Distal Triceps Knotless Anatomic Footprint Repair Is Superior to Transosseous Cruciate Repair: A Biomechanical Comparison

Jonathan Clark, M.D., Elifho Obopilwe, M.S., Angelo Rizzi, P.A.C., David E. Komatsu, Ph.D., Hardeep Singh, B.S., Augustus D. Mazzocca, M.D., M.S., and James M. Paci, M.D.

Purpose: The purpose of this study was to evaluate the biomechanical properties of a method of repair using bone tunnels with multiple high-strength nonabsorbable sutures and one knotless suture anchor compared with the standard transosseous technique for repair of the distal triceps. **Methods:** The triceps tendon footprint was measured in 18 cadaveric elbows (9 matched pairs), and a distal tendon rupture was created. Eighteen elbows (9 matched pairs) were randomly assigned to one of 2 repair groups: transosseous cruciate repair group or knotless anatomic footprint repair group. Cyclic loading was performed for a total of 1,500 cycles and displacement was measured. Data for load at yield and peak load were obtained. **Results:** The average bony footprint of the triceps tendon was 466 mm^2. Cyclic loading of tendons from the 2 repair types showed that the knotless anatomic footprint repair produced less displacement when compared with the transosseous cruciate repair ($P < .05$). Load at yield and peak load were also greater in the knotless anatomic footprint repair group ($P < .05$). **Conclusions:** Distal triceps knotless anatomic footprint repair in a cadaveric model had a significantly higher load and cycle to failure when compared with the traditional transosseous cruciate repair and produced less repair site motion. **Clinical Relevance:** The increased biomechanical strength and resistance to displacement at the tendon-bone interface may lead to improved clinical outcomes with the knotless anatomic footprint repair technique and warrants further clinical study.

Distal triceps tendon ruptures are rare and infrequently reported injuries. Anzel et al.[1] reviewed 1,014 tendon injuries and found only 0.8% to involve the distal triceps. The mechanism of injury is usually the result of an eccentric muscle contraction caused by an opposing force applied against an actively contracting triceps muscle. This commonly occurs while weight lifting or from a fall on an outstretched arm.[2] A direct blow or laceration to the tendon has also been described as a potential mechanism of injury.[3] Triceps tendon ruptures can also occur spontaneously with systemic diseases (particularly metabolic bone diseases such as hyperparathyroidism),[4] chronic corticosteroid use, corticosteroid injections for triceps tendonitis or olecranon bursitis,[5] or anabolic steroid use. Male individuals are roughly twice as likely to sustain this injury, and professional football players appear to be among the highest risk groups.[6] Most ruptures are located at the tendon insertion, but musculotendinous junction and muscle belly tears[7,8] have been described. Partial tears may also occur, which may be repaired using open or arthroscopic techniques.[9]

The traditional gold standard surgical treatment of triceps tendon rupture is a transosseous cruciate repair in which sutures placed in the distal triceps tendon are passed through crossed bone tunnels, drilled through the olecranon, and tied over a bone bridge.

More recently, repairs using newer techniques, such as suture anchor fixation and double-row repairs analogous to the transosseous equivalent repairs used in arthroscopic rotator cuff fixation, have been proposed.

From Department of Orthopaedic Surgery, Stony Brook University School of Medicine (J.C., A.R., D.E.K., J.M.P.), Stony Brook, New York; and Human Soft Tissue Research Laboratory, New England Musculoskeletal Institute, University of Connecticut Health Center (E.O., H.S., A.D.M.), Farmington, Connecticut, U.S.A.

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Address correspondence to James M. Paci, M.D., Department of Orthopaedic Surgery, Stony Brook University School of Medicine, 8181 SUNY HSC T-18 RM 020, Stony Brook, NY 11794, U.S.A. E-mail: james.paci@stonybrookmedicine.edu

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These studies describe biomechanically stronger and more anatomic repairs of the triceps tendon footprint using these suture anchor—based repair techniques.

Previously reported suture anchor techniques that require 2 to 4 suture anchors pose a theoretical risk of ulnohumeral joint penetration. In addition, these techniques require multiple knots using high-strength nonabsorbable suture in an area with a tenuous soft tissue envelope.

The purpose of this study was to evaluate the biomechanical properties of a method of repair using bone tunnels with multiple high-strength nonabsorbable sutures and one knotless suture anchor and compare it with the standard transosseous technique for repair of the distal triceps. We hypothesized that knotless anatomic footprint distal triceps repair would recreate the anatomic triceps insertion with increased load at yield and peak load and decreased displacement with cyclic loading compared with the transosseous cruciate repair technique.

Methods

Nine matched pairs (18 total) cadaveric elbows were used in this study. Each elbow was dissected to expose the tendinous insertion of the triceps onto the olecranon. The triceps tendon was then dissected off its bony insertion. Anatomic measurements were obtained with a gliding digital caliper (Absolute Digimatic; Mitutoyo C, Kawasaki, Japan) that allowed measurement of distances as small as 0.01 mm. The distal triceps footprint on the olecranon was measured in the proximal-to-distal and the medial-to-lateral planes. The area of the triceps bony insertion ‘‘footprint’’ was then calculated using the formula: area $=$ length $\times$ width. Each variable was measured once with the gliding digital caliper. These values were then averaged and standard deviations calculated using Microsoft Excel (Microsoft, Redmond, WA). Because this was a cadaveric study using specimens obtained from individuals significantly older than the typical clinical patient presenting with acute distal triceps rupture, dual-energy x-ray absorptiometry (DXA) bone mineral density was obtained at the olecranon as the region of interest to ensure that there was no significant difference in the quality of bone within the specimens tested. (Lunar DXE, Madison, WI).

Two treatment groups were then created, and one elbow from each matched pair was randomly assigned to each treatment group: transosseous cruciate repair technique ($n = 9$) or knotless anatomic footprint repair ($n = 9$). The triceps was then repaired according to the predetermined repair method.

Surgical Preparation

Transosseous Cruciate Suture Technique Triceps Repair. In a fashion similar to the technique used by van Riet et al.,[10] a transosseous cruciate suture technique distal triceps repair was performed. After debridement of any grossly pathologic tendon tissue, one No. 2 high-strength nonabsorbable suture was used to suture the triceps tendon in locking Krakow fashion with 5 passes up and down starting and ending at the distal triceps tendon tip medially and laterally, as previously described by Yeh et al.[11] The triceps footprint was identified, and crossed 2-mm tunnels were drilled from the proximal footprint to the dorsal ulnar surface, taking care to avoid entering the ulnohumeral joint. A suture passer was then used to pass the medial and lateral strands through the crossed tunnels. The elbow was cycled, and the sutures were then tied using a surgeons knot followed by 3 alternating half-hitches for a total of 5 throws. The decision to use 5 throws was based on previous studies that found increased square knot strength with an increasing number of throws up to 5 throws, after which the increase in strength leveled off.[12,13]

Knotless Anatomic Footprint Triceps Repair. The distal triceps tendon was debrided of any pathologic tendon tissue. The proximal extent of the footprint was identified and marked on the distal triceps with a pen. The distance from the tendon tip was verified by measuring the bony footprint on the olecranon. Two No. 2 high-strength nonabsorbable sutures were then passed in locking Krakow fashion starting and ending at the anterior aspect of the triceps at the proximal footprint line, taking care not to exit too far distally and making sure to enter and exit the anterior surface of the tendon (Fig 1A). Two No. 2 high-strength nonabsorbable loop-containing sutures were then passed at the proximal footprint line, one medially and the other laterally, with the looped end of the suture exiting the posterior triceps tendon (Fig 1B). The olecranon was then prepared by first debriding the triceps footprint to a clean bony bed for improved healing response. A 2-mm drill bit was then used to drill 2 parallel tunnels from the proximal footprint distal to the dorsal ulnar surface, taking care to be far medial and lateral while avoiding penetration of the joint surface (Fig 2A). The exiting holes should leave enough room to drill for placement of a 4.75-mm BioComposite SwiveLock suture anchor (Arthrex, Naples, FL) between the 2-mm tunnels. The drill for the 4.75-mm SwiveLock anchor was then passed followed by a tap between the 2-mm tunnels distally, aiming away from the joint (Fig 2B). Using a Hewson suture passer, the 3 medial sutures were passed through the medial tunnel proximally to distally. In similar fashion, the 3 lateral strands were passed through the lateral tunnel (Fig 3A). The medial strands were then marked with a pen. One strand from each of the medial and lateral Krakow strands