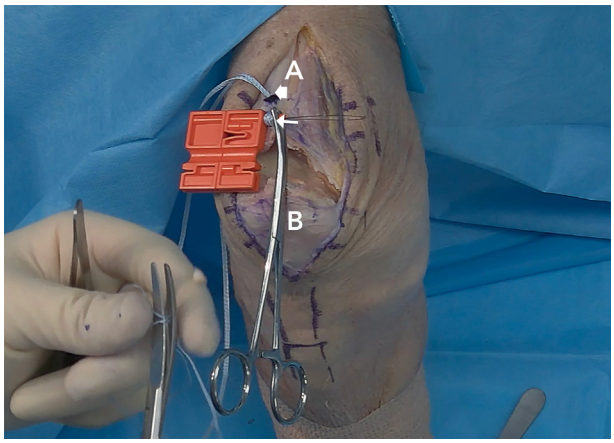

Fig 1. Anteroposterior view of right knee centered on quadriceps tendon rupture. The quadriceps tendon (A) and the patella (B) are identified. A full-thickness bite of the tendon is taken, centered on the quadriceps and starting 20 mm proximal to the tear, using the swedged FiberTape cerclage. The pre-tied knot must be pulled flush with the tendon at this point to ensure appropriate knot tightening. The narrow arrow indicates the starting point of the bite, as well as the pre-tied knot. The broad arrow indicates the exit of the retrograde bite.

and the patella. The hematoma is removed, and the degenerative portion of the tendon is sharply debrided back to healthy tissue. The remnant tendon on the superior pole of the patella is also resected. With a focus on the superior pole of the patella, the area of the quadriceps insertion is gently decorticated to bleeding bone to facilitate healing. Care is also taken to evaluate tearing of the medial and lateral retinaculum because it is important to repair extension of the tear into the retinaculum.

The swedged ends of a FiberTape cerclage (Arthrex, Naples, FL) are passed on a free needle (reverse cutting needle [AR-7280]; Arthrex) through the central quadriceps tendon with a full-thickness vertical bite (Fig 1). This retrograde pass is centered in the tendon and starts 20 mm proximal to the distal margin of the ruptured tendon. The pre-tied knot and the suture-passing plastic are then pulled down to the quadriceps tendon so that there is no slack.

Next, the swedge of the fibertape is cut and the 2 limbs of the FiberTape cerclage are divided. One simple stitch is passed proximally and medially with one limb and is passed proximally and laterally with the other limb. The medial limb is used for 3 Krackow locking sutures down the medial border of the tendon, and the lateral limb is used for 3 Krackow locking stitches down the lateral border of the quadriceps tendon (Fig 2). One additional pass of each limb is used to bring the firbertapes out the distal aspect of the tear. Care is taken to remove all slack during suturing.

At this point, 3 longitudinal tunnels are drilled through the patella in an antegrade fashion using a 2.4-mm Short Guide Pin (AR-1250SB; Arthrex) as in the case of a standard bone tunnel quadriceps tendon repair. The position of the medial hole is 5 mm from the medial border of the quadriceps insertion, the lateral hole is positioned 5 mm from the lateral border of the quadriceps insertion, and the central hole is positioned in the quadriceps tendon footprint, between the 2 aforementioned holes. The 2.4-mm Short Guide Pin can be used to used to facilitate both drilling and suture passage. The oscillating function of the drill is used to retrieve the guide pin distally to shuttle the sutures.

The loop of a FiberLink suture (Arthrex) is passed in an antegrade fashion down the central tunnel for shuttling (Fig 3). The lateral tape limb is passed in an antegrade fashion through the lateral bone tunnel, and the medial tape limb is passed in an antegrade fashion through the medial bone tunnel. The medial and lateral FiberTapes are then both retrieved and shuttled in a retrograde fashion through the central tunnel using the FiberLink (Fig 4).

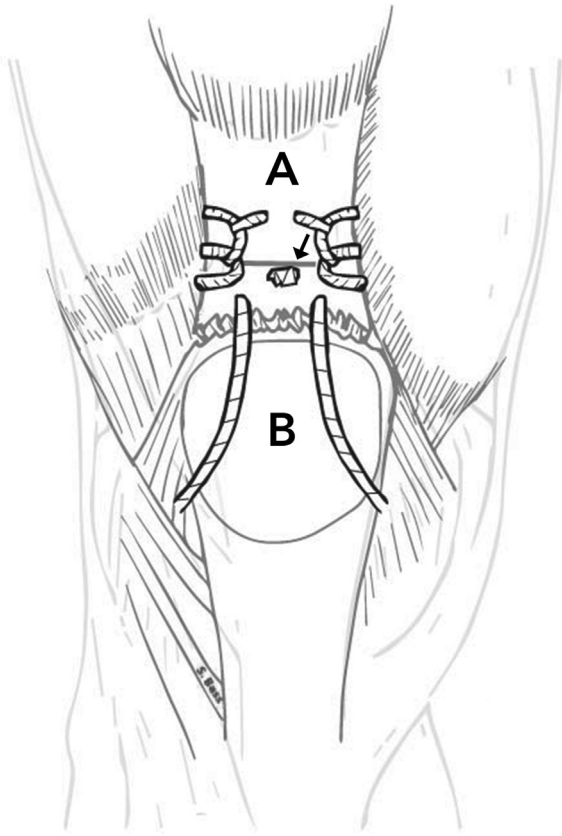

Fig 2. Anteroposterior view of right knee showing running locking Krackow stitches along medial and lateral borders of quadriceps tendon. The quadriceps tendon (A) and the patella (B) are identified. The shuttling device is not shown for the sake of clarity. The arrow points to the pre-tied knot, which has been pulled down to the quadriceps tendon. The locking stitches need to be redressed before final tightening of the construct to ensure that the pre-tied knot tightens correctly.

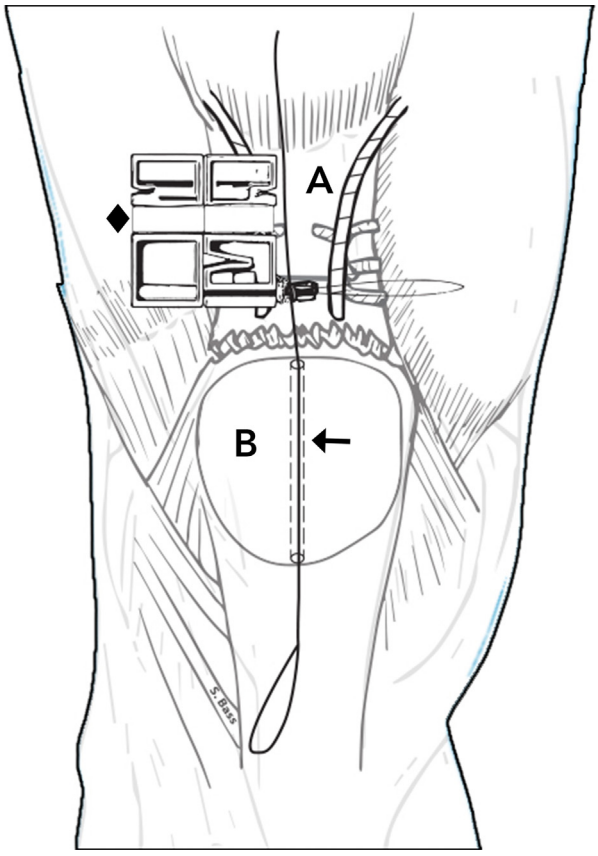

Fig 3. Anteroposterior view of right knee. The quadriceps tendon (A) and the patella (B) are identified. The shuttling device is indicated by the diamond. The loop of a looped suture (narrow arrow) is shuttled in an antegrade manner through the central tunnel. The 2 tape limbs are pulled proximally in the illustration for the sake of clarity.

A free needle is used to make an independent full-thickness pass of each tape limb through the distal central margin of the quadriceps tendon tear from the midsubstance to the bursal surface, exiting approximately 5 to 10 mm from the distal margin of the tear. This step is important because it allows for the tensioned knot to function as a bolster of the central tendon to the proximal patella. The 2 ends of the cerclage tape are then pulled independently, through the pre-tied knot, using the cerclage tape suture-passing device (Fig 5). At this point, the suturing of the quadriceps should be redressed to remove any slack from the Krackow sutures and to bring the pre-tied knot back down to the quadriceps tendon at its original position 20 mm from the margin. This is critical to ensure that the pre-tied knot tightens appropriately. Each tape is then independently tensioned manually until the quadriceps tendon is reapproximated to the proximal border of the patella (Fig 6). The tape tensioner (FiberTape cerclage tensioner; Arthrex) is used to mechanically tension the sutures (Fig 7). The knee is then brought into 90° of flexion to remove creep and slack from the system. One half-hitch is thrown to allow for re-tensioning of the construct. The knee is then ranged again, and the cerclage tape tensioner is used to remove slack. Three alternating half-hitches are placed to lock the construct. The FiberTape tails can now be used to reinforce the repair or can be cut using a scalpel.

The repair is oversewn using a No. 0 Vicryl suture (Ethicon, Somerville, NJ). Any retinacular tears are then repaired using No. 0 Vicryl in an interrupted figure-of-8 fashion. The wound is irrigated and closed in a layered fashion with No. 2-0 Vicryl for deep dermal closure and No. 3-0 Monocryl (Ethicon) for running subcuticular closure. The wound is then reinforced with the Prineo Wound Closure System (Ethicon). Some pearls and pitfalls of the surgical technique are outlined in Table 2.

Postoperative Rehabilitation

The patient is placed into a hinged knee brace locked in extension (T Scope; Breg, Carlsbad, CA). The patient is allowed to bear weight with crutches with the knee locked in extension. Starting at 2 weeks postoperatively,

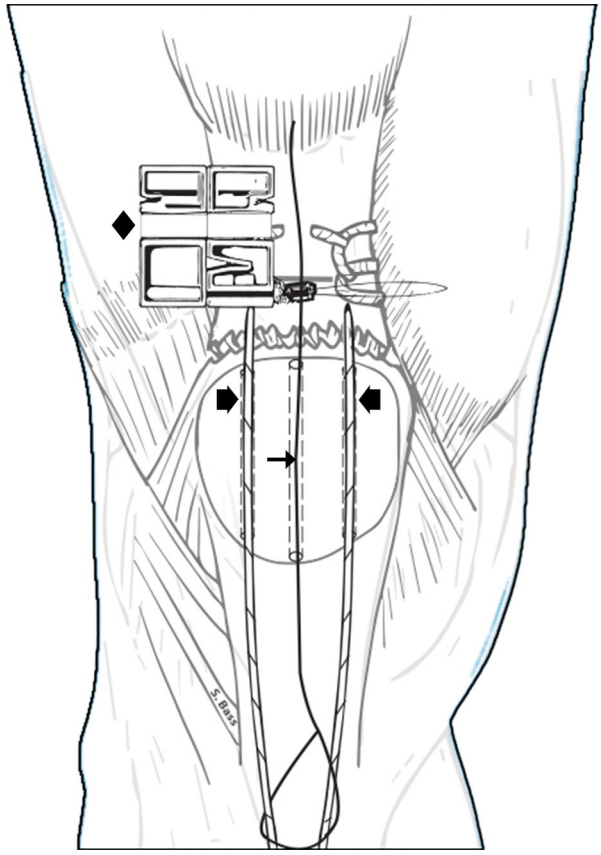

Fig 4. Anteroposterior view of right knee. The shuttling device is indicated by the diamond. The medial and lateral limbs have already been passed through the medial and lateral transosseous tunnels (broad arrows). The loop of a looped suture (narrow arrow) is shuttled in an antegrade manner through the central tunnel for retrieval of the 2 limbs.

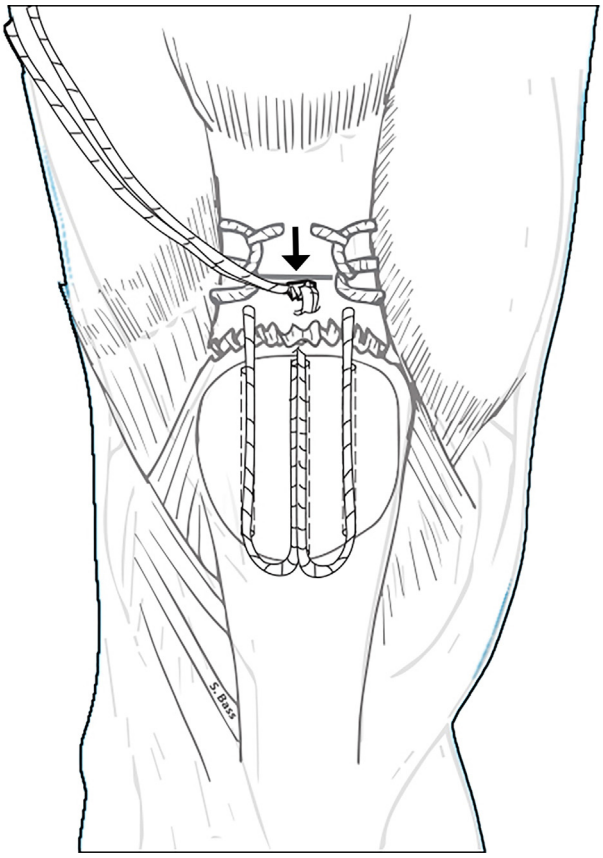

Fig 5. Anteroposterior view of right knee. Independent bites of the proximal tendon are taken through the tear before the 2 limbs are shuttled through the pre-tied knot using the shuttling device. The arrow indicates the pre-tied knot with the 2 limbs shuttled through it. Slack must be removed, and the pre-tied knot must be pulled down to the quadriceps tendon to ensure that it tightens most effectively.

the patient can begin gentle range of motion from 0° to 45° when non–weight bearing. At 6 weeks, the patient can unlock the brace from 0° to 45° while weight bearing and gradually increase with a goal of discontinuing use of the brace by week 8.

Discussion

Quadriceps tendon repair is a technique that has seen marked innovation in the past 10 years.[6,7] Authors have leveraged the dependable improvements in suture anchors and knotless technology to show significant improvements in the biomechanical reliability of new repair techniques.[3,5,7,8] Despite this, there continues to be room for improvement, with persistent deficits in terms of clinical outcomes reported in the literature.[9-11] In addition, with reliance on new implants, there is the ever-present concern of increasing the cost of a historically inexpensive procedure.

The proposed technique has several advantages over traditional transosseous repair as well as suture anchor repair. First, there is a built-in 2-to-1 mechanical advantage of the pulley formed by the repair coupled with the screw-type mechanical advantage of the tensioner. This allows for better compression of the tendon to the patella and is particularly advantageous in the setting of a quadriceps rupture with a delayed presentation. Second, the pre-tied knot allows for re-tensioning of the construct to remove any slack from the system. This allows for anticipation of gap formation and removal by re-tensioning until the second locking half-hitch is thrown. This could theoretically enable earlier, more aggressive rehabilitation as suggested by West et al.[12] Third, the theoretical simplicity of the procedure allows for quick and reproducible application with limited cost and supply needs.

Several critical steps are required for our technique to function. First, all slack must be removed from the sutures in the Krackow locking stitches, and the pre-tied knot must be pulled flush with the quadriceps tendon as proximally as possible. This is critical because the pre-tied knot must be under tension to tighten appropriately. This is best achieved after the 2 tails are shuttled

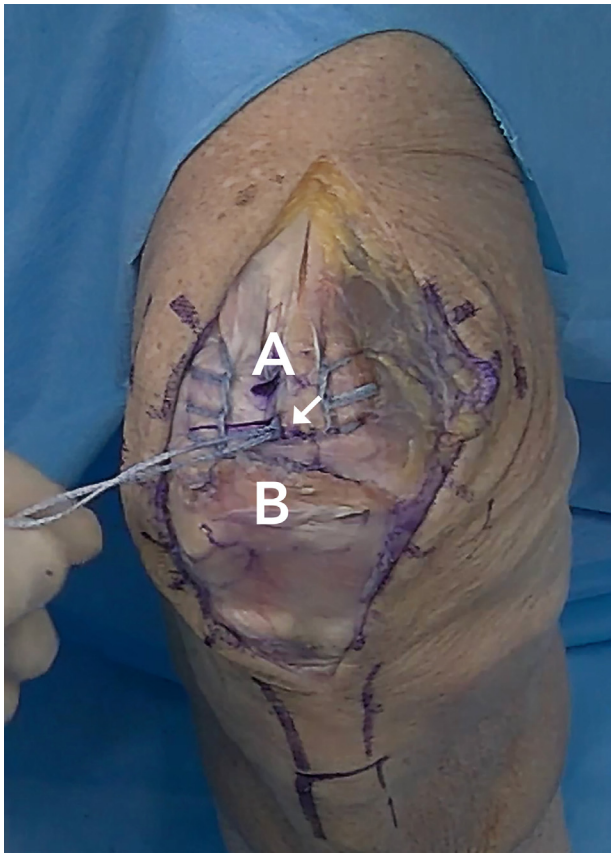

Fig 6. Anteroposterior view of right knee. The Krackow stitches have been redressed to remove any slack and to pull the pre-tied knot proximally before final tightening. The arrow points to the pre-tied knot, which is seated and tensioned appropriately with both limbs passed through it. The quadriceps tendon (A) and the patella (B) are identified. The gap between the 2 has been fully compressed.

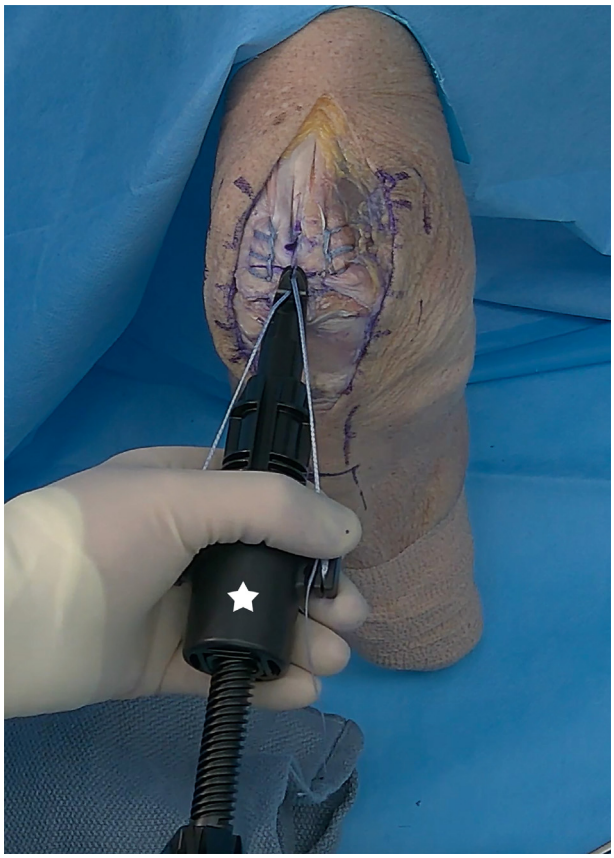

Fig 7. Anteroposterior view of right knee. The tensioner device (white star) is used to mechanically remove tension from the system after 1 half-hitch has been thrown. This can be repeated multiple times after the knee is flexed and remains effective until alternating, locking half-hitches are thrown.

through the pre-tied knot because it will prevent accidental pre-tightening or loss of the knot through the quadriceps tissue. Second, the first pass should start 20 mm up from the tear on the quadriceps. This allows for tolerance of some of the inevitable slack in tensioning. Third, once passed in an antegrade fashion and retrieved in a retrograde fashion through the central tunnel, the 2 limbs must be passed through the distal margin. This allows for the knot to function as a bolster and creates compression at each of the 3 tunnel sites. Finally, although experiential observation has shown good outcomes of this technique performed by 2 surgeons, further study is necessary to support this biomechanically and clinically.

Table 2. Pearls and Pitfalls of Re-tensionable Quadriceps Tendon Repair Technique

Pearls
The surgeon should remove all slack from the medial and lateral Krackow stitches and bring the pre-tied knot down to the quadriceps tendon. This is best performed after shuttling of the 2 limbs through the pre-tied knot. Slack can still be removed if the pre-tied knot fails to tighten because of too much slack.
A 2.4-mm short drill can be used to shuttle the sutures as well as to drill.
Articular injury should be avoided by using the appropriate drill trajectory.
After bone passage of the 2 limbs in an antegrade manner and retrograde manner, each should be passed independently through the distal margin of the tendon to create a bolster effect and ensure appropriate positioning.
Pitfalls
Failure to remove slack will result in failure of the pre-tied knot to tighten appropriately.
Failure to lay a knot stack flat may lead to prominence.

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