Knotless Suture Anchor With Suture Tape Quadriceps Tendon Repair Is Biomechanically Superior to Transosseous and Traditional Suture Anchor—Based Repairs in a Cadaveric Model

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Purpose: To compare the biomechanical properties of a knotless suture anchor with suture tape quadriceps tendon repair technique with transosseous and suture anchor repair techniques. **Methods:** Twenty matched pairs of cadaveric knees underwent a quadriceps tendon avulsion followed by repair via the use of transosseous tunnels with #2 high-strength sutures, 5.5-mm biocomposite fully threaded suture anchors with #2 high-strength sutures, or 4.75-mm biocomposite knotless suture anchors with suture tape. Ten knees were repaired via transosseous repair and 10 via fully threaded suture anchor repair, and their matched specimens were repaired with suture tape and knotless anchors. Biomechanical analysis included displacement during cyclic loading over 250 cycles, construct stiffness, ultimate load to failure, and failure mode analysis. **Results:** Compared with transosseous repairs, quadriceps tendons repaired with knotless suture tape demonstrated significantly less displacement during cyclic loading (cycles 1-20 3.6 ± 1.3 *v* 6.3 ± 1.9 mm, $P = .003$; cycles 20-250 2.0 ± 0.4 *v* 3.1 ± 0.9 mm, $P = .011$), improved construct stiffness (67 ± 25 *v* 26 ± 12 N/mm, $P = .001$), and greater ultimate load to failure (616 ± 149 *v* 413 ± 107 N, $P = .004$). Our repair technique also demonstrated improved biomechanical parameters compared with fully threaded suture anchor repair in initial displacement during cyclic loading (cycles 1-20 3.0 ± 0.8 *v* 5.1 ± 0.9 mm, $P < .001$), construct stiffness (62 ± 20 *v* 28 ± 10 N/mm, $P = .001$) and ultimate load to failure (579 ± 129 *v* 399 ± 87 N, $P = .006$). **Conclusions:** Repair of quadriceps tendon ruptures with this knotless suture anchor with suture tape repair technique is biomechanically superior in cyclic displacement, construct stiffness, and ultimate load to failure compared with transosseous and fully threaded suture anchor techniques in cadaveric specimens. **Clinical Relevance:** The demonstration that our repair technique is biomechanically superior to previously described techniques in a cadaveric setting suggests that consideration should be given to this technique.

Quadriceps tendon rupture represents an uncommon clinically entity with potentially devastating complications for a patient's knee function.[1-8] Clayton and Court-Brwon[9] recently reviewed the epidemiology of tendinous and ligamentous injuries and demonstrated quadriceps tendon injuries represented 1.3% of all such injuries with an average age of 50.7 years. These patients suffer routinely from serious medical comorbidities such as diabetes mellitus, renal failure, and disorders requiring long-term steroid use.[1-3,5,10-14] Quadriceps tendon rupture commonly occurs in an attenuated tendon during eccentric contraction such as during a simple fall.[1,2,5,13,14] Nonoperative management is appropriate for partial tears with an intact extensor mechanism; however, prompt operative intervention is indicated in cases of complete tear or an incompetent extensor mechanism.[1-3,12,13] Currently, the standard of care consists of repair with the use of nonabsorbable suture via transosseous tunnels[2,4,7,11,14]; however, newer repair techniques that use suture anchors have been described in the literature.[4,7,8,11,14-16]

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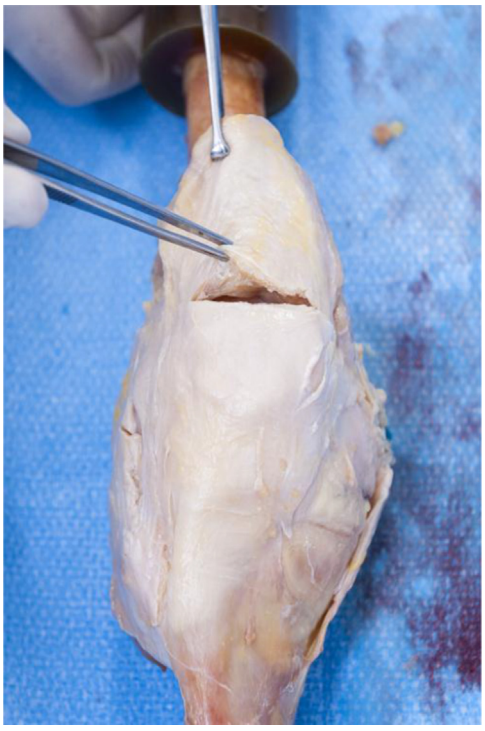

Fig 1. Simulated quadriceps tendon tear, anterior view. Photograph showing simulated quadriceps tendon tear in one of the cadaveric knees.

Currently, there is a paucity of evidence to support the superiority of transosseous tunnels over other techniques, and outcome studies have failed to show consistently excellent results in terms of functional outcomes. Outcome studies have reported clinically significant extension lag in greater than 20% of patients,[17-19] decreased range of motion of 8° compared with the contralateral knee,[12,20] quadriceps weakness greater than 20% in more than half their treated patients,[20] failure of more than half of patients to return to their preinjury level of athletic pursuit,[12,20] and chronic pain in one-third of patients. Problems with established repair techniques include prolonged operative time, extensive surgical dissection, and the need for transosseous tunnels with reports of resultant stress fractures reported in the literature.[6,16] Patients frequently endure prolonged knee immobilization postoperatively to preserve repair; however, this limits early functional rehabilitation, which has been shown to be associated with good and excellent Lysholm scores.[1,5,10,11,13,16,18,21]

There have been several case reports and 3 biomechanical studies evaluating the use of suture anchors in quadriceps tendon repair.[4,7,8,11,14-16] Three biomechanical studies have shown mixed results with suture anchors; one each demonstrated improved,[14] equal,[4] and worse[7] biomechanical characteristics with suture anchor fixation compared with transosseous fixation. Although controversy exists regarding strength of suture anchor repair, the authors of previous case reports have advocated earlier range of motion with suture anchors than with transosseous tunnel repair.[11,16]

The purpose of this study was to compare the biomechanical properties of a knotless suture anchor with suture tape quadriceps tendon repair technique with transosseous and suture anchor repair techniques. Our hypothesis is that knotless suture tape quadriceps tendon repair is biomechanically superior to transosseous tunnel and suture anchor repair techniques in a cadaveric model.

Methods

Twenty pairs of fresh frozen cadaveric knees (N = 40) were obtained for this study (Science Care, Aurora CO; LifeLegacy Foundation, Tucson, AZ). The specimens were thawed for 24 hours before undergoing a simulated quadriceps tendon tear (Fig 1) followed by repair with the use of transosseous tunnels with #2 high-strength suture (FiberWire; Arthrex, Naples, FL) 5.5-mm biocomposite fully threaded suture anchors (these are traditional anchors and require knot tying; 5.5-mm biocomposite Corkscrew FT with FiberWire; Arthrex) or 4.75-mm biocomposite knotless suture anchor with suture tape (4.75-mm knotless FiberTape repair with biocomposite SwiveLock suture anchor; Arthrex). Ten knees per group were repaired by the use of transosseous (n = 10) or 5.5-mm biocomposite fully threaded suture anchors (n = 10) and their matched specimens repaired with a 4.75-mm biocomposite knotless suture anchor with suture tape (n = 20). Matched pairs were alternated right and left during repair for randomization. All tendons were grossly examined before the study and were determined to be uninjured. Repair techniques are described individually in the sections to follow.

The knees (average age = 54.9 ± 13.7 years, 14 male, 6 female) were prepared by removing all soft tissues, save patellar tendon, the knee ligaments, and about 4 to 5 inches of the distal quadriceps tendon. A sharp blade was used to create a quadriceps tendon avulsion from the proximal edge of the patella, as shown in Figure 1. Retinacula were left intact until after repair to limit soft-tissue excursion during repair (Fig 1). Repairs were then performed, as described below, by the senior author (J.M.P.).

Transosseous Repair

After we debrided the distal quadriceps tendon, standard locking Krackow sutures were placed within the quadriceps tendon with 5 passes in a distal to proximal then a proximal to distal direction with a #2 high-strength suture. We then placed 1 suture medially with the 2 tails exiting the distal aspect of the quadriceps tendon and the other suture laterally with its 2 tails exiting the distal aspect of the quadriceps tendon for a