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Distal biceps short head tears: repair, reconstruction, and systematic review

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Background: Isolated short head tears of the distal biceps are uncommon and often underappreciated. The aim of this study was to describe the presenting features and management of acute and chronic short head ruptures treated at our unit and in the published literature.
Methods: Six short head ruptures in 5 patients are described. The clinical and radiographic findings, operative techniques, and postoperative outcomes are reported for all patients. A systematic review of the existing literature was also performed.
Results: All patients presented with pain and weakness following an acute traumatic event. One patient presented with bilateral tears 3 years apart. Four of the ruptures underwent acute repair. Two ruptures presented chronically with retracted short head tears and were treated with allograft reconstruction of the short head. Preoperative magnetic resonance imaging findings demonstrated retraction of the short head affecting only 1 muscle belly, and in all patients the hook test was intact. All patients reported excellent functional outcome scores with no postoperative complications. The systematic review identified 9 previously reported cases, of which 8 were treated surgically with a successful outcome. Detailed analysis of these cases demonstrated clinical findings consistent with our cases, and these are outlined in depth in the article.
Discussion/Conclusions: Isolated short head ruptures are a rare and distinct form of distal biceps tear that present with consistent clinical findings that can aid in diagnosis. They present acutely, have a poor natural history akin to complete tears, and have good outcomes with acute and delayed reconstruction.
Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Isolated short head; short head; single head; distal biceps tendon; rupture; tear; repair; reconstruction; management

Anatomy and pathoanatomy

The biceps brachii comprises 2 components: the short head, which arises from the coracoid process of the scapula, and the long head, which arises from the superior glenoid tubercle and superior labrum.

The muscle bellies of the long and short heads form a single functional unit in the upper arm, although the bellies can still be distinguished anatomically, the degree of which is variable between individuals. In most individuals, the musculotendinous units unite proximal to the elbow, forming a single tendon that externally rotates 90° before inserting into the bicipital tuberosity of the radius. In around 25% of individuals, the muscle bellies and tendons remain completely bifurcated all the way to their insertion,[2,8] and even in seemingly unified tendons the 2 heads can be identified as separate units during surgical exploration. In all cases, because the tendon externally rotates toward its insertion, the short head lies more distal, where it occupies a greater portion of the footprint at the apex of the radial tuberosity[8] (Fig. 1, *a*).

Institutional review board approval was not required for this study.

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Acute, complete ruptures are the most commonly presenting of the distal biceps and typically occur in men between 40 and 60 years of age, as a result of elbow flexion against an excessive eccentric load.[15,21,23] Treatment tends to be surgical for the majority of acute full-thickness ruptures. Partial tears of the distal biceps are less frequent, and do not usually present with the same acute traumatic history of a complete tear. Some patients with a partial tear have chronic pain because of enthesopathy of the biceps tuberosity, tendinosis, bicipitoradial bursitis, and degenerate tearing of the tendon.[17,23] There is no clear consensus regarding treatment of these tears, although physiotherapy, injections with steroid or platelet-rich plasma, and surgery have all been advocated. It has been proposed that tears involving >50% of the insertion may be suitable for surgical repair whereas smaller tears are suited to débridement.[3,21,23] This distinction seems intuitive but is arbitrary and lacks a robust evidence base because of the relative infrequency of these cases.

A distinct subset of partial tears reported in the literature very rarely,[5,13,22,24,26] and the subject of this article, is a true single-head tear (Fig. 1, *b*). This results in independent retraction of the torn head (short head usually) and presents with a history more akin to a complete acute rupture, with pain, deformity, and bruising. Examination findings in this scenario demonstrate an intact hook test[16] because of the intact normal long head. Patients may be treated in the same manner as a degenerate chronic partial tear with pre-existing tendinopathy; however, our experience has been that these tears present and behave differently to degenerate partial tears and may not be suitable for the same management protocol.

The aim of the article is to outline the pertinent presenting features, imaging findings, and techniques for acute and chronic reconstruction of isolated short head distal biceps tears using cases treated in our unit and those reported in the existing literature.

Materials and methods

There were 6 isolated short head ruptures treated in 5 patients by the senior author (J.P.). All patients had preoperative magnetic resonance imaging (MRI) performed using a flexion, abduction, external rotation protocol (FABS).[10] Patient-reported outcome measure (PROM) scores were collected prospectively. These were the visual analog scale for pain (VAS) score and the Oxford Elbow Score (OES). Patient satisfaction with treatment was rated as fully satisfied, partially satisfied, or unsatisfied. Patients were also asked whether they had returned to the same level of work and sports participation as compared to before their original injury. Preoperative clinical examination included the hook test,[16] assessment of biceps muscle symmetry compared to the opposite arm, and resisted supination and flexion strength. The hook test was performed with the patient's hand supinated in front of their face as originally described, and the other tests were performed with the elbow flexed at 90° and the arm at the patient's side. All clinical tests were repeated in the same manner postoperatively. All patients were followed up for a minimum of 6 months (6-24 months). Table I includes the individual patient demographic data.

For the literature review, the Embase, PubMed, and Google Scholar databases were searched to identify cases of isolated single-head distal biceps rupture. The references of relevant articles were manually searched to identify additional cases. Data collected about each case included age and gender of the patient, mechanism of injury, treatment (including intraoperative findings where applicable), and outcome. Data from all included cases was tabulated and analyzed alongside the cases reported from our practice (Table I).

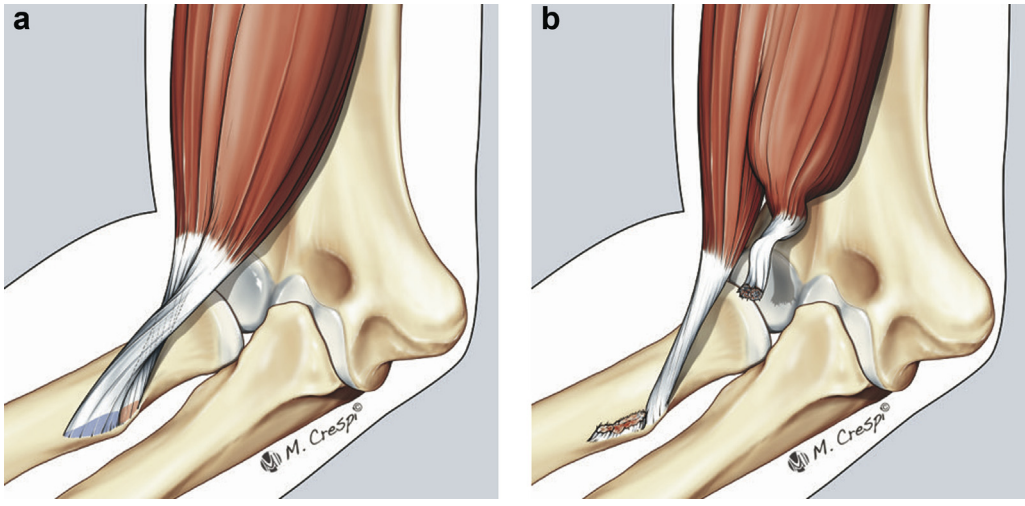

Figure 1 (**a**) Illustration demonstrating insertion of a bifid distal biceps tendon on the radial tuberosity. The short head is distal to the long head and occupies a larger footprint area. (**b**) With an eccentric flexion injury, it is postulated that the distal part of the tendon ruptures first and because of the bifid arrangement the force propagates between the long and short head, leaving the long head intact.

Table I Tabulation of the present authors' cases and cases reported in literature

Case	Age	Sex	Side	Dominant	Acute injury	Prodromal symptoms	Bruising	Asymmetry	Hook test	Supination strength	Flexion strength	MRI findings	Treatment	FU time, mo	Satisfied	PROM		Return to work	Return to sport
																OES	VAS score		
Authors' cases																			
1	34	M	L	N	Y	N	Y	Y	Intact	Decreased	Decreased	No MRI	Takedown and repair of both heads	24	Y	48	0	Y	Y
2	37	M	R	Y	Y	N	Y	Y	Intact	Decreased	Decreased	Short head tear	Short head repair	13	Y	44	0	Y	Y
3	49	M	L	Y	Y	N	Y	Y	Intact	Decreased	Decreased	Short head tear	Short head repair	18	Y	42	0	Y	Y
4	50	M	L	N	Y	N	Y	Y	Intact	Decreased	Normal	Short head tear	Short head repair	6	Y	48	0	Y	Y
5	48	M	L	N	Y	N	Y	Y	Intact	Normal	Decreased	Short head tear	Short head reconstruction	14	Y	40	1	Y	N
6	28	M	L	Y	Y	N	Y	Y	Intact	Decreased	Normal	Short head tear	Short head reconstruction	12	Y	48	0	Y	Y
Literature review																			
1[22]	39	M	R	Y	Y	N	Y		Intact			Complete tear	Short head repair	6					
2[13]	45	M	R	Y	Y	N	Y			Decreased	Decreased	Short head tear	Short head repair						Y
3[13]	43	M	R	Y	Y	N						Short head tear	Nonsurgical						
4[26]	52	M	R	Y	Y	N	Y	N	Intact	Decreased	Decreased	Short head tear	Short head repair	6				Y	Y
5[5]	43	M	R	Y	Y	N						Short head tear	Short head repair	24				Y	
6[24]	24	M	R		Y	N		Y	Intact	Decreased	Normal	Short head tear	Takedown and repair both heads	24				Y	Y
7[24]	58	M	L	N	Y	N			Absent	Decreased	Normal	Short head tear	Takedown and repair both heads	5				Y	
8[24]	33	M	R	Y	Y	N	Y	Y		Decreased	Decreased	Short head tear	Short head repair						
9[14]	40	M	R	N	Y	N	Y	Y	Intact	Normal	Normal	Short head rupture and retraction	Short head reconstruction	12	Y	100*		Y	Y

M, male; *L*, left; *R*, right; *N*, no; *Y*, yes; *MRI*, magnetic resonance imaging; FU, follow-up; *PROM*, patient-reported outcome measures; *OES*, Oxford Elbow Score; *VAS*, visual analog pain score.

* Mayo Elbow Performance Score.

Results

Authors' cases

Patient 1

A 34-year-old male right hand–dominant self-employed electrician presented after experiencing a ''popping'' sensation and pain in the antecubital fossa while performing a deadlift in the gym. He had no comorbidities and no history of steroid use. On examination, there was asymmetry of the biceps muscle belly and marked pain on resisted supination and flexion with weakness of supination. The bulk and tone of his biceps was reduced. The hook test was intact, with a clear hookable structure present in the cubital fossa. The patient elected for surgical exploration to avoid delays related to imaging. Intraoperatively, the short head was found to be completely ruptured, no signs of mucoid degeneration, with an intact normal-looking long head and normal-looking tuberosity. The short head was retrieved from within a common tendon sheath. The long head was released from the radial tuberosity and whipstitched with the short head to create a common distal tendon, which was then fixed to the tuberosity using a transcortical button (EndoButton, Smith & Nephew, Andover, MA, USA). Active range of motion within the limits of pain was permitted immediately with a sling for comfort. Lifting or passive stretching was not permitted for 6 weeks. He made a complete uneventful recovery with full return to sports and work in a manual job.

The same patient presented 3 years later with pain and bruising in the opposite elbow (right) after landing a punch (uppercut) heavily in a boxing class and feeling a ''popping'' sensation. Examination revealed decreased biceps bulk, with weak and painful resisted supination and flexion. The hook test was intact. MRI with FABS protocol demonstrated isolated short head rupture of the distal biceps with an intact long head and minimal retraction of short head tendon. Proximally, the muscle bellies were clearly separate. The patient opted for surgical repair because of the successful repair in his opposite arm. The intraoperative findings were identical to those in the opposite elbow; however, on this occasion, the short head was repaired in isolation using a single-incision transcortical button technique. He made an uncomplicated recovery with full return to work and sports and excellent PROM scores (Table I).

Patient 2

A 49-year-old fit and well left hand–dominant man with a desk job presented 1 week after experiencing a sudden sharp pain in the anterior aspect of his left elbow while bowling during a cricket match. He had no history of anabolic steroid use or smoking.

On examination of his elbow, bruising was visible in the anteromedial aspect of the forearm. There was asymmetry of the biceps muscle belly, but there was normal rise and fall of the muscle during active forearm rotation. The hook test was intact with some tendon clearly palpable, although the tension within the intact tendon was reduced compared with the opposite arm. There was pain over the tendon on hook testing and on resisted flexion and supination testing. There was mild weakness of both flexion and supination. Because of the equivocal examination findings, an MRI scan was performed. This demonstrated a partial tear of the distal biceps tendon tear involving the distal part of the tendon in isolation. The axial slices demonstrated distinct medial and lateral muscle bellies proximally with an isolated tear of the short head with retraction of approximately 10 cm.

Following discussion, the patient elected to proceed with surgical exploration and repair. Absence of the short head with an intact normal long head was confirmed through an anterior forearm incision. The short head was not easily retrievable through the distal incision; therefore, a separate proximal incision was made. The short head was found rolled up within a scarred tendon sheath, which was opened to release a seroma. There was a clear distinction between short and long head muscle bellies and tendons. The tendons did not exhibit signs of any degeneration and the tuberosity was normal in appearance. The short head was repaired using a transcortical button (Arthrex, Naples, FL, USA) placed through a tunnel created immediately distal to the intact long head. Sutures were placed between the 2 tendons to reinforce the repair. At 3 months following surgery, the patient had regained full range of motion with equal power and symmetric contour compared to the opposite arm. By 6 months, he had returned to all activities including cricket with no subjective weakness and excellent PROM scores (Table I).

Patient 3

A 50-year-old right hand–dominant sports physician sustained a hyperextension injury to his left elbow while goalkeeping in soccer and diving to make a save. He developed pain and an asymmetry of his biceps muscle belly. There was subtle bruising in the proximal forearm. There was no history of prodromal symptoms in the elbow.

On examination, there was clear asymmetry of the biceps muscle bellies, but preserved rise and fall of the biceps. The hook test was intact with a fully hookable tendon present. There was weakness on resisted supination but not on resisted flexion testing.

Medical history included hypercholesterolemia and a cardiac stent. Drug history comprised aspirin and a statin with no previous anabolic steroid use. MRI scan was performed because of the presence of an intact hook test. This revealed an isolated short head rupture without significant retraction (Fig. 2).

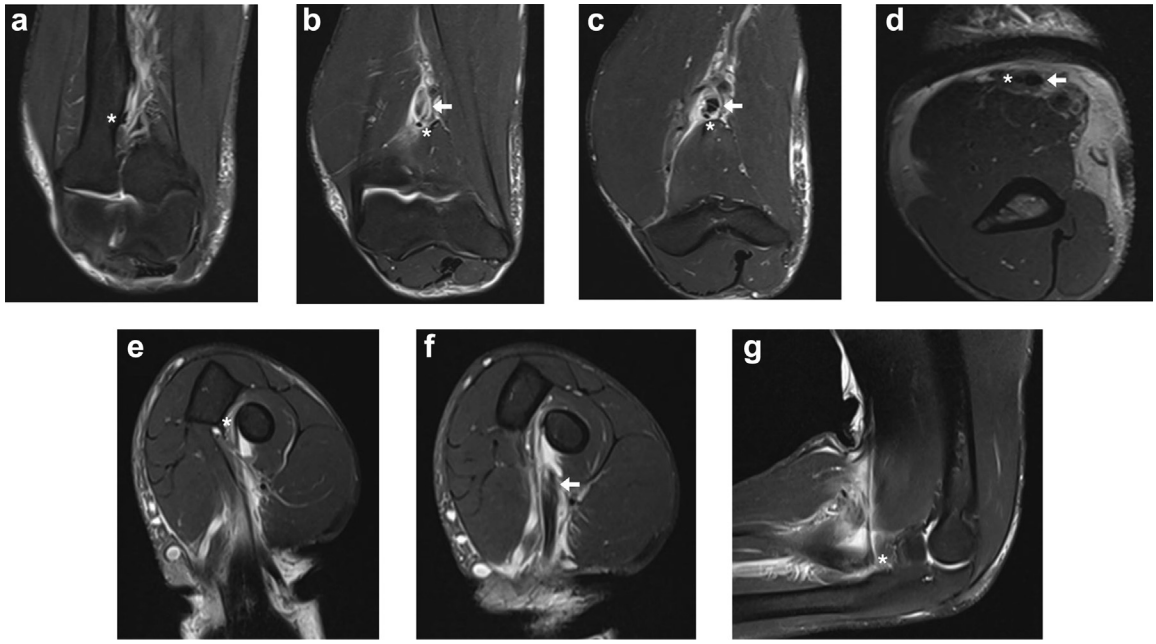

Figure 2 MRI sequences of a patient with minimally retracted isolated short head rupture. Long head tendon is indicated by asterisk and the short head by an arrow. (**a**) Proton density fat-suppressed coronal MRI demonstrating long head tendon inserting onto the radial tuberosity. Note absence of the short head tendon. (**b**) Three slices more proximally, the short head tendon is first appreciated with an abnormal signal within and around it. The long head is separate and normal in appearance but much smaller in caliber. (**c**) Further proximal, the tendon appearance of the short head is now similar to the long head and the two are noted to be rotating in orientation to each other. They are still distinct entities. (**d**) Proximal to the cubital fossa at the musculotendinous junction, the tendons are still clearly bifurcated, with the short head medial to the long head. (**e**) Proton density fat-suppressed FABS sequence. The long head is demonstrated with a normal attachment to the radial tuberosity with no signal change or abnormality. (**f**) More distally, the short head tear is clearly appreciated. With some high signal change within the tendon structure. (**g**) Proton density fat-suppressed sequence again demonstrates a normal attachment of the long head, which is small in caliber compared to the ruptured short head, which is not appreciated in this image as it is out of plane. *MRI*, magnetic resonance imaging; *FABS*, flexion, abduction external rotation protocol.

After discussion, he chose to proceed with surgical repair, which was performed 2 weeks after the original injury. Intraoperatively, the long head was noted to be intact, with a normal robust attachment to the tuberosity but diminutive in size compared with the short head. The short head was retracted by 3 cm and tethered to the recurrent radial vessels. On mobilization, the tendon was noted to show signs of pre-existing tendinopathy, which was débrided. Repair of the short head in isolation was performed using a transcortical button (EndoButton, Smith & Nephew). Active ROM was permitted postoperatively, and he made a full recovery with return to work and play with excellent PROM scores (Table I).

Patient 4

A 48-year-old right hand–dominant police officer was referred from another institution because of chronic elbow flexion weakness and upper arm cramping. Eight months prior, he had sustained an injury to his left elbow during restraint of an assailant. He was diagnosed with an acute distal biceps tear following an MRI and clinical examination in his local hospital. The operating surgeon felt that the biceps tendon was intact distally and on proximal exploration felt a musculotendinous rupture was present. This was oversewn with mattress sutures. The patient had persistent deformity, flexion weakness and pain, as well as a lateral cutaneous nerve (LCN) injury.

On examination in our institution, there was intact rise and fall of the biceps muscle belly on active forearm rotation although this was asymmetric compared with the left side. On resisted flexion, there was bunching up of the deep tissue immediately proximal to the previous scar. The hook test was intact, with a robust palpable tendon still present. Resisted flexion testing caused pain and weakness; however, resisted supination strength was relatively preserved with minimal pain. There was paresthesia in the LCN distribution but no other neurologic or vascular deficit.

Repeat MRI scan including a FABS protocol was performed. This demonstrated clear evidence of preserved long head attachment to the proximal part of the radial tuberosity, with the distal tuberosity devoid of the short head tendon. Proximally on the axial slices and FABS view (Fig. 3), the 2 heads were visible as separate entities with fat surrounding the medial short head. On review of the original MRI scan, this same pathology was evident but had been reported as a complete rupture.

Figure 3 MRI FABS view of patient with chronic short head rupture: (**a**) intact long head tendon seen inserting into bicipital tuberosity; (**b**) significant retraction of short head musculotendinous unit proximally; (**c**) axial slices demonstrating 2 heads visible as separate entities with fat surrounding the medial short head. *MRI*, magnetic resonance imaging; *FABS*, flexion, abduction external rotation protocol.

Given the chronicity of the tear and fat infiltration of the short head muscle belly, the patient was advised that a primary repair of the tendon may not be possible. After deliberation, the patient elected to proceed with surgery because of his ongoing symptoms and reduced functional capacity.

Preoperative PROMs indicated significant functional impairment (VAS score 8, OES 14, and Quick Disabilities of the Arm, Shoulder, and Hand score 70.5).

An extensile anterior incision was performed to explore the distal biceps in full. Proximally, the 2 muscle bellies were seen as distinct entities with a normal-looking long head extending to the radial tuberosity but an absent short head. The short head muscle belly was tethered to scar tissue with no residual short head tendon visible (Fig. 4). The LCN was found encased in scar tissue, from which it was dissected free. On passive forearm rotation, there was no excursion of the short head. Given the retraction and loss of tendon tissue a decision was made to perform a reconstruction of the short head. This was done using an Achilles tendon allograft in a similar manner to the technique previously described by the senior author (J.P.) for retracted chronic complete tears.[19] Side-to-side sutures were placed between the allograft and native long head tendon to reinforce the reconstruction.

Postoperatively, the patient's left arm was immobilized in a bulky bandage and sling for 2 weeks. Active elbow range of motion in all planes was commenced following wound review at this point with no lifting or passive stretching permitted for 3 months.

The preoperative LCN paraesthesia resolved within 2 weeks following the surgery. At 6 months, he had regained full range of motion with resisted supination and flexion power equivalent to the nonoperated arm. PROMs demonstrated significant improvements compared to preoperatively (Table I). He was able to return to work as a police officer at full capacity.

Patient 5

A 28-year-old male engineer presented after being involved in a rugby tackle 4 months previously. His dominant, left arm was hyperextended followed by sudden pain in the arm. The following day, he noticed some bruising around the elbow and down the forearm. A physiotherapist saw him and recommended rest initially. As the bruising settled, the patient noticed asymmetry between the 2 arms. Despite continued physiotherapy for 3 months, he had no symptomatic improvement and was referred to our institution. On examination, there was marked asymmetry with skin puckering just proximal to the antecubital fossa. The hook test was intact but the residual intact tendon was found to be slack in flexion. There was marked weakness in resisted supination but not so much in flexion. MRI scan confirmed an intact long head and ruptured, retracted short head tendon.

The possibility of requiring a graft from our previous experience was discussed and the patient elected to proceed with surgery. An extensile anterior approach was performed. The long head was found to be very thin but with a robust normal attachment to the radial tuberosity. No short head was visible and a thickened muscle belly was noted but no residual tendon tissue present for repair. An Achilles tendon allograft was used to reconstruct the short head in isolation. The long head was reefed into the repair but not detached from its insertion. At 12 months following surgery, the patient had full motion, equal supination and flexion strength, excellent PROMs, and has returned to full functional capacity.

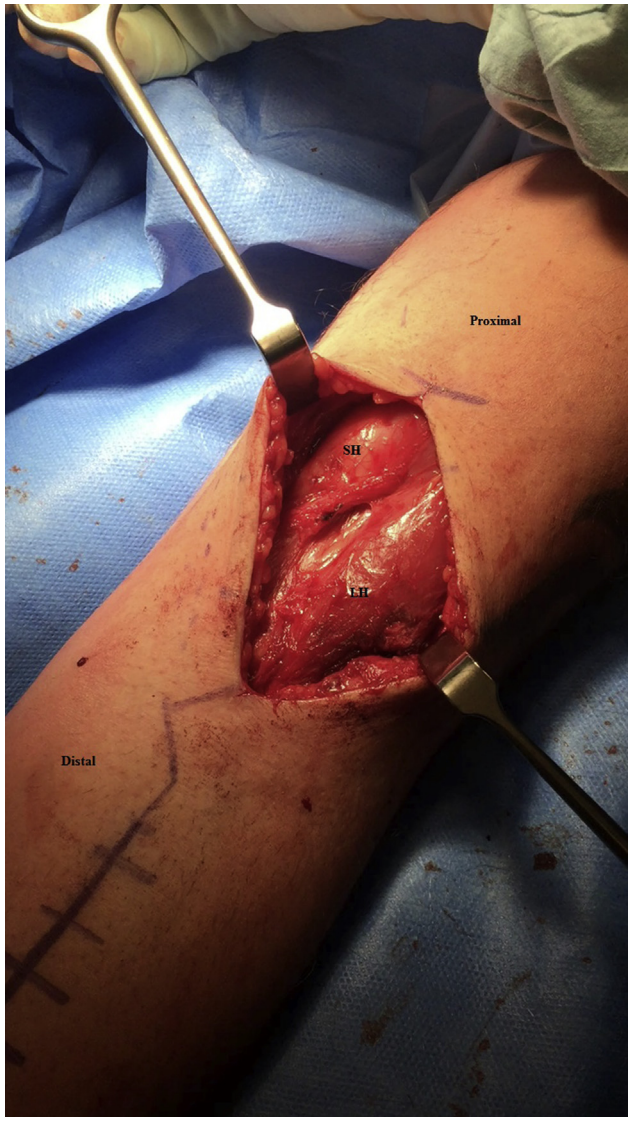

Figure 4 Intraoperative image of chronic short head rupture with intact long head (LH) and retraction of short head (SH) and tethering to surrounding scar tissue. On passive forearm rotation, there was normal motion and excursion of the long head muscle belly and tendon with no movement of the short head muscle belly, confirming complete rupture and retraction.

Literature review

Six articles describing an isolated single head rupture of the distal biceps comprising a total of 9 cases were

identified.[5,13,14,22,24,26] Details of these cases are included in Table I.

All reported tears involved the short head tendon and 7 underwent acute surgical repair. One had delayed presentation and underwent reconstruction of the short head. One case was treated nonoperatively.

All patients were male and all had a clear history of acute injury with no history of prodromal symptoms. The mean age of the patients was 42 years (range 33-58), which was similar to our series (mean age 41, range 28-50). The presence of bruising was documented in 5 patients and not commented on in the other 4. MRI was performed in all patients, confirming the diagnosis of short head tear in all cases; however, in 1 patient the MRI was reported as indicating a complete tear[21] but the long head tendon was found to be intact during surgery. Of the acutely treated cases, 5 cases had an isolated repair of the short head and the other 2 had takedown of the long head and repair of both tendons together. Satisfactory outcome was reported in all cases including the nonsurgical case; however, no PROMs were performed in any of the cases, and return to work status was only documented in 4 cases and return to sport in 2 cases.

The chronic case presented 2 years after injury with a delayed diagnosis and ongoing cramping pain and weakness. The patient was diagnosed with an isolated musculotendinous junction tear of the short head and treated with reconstruction of the short head using gracilis tendon autograft. The patient had a good outcome with good PROM scores and return to work and elite-level sports.[14]

Discussion

Anatomic and radiologic studies have demonstrated a clear bifid insertion of the distal biceps in at least 25% of individuals.[2,7,15] The degree of connection between the 2 tendons and muscle bellies is also known to vary[15]; however, the clinical implications of this anatomic variation are not fully understood.

The concept of a single-head tear of the distal biceps is recognized; however, the condition is uncommon and as described, there are only 8 specific cases previously reported in the literature. Several other studies focus on partial tears of the distal biceps and include descriptions of patients with similar clinical features to those we describe with an isolated short head tear.

Bourne and Morrey[4] described the surgical treatment of 3 cases of partial distal biceps rupture. Two of the cases were typical tendinopathy patients with chronic prodromal biceps pain leading to surgery; however, 1 patient had an acute injury with no prodromal symptoms, an intact feeling component to the biceps on clinical examination, weakness on strength testing, and the presence of normal tendon attachment adjacent to the torn component on surgical exploration. This case has all the hallmarks of a short head tear although at the time may not have been recognized as such.

Kelly et al[12] described the treatment of 8 distal biceps partial tears. Four of 8 patients had an acute injury leading to symptoms. They were all treated through a single posterior approach, and none of the patients exhibited retraction of the torn tendon, suggesting these tears were more degenerate in nature. Again, the concept of a single-head tear was not mentioned or discussed in this article, suggesting it was not a recognized entity at that time.

Ruch et al[20] performed a case control study of partial distal biceps tears and acute tears with a focus on complications. Fourteen of 15 cases in the partial tear group had degenerate tears to the undersurface (lateral) tendon fibers, but they did report 1 case with a clear isolated short head rupture and a normal-looking long head. Preoperative or imaging details regarding this case were not available as this was not the focus of their study.

Dirim et al[7] performed a cadaveric and clinical study using MRI to assess the variation in biceps anatomy. They retrospectively analyzed the MRI scans of 68 patients presenting to their institution with a distal biceps tear. They noted a bifurcated tendon in 8 (12%) of these patients. Four of these had isolated short head tears of the biceps as recognized on the MRI, with operative records confirming these findings in 2 of the patients.

It is likely that patients with an isolated short head rupture are among the 25% of the population with distinct short and long head component to the distal biceps.[2,8] Patient 1 in our series substantiates this view as he had exactly the same anatomic findings and injury presentation in both elbows 3 years apart. To our knowledge, an isolated distal biceps long head rupture has not been reported. It is not clear why the short head is more susceptible to rupture; however, it has previously been proposed that the short head is more responsible for flexion power than the long head because of its more distal position.[3] Given that the acute injury mechanism of a distal biceps rupture is typically an eccentric flexion contraction of the muscle, it is possible that the most distal fibers are damaged first under tension and that if the patient has a bifurcated insertion, the tear propagates up the bifurcation rather than into the long head attachment (Fig. 1, *b*). This pattern of tearing is distinct from that seen in chronic, degenerative partial ruptures where the tearing occurs across both components of the tendon on the undersurface (lateral insertional fibers) and propagates through the tendon with time.[23]

When repairing the short head, the tendon may be repaired in isolation or with the long head after releasing the long head tendon. Both techniques have been described with good outcomes.[5,13,22,24,26] Our experience reported in this study reflects our evolution of understanding of the pathology. In patient 1, it was only discovered intraoperatively that there was an isolated short head tear. Although the long head attachment was normal, it was taken down and repaired along with the short head. By the time the patient re-presented 3 years later with the same, it was understood that this injury was akin to a

Table II Features of full-thickness tears, isolated short head ruptures, and partial ruptures

	Full-thickness rupture	Short head rupture	Degenerate partial rupture
Epidemiology	Younger, male	Younger, male	Most common in young men Increased incidence in women, older patients, and metabolic conditions
History	Acute	Acute	Chronic
Examination	Bruising and deformity	Bruising and deformity	No bruising or deformity
Hook test	Absent (no tendon)	Intact	Intact and often painful
Imaging	FABS MRI: complete rupture Radiograph: normal	FABS MRI: short head rupture Radiograph: normal	FABS MRI: tendinosis, diffuse partial tearing and bursitis Radiograph: possible tuberosity hypertrophy or enthesopathy
Management	Offer surgery	Offer surgery	Nonsurgical (first-line)

MRI, magnetic resonance imaging; *FABS*, flexion, abduction external rotation protocol.

full-thickness tear rather than a degenerate partial tear, most likely because of a bifurcated distal biceps insertion. Hence, on this occasion when the long head was confirmed to be normal in appearance, it was preserved and the short head repaired in isolation. It is our preference to repair the short head tendon in isolation and preserve the native long head attachment, as tendon healing after repair is known to result in a histologically inferior enthesis.[27] The long head integrity and quality is assessed at its attachment to the tuberosity on its undersurface, which is where a degenerate pre-existing tear would be identified. By pronating the forearm and relaxing the tendon tension, the insertion can be more easily appreciated. The tendon is then hooked with an instrument and stressed to assess integrity. Patient 3 demonstrated a degenerate torn short head with a normal-appearing long head attachment. Hence, as with many complete tears, there may be pre-existing asymptomatic tendinosis present.

In all the cases described, the short head caliber was significantly greater than the long head, which is in keeping with their disproportionate footprint anatomy.[2] It was, therefore, possible to whipstitch the short head using the same techniques as for a complete biceps rupture. When performing an isolated repair, it is desirable to place the short head at the anatomic footprint. Using a single-incision cortical button technique this is not possible, and hence the tendon was placed as ulnar as possible on the tuberosity immediately adjacent to the long head, accepting a slightly lateralized insertion to its anatomic footprint. This posed no clinical consequence; however, other techniques have been described to reproduce the perfect anatomic relationship and would also be reasonable to use.[11,18,25]

In all our cases of isolated short head rupture and those reported in the literature, the patients had a clear history of a single inciting event that led to rupture without a history of prodromal symptoms, anabolic steroid use, or metabolic abnormality. That is to say, the history of injury was consistent with what might be expected for a complete rupture. Another presenting feature to note in all our cases was the presence of bruising in the anteromedial aspect of the forearm following injury, which is a consistent feature of an acute complete tear but usually absent in tendinopathy or degenerate partial tears.

The hook test, which has been shown to be 100% sensitive and specific for the diagnosis of complete distal biceps tears, was intact (presence of the biceps) in all our cases.[16] It was appreciable that the patient had asymmetry of their muscle belly in all cases indicating a significant tear, but there was still a tendon that could be fully ''hooked'' by the examiner. This is distinct from a complete tear, where even though tendon tissue or biceps aponeurosis may be palpable, because of minimal retraction the tendon cannot be hooked during examination.[16] The cases in the literature did not consistently use the hook test to describe their findings, but 3 of 4 that did also reported an intact hook test. A tabulation summary of the pertinent features associated with full-thickness tears, isolated short head ruptures, and partial ruptures is shown in Table II.

Fourteen of the 15 cases reported in this study had preoperative MRI confirming the diagnosis of a short head tear. One of our patients did not have an MRI, as clinically he was thought to have a complete rupture preoperatively and was the first case we encountered. The pertinent common MRI findings in our patients were as follows: a clear distinction of the 2 muscle bellies on an axial MRI scan proximal to the cubital fossa, isolated retraction of the short head seen in the medial aspect of the biceps on a FABS view scan, and an absent biceps from the distal aspect of the tuberosity with normal fibers inserting proximally (long head) (Fig. 2). The specific MRI features seen in the cases from the literature with acute rupture were not available for comparison, although in one case a diagnosis of complete tear was incorrectly made by the radiologist. This highlights the importance of clinical examination, history, and the surgeons' ability to interpret the MRI themselves.

Acute, complete distal biceps tears when missed or treated nonoperatively result in a strength deficit but do not usually cause pain, whereas partial tears related to tendinopathy frequently result in chronic pain and reflexive weakness because of the pain rather than a structural issue with the tendon.[6,9,17]

Two patients in our series and 1 reported in the literature[15] had delayed diagnosis and on presentation complained of weakness, dysfunction, and asymmetry of the muscle with an intact hook test. The case reported by Morrell et al[14] was thought to be a ''myotendinous rupture'' of the short head; however, intraoperatively no distal short head tendon was identified. Hence, we believe this was more likely to have been a short head rupture from the tuberosity as in all the other cases, but with chronic involution and retraction of the tendon stump as seen in our chronic cases. The patient also had bifid muscle bellies on the preoperative MRI scan as in our chronic cases, which fits with our hypothesis that these tears originate at the tuberosity with force propagation between the bifid tendons, which spares the long head. The loss of normal tendon tissue in the chronic setting is a consistent finding with chronic complete tears and hence adds further weight to our view that isolated short head tears should be considered and treated in the same way as a complete tear rather than as tendinopathy with an associated partial tear.

We do not advocate that every patient with an isolated short head tear must have acute surgery. Rather, as with complete tears, patients should be given the options regarding operative and nonoperative treatment with an understanding of the risks[1] and benefits of both. The natural history following an isolated short head tear has not been described; however, our experience with these 2 patients demonstrates the capacity of the short head tendon to retract rapidly and continue to cause ongoing functional deficit.

Conclusion

Based on the findings from our own experience and the cases reported in the literature, we recommend that clinicians maintain a level of suspicion for the diagnosis of isolated short head rupture in the setting of a patient with an acute injury, bruising and asymmetry of the biceps muscle belly but an intact hook test. For these patients, a FABS view MRI should be requested and scrutinized carefully to confirm the diagnosis. Early treatment should be offered with counseling similar to that given to patients with a complete tear.

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References

1. Amarasooriya M, Bain GI, Roper T, Bryant K, Iqbal K, Phadnis J, et al. Complications after distal biceps tendon repair: a systematic review [Epub ahead of print]. Am J Sports Med 2020. https://doi.org/10.1177/0363546519899933
2. Athwal G, Steinmann S, Rispoli D. The distal biceps tendon: footprint and relevant clinical anatomy. J Hand Surg 2007;32:1225-9. https://doi.org/10.1016/j.jhsa.2007.05.027
3. Bain G, Johnson L, Turner P. Treatment of partial distal biceps tendon tears. Sports Med Arthrosc Rev 2008;16:154-61. https://doi.org/10.1097/JSA.0b013e318183eb60
4. Bourne MH, Morrey BF. Partial rupture of the distal biceps tendon. Clin Orthop Relat Res 1991:143-8.
5. Cho CH, Song KS, Lee SM. Isolated short head component rupture of a bifurcated distal biceps tendon mimicking as a complete rupture. J Hand Surg 2011;36:333-4. https://doi.org/10.1177/1753193411402002
6. Dellaero DT, Mallon WJ. Surgical treatment of partial biceps tendon ruptures at the elbow. J Shoulder Elbow Surg 2006;15:215-7. https://doi.org/10.1016/j.jse.2005.08.020
7. Dirim B, Brouha S, Pretterklieber M, Wolff K, Frank A, Pathria M, et al. Terminal bifurcation of the biceps brachii muscle and tendon: anatomic considerations and clinical implications. Am J Roentgenol 2008;191:W248-55. https://doi.org/10.2214/AJR.08.1048
8. Eames MH, Bain GI, Fogg QA, van Riet RP. Distal biceps tendon anatomy: a cadaveric study. J Bone Joint Surg 2007;89:1044-9. https://doi.org/10.2106/JBJS.D.02992
9. Frazier M, Boardman M, Westland M, Imbriglia J. Surgical treatment of partial distal biceps tendon ruptures. J Hand Surg 2010;35:1111-4. https://doi.org/10.1016/j.jhsa.2010.04.024
10. Giuffrè BM, Moss MJ. Optimal positioning for MRI of the distal biceps brachii tendon: flexed abducted supinated view. Am J Roentgenol 2004;182:944-6. https://doi.org/10.2214/ajr.182.4.1820944
11. Hasan SA, Cordell CL, Rauls RB, Bailey MS, Sahu D, Suva LJ. Two-incision versus one-incision repair for distal biceps tendon rupture: a cadaveric study. J Shoulder Elbow Surg 2012;21:935-41. https://doi.org/10.1016/j.jse.2011.04.027
12. Kelly EW, Steinmann S, O'Driscoll SW. Surgical treatment of partial distal biceps tendon ruptures through a single posterior incision. J Shoulder Elbow Surg 2003;12:456-61. https://doi.org/10.1016/s1058-2746(03)00052-1
13. Koulouris G, Malone W, Omar I, Gopez A, Wright W, Kavanagh E. Bifid insertion of the distal biceps brachii tendon with isolated rupture: magnetic resonance findings. J Shoulder Elbow Surg 2009;18:e22-5. https://doi.org/10.1016/j.jse.2009.03.018
14. Morrell NT, Hammond TL, Lemos DF. Reconstruction of a chronic, isolated, myotendinous rupture of the short-head component of the distal biceps tendon. J Shoulder Elbow Surg 2019;28:e182-6. https://doi.org/10.1016/j.jse.2018.12.022
15. Morrey B, Askew L, An K, Dobyns J. Rupture of the distal tendon of the biceps brachii. A biomechanical study. J Bone Joint Surg 1985;67:418-21.
16. O'Driscoll SW, Goncalves LB, Dietz P. The hook test for distal biceps tendon avulsion. Am J Sports Med 2007;35:1865-9. https://doi.org/10.1177/0363546507305016
17. Phadnis J, Bain G. Distal biceps tendinopathy. In: Ring D, Steinmann S, editors. Advanced reconstruction: elbow. 2nd edition. Rosemont, IL: American Academy of Orthopaedic Surgeons. ISBN: 978-1-62552-546-8.
18. Phadnis J, Bain G. Endoscopic-assisted distal biceps footprint repair. Tech Hand Up Extrem Surg 2015;19:55-9. https://doi.org/10.1097/BTH.0000000000000078

19. Phadnis J, Flannery O, Watts AC. Distal biceps reconstruction using an Achilles tendon allograft, transosseous EndoButton, and Pulvertaft weave with tendon wrap technique for retracted, irreparable distal biceps ruptures. J Shoulder Elbow Surg 2016;25:1013-9. https://doi.org/10.1016/j.jse.2016.01.014
20. Ruch D, Watters T, Wartinbee D, Richard M, Leversedge F, Mithani S. Anatomic findings and complications after surgical treatment of chronic, partial distal biceps tendon tears: a case cohort comparison study. J Hand Surg 2014;39:1572-7. https://doi.org/10.1016/j.jhsa.2014.04.023
21. Safran MR, Graham SM. Distal biceps tendon ruptures: incidence, demographics, and effect of smoking. Clin Orthop Relat Res 2002;404:275-83.
22. Sassmannshausen G, Mair SD, Blazar PE. Rupture of a bifurcated distal biceps tendon. A case report. J Bone Joint Surg Am 2004;86:2737-40. https://doi.org/10.2106/00004623-200412000-00023
23. Sutton K, Dodds S, Ahmad C, Sethi P. Surgical treatment of distal biceps rupture. Am Acad Orthop Surg 2010;18:139-48. https://doi.org/10.5435/00124635-201003000-00003
24. Voleti PB, Berkowitz JL, Konin GP, Cordasco FA. Rupture of the short head component of a bifurcated distal biceps tendon. J Shoulder Elbow Surg 2017;26:403-8. https://doi.org/10.1016/j.jse.2016.09.050
25. Weinstein D, Ciccone W, Buckler M, Balthrop P, Busey T, Elias J. Elbow function after repair of the distal biceps brachii tendon with a two-incision approach. J Shoulder Elbow Surg 2008;17(Suppl):S82-6. https://doi.org/10.1016/j.jse.2007.07.006
26. Witney-Lagen C, Kothapalli S, Robinson R, Venkateswaran B. Isolated rupture of the separate insertion of the short head of biceps on the radial tuberosity: ultrasound and magnetic resonance imaging diagnosis with successful surgical treatment. Shoulder Elbow 2013;5:211-5. https://doi.org/10.1111/sae.12019
27. Zumstein MA, Lädermann A, Raniga S, Schär MO. The biology of rotator cuff healing. Orthop Traumatol Surg Res 2017;103(Suppl):S1-10. https://doi.org/10.1016/j.otsr.2016.11.003