Intrasubstance Ruptures of the Biceps Brachii: Diagnosis and Management

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**educational objectives**

As a result of reading this article, physicians should be able to:

1. Understand the pertinent anatomy and the function of the biceps brachii muscle.
2. Understand the mechanism of injury in traumatic intrasubstance ruptures of the biceps brachii and understand the characteristic physical examination in these patients.
3. Understand the role of advanced imaging modalities in the diagnostic workup of patients who have suspected intrasubstance ruptures of the biceps brachii.
4. Understand the operative and nonoperative treatment options and treatment outcomes.

**ABSTRACT**

Traumatic intrasubstance ruptures of the biceps brachii are rare and historically specific to military static line parachute jumps; however, these injuries have recently been reported in the civilian literature. Diagnosis is made by history, clinical weakness in supination and elbow flexion, extensive ecchymosis and edema, and a palpable defect. Ultrasound and magnetic resonance imaging are useful to confirm the diagnosis and injury severity. Nonoperative treatment involves splinting in acute flexion. Percutaneous...
The biceps brachii is composed of 2 tendonous origins proximally, with 2 muscle heads that coalesce to form a single tendinous insertion distally into the radial tuberosity of the proximal radius. The long head traverses the bicipital groove as it descends from its origin on the supraglenoid tubercle. The short head originates from the coracoid process of the scapula and joins the long head as a single muscle belly that courses along the anterior aspect of humeral shaft, forming a common tendinous insertion on the proximal radius at the radial bicapital tubercle. Cross-section analysis of this muscle demonstrates the tendinous origin of the long head extending ventrally over the proximal third of the muscle. The muscle then coalesces into its insertion tendon, which is found in the center of the muscle throughout its distal third.1

The biceps brachii receives innervations via branches from the musculocutaneous nerve, with the nerve to the short head branching more proximally than the nerve branch for the long head. The nerve courses over the brachialis muscle and under the middle third of the biceps brachii. Blood supply comes from branches of the anterior circumflex artery and the brachial artery.2

**Functional Biomechanics**

The function of the biceps brachii is complex. Although the common insertion of the biceps tendon on the radius implies similar action on the forearm at the elbow joint, the orientation of the longer tendon over the humeral head performs unique functions in shoulder stabilization. The long and short heads of the biceps brachii act at the elbow to flex and supinate the forearm. The biceps is a weak flexor at the elbow when the wrist is pronated compared with full supination. In addition, the biceps brachii is minimally involved in supination against resistance with the elbow fully extended; however, it is a chief supinator with the elbow flexed at 90°. The long head of the biceps brachii is active in abduction of the arm when the forearm is supinated. Both the long and short heads are active in forward flexion of the arm.3 In addition, the biceps brachii acts at the shoulder to abduct and flex the arm while stabilizing the humeral head within the glenoid.4

**Epidemiology**

The biceps brachii is commonly injured at its tendinous insertion on the proximal radius or at the tendinous origin of the long head. Gilcrest2 reported that the most commonly injured structure was the intra-articular tendon of the long head. The biceps brachii, followed by its extra-articular portion, then by ruptures at the myoteninmusinous junction, and then within the intramuscular substance. A commonly reported mechanism for these injuries is active forward flexion of the shoulder while the arm is extended.5

Injuries of the midsubstance of the biceps brachii are rare in the general population and are most commonly reported during US military static line parachute jumps (Figure 1).6 Tobin et al7 reported the first static line injury in 1941 after evaluating 800 paratroopers during >4000 jumps. This injury was thought to occur as the static line became misrouted under the arm at the time of exit from the aircraft. In a review of >176,000 parachute jumps from multiple countries, the average overall injury rate was 4.3%. The only country with reported static line injuries was the United States.8

In a study of injuries sustained in flight, a review of >242,000 jumps from military personnel at a US Army base found that of the 2000 injuries, only 5.7% occurred at altitude, of which 4.4% were static line injuries that resulted in intramuscular tears of the biceps brachii.9

**Injury Patterns**

In a US military static line parachute jump, a 1-inch nylon line is routed through the pack tray, which holds the parachute. The free end of this line is attached to a steel cable within the aircraft by the jumper. As the jumper leaves the aircraft, gravity and wind resistance accelerate his descent, and the weight of the jumper against a taut static line deploys the parachute.

As he prepares to exit the aircraft, the jumper holds the static line (which is already attached to the cable mechanism) with the arm that is opposite his respective aircraft door. As he nears the aircraft door, he hands off his static line to a jumpmaster situated just beyond the aircraft door. As each jumper hands off the static line, he must assure it is taken and controlled by the jumpmaster. Problems arise when the jumper’s static line is unsecured and passes medial to his arm as he exits the aircraft. This routes the static line from the pack tray to around the upper arm. As the jumper exits the aircraft, gravity and wind resistance accelerate his descent and the static line violently tightens around his arm, causing compression, forced abduction, and external rotation. This injury has also been reported as a result of entanglement in another jumper’s static line.10
Water skiing is a less commonly reported mechanism for midsubstance biceps ruptures. Cases have been reported describing a sudden forced extension injury to an arm that is held in elbow flexion while holding a tow rope. A single case report described a passenger in a moving vehicle whose arm was struck against a parked car, resulting in violent abduction and external rotation.

**Clinical Evaluation**

On examination, extensive ecchymosis and edema are often present. Other signs of blunt trauma, such as erythema, abrasions, and friction burns, are commonly reported. Significant tenderness over the anterior and anteromedial arm and a palpable defect may be present. This defect may be obvious in a complete rupture; however, it may be difficult to appreciate in the acute setting in partial injuries. A subtle groove may be present in a patient with a partial injury, and the size of the defect will increase with passive extension of the elbow. The patient may have pain with elbow flexion and supination, as well as with shoulder range of motion when the arm is unsupported in elbow extension. Predominantly, medial swelling and a medially oriented palpable defect have been associated with an isolated traumatic rupture of the short head of the biceps brachii (Figure 2).

**Neurologic Examination**

A positive Huerter’s sign describes the relative weakness of elbow flexion with the forearm supinated as opposed to pronated. In isolated injuries to the short head muscle belly, only minor strength deficits have been reported. No consistent sensory deficits have been described in association with this injury.

**Radiographic Examination**

Plain radiographs remain the initial imaging modality for shoulder, humerus, and elbow trauma, although no acute bony pathology is commonly associated with this injury. Although few reports of associated upper extremity bony injuries in polytrauma patients have been described, no consistent plain radiographic findings with this injury exist. Soft tissue edema or a biceps soft tissue defect can be appreciated on plain radiographs with more severe injuries.

**Ultrasound Findings**

Of 91 cases reported in the English literature (Table), 33 were diagnosed by clinical examination, 24 were evaluated using ultrasonography and 34 were evaluated using magnetic resonance imaging (MRI). Evaluation using ultrasonography can assist with characterization of the large intramuscular hematoma and the determination of the severity of muscle transection and degree of retraction.

No studies have demonstrated the accuracy of diagnosis of this injury with ultrasound evaluation. However, ultrasound has been reported as an adjunct to MRI in both diagnosis and determination of injury severity. Ultrasound has been able to detect the presence of an intramuscular hematoma and quantify the extent of muscle retraction. Because of its high resolution, low cost, and noninvasive nature for subcutaneous muscle bellies, such as the biceps brachii, ultrasound has been described as the optimal imaging technique for determining the degree of muscle retraction (Figure 3).

**Magnetic Resonance Imaging**

Magnetic resonance imaging has been reported as being useful for the detection and characterization of this injury. There is a diffuse signal abnormality across the belly of the biceps and coracobrachialis. Low signal on T1- and T2-weighted imaging consistent with edema can be noted, along with a focal area of high-signal intensity consistent with a large intrasubstance hematoma formation (Figure 4).

Magnetic resonance imaging has been used to determine the severity of injury, with some authors recommending surgical repair for patients in which transverse imaging demonstrated involvement of 95% of the biceps brachii muscle belly. When performed acutely, current imaging, including ultrasound and MRI, may be useful in diagnosing the structure injured and extent of the injury.

**Treatment**

Described treatments for both complete and incomplete traumatic tears in the midsubstance of the biceps brachii have spanned the spectrum from nonoperative to operative methods. Nonoperative care includes early short-term sling immobilization and comfort measures, whereas operative repair includes early intraoperative hematoma evacuation and primary repair with postoperative immobilization and aggressive rehabilitation.
Nonoperative Repair

The goal in nonoperative treatment of acute traumatic biceps brachii ruptures is to maintain reapproximation of the muscle bellies to allow healing. In the absence of hematoma aspiration, the defect is reduced by flexing and pronating the elbow and immobilizing the upper extremity.

One of the characteristic imaging and intraoperative findings is a large interfascial hematoma, measuring up to 250 or 300 mL. An interfascial hematoma separating the retracted ends of the biceps muscle bellies can be removed either surgically or with percutaneous needle aspiration to allow anatomical reduction of the muscular defect.

Only 1 study has compared nonoperative treatment with percutaneous hematoma aspiration and subsequent immobilization with operative repair. In this study, 20 patients were randomly assigned to 1 of these treatment groups. In the nonoperative treatment group, hematoma aspiration was performed within 72 hours of injury using a 16-gauge needle with the arm held in acute flexion. These patients were then treated with 6 weeks of splinting with the elbow acutely flexed followed by active range of motion exercises. No complications were seen in this treatment group. Participants in the operative group were treated with open biceps reapproximation within 72 hours of injury, followed by postoperative splinting. Measurement of elbow flexion strength using an ergometer at an average of 7.1 months after treatment revealed comparable strength between the operative and nonoperative groups (77% vs 76.5%, respectively) and significantly improved strength of elbow flexion in the operative group compared with the nonoperative group (53%).

Operative Repair

Surgical exploration typically reveals a lacerated and contused muscle belly. The appearance of the biceps at the level of the injury reveals intact fascia with a large hematoma filling the defect between the retracted ends of the muscle belly. Injuries with an associated blunt component (ie, static line injuries), the margins of the biceps muscle are described as cleanly transected perpendicular to longitudinal axis of the muscle. The large interfascial hematoma of up to 250 mL may be liquid in patients surgically explored within the first week or gel-like if explored 1 week after injury. The musculocutaneous nerve is easily visualized between the deep surface of the biceps brachii and the brachialis muscle.

In 1 series, the nerve was found to be contused in all patients, and in several cases branches were found disrupted or transected. Complete transsections have demonstrated substantial proximal muscle belly retraction. The amount of nonviable muscle requiring debridement is variable based on time from injury. Findings in late surgical patients demonstrate fibrotic changes with fibrous bridging seen across the defect.

Surgical repair of intrasubstance tears of the biceps brachii has been reported since early last century. The goals of surgical repair have been to reduce the defect, recover function and strength, and prevent the cosmetic deformity caused by muscle retraction. Primary repair has been described using chromic catgut to nonabsorbable sutures, as well as reinforcing with a fascial flap.

Biceps brachii repair is approached through a longitudinal anterior or anteromedial incision centered at the zone of the defect. Beach-chair positioning is optimal because the arm can be placed in 45° of abduction with 90° of elbow flexion to assist in repair. Intact fascia is identified and incised longitudinally to allow later repair. The interfascial hematoma is evacuated and thoroughly irrigated. At this point, the muscle belly ends are inspected and nonviable tissue is debrided. Blunt dissection beneath the epicymus allows for mobilization of the muscle ends. Locking intramuscular sutures are then secured with the elbow in flexion to allow the defect to fully reduce. The fascia is then repaired, and the subcutaneous tissues and skin are closed in layers.

Kragh and Basamania described a 6-cm anterior longitudinal incision with a multilayer closure technique using 2-0 absorbable braided sutures placed in locked-running fashion around the perimeter of the defect. A second layer consisting of #0 braided polysutures in a modified Mason-Allen technique secures each quadrant of both the proximal and distal muscle segments. Other authors report the use of an extensile deltopectoral incision and repair using 2-0 nonabsorbable sutures placed in Kessler and Bunnell fashion with a 1-0 nonabsorbable suture at the perimeter of the defect.

Postoperative Immobilization and Rehabilitation. Early reports described the use of a postoperative posterior splint with the elbow at 90° that was used until the injury had healed. Since then, postoperative immobilization recommendations have varied regarding both the degree of flexion and duration. Descriptions include elbow immobilization at >90° of flexion from 3 days to 3 weeks postoperatively, followed by the use of a dynamic splint for early motion. Postoperative night-time splinting for 4 weeks has also been described following primary repair, with transition to a
Biomechanical Evaluation of Strength of Repair. Chance et al 19 evaluated the pull-out resistance of various types of muscular suture techniques performed on several types of muscle bellies in cadaveric specimens. Six suture techniques were compared (Kessler, figure-of-eight, mattress, Mason-Allen, perimeter stitching, and a combination of Mason-Allen with perimeter stitching). The results demonstrated the superiority of the more complex suture techniques, including the Mason-Allen, perimeter stitching, and a combination of Mason-Allen with perimeter stitching. They also demonstrated that simple suture techniques (Kessler, figure-of-eight, and mattress sutures) fail longitudinally, whereas complex sutures tend to fail perpendicular to the longitudinal axis (transversely) across the muscle. Complex suture techniques were found to be significantly more resistant to pullout forces with the hinged brace at 4 weeks for extremes of flexion and extension. 13

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Injury</th>
<th>Time to Treatment</th>
<th>Treatment</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conwell</td>
<td>1</td>
<td>Multi-injury trauma</td>
<td>Day of injury</td>
<td>Open, debridement, no repair, splinting</td>
<td>Good outcome reported</td>
</tr>
<tr>
<td>Gilcrest</td>
<td>17</td>
<td>Various</td>
<td>Not reported</td>
<td>Surgical repair with primary reattachment using catgut suture and fascial flap</td>
<td>Not reported</td>
</tr>
<tr>
<td>Tobin et al</td>
<td>1</td>
<td>Static line</td>
<td>Not reported</td>
<td>Not reported</td>
<td>Not reported</td>
</tr>
<tr>
<td>Heckman &amp; Levine</td>
<td>48</td>
<td>Static line</td>
<td>Acute operation (n=20): &lt;1 wk; late operation (n=6): 4-18 mos; nonoperative group (n=22)</td>
<td>Not reported</td>
<td>53% return of elbow flexion in the nonoperative group vs 76.5% in the operative group. One wound infection was reported. No complications in nonoperative group.</td>
</tr>
<tr>
<td>Mellen</td>
<td>1</td>
<td>Static line</td>
<td>Day of injury</td>
<td>Open, exploration, hematoma evacuation, excision of intraluminal thrombus, brachial artery grafting and repair, no biceps repair performed</td>
<td>Skin breakdown and superficial wound infection reported. Visible and palpable defect persisted.</td>
</tr>
<tr>
<td>DiChristina &amp; Lustig</td>
<td>1</td>
<td>Water skiing</td>
<td>3 weeks</td>
<td>Open, primary repair, 3 weeks in splint</td>
<td>Full ROM, 5/5 strength at 4 months</td>
</tr>
<tr>
<td>Bricknell</td>
<td>1</td>
<td>Static line</td>
<td>Not reported</td>
<td>Closed, 4 weeks in sling</td>
<td>Visible and palpable defect persisted, no functional deficit compared to contralateral side</td>
</tr>
<tr>
<td>Balkissoon et al</td>
<td>2</td>
<td>Static line</td>
<td>5 days</td>
<td>MRI diagnosis, nonoperative</td>
<td>Not reported</td>
</tr>
<tr>
<td>Craig &amp; Lee</td>
<td>4</td>
<td>Static line</td>
<td>Not reported</td>
<td>Not reported</td>
<td>Not reported</td>
</tr>
<tr>
<td>Kragh &amp; Basamania</td>
<td>12</td>
<td>Static line</td>
<td>0-14 days</td>
<td>Nonoperative (n=3): sling &amp; NSAIDs. Operative (n=9): open, debridement, primary repair, 3-5 days immobility followed by dynamic splinting with extension limited to 30° with early active ROM.</td>
<td>All patients returned to full ROM. No complications, job changes, or poor functional outcomes reported. Patients disliked the popeye deformity. Nonoperative patients regained 63% of contralateral supination/extension compared with 89% of those repaired operatively.</td>
</tr>
<tr>
<td>Shah &amp; Pruzansky</td>
<td>1</td>
<td>Motor vehicle passenger</td>
<td>7 days</td>
<td>Open, debridement, primary repair, postoperative splinting for 4 weeks, followed by hinged bracing for 6 weeks</td>
<td>Full ROM, 5/5 strength at 5 months</td>
</tr>
<tr>
<td>Carmichael et al</td>
<td>1</td>
<td>Water skiing</td>
<td>5 days</td>
<td>Open, debridement, no repair</td>
<td>Full ROM, 5/5 strength at 8 months</td>
</tr>
<tr>
<td>Chen &amp; Chew</td>
<td>1</td>
<td>Pedestrian vs motor vehicle</td>
<td>Day of injury</td>
<td>MRI diagnosis, nonoperative, cast immobilization for 6 weeks in hyperflexed supinated position</td>
<td>Satisfactory cosmetic and functional results were reported</td>
</tr>
</tbody>
</table>

Abbreviations: MRI, magnetic resonance imaging; NSAIDs, nonsteroidal anti-inflammatory drugs; ROM, range of motion.
In cases where late repair has been performed, the defect has persisted; the authors concede that anatomic reapproximation of the ruptured muscle cannot be achieved in a chronic setting. In addition, these patients continued to have weakness of elbow flexion compared with those treated acutely. However, no wound com-
Complications were noted in this group. The authors concluded that although some functional improvement can be made and a reduction of the cosmetic defect is achieved, the functional recovery is better with more acute treatment (<72 hours).^{14}

**CONCLUSION**

Intrasubstance tears of the biceps brachii remain a rare injury; however, among at-risk US military static line parachutists, these injuries may comprise >4% of injuries at altitude. There is a paucity of randomized, controlled studies to support standardized operative or nonoperative treatment. Few treatment comparison studies have been performed. A statistical difference in supination strength has been shown in patients treated operatively vs those treated nonoperatively in 1 small study. The complications of operative treatment include wound breakdown and deep tissue infection, failure of repair and need for reoperation, and anesthesia risks; moreover, there is a clear lack of evidence showing increased functional outcomes of operative treatment compared with nonoperative treatment. Currently, no comprehensive data exist to support operative vs nonoperative treatment, and additional multi-center studies are needed to guide treatment.

**REFERENCES**