Distal Triceps Tendon Injuries

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INTRODUCTION

Distal triceps tendon injuries are rare and, often, initially unrecognized. In the largest published series of tendon injuries, Anzel and colleagues1 noted triceps tendon injuries to be the least common, accounting for 1% of tendon injuries. The triceps brachii is the chief extensor of the elbow and is critical for normal upper extremity function. The anatomy of the triceps muscle and tendon architecture has been well described and in recent years renewed interest has occurred in developing surgical repair techniques with better recreation of anatomy and improved biomechanical strength.

Triceps tendon injuries may occur in a variety of clinical scenarios and are most often associated with a distinct event recognized by the patient. There are several well-recognized risk factors that predispose to triceps injuries, both systemic and localized. Like other tendon injuries, triceps tendon ruptures may be partial or complete. The unique anatomy of the elbow extensor mechanism allows some preservation of strength even in the presence of a complete tendon rupture, which can lead to a missed diagnosis and delay in proper treatment. Treatment can be successful both conservatively and surgically in properly selected patients. This article reviews the anatomy of the triceps, the evaluation and treatment of triceps tendon injuries, and the clinical outcomes of treatment.

ANATOMY

The triceps muscle is pennate and composed of 3 distinct muscle bellies: the long, lateral, and medial heads. The triceps is innervated by the radial nerve, which is the terminal branch of the posterior cord of the brachial plexus. The radial nerve is composed of branches of the sixth, seventh, and eighth cervical nerve roots. The long head of the triceps has a broad origin at the infraglenoid tubercle of the scapula and inferior glenohumeral joint capsule.2 The lateral head has a proximal origin from the humerus just lateral to the teres minor insertion extending distally from the lateral aspect of the spiral groove and lateral intermuscular septum. The medial head originates from the humerus distal to the spiral groove and the medial aspect of the intramuscular septum.

The insertion of the triceps tendon can be divided into the central tendon insertion into the olecranon process and the lateral triceps expansion. The central tendon is thicker medially where a distinct rolled edge is formed by a confluence of the medial and long head tendons (Fig. 1).3

KEYWORDS

- Triceps tendon injury
- Triceps rupture
- Elbow
- Distal triceps
- Treatment

KEY POINTS

- Distal triceps ruptures are uncommon injuries.
- Advanced imaging is required for an accurate diagnosis.
- Complete tendon injuries are best managed surgically, whereas some partial tears can be treated conservatively.
- Surgery is successful in restoring function.
The deep surface of the tendon is covered by muscle fibers from the medial head (Fig. 2). Although some investigators think that the medial head tendon has a distinct insertion, others have shown that the medial tendon blends with the remaining tendon, forming a single tendon confluence. The total width of the triceps tendon insertion is 4.0 to 4.2 cm. The thickness of the central tendon just proximal to the olecranon tip is 6.8 mm. The olecranon footprint tendon insertion is wide and dome shaped (Fig. 3). The triceps insertion begins 12 to 14 mm distal to the tip of the olecranon and has a mean width of 20.9 mm and length of 13.4 mm, with dimensions correlating with the size of the bony olecranon. One study showed that the mean area of the footprint insertion was 466 mm², whereas another study using a three-dimensional modeling system suggested that the mean insertion was 646 mm².

The lateral triceps expansion serves as an important reinforcement of central tendon and can maintain active elbow extension in the presence of a central tendon rupture. The lateral triceps expansion is thinner than the central tendon covering the anconeus muscle and blends with the extensor carpi ulnaris and dorsal antebrachial fascia, eventually inserting into the dorsolateral ulna (Fig. 4). The mean width of the lateral expansion is between 14.4 and 16.8 mm, which is approximately 70% of the width of the central triceps tendon.

**RISK FACTORS AND INJURY MECHANISM**

Triceps tendon injuries are most common in weightlifters and athletes; football players may be at particular risk. Chronic anabolic steroid and corticosteroid use are considered risk factors given their deleterious effect on tendon strength. Likewise, triceps injuries have been linked to local corticosteroid injections for triceps tendonitis or olecranon bursitis. A variety of systemic disorders, including renal osteodystrophy, hyperparathyroidism, and diabetes mellitus, can predispose to triceps injuries.

Triceps tendon ruptures usually occur as a result of a forceful eccentric contraction of the triceps, such as a fall on the outstretched hand or during weight lifting. Usually the injury occurs at the level of the tendon insertion into bone; however, musculotendinous ruptures can occur. Direct blunt trauma to the posterior arm is a less common mechanism and generally requires high energy. Even less commonly, lacerations can lead to direct transection of the tendon.
CLINICAL EVALUATION

Most injuries result from a recognizable event by the patient, often accompanied by a painful pop or tearing sensation. A subjective loss of elbow extension strength is common. Acute injuries are accompanied by variable amounts of swelling of the olecranon bursa and localized bruising. Physical examination usually reveals localized tenderness and swelling and often a palpable defect in the tendon confirming the diagnosis. Usually full elbow range of motion is present, and posterior pain may be present with terminal flexion motion. Inability to extend the elbow against gravity is a sign of a complete rupture; however, the converse is not always true. Because of the integrity of the lateral triceps expansion complete central tendon rupture often preserves antigravity elbow extension. Therefore, accurate diagnosis can be misleading by clinical examination alone. One study showed that approximately half of acute triceps tendon ruptures were initially misdiagnosed. Both partial and full-thickness rupture has loss of elbow extension power compared with the opposite extremity.

A modification of the Thompson calf squeeze test has been proposed to rule out complete triceps tendon ruptures. During this test the upper arm is placed on a table surface with the patient prone and the forearm allowed to hang freely over table edge. The triceps muscle is manually squeezed with the arm relaxed. Similar to the ankle during the Thompson test, when the muscle is squeezed the elbow should extend slightly.

DIAGNOSTIC IMAGING

Plain radiographs should be obtained on presentation and include anteroposterior, lateral, and oblique views of the elbow. The presence of a small avulsion fracture from the olecranon process (flake sign) is pathognomonic of a triceps rupture (Fig. 5).

Advanced studies such as MRI, computed tomography scan, or ultrasonography (US) are usually necessary to confirm the diagnosis and can give some idea of the chronicity of injury. Both MRI and US can distinguish partial from complete tendon injuries. MRI can be particularly helpful to identify associated soft tissue injuries. The triceps tendon is best visualized on the sagittal images (Fig. 6). Complete discontinuity of the central tendon from the olecranon indicates a full-thickness tear, often associated with a fluid gap on T2 imaging. Partial tears appear as an area of increased T1 and proton density signal within the tendon and, when acute, have increased T2 signal intensity. Partial tears may include either the deep or superficial layers. Partial tears may be

Fig. 4. Superficial appearance of the triceps tendon insertion. (A) The lateral triceps expansion is continuous with the anconeus muscle and lateral antebrachial fascia inserting distally into the dorsolateral ulna. (B) The lateral triceps expansion is broad and thinner than the central tendon, and is approximately 70% of the width of the central tendon.

Fig. 5. Flake sign. Lateral radiograph of an elbow with a triceps tendon tear. Note the displaced avulsion of an osteophyte from the olecranon tip indicating a triceps tendon injury.
TREATMENT RECOMMENDATIONS

Because there exists no classification system for triceps tendon ruptures, injuries are generally described by severity and location: partial versus complete ruptures and tendon versus musculotendinous injuries. Most triceps tendon injuries occur at the tendon insertion. Advanced imaging is usually necessary to confirm the severity of injury and the recommended treatment is dictated by the injury severity and the age and physical demands of the patient. In general, partial tears with minimal strength loss can be managed nonsurgically and complete ruptures are treated with surgical repair.

Conservative Treatment

Tears of the triceps occurring within the muscle or musculotendinous junction are thought to have good healing potential and are generally treated conservatively. Partial tears of the tendon are more controversial. In sedentary individuals, all partial tears can be managed conservatively. When partial tears are not associated with tendon retraction, strength is usually preserved and conservative treatment is preferred. Treatment includes a brief period (3–4 weeks) of immobilization at 30° flexion followed by progressive elbow flexion mobilization. Progression of elbow motion is allowed as tolerated beyond 4 weeks.

There is little literature regarding outcomes of conservative treatment of partial triceps tendon injuries. Mair and colleagues reported the results of 10 partial triceps injuries in football players treated conservatively. The tears involved between 30% and 75% of the tendon. Four elbows eventually required surgery, 3 because of residual weakness and 1 because of early full tendon rupture. The remaining 6 elbows recovered with no residual symptoms.

Surgical Treatment

Most complete triceps tendon injuries should be managed with surgical repair. The exceptions include very low demand patients or those not medically fit for surgery. Partial tendon injuries that are high grade (involving >50% of the tendon), associated with tendon retraction and extension weakness, or that have failed conservative treatment are also recommended for surgical repair (Fig. 7). These indications are particularly applicable in active individuals and athletes. Ideally, surgery should be performed within 2 to 3 weeks for acute complete tears with tendon retraction. Primary repair can be performed in a delayed...
fashion and may be more feasible with injuries associated with less tendon retraction.

**SURGICAL TECHNIQUE**

A variety of techniques have been described for triceps tendon repair. There is no clear superior technique in terms of clinical outcomes but each has theoretic advantages. All techniques focus on reattachment of the torn central tendon to the olecranon. In addition, any disruption of the lateral triceps expansion should be performed and helps to augment the primary repair. In cases in which there is a significant amount of olecranon bone attached to the displaced triceps tendon, it may be favorable to reattach the bone fragment with either heavy sutures or anchors rather than to excise the bone.

Perhaps the most historically popular triceps repair technique involves the creation of bone tunnels in the olecranon. Purchase of the central tendon is achieved with high-tensile, braided sutures in a running, locked (Krackow) fashion or with use of a Bunnell-type suture configuration. The strands of suture are threaded through bone tunnels; both crossing tunnels\(^1^3\) (Fig. 8) and 3 parallel tunnels\(^2^3\) (Fig. 9) have been described. The sutures are then tied over the olecranon as a bone bridge with the elbow held in near full extension. Alternatively, the triceps may be reattached with the use of suture anchors placed within the olecranon tip.\(^2^1,2^4–2^6\) With these techniques, side-to-side sutures are recommended to reinforce the edges of the repair.

Modified repair techniques have recently become more popular in attempts to restore a larger, native anatomic footprint and improve the mechanical strength of the repair. The strength of the native triceps tendon has been shown to rival that of the patellar tendon at roughly 1700 N in cadavers.\(^2^7,2^8\) Yeh and colleagues\(^7\) showed significantly greater repair strength (under cyclical loading) with a transosseous-equivalent repair compared with both traditional bone tunnel and suture anchor repairs. In addition, the transosseous-equivalent repair gave a better recreation of the native triceps footprint qualitatively compared with the other techniques, although this was not quantified. With the transosseous-equivalent repair, 2 anchors are positioned in the proximal olecranon approximately 12 mm from the olecranon tip.
the olecranon tip. Sutures from these anchors are then passed through the tendon creating horizontal mattress stitches. These sutures, along with the tails of a Krackow-type suture weaved through the triceps tendon, are then secured to 2 anchors placed more distally on the dorsal aspect of the ulna (Fig. 10).\(^7\) This arrangement effectively compresses the distal tendon footprint against the bone, creating a larger area of boney apposition and better recreating the large area of the native triceps footprint. Alternatively, medial mattress stitches from anchors can be combined with a central tendon Bunnell-type suture secured through crossing bone tunnels.\(^29\)

Knotless repair constructs have recently been studied and show favorable biomechanical strength.\(^30,31\) In addition, this type of repair can be performed with 1 anchor, thereby creating less expense than transosseous repair techniques. Clark and colleagues\(^31\) studied an anatomic knotless repair compared with a traditional cruciate bone tunnel repair in cadaveric elbows. The knotless repair showed significantly less displacement under cyclic loading and better peak load to failure and yield strength than the traditional repair. With the anatomic knotless repair, 2 core high-tensile, braided sutures are woven through the central triceps tendon, creating 4 repair strands (2 medial and lateral suture ends) (Fig. 11). A shuttle suture is passed through the distal tendon on both the medial and lateral aspects of the tendon as well. Two parallel bone tunnels are created at the medial and lateral aspects of the olecranon, exiting the dorsal aspect of the ulna. The 3 strands of suture are passed through the olecranon bone tunnel on both the medial and lateral sides. Next, each shuttle suture is used to repass the free ends of the Krackow suture back through each of the bone tunnels, creating a cruciate repair (1 limb from the medial and lateral sides are crossed into the opposite tunnel). All slack is taken out of the 4 Krackow strands and the elbow is extended. All 4 strands are then secured to an interference fit–type anchor placed after predrilling into the dorsal apex of the olecranon, angled away from the articular surface.

**POSTOPERATIVE CARE**

Most protocols recommend immobilization of the elbow at 30° to 45° for a short period (1–2 weeks) to allow skin healing and protect the repair.\(^15,22\) Gentle active elbow flexion and passive or gravity-assisted extension starts at 2 weeks and continues until full range of motion has returned. Active elbow extension is initiated at 4 weeks. Light strengthening begins at 6 weeks with slow progression until 3 months. Heavy lifting and weight training should be delayed until 4 to 6 months following surgery.\(^13\) With the advent of stronger repair constructs, some investigators have recommended a more accelerated rehabilitation protocol. We prefer to place the arm in a sling rather than a splint and begin immediate active and passive range of motion of the elbow and forearm unrestricted. Patients should avoid lifting more than 2.3 kg (5 pounds) during this phase. Light triceps strengthening is initiated 6 weeks after surgery and advanced as tolerated. Direct comparisons between rehabilitation timelines have not been performed, therefore the advantages and safety of accelerated rehabilitation protocols have not been established.

**REVISION, CHRONIC, OR DIFFICULT ACUTE REPAIRS**

In some instances, primary repair of the tendon can be difficult either because of a fixed retracted position of the tendon, which may be seen in cases of chronic rupture (>6 weeks), or in cases of deficient or poor-quality tissue, such as a revision repair. In cases in which direct primary repair is
suspected to be difficult, potential tendon augmentation should be discussed with the patient before surgery. A variety of tendon augmentation procedures have been described and include allograft or autograft hamstring tendon augmentation, rotational anconeus flap, Achilles tendon augmentation, and ligament augmentation devices.\textsuperscript{15,32–34} The method of reconstruction in these cases depends on several factors, including surgeon preference, tendon mobility and tissue quality, and a variety of host factors.

Repair augmentation with tendon can substantially improve the repair strength compared with primary repair. Petre and colleagues\textsuperscript{27} compared the biomechanical strength of the intact triceps tendon with direct tendon repair and repairs augmented with flexor carpi radialis tendon. Although neither repair construct was a strong as the native tendon, the augmented repairs were nearly twice as strong as the repairs without augmentation. In scenarios with deficient or poor-quality tissue, hamstring augmentation can be used to reinforce the repair or gain tendon length. The tendon is woven in a Bunnell fashion through the residual tendon (Fig. 12). A transverse bicortical tunnel is drilled 1 cm from the olecranon.

Fig. 11. Knotless repair construct. (A) The central tendon is secured with 2 separate sutures passed through the tendon in a Krackow configuration creating 4 separate strands (2 medial and 2 lateral sutures). In addition, a shuttle suture is passed through the medial and lateral aspects of the distal tendon. Three strands of suture are passed through a medial and lateral longitudinal bone tunnel in the olecranon. (B) Each shuttle suture is used to repass the free ends of both the medial and lateral Krackow sutures back through each of the bone tunnels, creating a cruciate repair. (C) A bone tunnel is created distal to the olecranon tip on the dorsal surface of the bone, away from the articular surface. (D) The 4 limbs of suture are passed through an interference fit-type anchor to be secured into the bone tunnel. Note the extended position of the elbow to facilitate reduction of the tendon. (E) Secured knotless cruciate repair of the triceps tendon.
tip. The free ends of the graft are passed through the tunnel from opposite directions. An interference screw is placed, securing the graft within the tunnel with the elbow in extension.

CLINICAL OUTCOMES AND COMPLICATIONS

The clinical results of acute distal triceps tendon repairs are generally good; however, reruptures have been described to occur in up to 20% of cases. Successful repair is more predictable when performed within 2 to 3 weeks of injury. One series noted that a primary repair was feasible in only 6 of 15 cases when surgery was performed more than 25 days after the injury. Most studies reporting the outcomes of triceps tendon repair are retrospective and consist of small case series without control groups or direct comparisons of various repair constructs. In addition, outcomes are not reported in a consistent fashion and often lack validated scales of upper extremity function.

Van Riet and colleagues showed peak strength of 92% (range of 75%–106%) and loss of extension of $8^\circ$ compared with the uninjured side at 1 year postoperatively in 14 acute tears (average of 63 days before surgery) that were primarily repaired using the transosseous cruciate technique. Mair and colleagues treated 11 acute complete triceps tears in professional football players with immediate repair. All but 1 missed an entire season. There was 1 tendon rerupture. The remaining patients were doing well at 3 years postoperatively with no pain or subjective weakness. Bava and colleagues noted good results in 5 acute tears repaired with suture anchors at a mean 32 months following surgery. Function was nearly normal in these patients with a mean DASH (Disabilities of the Arm, Shoulder, and Hand) score of 1.4, American Shoulder and Elbow Surgeons elbow score of 99.2, and a mean Mayo Elbow Performance Index of 95.8. The results of more anatomic repair constructs are largely unknown. Kokkalis and colleagues reported the results of 11 acute triceps tendon tears repaired with a double-row technique at a mean of 21 months following surgery. All repairs were performed within 3 weeks of injury. The mean visual analog scale pain score decreased from 8.5 preoperatively to 2.4 at follow-up. The mean loss of elbow extension was $7^\circ$ and the mean arc of elbow motion was $136^\circ$. Elbow extension strength was significantly improved but not quantified. Nine of the 11 patients were completely satisfied with the surgery and had returned to full activity.

Results of repairs of chronic ruptures often lack quantitative data and objective outcome measures. However, Van Riet and colleagues measured the outcomes of 9 chronic ruptures (average of 163 days before surgery) that underwent reconstructions. These patients showed, on average, 66% peak elbow extension strength (range of 35%–100%) and loss of elbow extension of $13^\circ$. Despite the wide range of peak strength, this report shows that reconstructions of chronic tears are inferior to primary repairs of acute tears. The results of repairs and reconstructions from 3 recurrent rupture cases by van Riet and colleagues were functionally equivalent to results of first-time primary repairs.

Fig. 12. Triceps tendon repair with graft augmentation. The triceps tendon is reinforced with a hamstring graft woven through the tendon in a Bunnell-type manner (A). The tendon is fixated through the olecranon through a transverse bone tunnel (B). (From Yeh PC, Dodds SD, Smart LR, et al. Distal triceps rupture. J Am Acad Orthop Surg 2010;18(1):31–40; with permission.)
Common complications of triceps tendon repairs include olecranon bursitis, localized soft tissue irritation from sutures or wires, residual mild elbow flexion contracture, and elbow extension weakness. In addition, rerupture remains a concern, especially with poor-quality tissue or delayed repairs performed under tension.

SUMMARY

Acute triceps ruptures are an uncommon entity, occurring mainly in athletes, weight lifters (especially those taking anabolic steroids), and following elbow trauma. Accurate diagnosis is made clinically, although MRI may aid in confirmation and surgical planning. Acute ruptures are classified on an anatomic basis based on tear location and the degree of tendon involvement. Most complete tears are treated surgically in medically fit patients. Partial-thickness tears are managed according to the tear severity, functional demands, and response to conservative treatment. Surgical repair offers predictable return of function with a small risk of loss of elbow motion. Even surgical treatment of chronic tears has shown improved elbow extension strength and patient satisfaction. We favor an anatomic footprint repair of the triceps to provide optimal tendon-to-bone healing and, ultimately, functional outcome.

REFERENCES


