Triceps Repair and Restoration of Triceps Footprint With Anchorless Suture Fixation

Matthew Steffes, MD, Samantha Tayne, MD,* Feroz Osmani, MD,* Gary Edwards, MD,* Kyle MacGillis, MD,* Walter Kim, MD,* Jon E. Hammarstedt, MD,† and Benjamin Goldberg, MD**

Abstract: Triceps tendon rupture is an uncommon yet potentially devastating injury affecting patients over a broad demographic. Surgical treatment is essential to restore upper extremity functional status, and a vast array of techniques has been implemented with different fixation devices including suture buttons, intraosseous anchors, and suture repairs. Outcomes of distal triceps tendon repair have demonstrated nearly full return of functional capacity. Complications include infection, ulnar nerve neuropathy, arthrofibrosis, flexion contracture, hardware irritation, and most commonly, repair failure. We illustrate a triceps repair technique with suture fixation that restores the tendinous footprint without need of an adjunctive device.

Key Words: triceps rupture, suture anchor, triceps repair, elbow surgery

(*Tech Hand Surg* 2018;22: 89–93)

Triceps tendon rupture is an uncommon yet potentially devastating injury affecting patients over a broad demographic.[1,2] Distal triceps tendon rupture is most commonly seen in the active population, associated with weight lifters or high-energy trauma.[1,2] Other risk factors include local or anabolic steroid use, olecranon bursitis, hemodialysis, metabolic bone disease, hyperparathyroidism, and chronic renal failure.[1] The most common mechanism of injury is sudden eccentric loading on a contracted triceps muscle, often seen in a fall on an outstretched hand and heavy weight lifting.[2] The vast majority of triceps tendon ruptures occur at the olecranon insertional footprint and less frequently at the muscle belly or myotendinous junction.[3]

Surgical treatment is essential to restore upper extremity functional status, and a vast array of techniques have been implemented with different fixation devices including suture buttons and intraosseous anchors.[1] Surgical repair involves identification of rupture level with primary reattachment of the avulsed tendon to the olecranon footprint. The technique includes a Krackow or Bunnell stitch through the tendinous triceps, passage through transosseous drill holes into the olecranon, and tied over a bone bridge.[4] Other techniques involve direct tendon repair to a raised periosteal flap.[5] In the following described technique, we will illustrate a triceps repair technique with suture fixation that restores the tendinous footprint without need of an adjunctive device.

From the *Department of Orthopaedic Surgery, University of Illinois at Chicago, Chicago, IL; and †Department of Orthopaedic Surgery, Allegheny General Hospital, Pittsburgh, Pennsylvania.
Conflicts of Interest and Source of Funding: No support received from pharmaceutical, industry, or National Institutes of Health (NIH); Wellcome Trust; Howard Hughes Medical Institute (HHMI). The authors report no conflicts of interest.
Address correspondence and reprint requests to Matthew Steffes, MD, University of Illinois at Chicago College of Medicine, 835 S Wolcott Ave., M/C 844, Chicago, IL 60612. E-mail: msteffes8@gmail.com.
Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.

ANATOMY

The triceps brachii muscle is composed of 3 heads: the long, medial, and lateral. The long head originates at the infraglenoid tuberosity traversing both the glenohumeral and ulnohumeral joints. The long and lateral muscle bellies originate from the humerus and converge into a single confluent triceps tendon, at the distal posterior brachium. The medial head has a separate muscle belly originating distal to the spiral groove, which then forms a separate tendon with a muscle belly deep and more distal to the long and lateral head tendon. These tendons become confluent forming the proper triceps tendon, which inserts over a broad area rather than a point insertion.[6] This footprint begins on average 12 mm distal to the olecranon process with an overall area of 466 mm^2.[7] In addition, there is a lateral triceps expansion which inserts on the extensor carpi ulnaris and anconeus fascia, further contributing to the extensor mechanism. The triceps brachii myotendinous unit is the only muscle in the posterior compartment of the arm and acts to extend the forearm and hand to position it in the environment during reach and push off during chair rise. Both the proper triceps tendon and lateral expansion contribute to this function. Range of motion is full extension (0* flexion) to full flexion (135* flexion).[8]

INDICATIONS AND CONTRAINDICATIONS

Patients with triceps tendon rupture present with pain and swelling over the posterior aspect of the elbow with an extensor lag and diminished strength against resistance. Routine diagnostic radiographic imaging of the elbow, arm, and forearm is necessary to rule out secondary injuries and may also show the presence of bony avulsion from the olecranon, indicating tendon rupture.[2] MRI and ultrasonography serve to distinguish complete from partial tears.[9,10]

Triceps rupture management is dictated by the location of the tear, functional strength of the extremity, and the patient's medical and functional status. Generally, nonoperative treatment is indicated for partial tears (< 50% complete) of the muscle belly, musculotendinous junction, or tendon insertion without significant loss of function. Nonoperative treatment consists of splint immobilization for 4 weeks at 30 degrees of flexion.[11] Follow-up care and serial examination after physical therapy is necessary for evaluation of extension strength and range of motion.

Complete tears at the tendinous insertion associated with significant functional deficit are generally managed surgically.[12] Partial tears may also be managed surgically if located at the myotendinous junction or tendon insertion in highly active patients, athletes, and laborers, or in patients who have failed conservative therapy. Prompt intervention is necessary for adequate functional restoration and ideally should take place within 3 weeks of the injury.[2]

Unfortunately due to the rare nature of this injury, patients may be misdiagnosed or initially treated conservatively. This can

Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.

be problematic due to muscle and tendon retraction, causing direct reattachment to be difficult or impossible. Chronic triceps tendon ruptures may be treated with a variety of techniques as described by Sanchez-Sotelo and Morrey.[13]

SURGICAL TECHNIQUE

Setup

A regional anesthetic block is performed in addition to general anesthesia and intubation at the discretion of the anesthesia provider. The patient is then placed prone on a padded radiolucent table with operative extremity prepped and draped with a sterile tourniquet placed high on the arm.

Exposure

The arm is exsanguinated and a standard posterior incision is made over elbow that deviates laterally avoiding the olecranon process using a #10 scalpel blade (Fig. 1). Sharp dissection through the subcutaneous tissue is made raising small skin flaps laterally and medially. The ulnar nerve location is noted and decompressed if symptomatic or in chronic ruptures (Fig. 2). The tendon rupture is easily identifiable at this stage and the defect is exposed. The tendon edges are debrided and the insertional olecranon footprint is visualized and debrided of any loose connective tissues (Fig. 3).

Reconstruction

The proximal medial and lateral edge of the footprint is identified and a 0.062 K-wire is used to drill 2 parallel tunnels from proximal to distal through the olecranon and exiting at the proximal dorsal ulna (Fig. 4). A looped suture passer is then passed from proximal to distal to pull a looped #2 polyethylene suture through so that the loop is sitting through the distal hole of each tunnel. This is repeated in the second tunnel previously drilled. A Krackow locking stitch is then placed in the ruptured tendon using a #2 polyethylene suture (Figs. 5, 6). Each limb of the repair is then pulled through the corresponding bone tunnel from distal to proximal using the previously placed looped FiberWires. This approximates the ruptured tendon edge at the distal extent of the anatomic footprint with the bulk of the tendon lying over the footprint. The free suture ends coming out of the proximal olecranon tunnel holes are tied over the top of

FIGURE 1. Standard operating room setup with the patient in the prone position with a sterile tourniquet and posterior incision which deviated laterally to avoid the tip of the olecranon.

FIGURE 2. Surgical approach exposing the triceps tendon defect and identifying the ulnar nerve.

FIGURE 3. The free triceps tendon edges (forceps) and anatomic footprint is visualized.

Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.
Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.

FIGURE 4. Suture passer is placed antegrade through the tunnel.

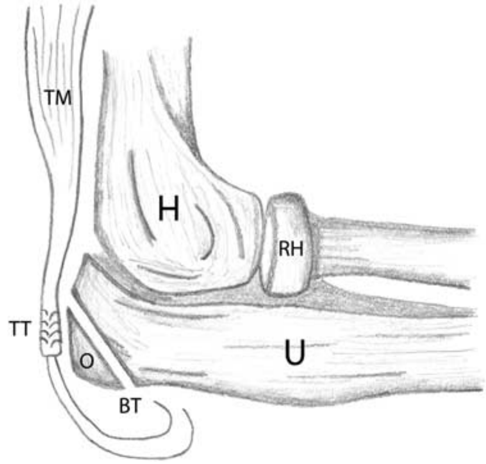

FIGURE 6. Orientation of the elbow structures in relation to the tendon repair. Humerus (H), Ulna (U), Radial head (RH), Olecranon (O), Bone tunnel (BT), Triceps muscle (TM), Triceps tendon (TT).

the tendon producing a repair analogous to a double row repair using transosseous tunnels (Figs. 7, 8).

Closure

Once the repair is securely tied, the repair is tested with range of motion of the elbow to ensure no gapping. The wound is irrigated with sterile warm saline and the retinaculum is closed over the repair with a 0-vicryl suture. Subcutaneous tissue is closed with

FIGURE 5. The tendon suture tails are pulled through the bony tunnels and tensioned.

FIGURE 7. The suture ends are tied superficial to the tendon.

Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.

Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.

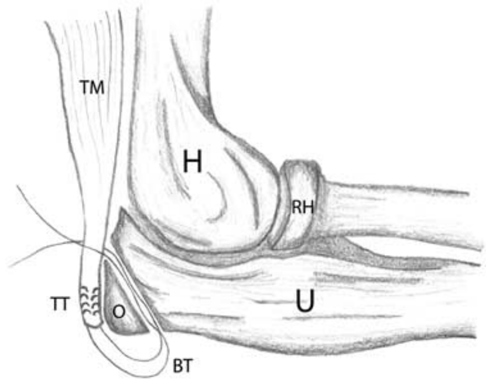

FIGURE 8. Diagram of the final repair. Humerus (H), Ulna (U), Radial head (RH), Olecranon (O), Bone tunnel (BT), Triceps muscle (TM), Triceps tendon (TT).

2-0 vicryl suture, followed by a subcuticular running 3-0 monofilament stitch, topical skin adhesive, and soft dressings.

Rehabilitation

A sling is used for transportation home and immediately discontinued and aggressive passive and active range of motion exercises are begun with a 1-pound weight restriction for 3 months. A supervised therapy program is offered on a patient-by-patient basis.

CASE SERIES

I have performed 3 of these procedures using the technique described over the course of 11 months. Average office visit follow-up was 3.7 months. Average phone call follow-up was 6 months. One patient was lost to follow-up after 1 month and was unable to be reached by phone. We routinely dismiss patients by the 3-month mark unless complications or other issues arise. The other 2 patients have done well and I have had no tendon repair failures at the date of submission. The patient lost to follow-up did note numbness and tingling of the ulnar-distributed fingers that was not present preoperatively and the ulnar nerve was not decompressed during this procedure. This patient did, however, suffer from multiple medical comorbidities including moderate dementia, which may have complicated the clinical picture. Attempts to contact this patient were unsuccessful.

CASE EXAMPLE

A 59-year-old male presented with right arm pain and weakness after attempting to support a motorcycle that was tipping over toward him. While pushing the motorcycle back upright, he felt pain and a pop at his elbow, and subsequently developed diffuse bruising. On examination, he was exquisitely tender over his olecranon process. Pain is present over the proximal aspect of his triceps and with compression of the triceps tendon. There is no tenderness present in the anterior elbow or along the medial, and lateral aspect. Radiographs demonstrated a small avulsion fracture of the olecranon, consistent with a triceps tendon tear. The decision was made for distal triceps tendon surgical repair as described in the technique section. At 3 weeks postrepair, he rated pain 1/10 with no symptoms of ulnar neuritis, and was regaining function with gentle range of motion exercises. At 10 months postoperatively, he had full extension of his elbow with flexion to 120 degrees, and full pronation and supination. Patient was quite satisfied with his outcome and had resumed his preinjury weight-training regimen. A DASH score of 32, Quick DASH score of 10, and Mayo Elbow Performance Index of 100 were recorded, and patient was subsequently discharged from our service.

EXPECTED OUTCOMES/DISCUSSION

Although distal triceps ruptures are a rare occurrence, proper surgical technique is essential in creating a stable and functional upper extremity. Early techniques as described by van Riet et al,[2] utilized locking stitches and transosseous tunnels to repair the tendon. These often failed to fully restore the anatomic footprint of the triceps insertion. As our understanding of the anatomy of these injuries advanced so did the incorporation of adjunctive fixation devices like suture anchors. These techniques for triceps rupture utilizing adjunctive fixation devices, which can be costly and depends on the fixation and proper use of the device, are not without their own limitations. Suture anchors require both bone of a certain density and quality, and must be placed at a specific location and trajectory to avoid ulnohumeral joint penetration. Lacking of either or both of these is not uncommon on the olecranon and would create either a suboptimal construct prone to screw pullout or to under-restorating the footprint leading to a biomechanically weaker construct. Yeh et al[7] demonstrated that repairs fully restoring the footprint had the least amount of displacement under cyclic loading conditions compared with other nonanatomic repairs. In addition Clark et al[14] showed less displacement under cyclic loading with anatomic repair compared with traditional transosseous cruciate repairs. Although rare, iatrogenic fracture has been described with suture anchor placement as well. Our technique creates a repair that is biomechanically similar to those previously demonstrated to be biomechanically superior.[7] This in theory would also create a construct that would prevent shortening of the triceps over time, which has been showed to lead to loss of nearly 40% of muscle strength.[15]

Surgical incisions about the olecranon are of themselves troublesome. These incisions violate Langer's lines and are subjected to distracting forces which negatively impact wound healing and cosmesis. In addition the sparse soft tissue envelope encasing this area makes symptomatic and painful hardware a common occurrence. These factors combined make the need for a smooth and low-profile construct paramount. By weaving the repair sutures from distal to proximal and tying these to the proximal tendinous tissues, we create compression of the tendon to the bony interface lessening the overall thickness and smoothing out of the repair.

Separately, our technique only requires the use a 0.062 K-wire and a fiber loop, without any additional implants or specialized instruments. The benefits of this is 2-fold. Operative and tourniquet time is decreased lessening the anesthetic burden on the patient and the surgical costs. This poses a cost-effective option in an era of cost conscious and patient-centered medicine.

COMPLICATIONS

Outcomes of distal triceps tendon repair have demonstrated nearly full return of functional capacity. Complications for all techniques include infection, ulnar nerve neuropathy, arthrofibrosis, flexion contracture, hardware irritation, and most commonly, repair failure.[1,2,14] Van Riet et al[2] described ulnar neuropathy that had developed in a patient treated with tension-band wiring that resolved over time with no residual defect. Flexion contracture can be a frustrating side effect, which is why effective postoperative physical and occupational therapy is essential and the reason we begin immediate aggressive range of motion. Hardware irritation and prominence is limited in our procedure, though the FiberWire suture can cause irritation. Rerupture following primary repair is the most common complication and may be managed with

Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.
Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.

revision repair and has been shown to provide a good functional result.[2] A potential benefit of our technique is that most revision and reconstruction techniques would be feasible given the little bone loss or footprint distortion There is an additional small risk of iatrogenic fracture or violation of the articular cartilage in our technique due to drilling transosseous tunnels. However, we believe this risk to be minimal, and in fact may be less that the risk of iatrogenic fracture as compared with using large suture anchors.

In summary, distal triceps tendon ruptures are a highly debilitating injury for the patient and pose a unique challenge to the surgeon in restoring the limb to a useful and pain-free extremity. The technique described provides a quick, straight-forward, and cost-effective alternative that restores the anatomic footprint of the tendon with few complications and exceptional patient outcomes.

REFERENCES

1. Bunshah JJ, Raghuwanshi S, Sharma D, et al. Triceps tendon rupture: an uncommon orthopaedic condition. *BMJ Case Rep*. 2015;2015:1–4.
2. van Riet RP, Morrey BF, Ho E, et al. Surgical treatment of distal triceps ruptures. *J Bone Joint Surg Am*. 2003;85:1961–1967.
3. Bach BR, Warren RF, Wickiewicz TL. Triceps rupture: a case report and literature review. *Am J Sports Med*. 1987;15:285–289.
4. Tsourvakas S, Gouvalas K, Gimtsas C, et al. Bilateral and simultaneous rupture of the triceps tendons in chronic renal failure and secondary hyperparathyroidism. *Arch Orthop Trauma Surg*. 2004;124:278–280.
5. Pina A, Garcia I, Sabater M. Traumatic avulsion of the triceps brachii. *J Orthop Trauma*. 2002;16:273–276.
6. Madsen M, Marx RG, Millett PJ, et al. Surgical anatomy of the triceps brachii tendon: anatomical study and clinical correlation. *Am J Sports Med*. 2006;34:1839–1843.
7. Yeh PC, Stephens KT, Solovyova O, et al. The distal triceps tendon footprint and a biomechanical analysis of three repair techniques. *Am J Sports Med*. 2010;38:1025–1033.
8. Willing RT, Nishiwaki M, Johnson JA, et al. Evaluation of a computational model to predict elbow range of motion. *Comput Aided Surg*. 2014;19:57–63.
9. Tagliafico A, Gandolfo N, Michaud J, et al. Ultrasound demonstration of distal triceps tendon tears. *Eur J Radiol*. 2012;81:1207–1210.
10. Kijowski R, Tuite M, Sanford M. Magnetic resonance imaging of the elbow: part II. Abnormalities of the ligaments, tendons, and nerves. *Skeletal Radiol*. 2005;34:1–18.
11. Harris PC, Atkinson D, Moorehead JD. Bilateral partial rupture of triceps tendon: case report and quantitative assessment of recovery. *Am J Sports Med*. 2004;32:787–792.
12. Strauch RJ. Biceps and triceps injuries of the elbow. *Orthop Clin North Am*. 1999;30:95–107.
13. Sanchez-Sotelo J, Morrey BF. Surgical techniques for reconstruction of chronic insufficiency of the triceps: rotation flap using anconeus and tendo achillis allograft. *J Bone Joint Surg Br*. 2002;84:1116–1120.
14. Clark J, Obopilwe E, Rizzi A, et al. Distal triceps knotless anatomic footprint repair is superior to transosseous cruciate repair: a biomechanical comparison. *Arthroscopy*. 2014;10:1254–1260.
15. Hughes RE, Schneeberger AG, An KN, et al. Reduction of triceps muscle force after shortening of the distal humerus: a computational model. *J Shoulder Elbow Surg*. 1997;6:444–448.

Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.

Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.