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Allograft distal biceps reconstruction after closed intramuscular transection with delayed presentation

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Closed transection of the biceps brachii is a rare yet documented injury. Initially described in paratroopers[6,10,17] and recently described in wakeboarders,[14] traumatic loss of biceps function can lead to diminished supination and flexion strength, cosmetic deformity, and long-term disability. In both activities, the mechanism of injury by which the biceps muscle belly is ruptured is similar and typically involves a sharp force directed through a static line. Though uncommon, static-line injuries and other analogous injury patterns can result in significant soft-tissue compromise and bicipital discontinuity. Given this complexity, treatment can be difficult and nonoperative management is associated with suboptimal clinical outcomes.[13] The purpose of this study is to describe the successful treatment of a complete intramuscular biceps transection with segmental myotendinous tissue loss using a novel surgical technique and Achilles allograft.

Case presentation

A 22-year-old, right hand–dominant active-duty service member presented for care 9 days after sustaining an injury to the right arm while wakeboarding. The patient described a closed traction injury to his right arm after circumferentially wrapping it in the towrope during takeoff, resulting in significant pain, swelling, and limited range of motion at the elbow. He had previously presented to a local facility for evaluation, where baseline imaging showed no fracture and he was subsequently discharged with follow-up on return to his duty station.

Initial examination showed diffuse edema and ecchymosis about the right upper extremity with a 5 × 7–cm, tense soft-tissue mass evident on the volar-ulnar aspect of the proximal forearm. There was an irregular contour over the bicipital region with a corresponding palpable defect along the distal anterior aspect of the arm. Extension and pronation-supination were limited because of pain and edema, and the patient was unable to perform active flexion at the elbow. Neurovascular evaluation was significant for absence of sensation in the lateral antebrachial cutaneous nerve distribution.

Radiographs of the upper extremity showed no bony abnormalities, with abnormal soft-tissue shadowing in the proximal forearm. However, subsequent magnetic resonance imaging showed a full-thickness intramuscular discontinuity of the biceps and brachialis with segmental muscle loss and distal displacement into the forearm (Fig. 1). To improve the functional outcome for this young active-duty service member, immediate surgical exploration was planned 12 days after the initial trauma.

By use of the anterolateral approach to the elbow, surgical exploration confirmed complete transection of both heads of the biceps with incarceration of the distal biceps muscle within the proximal forearm. Additional evaluation showed irreparable avulsion of the distal musculocutaneous nerve and partial disruption of the brachialis muscle. After debridement of nonviable muscle and soft tissue, a 7-cm segmental defect of the distal biceps noted (Fig. 2).

To bridge the gap between the proximal and distal aspects of the transected biceps, an Achilles tendon–calcaneus allograft was chosen for the reconstruction to restore normal contour, flexion

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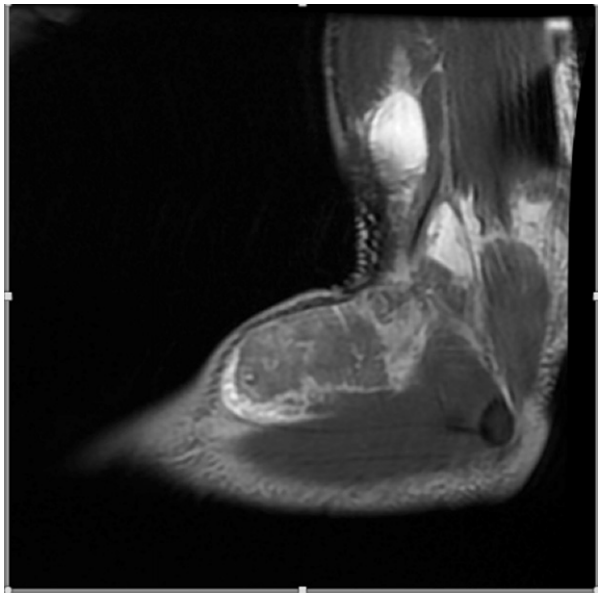

Figure 1 T2-weighted magnetic resonance image showing increased signal and segmental defect of biceps brachii muscle with incarceration of distal segment in forearm.

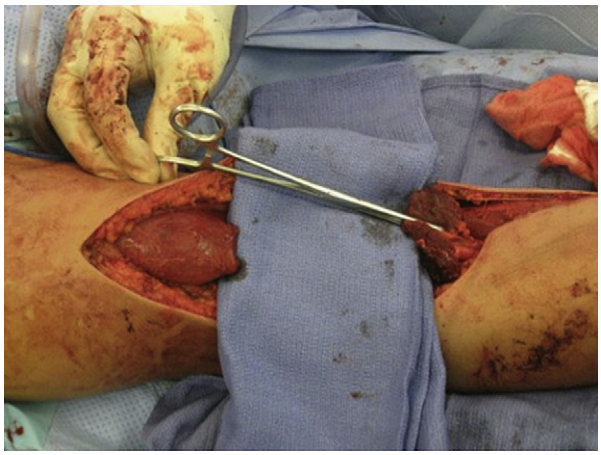

Figure 2 Required debridement of nonviable necrotic tissue produced a 7-cm segmental defect in the biceps brachii muscle.

and supination strength, and functional range of motion (Fig. 3). Given that the native distal biceps myotendinous junction was intact and still anatomically attached to the radial tuberosity, the bone block was removed from the Achilles allograft and the distal tendon was secured to the distal biceps stump with a No. 2-0 nonabsorbable braided suture and a modified Pulvertaft weave technique. The broader proximal aspect of the allograft was then fanned over the proximal biceps stump with the arm in 40° of flexion and full supination and secured into the epimysium tissue with copious No. 2-0 nonabsorbable braided suture in a Mason-Allen configuration. Finally, the reconstruction was reinforced with a circumferential running, No. 3-0 absorbable suture around the allograft perimeter, and a meticulous, layered soft-tissue closure was performed.

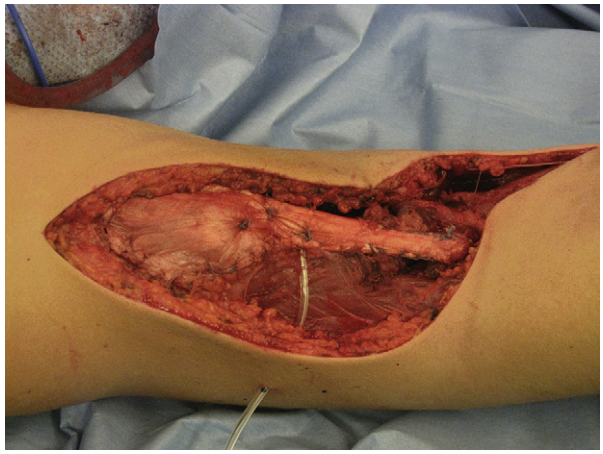

Figure 3 An Achilles tendon–calcaneus composite allograft was used to reconstruct the transected biceps brachii muscle. A Jackson-Pratt drain can be seen lateral to the graft.

Postoperatively, the patient was immobilized in 30° of flexion in a posterior splint. At 2 weeks postoperatively, surgical wounds were largely healed and the patient was allowed gentle, passive flexion range of motion out of his custom splint within a safe zone of 30° to 130°. At 6 weeks postoperatively, pronation-supination was initiated and unrestricted passive and active-assisted range of motion was permitted with occupational therapy. With continued range-of-motion exercises and strength training initiated at 3 months, the patient showed a continually improving clinical course, and he was cleared for return to unrestricted activity at 6 months postoperatively. At 2-year follow-up, he showed full range of motion in bilateral elbow flexion-extension (right, −2° to 135°; left, 0° to 136°) and pronation-supination (right and left, 90° to 90°), as well as equal strength in both supination and flexion. He performed push-ups and upper-body physical fitness measures without difficulty, although he noted occasional discomfort with high-volume repetitions and ultimately elected for permanent profile limitations while remaining on active-duty service.

Discussion

Impairment of the biceps brachii muscle is a major predictor of function of the upper extremity. The biceps contributes significantly to elbow flexion and, more importantly, forearm supination; conservative management of distal biceps ruptures often results in persistent pain, endurance weakness, and strength deficits of up to 60%.[3,4,12] Although ruptures of the distal biceps tendon and the functional outcomes have been extensively studied, closed transection of the biceps muscle belly is a much less common injury and the literature is sparse.

Whereas Gilcrest[5] was the first author to describe 2 cases of isolated rupture of the short head of the biceps in 1934, Tobin et al[17] were the first authors to describe a mechanism of injury for closed biceps transection in 800 military parachutists during more than 4000 jumps. In their description, injury frequently resulted from the static line inadvertently

wrapping under the paratrooper's arm during aircraft exit. The static line, which eliminates the need for a ripcord by connecting the parachute directly to the plane, continues to play out until a force of 6.33 kg force/cm^2 (80 lb/in^2) is achieved.[6] This creates a localized abduction force against the arm, squeezing the biceps against the humerus until the muscle belly is violated. Patients characteristically presented with abrasions and contusion of the mid portion of the arm without evident laceration. Similar to the current case, a palpable defect was usually present, although because of edema, the defect was difficult to identify acutely and most patients were treated with conservative therapy with varying outcomes. After nonoperative treatment, patients consistently complained of increased fatigability with elbow flexion and other upper extremity activities.

Since the initial report by Tobin et al[17] in 1941, multiple other cases of closed transection of the biceps have been reported. In addition to static-line injuries during parachuting,[6,10] injury has also occurred during waterskiing,[1,2,11] gymnastics,[9] motor vehicle accidents,[16] and more recently, wakeboarding.[14] When wakeboarders are performing aerial tricks while being towed by a boat, the handle of the towrope is often placed in the bend of the elbow.[14] While they are in the air, there is a period where there is slack in the line, which can cause the handle to slide up or down the arm of the boarder. Upon rapid tensioning of the line during landing, a traumatic blunt force squeezes the biceps beyond the point at which the maximal force can be displaced, causing a rupture. Alternatively, the athlete's extremity may also become entangled in the towrope after falling or when there is slack in the line.

In the only series involving wakeboarding, Pascual-Garrido et al[14] described 2 patients with complete transection of both heads of the biceps, similar to the case presented in our report. Both of these patients were treated surgically, although a different operative technique was used for each patient. One patient, a 24-year-old man, was treated with direct reapproximation of the muscle bellies, whereas the other patient, a 44-year-old man, was treated with complete removal of the biceps muscle because of necrosis without secondary reconstruction. At 4 years' follow-up, both patients reported no limitations of function; however, the authors objectively noted diminished strength about the elbow.

Multiple techniques exist for surgical treatment of the described intramuscular or myotendinous biceps injuries, including both repair and reconstruction. Direct reapproximation has been attempted,[1-3,10,14] with variable success and inconsistent clinical outcomes ranging from diminished[10,14] to full return of strength[1-3] as compared with the unaffected limb. The disparity of outcomes could also be predicated on fundamental differences in physical rehabilitation regimens or undiagnosed musculocutaneous nerve and local soft-tissue injury. In addition, Kragh and Basamania[7] have recommended a technique for surgical repair of closed biceps transection in which the muscle fibers and epimysium were repaired using a combination of running interlocked and modified Mason-Allen suture configurations. Their study showed that patients receiving this surgical repair had improved supination torque, cosmetic appearance, and overall satisfaction when compared with patients who received nonoperative management.

The use of Achilles tendo–calcaneus composite allograft has been reported in the literature with success for chronic distal biceps tendon repairs.[15] The authors report excellent results with regard to range of motion and Mayo Elbow Performance Score. This specific Achilles allograft was stated to be superior because of its strong mechanical properties and large aponeurotic tissue, which allow for secure fixation of the proximal remnant. However, other autograft and allograft sources, including semitendinosus, have been used successfully and subsequently described in case reports and small patient series.[8,18]

To our knowledge, only 1 prior publication has addressed bicipital discontinuity with significant tissue loss. Pandit et al[13] described a 5-cm muscle belly defect found in a patient presenting after 30 months of nonoperative conservative management after a static-line parachute injury. The patient had a 34% deficit in forearm flexion torque and a 22% deficit in supination torque measured with a dynamometer. This case report largely focused on biomechanical disadvantages of nonoperative management in intramuscular biceps disruption or distal biceps tendon tears. The authors concluded that the optimal way to resolve this persistent functional deficit and improve subjective patient outcomes was early surgical intervention.

Conclusion

Achilles tendon allograft reconstruction has shown clinical success for distal biceps injuries. With a substantial defect not amenable to direct reapproximation, we recommend this technique as a viable reconstructive option to maintain cosmetic appearance, flexion and supination strength, exercise endurance, and overall patient satisfaction.

Disclaimer

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