ORIGINAL ARTICLE

New endoscopic classification for subscapularis lesions

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Accepted: 25 September 2012

KEYWORDS
Subscapularis tears; Classification; Anatomical lesions

Summary
Background: The absence of a coherent classification system has hampered communication about the treatment and outcomes of the various types of subscapularis tendon lesions. In addition, a reliable classification system allows comparisons of epidemiological and therapeutic data. The classification systems used until now fail to incorporate the radiological and intraoperative abnormalities of the bicipital sling, and they do not consider the degree of subscapularis tendon cleavage. Here, we describe a new arthroscopy-based classification system intended for therapeutic and prognostic purposes.

Methods: A prospective multicentre study sponsored by the French Society for Arthroscopy was conducted from March 2010 to January 2011 in 150 isolated subscapularis lesions with or without limited anterosuperior involvement. The bicipital sling and insertion of the deep subscapularis

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doi:10.1016/j.otsr.2012.10.003
layer were routinely investigated by arthroscopy with video recording. Each lesion was classified after a consensus was reached among four surgeons.

Results: We identified four lesion types based on the bicipital sling findings. Type I was defined as partial separation of the subscapularis tendon fibres from the lesser tuberosity with a normal bicipital sling. Type II consisted of a partial subscapularis tear at the lesser tuberosity attachment combined with partial injury to the anterior wall of the bicipital sling, without injury to the superior glenohumeral ligament. Type III was complete separation of the subscapularis fibres from the lesser tuberosity with extensive cleavage of the bicipital sling. Finally, in Type IV, all the subscapularis fibres were detached and, in some cases, conjunction of the subscapularis and supraspinatus fibres produced the comma sign. Nearly all the lesions identified intraoperatively during the study fit one of these four types.

Discussion: A reproducible classification system that allows different surgeons to establish comparable homogeneous patient groups is useful for both therapeutic and prognostic purposes. We defined four types of subscapularis lesions that are easy to identify as either isolated lesions or combined with anterosuperior rotator cuff tears. Long head of biceps tendon abnormalities and fatty degeneration of the shoulder muscles can be added to our classification system. Studies of intraobserver and interobserver reproducibility are needed to complete the process of validating the diagnostic and/or prognostic usefulness of this new classification scheme.

Level of evidence: II.

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Introduction

Recent anatomic studies have produced new information on subscapularis muscle anatomy, particularly regarding tendon attachment to the lesser tuberosity and relationships of the tendon with the other components of the rotator interval. The anatomic characteristics of the subscapularis tendon differ markedly from those of the other rotator cuff tendons, i.e., the supraspinatus and infraspinatus tendons.

The rotator interval is composed of the superior glenohumeral ligament, the two coracohumeral ligament bundles, and the glenohumeral joint capsule [1–5]. Jost et al. [6] identified three layers: the deep layer, composed of the superior glenohumeral ligament; the intermediate layer, composed of the two bundles of the coracohumeral ligament; and the superficial layer, formed by the supraspinatus fibres posteriorly and the subscapularis fibres anteriorly [6–8]. The superficial layer overlies the uppermost part of the bicipital sling, as well as the transverse humeral ligament that extends between the two edges of the bicipital groove in the humerus. Arai et al. [9,10] described a tendinous slip composed of the uppermost fibres of the subscapularis tendon extending to the anterior wall of the bicipital sling, formed by the proximal portion of the lesser tuberosity. A depression in these fibres produces a fibrous groove (anterior portion of the proximal bicipital sling) with the superior glenohumeral ligament and medial bundle of the coracohumeral ligament (Fig. 1) [8,11]. The inferior portion of the subscapularis tendon contains a contingent of muscle fibres that attach directly to the distal lesser tuberosity, along a narrow vertical footprint. The superior portion of the subscapularis tendon attachment is composed of a main contingent having a roughly triangular downwards-pointing footprint and of a secondary contingent that attaches directly to the transverse humeral ligament over the roof of the bicipital sling and coalesces with the superficial supraspinatus fibres [4,12,13] (Fig. 2). Finally, the uppermost part of the tendon does not attach to the lesser tuberosity but instead forms the floor of the most proximal portion of the bicipital sling.

During open surgery, adequate visualization of the subscapularis is difficult to achieve, and the frequency of subscapularis tendon lesions was consequently underestimated for many years [14,15]. Initial studies by Walsh et al. [16] identified hidden lesions of the subscapularis that were covered by intact superficial fibres. Only after the bicipital sling and rotator interval are opened can these lesions be visualised and repaired. The introduction of arthroscopic-assisted procedures for rotator cuff surgery improved the diagnosis of subscapularis tendon lesions [17]. In a study of

Figure 1  Anatomy of the rotator interval. A: coracohumeral ligament; B: long head of biceps tendon (red); C: superior glenohumeral ligament (green); D: tendinous slip (yellow); E: transverse humeral ligament (beige); F: subscapularis muscle.
348 rotator cuff tears by Garavaglia et al. [18], subscapularis tendon lesions were found in 37% of cases.

Classification systems for subscapularis tendon lesions have been developed by Lafosse et al. [19], Garavaglia et al. [18], and Fox et al. [20]. All three systems use descriptions derived from those of supraspinatus tendon lesions. The tears are described in the superior-to-inferior direction, without taking into account the anterior part of the bicipital sling or the thickness of the tears, even in the modified versions of these classification systems [20,21]. Garavaglia et al. [18] defined six grades with a distinction, among grade I lesions, of minor fraying of the upper tendon edge (grade la) and of partial tears in the deep tendon fibres (grade lb). This system gives considerable importance to the comma sign seen when the upper two-thirds of the tendon are torn, as initially described by Lo and Burkhart [22].

Here, our objective was to develop a new classification system for subscapularis tendon lesions that takes into account the anatomic abnormalities at both the lesser tuberosity and the bicipital sling, as identified during the diagnostic step of shoulder arthroscopy.

Materials and method

A prospective study sponsored by the French Society for Arthroscopy (Société française d’arthroscopie [SFA]) was conducted from March 2010 to January 2011 in 12 surgical centres in 176 consecutive patients with subscapularis tendon lesions that were either isolated or combined with deep supraspinatus tendon tears or minor full-thickness tears. We excluded patients with extensive full-thickness tears and patients undergoing revision rotator cuff surgery.

Video recordings of the arthroscopic procedures performed in the 176 study patients were reviewed by four senior surgeons working in three different centres. The surgeons worked independently of one another and used a standardised form to describe the lesions.

The diagnostic step of the arthroscopy procedure was standardised. The posterior approach and a 30° arthroscope were used. The upper portion of the subscapularis was explored first, with the arm in neutral rotation. The arm was then rotated internally to visualise the most medial part of the subscapularis footprint on the lesser tuberosity, by opening up the angle between the tendon fibres and humeral head. The size and height of the footprint were evaluated according to Wright et al. [23]. The bicipital sling and its upper opening were then examined, followed by the biceps tendon and components of the rotator interval. The condition and position of the biceps tendon were assessed using the criteria of Walch et al. [24]. Special attention was given to the condition of the anterior wall of the bicipital sling, where complete or incomplete tears were sought. After debridement and division of the superior glenohumeral ligament, which were the first steps of the repair procedure [10], complete exploration of the lesions was possible. In particular, the height and extent of the lesions were assessed, most notably at the lesser tuberosity. If needed, an anterosuperior portal was created for introduction of the arthroscope along the axis of the tendon. Table 1 lists the 12

<table>
<thead>
<tr>
<th>Anatomic structure</th>
<th>Possible descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Anterior wall of the bicipital sling</td>
<td>Normal, partial tear, complete tear</td>
</tr>
<tr>
<td>2 Anterior and superior pulley of the biceps</td>
<td>Normal, distended, torn</td>
</tr>
<tr>
<td>3 Comma sign</td>
<td>Present, absent</td>
</tr>
<tr>
<td>4 Connection between supraspinatus and subscapularis fibres without rotator interval disruption</td>
<td>Present, absent</td>
</tr>
<tr>
<td>6 Biceps tendon position</td>
<td>Normal, subluxation, luxation, absent</td>
</tr>
<tr>
<td>7 Subscapularis tendon detachment from the lesser tuberosity</td>
<td>None, upper third, upper two-thirds, &gt; upper two-thirds</td>
</tr>
<tr>
<td>8 Depth of detachment</td>
<td>None, partial, total</td>
</tr>
<tr>
<td>9 Subscapularis tendon retraction</td>
<td>Absent, intermediate, to the glenoid labrum</td>
</tr>
<tr>
<td>10 Trophicity of the subscapularis tendon</td>
<td>Good, fair, poor</td>
</tr>
<tr>
<td>11 Lamellar dissection of the tendon</td>
<td>Present, absent</td>
</tr>
<tr>
<td>12 Type of tear</td>
<td>Isolated + deep aspect of supraspinatus + full-thickness tear in supraspinatus</td>
</tr>
</tbody>
</table>
criteria that were assessed during arthroscopic exploration and during interpretation of the video recordings.

Results

Bicipital sling and associated lesions

In 36 cases, examination of the bicipital sling was considered to contribute no information to the evaluation of the anterior sling wall. The sling was classified as normal in 14 cases. In 12 of these cases, partial separation of the subscapularis tendon from the lesser tuberosity was noted. In the remaining two cases, the subscapularis was completely detached, leaving the bicipital sling intact but resulting in complete disappearance of the anterior portion of the sling, which was replaced by a comma sign.

In 72 cases, a partial tear was seen in the anterior sling wall. The concomitant subscapularis tears were full-thickness in ten cases and partial-thickness in 62 cases. In 14 of these 62 last cases, the subscapularis was detached over more than one-third of the height of the lesser tuberosity. In these cases, examination of the anterior sling (composed of the tendinous slip medially, superior glenohumeral ligament and medial coracohumeral ligament anteriorly, and superficial rotator interval fibres laterally) showed no lesions in 24 cases, distension with no risk of biceps tendon subluxation in 32 cases, and tears in two cases.

Finally, in 54 cases, there was a complete tear in the anterior wall of the bicipital sling. In 52 of these 54 cases, the subscapularis was completely detached, over more than one-third of the height of the tuberosity in 39 cases and over the full height in 13 cases.

The comma sign was seen in 62 cases. In all these cases, there was a complete tear in the anterior sling, with disappearance of the superior glenohumeral ligament and coracohumeral ligament (Fig. 3).

Long head of biceps tendon (LHBT) and associated lesions

The condition and position of the long head of biceps tendon (LHBT) could be adequately determined in 162 of the 176 cases.

The LHBT was torn in 22 cases and was permanently displaced medially in 17 cases.

The LHBT was subluxed in the sling in 56 cases with distension of the front of the pulley. The LHBT was centered in the sling in 67 cases.

The appearance of the LBHT was normal in 39 cases (three LHBT dislocated, seven LHBT subluxed, 29 LHBT centered in the sling) and pathologic in 113 cases.

In the 67 cases of LHBT centered in the sling, the anterior wall of the sling could not be evaluated in 50 cases. The sling was normal in 11 cases, with a partial tear in 30 cases, and a complete tear in nine cases.

In the 39 normal LHBT, the anterior wall of the sling was normal in 10 cases, with a partial tear in 17 cases and with a complete tear in nine cases (the anterior wall of the sling could not be evaluated in three cases).

In 113 damaged LHBT, the anterior wall of the sling was normal in two cases, with a partial sling tear in 48 cases, and with a complete tear in 35 cases (the anterior wall of the sling could not be evaluated in 28 cases).

Other features

Tendon quality could not be assessed in a reproducible manner.

The shape of the coracoid process and the space between the conjoined tendon and subscapularis were classified as normal in every case.

Anterosuperior subluxation of the humeral head was not found in any of the cases.

Lesion patterns

A systematic analysis of the individual lesions allowed us to identify four patterns:

- type 1 (n = 14) was defined as a normal anterior sling wall with partial subscapularis tendon detachment;
- type 2 (n = 72) combined partial subscapularis separation from the lesser tuberosity and a partial tear in the anterior sling wall;
- type 3 (n = 54) was a complete subscapularis tendon detachment and a complete tear in the anterior sling wall, with the most superficial fibres remaining continuous with the sling;
- in type 4 (n = 36), was a complete detachment of the subscapularis tendon from the humerus by a full-thickness tear, leaving a free lateral edge.

Discussion

This study rests on systematic descriptions of lesions found during arthroscopy. We were able to define four main lesion types in a large patient population. Although lesion severity
Figure 4  Type 1 lesion. On the left, the subscapularis tendon fibres are frayed and partially separated from the humerus. On the right, note the intact bicipital sling and the erosion in the superior glenohumeral ligament and tendinous slip (arrow).

Figure 5  Type 2 lesion. On the left, tear in the bicipital sling. On the right, the probe introduced into the tear is lifting the superficial subscapularis fibres. 1: biceps: long head of biceps tendon; 2: coracohumeral ligament; 3: tear in the bicipital sheath; 4: humeral head.

would seem to increase from Type 1 to Type 4, we cannot state with confidence that a continuum exists across the four lesion types.

Subscapularis tendon lesions, including severe forms, can exist in the absence of damage to the LHBT or bicipital sling, indicating that the biceps does not play a predominant role in the genesis of subscapularis lesions [24]. Subscapularis tendon damage is likely to be secondary only when delamination is found, with a complete tear in the anterior sling wall and LHBT luxation between the two layers [25,26]. Thus, although subscapularis lesions are consistently present in patients with LHBT luxation or subluxation, the reverse is not true, as subscapularis lesions may exist without LHBT luxation. Our results confirm that subscapularis lesions can antedate biceps lesions and that the two can progress independently of each other [17].

Current classification systems describe the size of the lesion relative to the height of the subscapularis footprint on the lesser tuberosity, without taking into account the thickness of the tear or the presence of bicipital sling lesions [18–20]. Lafosse et al. [19] described five grades: I, partial tear in the upper third; II, complete tear in the upper third; III, complete tear in the upper two-thirds; IV, complete tear with a normally centred humerus and a fatty degeneration grade no greater than 3; and V, superior humeral head subluxation and fatty degeneration grade grater than 3. Intraoperative evaluation of muscle trophicity has proven highly subjective and difficult to quantify and, consequently, contributes little to the diagnosis. The size and degree of fatty degeneration of the muscles are best assessed by computed tomography-arthrography and magnetic resonance imaging with intra-articular gadolinium injection. Finally, in our opinion, the articular layer concept introduced in a 2010 classification system modification is a source of additional complexity. The classification systems devised by Fox et al. [20] and Garaviglia et al. [18] fail to substantially improve the description of lesions other than those strictly confined to the tendons.

The classification system with four lesion types developed in our study relies both on the lesions at the lesser tuberosity and on those affecting the bicipital sling. Indeed, connections exist between the subscapularis and supraspinatus fibres and the components of the rotator interval. Given that the potential for lesion progression remains unclear, we used the term ''type'' instead of ''stage'' or ''grade''. Type 1 is defined as subscapularis tendon separation from the lesser tuberosity — usually partial — with no abnormalities of the bicipital sling or superior glenohumeral ligament. The anatomical condition of the bicipital tendon varies, as does the vertical extent of the lesion (Fig. 4).
In Type 2 lesions, the subscapularis tendon is separated from the lesser tuberosity and there is a partial lesion of the bicapital sling that spares the anterior LHBT pulley and the tendinous slip. The superior glenohumeral ligament is intact. A probe introduced through the partial sling tear (usually located in the anterior wall) can be used to lift the superficial layer of the subscapularis, which is no longer attached to the lesser tuberosity (Fig. 5).

Type 3 lesions combine complete subscapularis tendon separation and a complete tear in the anterior sling wall. The anterior bicapital pulley may be normal, distended or, in a minority of cases, completely torn. Tendon retraction is minimal, because the superficial tendon layer remains normally attached to the bicapital sling and connected to the superficial supraspinatus fibres. The vertical extent of the lesion varies and may be difficult to assess, since the middle glenohumeral ligament may be difficult to differentiate intraoperatively from the subscapularis tendon. The superior glenohumeral ligament may be torn, exposing the medial part of the coracohumeral ligament (Fig. 6).

Finally, in Type 4 lesions, the subscapularis tendon is completely detached, leaving a free edge, which may remain continuous with the fibrous scar tissue adhering either to the humerus or to the subacromial bursa. The degree of tendon retraction is variable, and the stump may reach the level of the glenoid labrum. When the supraspinatus tendon is detached also, the comma sign is readily seen and links the subscapularis to the supraspinatus. During arthroscopic dissection, care should be taken to individualise the free edge of the subscapularis tendon and the comma sign, to allow an assessment of reducibility followed by reduction of the subscapularis to the lesser tuberosity (Fig. 7). The vertical extent of the lesion is difficult to assess, as the level of attachment of the middle glenohumeral ligament on the humerus varies and the subscapularis muscle fibres are difficult to identify, although the upper edge of the latisimus dorsi muscle is visible during the extraarticular step [27].

This new classification system seems more appropriate for the lesions seen during arthroscopic exploration of the subscapularis, allowing them to be described in greater detail. It takes into account the anatomic difference between the subscapularis and supraspinatus footprints on the humerus. Using these data to interpret radiological images, including those obtained by computed tomography-arthrography and magnetic resonance imaging, may improve the diagnosis and classification of subscapularis lesions during the imaging workup. In this initial descriptive study, we did not evaluate intraobserver or interobserver reproducibility. However, the assessments of the four observers seemed concordant. Reproducibility will be validated in a subsequent study.
Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References


