Musculotendinous infraspinatus ruptures: An overview

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Summary

Background: Musculotendinous infraspinatus ruptures belong to the category of "muscle strain injuries". They differ from a classic rotator cuff tear by the following features: tendon attachment remains intact and the acute initial stage typically undergoes an intense muscular edema, replaced, 6 to 12 months later, by complete and permanent fatty infiltration of this muscle.

Methods: Between 1993 and 2007, we prospectively identified 59 musculotendinous ruptures of the infraspinatus muscle tendon complex. Fifty-eight percent of these patients were females. The average age at presentation was 50 years old. Onset was non traumatic in 78% of these cases. Twenty-nine patients were seen at the acute lesion stage with pain and, on T2 fat saturated MRI sequences, muscular edema. A second group of 30 patients presented with a stage 4 fatty infiltration of the infraspinatus muscle tendon complex. Fifty-eight percent of these patients were females. The average age at presentation was 50 years old. Onset was non traumatic in 78% of these cases. Twenty-nine patients were seen at the acute lesion stage with pain and, on T2 fat saturated MRI sequences, muscular edema. A second group of 30 patients presented with a stage 4 fatty infiltration of the infraspinatus muscle tendon complex. Fifty-eight percent of these patients were females. 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Results: Twenty-four patients underwent surgery, while the remaining 35 were treated conservatively. The average follow-up, for all of them, was 46 months (12–125). The Constant score increased from 51.7 to 69.4 ($p < 0.001$). There was no significant difference between the operated and the non-operated groups ($p = 0.325$). All the patients seen at the acute painful edematous stage progressed to stage 4 complete fatty infiltrations, irrespective of selected treatment. None of the patients who underwent surgery had any regression of their fatty infiltration.

Conclusions: Early diagnosis of this lesion can be made using T2 fat saturated MRI imaging. We hypothesize that early tendon repair which restores muscle tension in the infraspinatus may halt the progression of this entity and prevent complete functional loss of this muscle.
Introduction

Fatty infiltration of the rotator cuff was initially described by Goutallier et al. [1] and reported to be a direct consequence of full thickness rotator cuff tears. In 1997, we reported twelve cases of isolated stage 4 fatty infiltration of the infraspinatus with no associated full thickness rotator cuff tendon tears; these 12 cases were discovered on arthro-CT and EMG studies eliminated a neurological origin [2]. Since then, we have prospectively collected all of these cases encountered in our daily practice of shoulder surgery. Thanks to the frequent and easy practice of MRI at increasingly earlier stages of shoulder pain, in 2006, we described isolated ruptures of the musculotendinous junction of the infraspinatus whose anatomical, clinical, and radiological characteristics, as well as their progression are now known [3,4]. The insertion of the tendon into the greater tuberosity as well as the articular capsule remains intact in these cases, therefore, there is no full thickness tear of the rotator cuff in the arthrographic sense of the word. It is associated with an acute phase including a severe inflammatory reaction of the muscle and its retraction into the fossa. Several months later, severe fatty infiltration develops and replaces the initial muscular edema.

Numerous arguments and similarities have allowed us to associate the two stages of this lesion discovered 10 years apart. These musculotendinous ruptures cannot be identified on arthro-CT in their early stages, and can only be detected on T2 fat saturated MRI images, which show marked muscular edema and effusion at the level of the rupture. In less than 1 year, the muscular edema progresses to a phase of scar tissue formation characterised by complete infraspinatus fatty infiltration with no full thickness cuff tear and which can be clearly identified on arthro-CT. This is the clinical picture, which we described in 1997 without knowing its origin.

We collected all the cases of musculotendinous rupture, which we encountered, whether they were in the acute phase with muscular edema, thanks to T2 fat saturated MRI sequences, or in the later phase with isolated fatty infiltration of the infraspinatus identified on a scan or on T1 MRI sequences. The purpose of this study was to evaluate the epidemiology, the etiopathogenesis and the results of our treatment in these cases.

Material and methods

Between January 1993 and December 2007, we collected 59 cases of isolated musculotendinous infraspinatus rupture. There were more (34) women (58%) than men (25), the right side was affected in 39 cases (66%) and the dominant side in 40 (68%). The onset was progressive in 46 cases (78%): the patient complained of long lasting chronic shoulder pain which had progressed for an average of 37 months (1—120 months) and of pain becoming more acute spontaneously or because of a minor trauma or excessive physical activity in 28 cases (60.8% of the progressive forms). A traumatic cause was found in 13 cases (22%): the trauma was never severe; and the reported “traumas” included “an awkward movement”, intense sports activity, an unusual physical activity or simple falls. Twelve cases were con-

firmed “work-related accidents”. The average age when the symptoms began was 46.4 years old for the entire series, 47.1 years old in the progressive forms and 44.1 years in the traumatic forms ($p=0.4$).

Methods

All cases were followed prospectively. Clinical follow-up included evaluation of the Constant score [5], measurement of passive and active articular amplitude, and testing the rotator cuffs. The subjective result was based on the answer to the question “are you very satisfied, satisfied, dissatisfied, or very dissatisfied with your treatment?” as well as by determining the Subjective Shoulder Value (SSV) which is the subjective evaluation by the patient of his/her shoulder function compared to a “normal” shoulder without any pathology [6]. All of the patients underwent a standard radiological work-up including three frontal plain X-rays with neutral, internal, external rotations and a profile of the scapula. Thirty-six patients (61%) presented with or had presented with calcific tendinitis. This calcification could include any of the classically described types [7] homogeneous type A or B 14 times, heterogeneous type C with diffuse microcalcifications 11 times (Fig. 1A) or very small calcifications at the site of insertion eight times (Fig. 1B). In two cases, the form of the microcalcifications was arched, following the surface of the supraspinatus. It was located in the supraspinatus in ten cases, the infraspinatus in 15 cases, in between the two or on both tendons in ten cases and in one case, there was a double supraspinatus-subscapularis calcification.

Besides the clinical follow-up and plain X-rays, secondary imaging was always performed. Initial imaging was MRI in 40 cases, arthro-CT in 16 cases and arthro-MRI in three cases. Patients could be divided into two groups according to imaging results.

First group: patients seen in acute phase

A first group of 29 patients (49%) who presented with edema of the infraspinatus on initial imaging (Fig. 2). Edemas were identified on T2 fat saturated MRI images while they could not be seen at all on T1 sequences or arthro-CT. The average age when the first images were obtained was 48.6 years old in this group and the average delay between the onset of pain or the increase in pain and the first MRI was 3.5 months (range 1—7 months). There were two associated signs on MRI besides edema: effusion at the point of disruption which appeared as a hypersignal on both T2 and T2 fat saturated images, and muscular retraction which appeared as a dense hyposignal. Retraction was sometimes difficult to identify because of the oblique shape of the infraspinatus muscle in all the images. Normally, the edema during this acute phase was very intense for the first 3 months, then gradually subsided to disappear around the 8th month. Fatty infiltration began to appear on T1 sequences as early as the 3rd month. It co-existed with edema at first, then developed very rapidly and reached a maximum severity between 8 and 12 months.

No full thickness tears were found in the tendons; 12 patients (41%) had no tendon lesions, tendinopathy was present in 11 patients (38%) and a partial thickness tear of
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Figure 1  a: type C calcifications, diffuse irregular heterogenous calcifications present in 19% of our series; b: micro calcifications at the site of insertion present in 14% of the cases.

Second group: patients seen in late chronic phase

A second group of 30 patients (51%) with isolated stage 4 fatty infiltration of the infraspinatus on initial images. Images were obtained with arthro-CT in 18 cases and MRI in 12 cases. In this group, the average delay between the onset of shoulder problems and imaging was 45.4 months (12–120 months) and the average age at imaging was 49.4 years old. At this late stage, fatty infiltration was identified on T1 MRI sequences and in coronal, sagittal and axial slices on arthro-CT (Fig. 3B). An isolated 2 to 3 mm diameter ossification was identified directly in the infraspinatus muscle (Fig. 4) in five patients who underwent arthro-CT, (27.7% of patients who underwent a CT-scan). It was never identified on MRI because the hyposignal cannot be differentiated from fibrous scar tissue. In these patients seen at stage 4 fatty infiltration, secondary images did not show any full thickness cuff tears and there was no tendon lesion in five cases (17%), tendinopathy in four cases (13%) and a partial thickness tear in 21 cases (70%) (Table 1).

An EMG examination was performed in 23 cases to evaluate conduction velocity and investigate any neurological damage: there was no sign of neurological damage to the deltoid or the rotator cuff muscles. Conduction velocity was always normal in the suprascapular, median, ulnar and radial nerves in the 23 patients tested.

Figure 2  Acute phase musculotendinous infraspinatus rupture; a: T2 Fat Sat coronal sequence: marked inflammatory reaction in the muscle with muscular edema, hematoma at the rupture site and muscle retraction in the infraspinatus fossa; b: drawing of acute phase musculotendinous rupture.
Figure 3  Axial MRI image of infraspinatus musculotendinous rupture; a: acute phase, muscular edema on axial T2 fat saturated images; b: the same patient 10 months later: stage 4 fatty infiltration on T1 images.

Figure 4  Sequellar ossification of the infraspinatus muscle present in 27.7% of patients who presented at the chronic fatty infiltration phase and who underwent a scan.

Treatment

Thirty-five cases (59%) received conservative treatment either because the diagnosis was not made initially, or because the patient chose this option. The goal of conservative treatment was first to relieve pain by resting the shoulder, with physical therapy sessions, NSAIDs, shock waves and cortisone injections. During the second phase of treatment, the goal was to maintain articular amplitude with physical therapy, balneotherapy and adapting daily movements and professional or sports activities.

Twenty-four patients (41%) underwent surgery. Surgery was open in 15 patients and arthroscopy was performed in nine. The average delay between the onset of pain and surgery was 18.5 months (2—48 months). Five cases underwent surgery during early stages when edema was still present, 19 underwent surgery after fatty infiltration of the muscle had developed. The goal of surgery was to explore and treat the musculotendinous disruption or to treat the partial thickness tear of the supraspinatus and/or infraspinatus tendon. Reports of surgery show that 13 lesions were identified while 11 were not correctly identified. The lesions that were identified were described as ruptures of the infraspinatus musculotendinous junction. Although in certain cases, the rupture was covered by scar tissue, the articular capsule was always intact. Treatment included a latero-lateral suture between the teres minor and the supraspinatus (six cases) or a transosseous reinsertion on the anatomical neck of the retracted stump of the infraspinatus (five cases) or more recently, in two cases, direct arthroscopic suture of the muscle and tendon stumps. In 11 cases where the lesion was not identified, an isolated acromioplasty was performed in four cases and reinsertion of a partial thickness tear of the supraspinatus or the infraspinatus was performed in seven cases.

Besides clinical follow-up, successive images were obtained to follow the course and analyse this poorly defined lesion: a total of 105 MRI, 45 arthro-CT and 12 arthro-MRI were performed and available. Only one set of images was available in seven patients, two sets of images were

Table 1  Comparison of results of operated and non-operated patients.

<table>
<thead>
<tr>
<th></th>
<th>Surgical treatment</th>
<th>Medical treatment</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>24</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Delay</td>
<td>46.9 months</td>
<td>54.9 months</td>
<td>NS</td>
</tr>
<tr>
<td>Constant score</td>
<td>71.6 pts</td>
<td>67.6 pts</td>
<td>NS</td>
</tr>
<tr>
<td>Constant score gain</td>
<td>20 pts (+16.5)</td>
<td>14.1 (+16)</td>
<td>NS</td>
</tr>
<tr>
<td>Subjective: VS or S</td>
<td>73%</td>
<td>69%</td>
<td>NS</td>
</tr>
<tr>
<td>SSV %</td>
<td>73%</td>
<td>62.6%</td>
<td>0.02</td>
</tr>
</tbody>
</table>

SSV: subjective shoulder value; VS: very satisfied; S: satisfied; pts: points.
available in 18 patients, three sets in 19, four sets in 11 patients and five or more imaging results in four patients. Average follow-up from the onset of shoulder problems to the last follow-up consultation was 50.1 months (12–120) for the whole series. The average delay between the first and last images was 40.7 months (12–120).

Statistical analysis

To compare qualitative variables, the Fischer exact test (dichotomous variables) or the Chi² test for goodness of fit (variables with more than two modalities) were used. The Yate’s correction or MonteCarlo simulations were used for small groups. For quantitative variables, a one-way analysis of variance (ANOVA) and a Bonferroni test of multiple comparisons were used. Results were significant if \( p < 0.05 \).

Results

Twenty-four patients underwent surgery and 35 received conservative treatment. Results in Table 1 show that there was no statistically significant difference in the Constant score for a similar follow-up period between patients who underwent surgery and those who did not. Only the SSV was statistically better in patients who underwent surgery.

Twenty-two of the 24 patients who underwent surgery were followed-up for at least 1 year and for an average of 46.9 months (12–120). The average Constant score increased from 51.6 points (35–78) preoperatively to 71.6 points (40–95) postoperatively (\( p = 0.0002 \)). The subjective results were satisfying or very satisfying in 17 cases, five patients were dissatisfied: three because the repair was a failure resulting in a full thickness cuff tear and requiring a second intervention within an average of 18 months. The two other dissatisfied patients had a very difficult post-operative course with frozen shoulder which progressed for 6 to 18 months; these cases were work-related accidents. One of the 35 patients treated medically died after a single intervention within an average of 12–52 months. All progressed to severe fatty infiltration whatever the type of treatment; with or without surgery, with open surgery or with arthroscopy, with musculotendon or tendon repair. In patients presenting with fatty infiltration who underwent surgery, only one set of images was available in seven; in the 23 other cases with at least two secondary sets of images, no improvement was found in the muscular lesions whatever the treatment (Fig. 4).

### Influence of initial lesions

With an equivalent follow-up delay after surgery, there was no significant difference between the Constant score in patients who were first seen during the edema phase (65.8 pts) and those seen when the disease had reached stage 4 fatty infiltration (72.7 pts), (Table 2). Of the 29 cases seen at the edema phase, eight underwent surgery and 21 received conservative treatment. Sixteen of the 30 cases seen at stage 4 fatty infiltration underwent surgery, and 14 received conservative treatment. With all the cases available and with an equivalent follow-up period, no statistically significant difference in the Constant scores or the subjective results was found among these groups. All of the patients who were first seen at the edema phase were evaluated on MRI within an average of 40.7 months (12–87 months). All progressed to severe fatty infiltration whatever the type of treatment; with or without surgery, with open surgery or with arthroscopy, with musculotendon or tendon repair. In patients presenting with fatty infiltration who underwent surgery, one set of images was available in seven; in the 23 other cases with at least two secondary sets of images, no improvement was found in the muscular lesions whatever the treatment (Fig. 4).

### Influence of the type of surgery

Thirteen patients underwent repair of the musculotendinous rupture and 12 of these were seen at follow-up within an average of 30.8 months (12–52 months). Results were satisfactory in 11 of the 12 lesions that were identified, repaired and seen at follow-up, while one presented with a full thickness tear that required additional surgery. Seven of the ten patients seen at follow-up who did not undergo musculotendinous rupture repair, but who underwent acromioplasty or repair of a partial thickness tear of the supra- or infraspinatus, are in good condition and are satisfied with the results while three presented with a full thickness cuff tear requiring additional surgery. With the

<table>
<thead>
<tr>
<th>Presenting stage</th>
<th>Follow-up (months)</th>
<th>Number of cases</th>
<th>Constant Score (Points)</th>
<th>SSV (%)</th>
<th>Subjective VS or S (%)</th>
<th>Constant score gain (points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire series</td>
<td>50.1</td>
<td>59</td>
<td>69.2</td>
<td>66.9</td>
<td>71</td>
<td>16.2</td>
</tr>
<tr>
<td>Fatty I</td>
<td>57.1</td>
<td>30</td>
<td>72.7</td>
<td>69.2</td>
<td>77</td>
<td>17.5</td>
</tr>
<tr>
<td>Edema</td>
<td>43.3</td>
<td>29</td>
<td>65.8</td>
<td>64.6</td>
<td>64</td>
<td>15.8</td>
</tr>
<tr>
<td>Operated</td>
<td>46.9</td>
<td>24</td>
<td>71.6</td>
<td>73</td>
<td>73</td>
<td>20</td>
</tr>
<tr>
<td>Not operated</td>
<td>54.9</td>
<td>35</td>
<td>67.6</td>
<td>62.6</td>
<td>69</td>
<td>14.1</td>
</tr>
<tr>
<td>Workman comp</td>
<td>39.8</td>
<td>12</td>
<td>57.5</td>
<td>55.8</td>
<td>33</td>
<td>2.8</td>
</tr>
<tr>
<td>Not workman comp</td>
<td>52.9</td>
<td>47</td>
<td>72.4</td>
<td>70.1</td>
<td>81</td>
<td>20.8</td>
</tr>
<tr>
<td>Calcification</td>
<td>47.1</td>
<td>36</td>
<td>70.6</td>
<td>67.4</td>
<td>70</td>
<td>17.5</td>
</tr>
<tr>
<td>No calcification</td>
<td>54.9</td>
<td>23</td>
<td>66.9</td>
<td>66</td>
<td>70</td>
<td>15.2</td>
</tr>
</tbody>
</table>

Fatty I: fatty infiltration; WA: work related accident; SSV: subjective shoulder value; VS: very satisfied; S: satisfied.
number of available cases and equivalent follow-up, no statistically significant difference was found in the objective or subjective results among the different groups.

**Influence of work-related accidents**

Twelve patients had a work-related accident. The Constant score at the beginning was identical to that in patients who did not have a work-related accident (Table 2). With an equivalent follow-up period, there was a statistically significant difference in the Constant score \( p = 0.004 \) and the subjective results: 67% of patients who had a work-related accident were dissatisfied or very dissatisfied versus 19% of dissatisfied patients in patients whose injury was not work-related \( p = 0.005 \).

**Influence of calcifications**

Thirty-six of the patients (61%) presented or had presented with calcifications. With equivalent follow-up, there was no statistically significant difference in the Constant score, the subjective results or in tendon lesions in these patients (Table 2).

**Influence of tendon lesions**

During initial imaging, 29% of patients had no tendon lesion, 25% had a tendinopathy and 49% had a partial thickness tear. These partial thickness tears included an equivalent number of intratendinous, deep articular surface and superficial bursal surface tears. The small number of patients in each group made it impossible to define a significant difference among them, which is why we grouped them together. After an average follow-up of 40.7 months, 56% had no tendon lesion, 3% had a tendinopathy and 42% had a partial thickness tear. We did not find any statistically significant correlation between tendon lesions, age, sex, progressive or traumatic onset, the number of cortisone injections, needling, calcifications or management of a work-related injury. The delay between the onset of shoulder problems and initial imaging was 45.9 months in patients with tendon lesions and 36.7 months in those without \( p = 0.2 \). When there was no partial thickness tear, the Constant score was 60.2 points while it was 55.4 in patients with a partial thickness tear \( p = 0.2 \). On the other hand, the initial stage at presentation influenced the presence or not of tendon lesions: 21% of the patients who presented at the edema phase had a partial thickness tear versus 70% who presented with stage 4 fatty infiltration \( p < 0.001 \). In patients who did not undergo surgery, the percentage of tendon lesions at the last follow-up was the same as in the initial images in patients who presented at the fatty infiltration phase, while it had increased in patients who presented at the edema stage (35% vs 21%) but with the number of available cases, this difference is not statistically significant. Tendon lesions observed during the final follow-up were correlated to the Constant score \( p = 0.007 \), to subjective results \( p = 0.01 \) and to the SSV \( p = 0.007 \).

**Discussion**

Musculotendinous ruptures of the infraspinatus can be distinguished from classic rotator cuff tears in many ways: anatomically, epidemiologically, imaging characteristics, progression, treatment and results. Anatomically, this entity corresponds to the classic definition of "muscle strain injuries" [8–12]:

- the rupture occurs at or adjacent to the musculotendinous junction rather than at the site of tendon insertion;
- rather than being the consequence of direct trauma, the rupture is a result of an indirect mechanism such as a sudden muscular contraction, or against resistance, during a position of maximum lengthening, favored by muscle fatigue;
- there is an intense inflammatory reaction of the muscle during the acute phase characterised by edema;
- retraction of the muscle with modification of the architecture of the muscle fibres and opening of the pennation angle occurs (Fig. 5).

Epidemiologically, the average age at diagnosis was 49 in our series, very close to the average age of 48 found in the

![Figure 5](https://www.elsevier.com/books-and-journals/elsevier-manuscript-service)
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There are a certain number of differences from rotator cuff tears: the origin is traumatic in only 22% of cases, and is not associated with severe trauma in any, while 50% of isolated supraspinatus or subscapular tears are associated with initial trauma [13–15]. The high percentage of patients presenting with calcific tendinitis in our cases (61%) and the large number of women (58%) is also significantly different from tendon ruptures. Calcific tendinitis is rare in rotator cuff tears, which are also more frequent in men [13–15]. This observation strongly suggests that there is a relationship between musculotendinous ruptures and calcifications and also perhaps, their treatment. Local cortisone injections and needling treatment, which was performed in 95% and 20% of the cases respectively before the present lesion was identified, may have weakened the infraspinatus or resulted in a type of muscle fatigue which is so typical of “muscle strain injuries”. The injections may even have been a direct cause of rupture: indeed in nine of the 11 needling performed, acute edematous lesions were discovered immediately after an extremely painful injection and five patients declared that the intense pain began immediately after an extremely painful injection. The possible harmful effect of cortisone injections into tendons has already been reported in experimental studies [16] in the rotator cuffs [17] and the lower limbs [18,19]. However, the musculotendinous junction of the infraspinatus is protected from behind by the acromial arch and is not in the area where injections are usually administered. Moreover, if there was a relationship, this would have been identified long ago due to the number of injections made into the shoulder. We think that cortisone injections may play a role in weakening the musculotendinous junction rather than causing direct mechanical injury, thus increasing the chronic degeneration of the cuff, but this remains to be proven. The iatrogenic role of needling on the infraspinatus is also possible which means that the indication and administration of this treatment should be made with caution.

Musculotendinous rupture usually occurs in the presence of existing chronic degeneration indicated by calcific tendinitis, repeated cortisone injections as well as partial supraspinatus or infraspinatus thickness tears. Partial thickness tears were identified in 20% of patients with acute phase edema, although muscular edema sometimes extends to the tendon making it difficult to evaluate. Thirty-five percent of the 20 cases first seen at the edema phase who did not undergo surgery had partial thickness tears on MRI follow-up imaging performed an average of 37.4 months later (12 to 84). The difference is not statistically significant (p=0.3). The percentage of partial thickness tears reached 70% during initial imaging in patients presenting with chronic infraspinatus fatty infiltration stage 4, and this percentage did not change in the final follow-up. Therefore, the poor outcome in the muscles is clearly associated with a poor outcome in the tendons. This tendon degeneration raises several questions: are these secondary partial thickness tears of the muscles the sign of a degenerative condition of the rotator cuff favored by calcifications, cortisone injections and needling treatments? Or do the tendons deteriorate due to functional overload because of the lack of an effective infraspinatus muscle? Because of the number of cases in this study, we could not identify any statistical relationships to respond to this question.

Imaging is essential to identify this entity. Although the MR images available in this study were performed in different centers, the brand and size of the device did not influence the images obtained. On the other hand, the sequences obtained played an essential role in detecting this lesion: in the acute phase, muscle edema was particularly easy to identify on T2 fat saturated sequences, while it was impossible to see on CT or T1 sequences. On proton density weighted sequences or T2 sequences, it can be difficult to distinguish edema from fatty infiltration. This marked edema at the beginning becomes less extreme as the months go by and it is practically impossible to see after the 6th month because it is replaced by fatty infiltration which is complete less than 1 year after the initial phase. This edema is associated with a hypo-dense image of musculotendinous retraction, which makes it possible to differentiate it from other muscular edemas which leave the musculotendinous architecture intact, for example in cases of neurological injury due to suprascapular nerve compression [20,21] Parsonage-Turner syndrome [22] or inflammatory muscular injuries [23,24]. EMG studies, systematically performed at the beginning of our experience when we did not know the origin of this lesion, were always negative, which also made it possible to eliminate any possible neurological origin.

The rapid progression towards severe fatty infiltration in less than 1 year is also a distinguishing factor of this lesion compared to classic rotator cuff tears where fatty infiltration occurs much later. In five cases (27.7% of cases who underwent arthro-CT during the chronic stages of the condition), this isolated infraspinatus fatty infiltration was accompanied by ossification of the infraspinatus muscle. This ossification has already been described during scar tissue formation of the lower limbs [10,11] and it is an additional reason to distinguish these lesions from rotator cuff tears where there is never scar tissue ossification.

The treatment offered to our patients was not standardized or systematic because we were not aware of this specific lesion at the time. Six cases underwent surgery during the edematous stage (four cases of open surgery, and two more recent cases with arthroscopy). In the six cases where musculotendinous rupture was identified, described as an “exploded tendon”, the articular capsule remained intact. Unfortunately, surgical repair with lateo-lateral suture or with suture anchors placed at the edge of the articular cartilage performed four times with open surgery, did not prevent progression towards stage 4 fatty infiltration. More recently, we performed arthroscopy in two cases, 3 and 4 months after the rupture had occurred; the lesion was easy to identify, the retracted muscle stump was easy to find in the infraspinatus fossa and was sutured with simple stitches onto the tendon. One of these patients was operated on less than 1 year ago, and the other underwent MRI after 12 months of follow-up showing progression towards stage 4 fatty infiltration. Therefore, we cannot conclude that early suturing can prevent fatty infiltration, but we do know that without surgical repair, the infraspinatus muscle will be completely lost, as seen in patients who only received medical treatment. Under these conditions, it seems reasonable
to propose arthroscopic repair as early as possible, and probably no more than 3 months after the onset of the lesions because once fatty infiltration has developed, repairing the musculotendinous lesion, which was performed seven times in our series, does not provide any significant improvement compared to conservative treatment and this late measure does not seem justified or useful. On the other hand partial thickness tears observed during the fatty infiltration stage are a therapeutic problem. It is clear that a number of our patients consulted for pain or difficulty that was not due to sequella from the musculotendinous rupture, but from the partial thickness tear of a tendon. In the presence of severe fatty infiltration of the infraspinatus muscle, we often hesitated to suggest tendon repair because we feared that recovery would be difficult. The results obtained with an identical Constant score in patients without tendon lesions and a percentage of satisfaction of 77% show that repair of a partial thickness tear could be proposed under the same conditions as patients who have an intact infraspinatus muscle as long as symptoms and pain justify this option.

In conclusion, musculotendinous ruptures of the infraspinatus can be differentiated from classic rotator cuff tears anatomically, by the course of the lesion and therapeutically. Without treatment, this lesion progresses towards definitive muscular retraction, complete fatty infiltration of the muscle and partial thickness tears which are certainly progressive. Very early diagnosis of the marked muscular edema, thanks to MRI, can make it possible to restore muscle tension by arthroscopic suture. Further evaluation of this treatment will show if very early intervention is effective. During the chronic stage, repairing the musculotendinous lesion is not effective. On the other hand, traditional treatment of partial thickness tears of the supra and infraspinatus tendons can provide satisfactory results when the patient’s symptoms justify a surgical intervention.

Conflicts of interest

None.

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References