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SCIENTIFIC ARTICLE

Delaminating infraspinatus tendon tears with differential retraction: imaging features and surgical relevance

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Abstract
Objective To describe infraspinatus tendon injuries with associated intramuscular edema in light of more recently elucidated anatomical knowledge.
Material and methods A retrospective review was performed to identify MRI cases with infraspinatus tendon injury accompanied by muscle edema. MR images were reviewed to evaluate the location of the injury, to assess the degree of tendon retraction, and to assess for muscular changes. Clinical and surgical data were reviewed when available.
Results Twenty-three patients were identified (13 males, 10 females, mean age of 52 years). MRI demonstrated infraspinatus muscle edema in all cases with variably retracted infraspinatus tendon fibers. Three patients (13 %) presented acutely after traumatic falls, 11 patients (48 %) presented after a minor trauma or recalled event, and 9 patients (39 %) presented with more chronic symptoms. Of the nine patients who underwent arthroscopic surgery, six patients (67 %) did not have an identifiable corresponding lesion, despite the findings described on the preoperative MRI. In these six cases, some superficial fibers of the transverse portion of the infraspinatus tendon remained intact on the MRI. Three patients (13 %) had follow-up MRI examinations with one progressing to severe muscle atrophy, one without progression of existing muscle atrophy, and one with no atrophy on the initial or subsequent evaluation. Eighteen of 23 patients had concomitant partial-thickness or full-thickness tears of the adjacent supraspinatus tendon.
Conclusion Injuries of the infraspinatus tendon with resultant muscle edema and variable muscle atrophy may, in fact, represent delaminating type injuries with differential retraction of a layered tendon and may be missed on arthroscopy.

Keywords Infraspinatus · Novel lesion · Delaminating · Rotator cuff

Introduction

Isolated injuries of the infraspinatus tendon are unusual, but not infrequent [1–6]. A peculiar pattern of infraspinatus injury occurs in association with a characteristic pattern of muscle edema. The precise location of the tendon tear has been postulated to involve anywhere from the distal tendon near the footprint to the musculotendinous junction [1–3, 7], and these injuries have been described as "novel lesions" of the infraspinatus [1]. Patients often present with pain, and previous studies have shown these injuries to be functionally significant since there is weakness during external rotation, particularly against resistance [1].

However, recent anatomic investigations have demonstrated a more complicated structure to the infraspinatus tendon than previously recognized. Specifically, it is now known that the infraspinatus tendon is layered and derived from two muscle bellies, with a more superficial tendon inserting onto a deeper tendon, the latter of which inserts into the greater tuberosity footprint [8]. Therefore, isolated injuries to the

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superficial tendon would not be visible during glenohumeral arthroscopy and may potentially be occult during bursoscopy.

The purpose of our study is to describe infraspinatus injuries involving the tendon or musculotendinous junction with associated intramuscular edema (the so-called “novel lesion”) in light of recently elucidated anatomical knowledge. We postulate that these injuries may represent delaminating tears with differential retraction, involving the more superficial portion of the layered tendon. Additionally, we hypothesize that some injuries to the superficial tendon of the infraspinatus may be arthroscopically occult, even when the diagnostic findings are suggested on preoperative magnetic resonance imaging (MRI).

Materials and methods

Patient selection

This retrospective chart review study was performed utilizing records from two institutions. Institutional review board approval was obtained at both institutions. Informed consent was waived in this HIPPA compliant study. A retrospective database search of the Radiology Information System (RIS) was performed over a 3-year period from January 2010 to December 2012. A key word search for the term “novel lesion” was applied to the search algorithm, as our group began to document these cases using this terminology following the publication of the findings by Lunn et al. [1]. Inclusion criteria included any injury involving the tendon or musculotendinous junction with associated intramuscular edema, with or without fatty infiltration.

MR imaging evaluation

All MR examinations were performed on 1.5-T MRI systems. As this study spanned two different institutions, imaging protocols slightly differed between the two. However, the imaging protocols included common sequences that were comprised of one axial fluid-sensitive, two sagittal oblique, and two coronal oblique sequences. These included: axial proton density (PD) or intermediate fat suppressed [TR (range in ms)/TE(range in ms) 2000–2600/20–40], coronal oblique PD (TR/TE 1400/20), coronal oblique PD or intermediate fat suppressed (TR/TE 2200–2300/20–40), sagittal oblique T1 (TR/TE 500/10), and sagittal oblique PD or intermediate fat suppressed (TR/TE 2200–2300/20–40). In two cases, an MR arthrogram was performed. In those cases approximately 10–12 ml of a solution consisting of 0.5 ml of gadopentetate dimeglumine (Magnevist; Schering, Berlin, Germany) diluted in 100-ml equal parts of saline solution and iodinated contrast agent (Iohexol, Omnipaque 350; Bayer Healthcare Pharmaceuticals, Leverkusen, Germany) was injected into the glenohumeral joint under fluoroscopic guidance using a standard anterior approach. Axial, coronal oblique, sagittal oblique, and abduction/external rotation T1-weighted fat-suppressed sequences were performed (TR/TE 500–600/10–20) as well as one coronal oblique intermediate fat-suppressed sequence (TR/TE 5333/67). Finally, one patient underwent same-day non-contrast shoulder MRI followed by an MRI arthrogram. However this was performed on a follow-up study, not during the initial evaluation.

The MR images were subsequently reviewed by two fellowship-trained musculoskeletal radiologists (blinded for review purposes) in consensus, with 5–6 years of experience in musculoskeletal subspecialized radiology departments. The injuries of the infraspinatus were graded based on the superior-inferior location of the tear, according to involvement of either the transverse or oblique portions according to the tendon architecture described by Kato et al. [8] and subdividing each component into superficial and deep tendon portions. The injuries were also categorized based on their medial-lateral location, according to involvement of the distal tendon, mid tendon, or myotendinous junction. Medial tendon retraction was also measured and recorded. Additionally, when differential fatty infiltration was observed, the portion of the muscle that was predominantly involved was recorded (transverse versus oblique). The presence of concomitant supraspinatus tendon tears was also recorded.

Chart review

Review of the patient’s charts was also performed retrospectively with attention to the history and clinical examination findings. The presence or absence of preceding trauma was recorded. Minor trauma or specific recalled events were grouped separately. If available, presence of impingement signs and hand dominance were recorded. Any deficits in external rotation were also noted, as the infraspinatus muscle is a primary external rotator of the glenohumeral joint.

Statistical analysis

Descriptive statistics were performed. The chi-square test was used to assess for any relationships among gender, dominance, differential fatty infiltration, and transverse head or oblique head involvement. Univariate regression was used to assess the relationship of gender and age to tear retraction. Logistic regression was used to assess the relationship between age and transverse versus oblique head involvement as well as with medial-lateral location of tendon injury. Paired t-tests were utilized to assess any differences between pre- and postoperative external rotation.

Results

Patient cohort

Twenty-three patients (13 males and 10 females) were included in the study. The average age at presentation was 52 years (range 24–75 years). Ten left and 13 right shoulders were affected. Eleven injuries occurred in the dominant shoulder, two injuries occurred in the non-dominant shoulder, and the dominance was unknown in the remaining ten patients. Clinical follow-up with or without imaging follow-up was performed in 17 patients (74 %) with an average follow-up of 206.2 days (range 55 to 580 days). The remaining patients had no additional clinical follow-up after the initial evaluation.

Imaging

Table 1 summarizes the characterization of infraspinatus tendon tearing based on either superficial or deep fiber involvement of the transverse or oblique part and whether the mid or distal portion of each tendon component was affected. In three patients, there was involvement of all layers of both tendon components, representing full-thickness tearing. With regard to the transverse component, the superficial fibers were affected in 14 (60 %) cases, the deep fibers were affected in 21 (91 %) cases, and both deep and superficial layers were affected in 12 (52 %) cases. There were no cases where any part of the oblique tendon was intact. With regard to the oblique component, the superficial fibers were affected in 14 (60 %) cases, the deep fibers were affected in 21 (91 %) cases, and both deep and superficial layers were involved in 6 (26 %) cases. In two (9) cases, the oblique tendon was intact in its entirety.

All cases demonstrated infraspinatus muscle edema and variably retracted infraspinatus tendon fibers (Figs. 1 and 2). The average distance of tendon retraction from the medial margin of the greater tuberosity footprint was 3.8 cm (range 0.9–7.4 cm). No underlying tendon calcification was demonstrated. In all cases, the transverse tendon part was involved, and in all but two cases (21/23, 91 %) the oblique tendon part was involved. There was variable involvement of superficial and deep fibers of either component. The location of the tear in the medial-lateral dimension involved primarily the distal portions of the transverse (19/23, 83 %) and oblique (18/21, 86 %) tendon fibers near the footprint. The mid-tendon more medial to the footprint was involved in four cases (4/23, 17 %) of transverse tendon involvement and three cases (3/21, 14 %) of oblique tendon involvement. In no cases was a primary musculotendinous disruption identified since a clearly identifiable tendon stump was present in all cases.

Of the MR arthrogram studies that were performed in two patients, neither demonstrated any contrast communication to the overlying subacromial-subdeltoid bursa to indicate the presence of a full-thickness tear. Both showed an intact infraspinatus tendon footprint and a variably retracted tendon with accompanying intramuscular edema. The injury was not obvious on the T1-weighted fat-suppressed images, but was easily identifiable on fluid-sensitive sequences (Fig. 3).

Three cases (3/23, 13 %) had follow-up MRI at an average of 18 months after initial imaging. One patient who underwent arthroscopy had a follow-up MRI approximately 18 months after surgery, which showed resolution of the infraspinatus muscle edema but progression of severe atrophy and fatty degeneration of the muscle (Fig. 4). Another patient who underwent interval arthroscopic cuff repair showed no significant progression of fatty atrophy of the muscle, which had already been present on the initial MRI. In one case, follow-up MRI approximately 31 months later revealed that the infraspinatus muscle edema had completely resolved, with normalization of the muscle without any atrophy, but with residual thickening of the tendon.

In six patients (6/23, 26 %), there was differential atrophy and fatty infiltration of the infraspinatus muscle that appeared to affect the upper part of the muscle more than the lower part (Fig. 5). In six patients (6/23, 26 %), there were atrophy and fatty infiltration that were global and affected the entire infraspinatus muscle.

In five patients (5/23, 22 %), the adjacent supraspinatus tendon was intact, and in six patients (6/23, 26 %), there was full-thickness tearing of the supraspinatus tendon. In the remaining 12 patients (12/23, 52 %), there were varying degrees of partial-thickness tearing of the supraspinatus tendon.

Clinical evaluation

Three patients (3/23, 13 %) presented acutely after a traumatic fall. Eleven patients (11/23, 48 %) recalled a single event that led to symptoms: eight after a lifting or pulling episode, one after performing yoga maneuvers, and two after performing throwing motions. The remaining nine patients (9/23, 39 %) presented with pain without a preceding injury or event, and one of these patients had a history of rheumatoid arthritis. External rotation strength and presence of pain were recorded in 11 patients on clinical examination, and in 6 (6/11, 55 %) there was documented weakness. Seven patients (7/11, 64 %) had documented pain with external rotation, with four of these patients having pain particularly with resisted external rotation. In the

Table 1 Characterization of infraspinatus tendon tears

Infraspinatus tendon retraction (cm)	Infraspinatus muscle fatty degeneration*	Differential fatty degeneration (predominant)	Transverse (superficial versus deep)	Transverse (mid versus distal)	Oblique (superficial versus deep)	Oblique (mid versus distal)
0.9	0	n/a	Superficial/deep	Distal	Superficial	Distal
2.3**	0	n/a	Superficial/deep	Distal	Superficial	Distal
1.6	4	Y (transverse)	Superficial/deep	Distal	Intact	Intact
3.6**	0	n/a	Superficial/deep	Distal	Superficial	Mid
5.4**	3	Y (transverse)	Deep	Distal	Superficial	Distal
4.5	1	N	Deep	Distal	Superficial	Distal
2.7**	0	n/a	Superficial/deep	Distal	Superficial	Distal
7.6**	0	n/a	Deep	Distal	Superficial/deep	Distal
3.1**	2	Y (transverse)	Superficial/deep	Distal	Superficial/deep	Distal
6.3	4	Y (transverse)	Superficial/deep	Mid	Intact	Intact
3.5**	0	n/a	Deep	Distal	Superficial	Distal
4.5**	2	Y (transverse)	Superficial/deep	Distal	Superficial	Distal
0.9	2	N	Superficial/deep	Distal	Superficial	Distal
4.3	2	N	Superficial/deep	Distal	Superficial/deep	Distal
2.8	3	N	Superficial/deep	Distal	Superficial/deep	Distal
7.4	0	n/a	Deep	Distal	Superficial	Distal
3.5	0	n/a	Superficial	Mid	Superficial	Mid
4.3	0	n/a	Superficial	Distal	Superficial/deep	Mid
7.6	0	n/a	Deep	Mid	Superficial	Distal
0	0	n/a	Deep	Distal	Superficial	Distal
3.8	3	Y (transverse)	Deep	Distal	Superficial/deep	Distal
4.3	1	N	Superficial/deep	Mid	Superficial	Distal
3.3**	0	n/a	Deep	Distal	Superficial	Distal

*Goutallier grade [11]

**Indicates patients who underwent arthroscopic surgery

remaining patients, the clinical examination did not test infraspinatus function specifically. No patients had any corticosteroid injections prior to presentation. Five patients did undergo a subsequent corticosteroid injection as part of their treatment.

Nine (9/23, 39 %) patients eventually underwent arthroscopic surgery an average of 65.9 days after the MRI examination (range: 14 to 172 days). One of the nine surgically managed patients reported a traumatic fall, while the remaining patients had no or minor trauma. The remaining patients were managed conservatively with physical therapy and/or corticosteroid injections or had no further clinical follow-up. Of the nine patients who had arthroscopic surgery, the average follow-up time after surgery was 141.8 days (range 13–210 days). Three patients (3/9, 33 %) had bursal-sided partial-thickness tearing of the infraspinatus tendon on arthroscopy, which corresponded to the findings seen on their preoperative MRI (Fig. 6). In the remaining six patients (6/9, 67 %), the infraspinatus injury was not identified arthroscopically. A review of the imaging of all patients who had occult tears showed that some superficial fibers of the transverse portion of the infraspinatus tendon remained intact (Figs. 1 and 7). Three patients underwent arthroscopic rotator cuff debridement, while the remaining six patients underwent arthroscopic rotator cuff repair. Of the patients who underwent surgery, only six had pre- and postoperative external rotation testing. At the extremes, there was one patient who lost 30° of external rotation, and another patient who gained 40° of external rotation. There was an average gain of approximately 3° of external rotation among the six patients postoperatively. The majority of patients did not undergo external rotation strength testing postoperatively. Seven of the nine patients who underwent surgery were doing well postoperatively with reduction of pain. Two patients experienced worsening symptoms and subsequently underwent postoperative MRI evaluations.

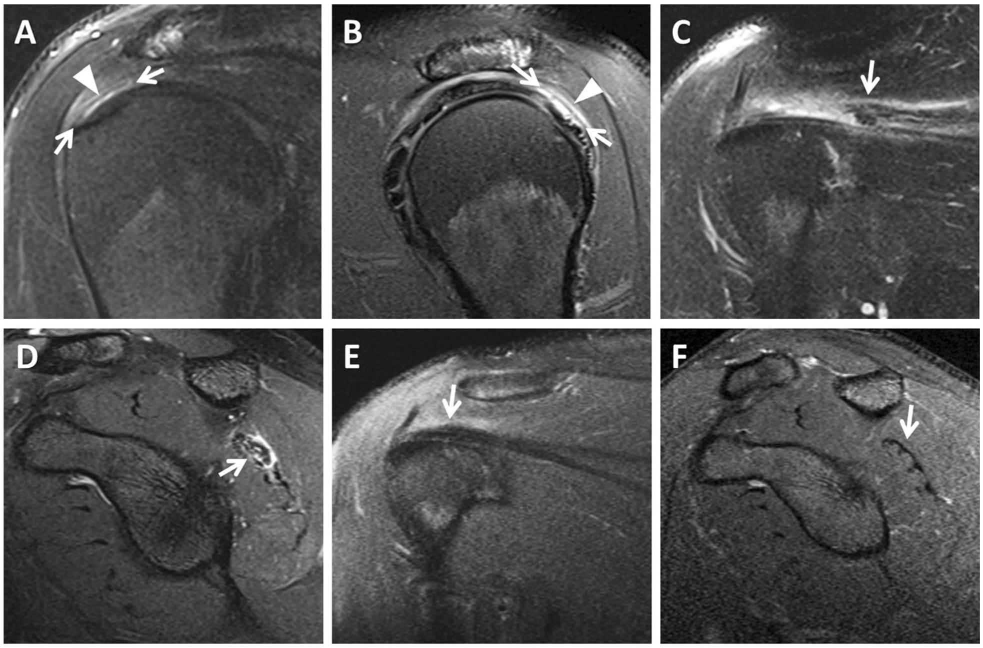

Fig. 1 A 39-year-old male with injury and pain, although external rotation strength was maintained. (**a** and **b**) Oblique coronal and sagittal fluid-sensitive sequences at the footprint show a tear of the transverse portion of the infraspinatus tendon, with the deeper fibers of the oblique portion intact. A portion of the superficial surface of the transverse part remained intact (*arrowhead*). (**c** and **d**) Images obtained more posteriorly and centrally show that the transverse tendon is retracted to the glenoid margin (*arrows*). During subsequent arthroscopy, an infraspinatus tendon tear was not visualized (not shown). (**e** and **f**) Coronal and sagittal fluid sensitive sequences several months prior to injury show that the infraspinatus was previously intact (*arrows*)

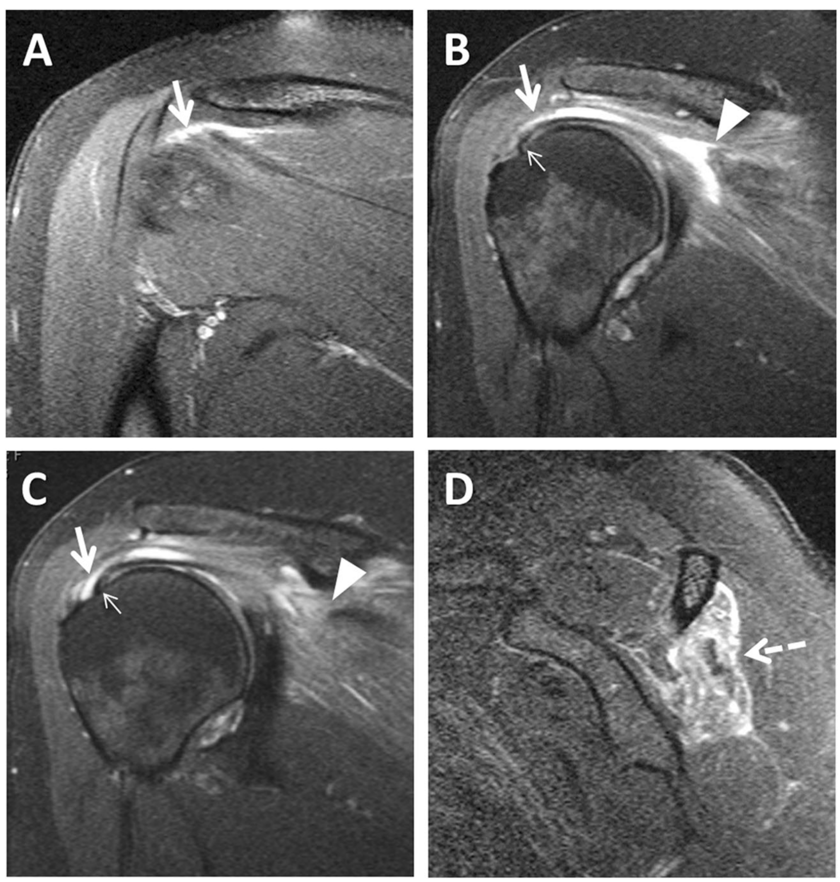

Fig. 2 (**a**) A 44-year-old female presenting with 10 months of pain after moving boxes, but maintained external rotation strength. Oblique coronal fluid-sensitive image shows minimal retraction of the torn bursal surface fibers of the infraspinatus tendon with surrounding edema. (**b**, **c**, and **d**) A 63-year-old female presenting 1 month after a yoga injury with pain and decreased external rotation strength. Sequential oblique coronal (**b** and **d**) and sagittal (**d**) fluid-sensitive images show moderate-grade intrasubstance partial-thickness tearing of the infraspinatus tendon near the footprint (*arrows*), with a thickened and retracted tendon more centrally (*arrowhead*) and intra-muscular edema of the infraspinatus. Note the intact articular-sided fibers (*small arrow*), which represent those derived from the oblique tendon. There is isolated infraspinatus muscle edema (*dashed arrow*)

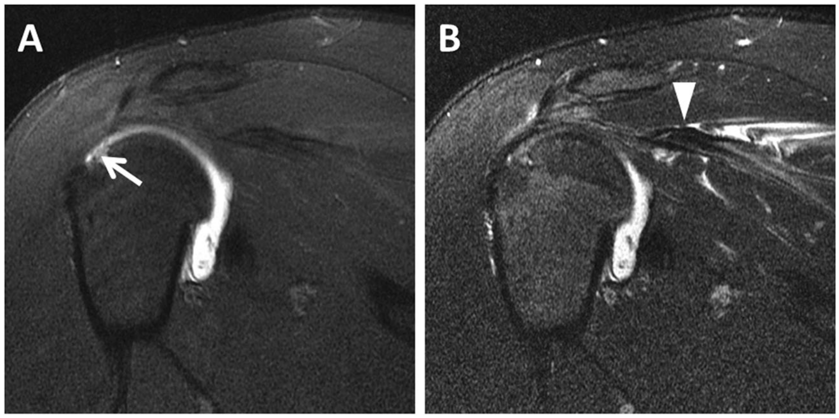

Fig. 3 A 27-year-old male with a lifting injury 1 day earlier presenting with pain and decreased external rotation strength. (**a**) Coronal T1-weighted fat-suppressed image after arthrography fails to show any communication of contrast from the glenohumeral joint to the overlying subacromial-subdeltoid bursa. The infraspinatus tendon footprint was intact on MR arthrography (*arrow*) as well as on arthroscopy. (**b**) However, a corresponding coronal fluid-sensitive image shows edema about a retracted infraspinatus tendon (*arrowhead*), composed primarily of the superior or transverse portion. On the T1-weighted fat-suppressed sequences, of the study, this injury was not well demonstrated, but in retrospect there is subtle increased signal intensity about the tendon fibers, which may be related to T1 shortening from intra-muscular hemorrhage. This finding was identified on arthroscopy only from the bursal side, and a primary repair was performed

Statistical analysis

There was no relationship between gender and hand dominance ($p = 0.067$) or with tearing of either part of the infraspinatus tendon or location of injury ($p = 0.121$ to 0.683). Age did not correlate with the degree of tendon retraction ($p = 0.405$) or with tearing of either part of the infraspinatus tendon or location of injury

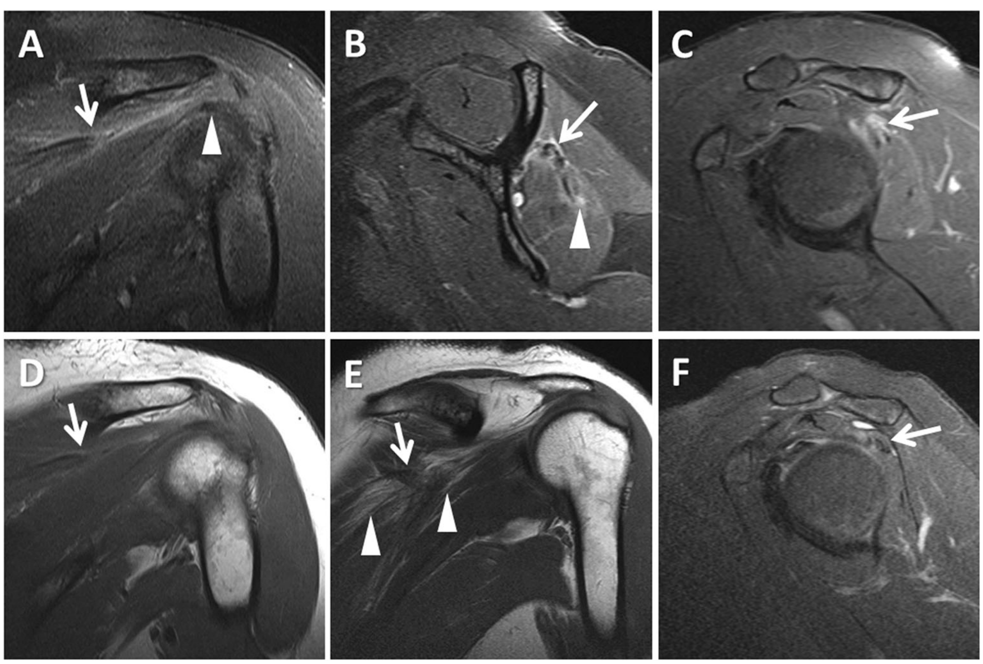

Fig. 4 A 45-year-old female with atraumatic pain and preoperative (**a**-**d**) and 18-month postoperative (**e**-**f**) examinations. Arthroscopy performed 38 days after the preoperative examination did not show an abnormality of the infraspinatus. (**a**) Coronal fluid-sensitive image shows an intact footprint representing fibers of the oblique tendon (*arrowhead*) with torn and retracted fibers of the transverse tendon of the infraspinatus (*arrow*). (**b** and **c**) Edema is noted surrounding the musculotendinous junction of the infraspinatus, along both the transverse tendon (*arrow*) and oblique tendon (*arrowhead*). (**d**) Coronal PD-weighted image shows retracted tendon but preserved muscle bulk. (**e**) Coronal PD-weighted image 18 months after surgery shows progression of fatty infiltration of the muscle (*arrowheads*) around the torn and retracted tendon (*arrow*). (**f**) Sagittal fluid-sensitive image 18 months after surgery shows a thickened transverse tendon with resolution of the edema affecting the transverse muscle fibers (*arrow*)

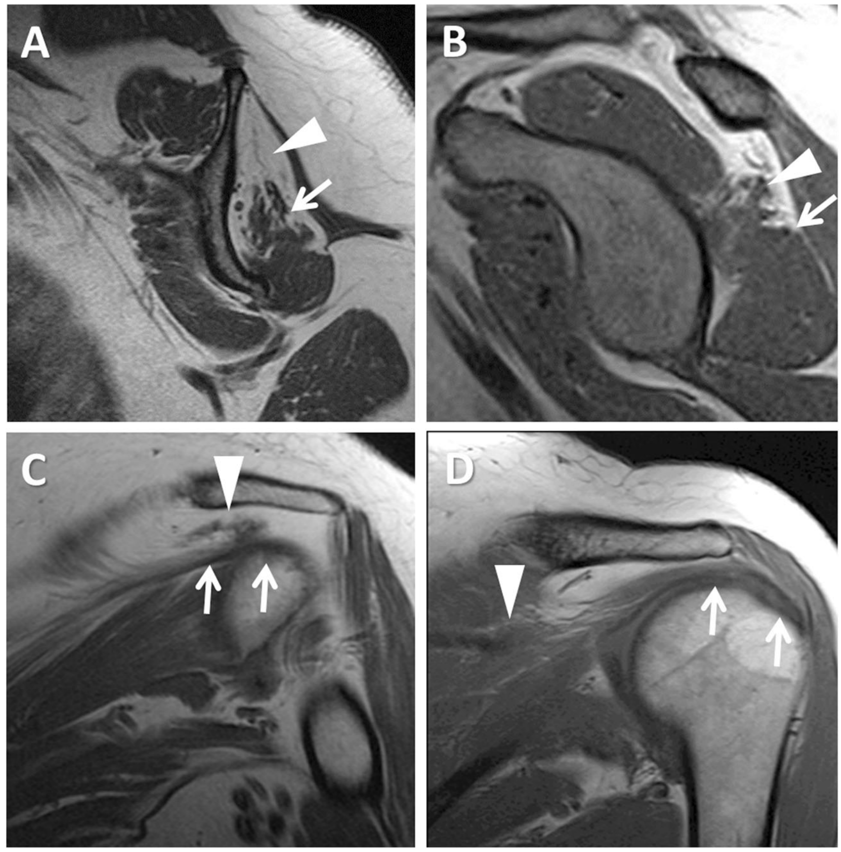

Fig. 5 Two patients presenting with partial-thickness distal infraspinatus tendon tears. In both cases, the oblique tendon was completely intact, but the transverse tendon was completely torn. Differential atrophy and fatty infiltration of the infraspinatus predominantly in the upper portion of the muscle (*arrowhead*) can be observed compared with the lower portion of the muscle (*arrow*) on coronal PD-weighted sagittal oblique images. (**a**) A 37-year-old female with chronic left shoulder pain and no preceding trauma. (**b**) A 45-year-old female with pain after lifting boxes 5 months earlier. (**c** and **d**) Corresponding PD-weighted coronal oblique in the same two patients showing retracted tendon fibers comprised of the transverse component (*arrowhead*), with intact tendon fibers comprised of the oblique component

($p = 0.259$ to 0.667). Differential fatty degeneration of the infraspinatus muscle was not associated with transverse or oblique involvement ($p = 0.154$–0.819). Oblique head involvement was seen only in the dominant extremity and was not involved in non-dominant extremities ($p = 0.001$). No significant differences between pre- and postoperative external rotation were found ($p = 0.752$).

Discussion

An injury to the infraspinatus with intense intramuscular edema on MR imaging is referred to in the surgical literature as the “novel lesion of the infraspinatus,” a term coined by Lunn et al. in 2000 [1]. Other authors have highlighted the importance of these lesions, since early diagnosis and tendon repair may restore muscle

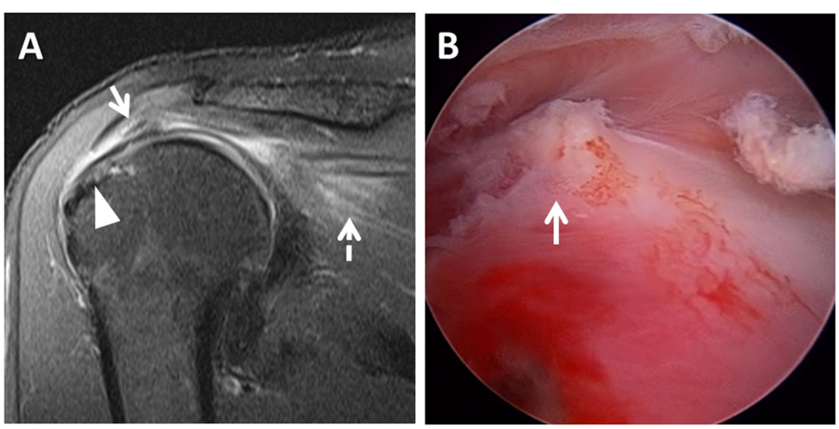

Fig. 6 A 41-year-old male presenting with posterior shoulder pain for 6 months after throwing a ball. (**a**) Coronal fluid-sensitive image shows an intact footprint (*arrowhead*) and with torn and retracted bursal-sided fibers of the infraspinatus tendon, representing fibers of the transverse part of the infraspinatus. Accompanying infraspinatus muscle edema is present medially (*dashed arrow*). (**b**) Corresponding arthroscopic image performed 100 days after the MRI, as viewed from the subacromial-subdeltoid bursa, demonstrates the torn and retracted bursal fibers (*arrow*)

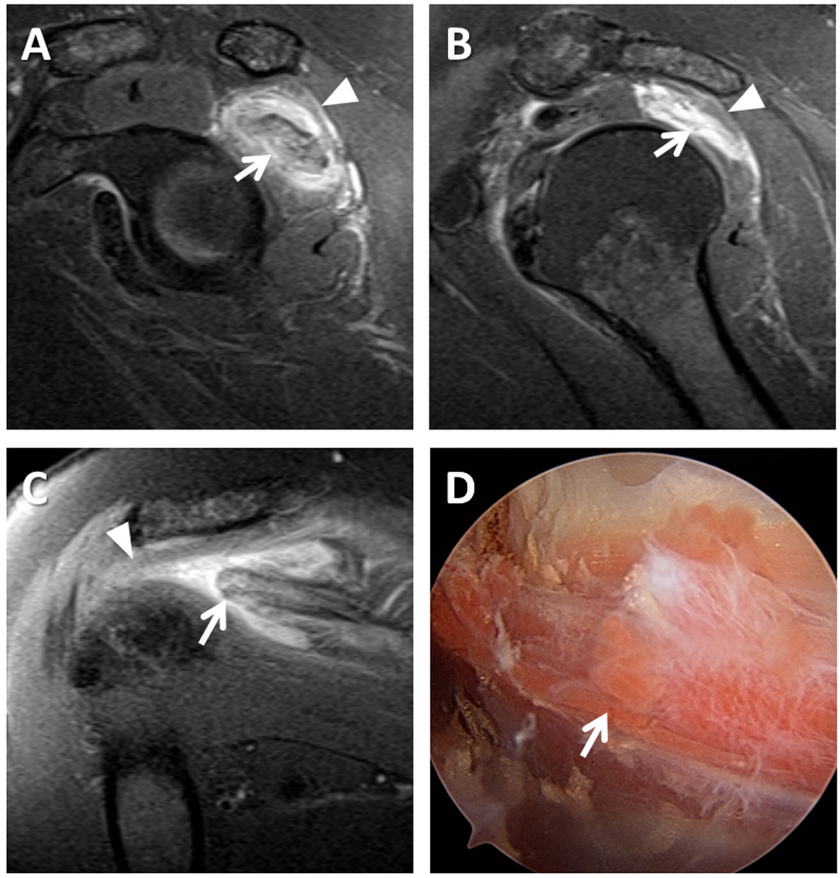

Fig. 7 A 69-year-old female with injury, pain, and loss of function. (**a**–**c**) Sagittal fluid-sensitive sequences show a tear of the transverse portion of the infraspinatus tendon predominantly involving the deep surface, which is retracted to the glenoid margin (*arrows*). A thin portion of the superficial tendon remained predominantly intact (*arrowheads*). (**d**) During subsequent arthroscopy, thorough examination revealed an edematous infraspinatus muscle as viewed from the bursal side (*arrow*), but no tear

tension and prevent complete functional muscle loss [2–4]. However, since the characterization of this distinct entity by Lunn et al., Kato et al. [8] have revised the existing knowledge of the infraspinatus muscle and tendon anatomy. Specifically, the authors showed in an elegant anatomical and histological study that the infraspinatus is composed of an inferior (or oblique) muscle belly and a superior (or transverse) muscle belly [8]. To our knowledge, characterization of the "novel lesion of the infraspinatus" has not previously been performed in light of this important and recently elucidated anatomic knowledge.

Our investigation describes the imaging features of infraspinatus injuries presenting with edema, while taking into account the unique anatomy of the infraspinatus muscle and tendon. We have found that the "novel lesion of the infraspinatus" most typically represents a delaminating injury with differential retraction, involving the transverse portion of the tendon in all cases while also involving the oblique portion in nearly all cases. Failure of the transverse portion is in keeping with the anatomical findings by Kato et al., who found that the transverse part attaches to the tendinous oblique part via a "thin membrane-like tissue" [8]. All of our cases involved disruption of the tendon, since blind ending tendon stumps were identified. In the patient population described by Lunn et al., the location of injury was more variable, including nine injuries "within" the tendon, eight within the myotendinous junction, and two in which the location of injury could not be determined [1]. More recently, Guerini et al. [4] investigated the use of ultrasound in the diagnosis of myotendinous junction injuries of the infraspinatus and identified 15 patients in their retrospective study, all with MRI correlation. They found that in 60 % of their cases, the distal infraspinatus tendon had an abnormal sonographic appearance. Thus, they postulated that the myotendinous disease may have originated from the distal tendon. Taneja et al. [9] also recently described myotendinous junction injuries of the superior cuff. In approximately 25 % of their cases affecting the supraspinatus muscle, they were able to identify a full- or partial-thickness tear with focal tendon retraction. In contradistinction, they did not identify a tendon tear in the infraspinatus muscle injuries. The uncertainty in determining the location of injury and variably reported frequencies highlights the overall difficulty with grading and characterizing these unusual injuries. However, we believe that potential misinterpretation can occur regarding the location of injury when the variably retracted tendon becomes located near the native myotendinous junction with the presence of a fluid gap and muscular edema. The actual cause of the muscle edema remains to be elucidated, but is a characteristic finding of this lesion. Potential causes include reactive muscle edema from the retracted tendon tear, a superimposed myotendinous strain, or possibly acute to subacute denervation edema from disruption of the neural pedicle related to muscle and tendon retraction.

Our results confirm that this is a clinically and surgically important lesion. In our study, 55–64 % of patients presenting with the "novel lesion" demonstrated pain or weakness. Interestingly, 39 % did not recall a preceding injury or inciting event. In 67 % (6/9) of the patients in our study who underwent arthroscopy, an infraspinatus injury was not identified. This is comparable to Walch et al., who found that 46 % (11/24) of their cases were surgically occult [3]. When we reviewed the imaging of our six surgically occult patients, it was apparent that some superficial fibers of the transverse portion were intact. These intact superficial fibers may conceal the lesion when performing bursoscopy. Similarly, the intact deep fibers of the oblique portion may conceal the lesion from arthroscopy. In one of our cases (Fig. 7), the surgeon thoroughly interrogated the muscle as far medially as the glenoid and noted the visually intact muscle appeared edematous. This may be a secondary sign of underlying concealed delamination.

Outcomes of this pattern of infraspinatus tendon injury are variable. In the investigation of Lunn et al. [1], 5 of their 19 patients underwent arthroscopic repair. Although they found an overall improvement in clinical pain and function scores (Constant score) regardless of treatment arm, they found no difference in the degree of improvement in Constant score between the operatively and conservatively managed patients. All developed severe (Goutallier stage 4) fatty infiltration regardless of treatment arm. Similarly, in the investigation of Walch et al., 24 of 59 of their patients eventually underwent surgery, and there were no statistically significant differences in Constant score or subjective results between the surgically versus medically treated groups [3]. Although all of their patients who presented with acute edema in the infraspinatus muscle developed severe (stage 4) fatty infiltration irrespective of treatment, the investigators hypothesized that even earlier tendon repair may restore muscle tension and prevent complete functional muscle loss. In our series only three patients had MRI follow-up; however, one conservatively treated patient demonstrated normalization of the infraspinatus muscle signal without residual atrophy or fatty infiltration on imaging at 2.5 years after injury. In light of the patients reported by Lunn et al. [1] and Walch et al. [3], normalization of muscle with retained volume can be considered possible, but extremely rare.

Limitations of this study are as in any retrospective study, which include selection bias and missing potential cases that were not identified by the inclusion criteria, specifically since only those cases with the term "novel lesion" were included. While we could have performed the image analysis independently, consensus agreement was performed since there was no reference standard in this study and both readers had similar years of experience. The lack of a consistent gold standard also makes this study problematic. As shown in prior investigations, arthroscopy could not consistently identify the lesion. In our investigation, it also proved to be an imperfect reference standard as more than half of the infraspinatus lesions identified on the preoperative MRI were not detected despite thorough arthroscopic evaluation. The grading system we proposed did not produce any significant correlations; however, we were able to make general observations that appear to correspond to the anatomic investigations by Kato et al. [8]. Additionally, retrospective review showed that all cases that were missed on arthroscopy had some superficial fibers of the transverse portion remaining intact, likely concealing the deeper lesion on bursoscopy. We could not assess the significance of the clinical presentation (i.e., trauma versus atraumatic) because of our overall limited number of patients. Long-term follow-up was not available in many of the patients in this study, and it was difficult to assess whether the majority of these injuries progressed to fatty atrophy, as previously described by Lunn et al. [1]. Finally, no electrodiagnostic studies were performed in these patients, although recent studies debate any electromyographic association of suprascapular nerve neuropathy with rotator cuff tear [10].

In conclusion, the "novel lesion," as described by Lunn et al. [1], likely represents a delaminating injury in the layers of the infraspinatus tendon involving the transverse and oblique portions of the tendon resulting in differential retraction of varying degrees. It often results in persistent tendon abnormalities on follow-up imaging with or without accompanying muscle atrophy and fatty degeneration. It may not be an entirely isolated lesion and could be associated with varying degrees of tearing of the adjacent supraspinatus tendon. Finally, it may be difficult to detect on arthroscopy even if the lesion is prospectively identified on MRI.

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Compliance with ethical standards

Conflict of interest No conflict of interest.

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