

# Impingement of the deep surface of the subscapularis tendon and the reflection pulley on the anterosuperior glenoid rim: A preliminary report

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*Sixteen patients underwent detailed arthroscopic evaluation; all had moderate to severe, primarily unexplained shoulder pain provoked by anterior elevation and internal rotation, and all were nonresponsive to subacromial injection of local anesthetic. None of the patients had any symptoms or signs of instability. Partial subscapularis lesions were documented in 10 of 13 patients who had undergone preoperative arthro-magnetic resonance imaging. At arthroscopy, an isolated lesion of the common humeral insertion of the superior glenohumeral and coracohumeral ligaments (a so-called pulley lesion) was found in 3 cases, a lesion associating a pulley and an articular side partial subscapularis lesion in 10 cases, and an isolated articular side partial subscapularis tear in 3 cases. The most painful movement, which consisted of flexion and internal rotation, caused impingement of the involved ligamentous and/or capsular insertions in all patients. If the arm was elevated above 90 degrees, the zone of mechanical contact was between the long head of the biceps and the pulley region and superiormost aspect of the labrum; if elevation was decreased, impingement occurred between the tendinous insertion of the subscapularis and the anterior glenoid labrum and rim. This study suggests that in addition to the posterolateral impingement of the supraspinatus tendon originally described by Walch, anterosuperior impingement of the deep surface of the subscapularis is a form of intraarticular impingement responsible for painful structural disease of the shoulder. (J Shoulder Elbow Surg 2000;9:483-90.)*

Various causes of chronic shoulder pain have been identified. When associated with vigorous overhead activity, pain is often due to pathologic changes in the musculotendinous units of the rotator cuff. The two most frequently considered etiologies of these cuff changes

are a degenerative process associated with tension overload<sup>10</sup> or subacromial impingement.<sup>13</sup> More recently, Walch et al<sup>23,22</sup> and, later, Jobe and Sidles<sup>7</sup> have documented a mechanical contact between the deep surface of the supraspinatus and the posterolateral glenoid rim in a position of abduction and full external rotation. These studies have documented that movements of large amplitude can cause a mechanical contact for a rotator cuff tendon within the shoulder and that such a contact can be the cause of painful structural damage to the deep surface of the supraspinatus tendon and the posterolateral labrum.

In cadaver studies,<sup>1</sup> complete ruptures of the subscapularis tendon are found much less frequently than complete ruptures of the supraspinatus tendon; conversely, partial subscapularis tears are surprisingly frequent.<sup>1,18</sup> They invariably involve the articular side of the superiormost aspect of the tendon immediately adjacent to its insertion at the lesser tuberosity and are frequently associated with lesions of the tendon of the long head of the biceps muscle and lesions of the reflection pulley.<sup>16-18,24,25</sup>

In vivo, routine exploration of the rotator interval with inspection of the pulley at repair of presumably "isolated" supraspinatus tears documents that such lesions of the pulley and superiormost aspect of the subscapularis tendon, associated with thickening or subluxations of the tendon of the long head of the biceps muscle, are more frequent than is to be expected from inspection of the outside of the subscapularis insertion.<sup>18,24</sup> Indeed, even complete tears of the subscapularis, in contrast to those of the supraspinatus, might not be visible from the outside, inasmuch as the detachment of the deep layers of the tendon is hidden by a superficial layer of scar tissue that mimics a normal cuff. This covering scar tissue is a prolongation of the original subscapularis tendon into the transverse ligament. It covers the bicipital groove and inserts at the greater rather than at the lesser tuberosity<sup>2,3,16</sup>; accordingly, opening of the rotator interval and of the bicipital groove may be necessary to confirm the diagnosis.<sup>2,24</sup>

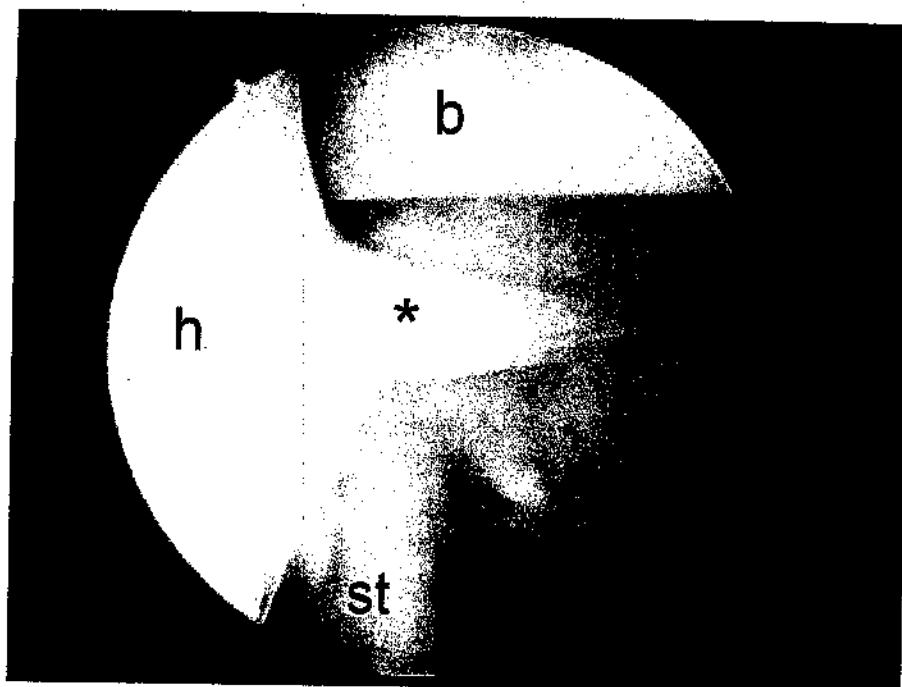
Autopsy,<sup>1,18</sup> imaging,<sup>17,18,25</sup> and surgical studies<sup>14</sup> have documented that lesions of the subscapularis tendon develop on the deep surface of the superior border of the tendinous insertion, that they can be associ-

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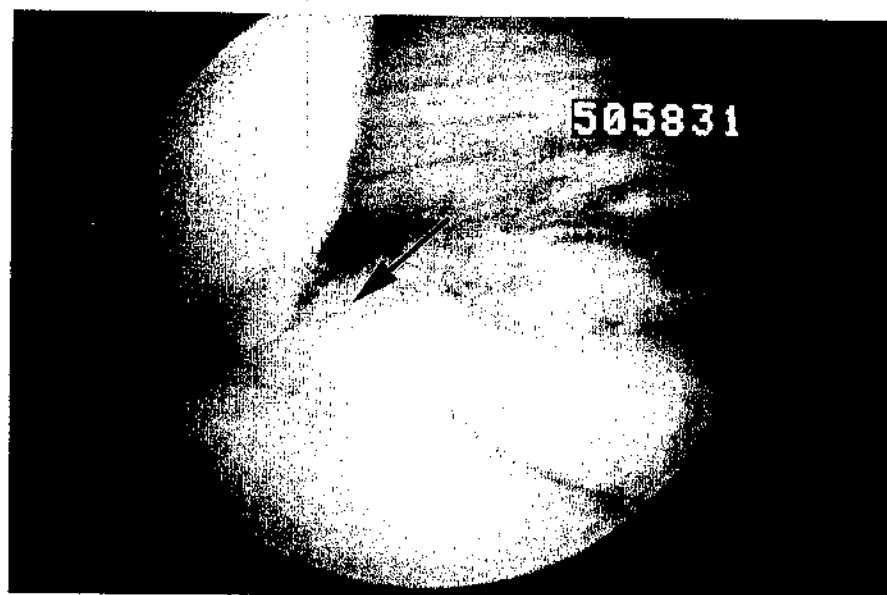
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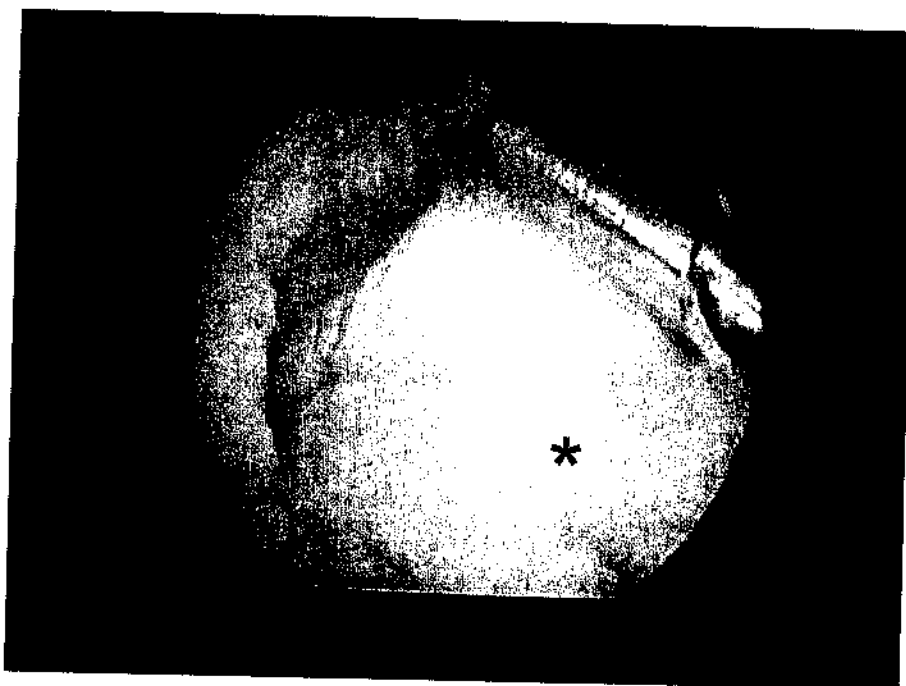
**Figure 1** Normal anatomy of pulley region: tendon of long head of biceps (*b*) is smooth, stable in groove. Superior glenohumeral ligament (*asterisk*) inserts above subscapularis tendon (*st*) and forms suspensory mechanism for biceps tendon. Humeral head (*h*) can also be seen.



**Figure 2** Insertion of superior glenohumeral ligament is destroyed (*arrow*); subscapularis tendon is normal; biceps tendon shows slight degeneration immediately adjacent to lesion of superior glenohumeral ligament insertion.

ated with lesions of the common attachment of the superior glenohumeral and coracohumeral ligament, and that they are often associated with subluxations of the tendon of the long head of the biceps.<sup>16,20</sup> The eti-

ology of these tears is unclear, and in the current literature there is no rational hypothesis that explains the variable presentation (from biceps to subscapularis) of these lesions.<sup>1,14,18,24</sup>



**Figure 3** Biceps tendon can be subluxated out of groove and over ruptured insertion of superior glenohumeral ligament (asterisk).

It is the purpose of this study to present the anatomical and arthroscopic findings in 16 cases of documented, typical, partial articular side tears of the uppermost aspect of the subscapularis tendon, either associated with lesions of the pulley and the tendon of the long head of the biceps or not so associated, and to describe a mechanical contact thought to be responsible for the development of these lesions.

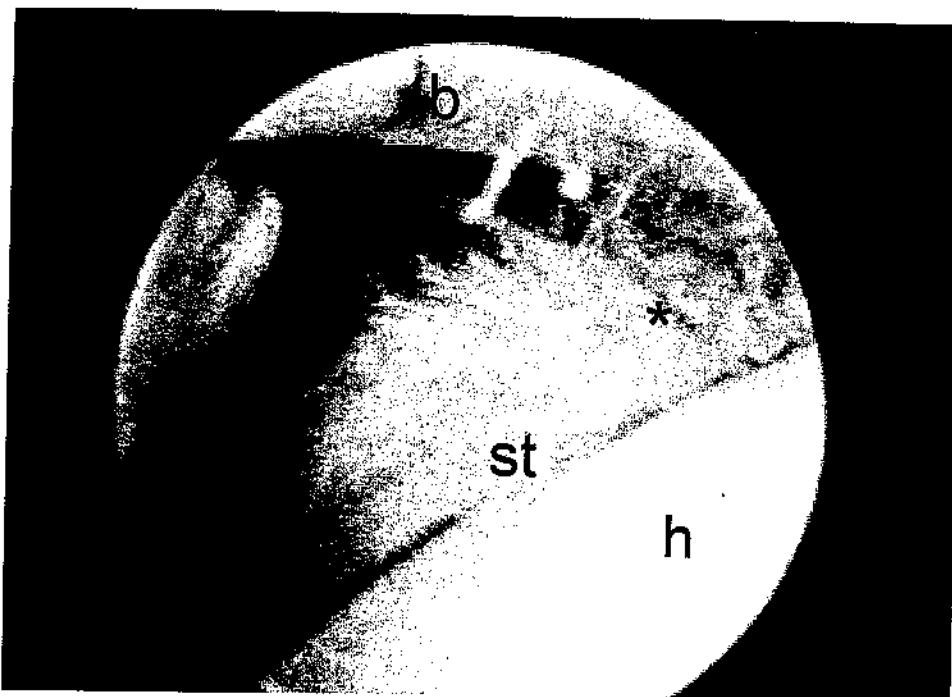
#### MATERIAL AND METHODS

We studied 16 consecutive patients with chronic shoulder pain provoked by anterior elevation and internal rotation and associated with lesions of the humeral insertion of the superior glenohumeral/coracohumeral ligament complex (the pulley) and/or the superior aspect of the insertion of the subscapularis tendon.

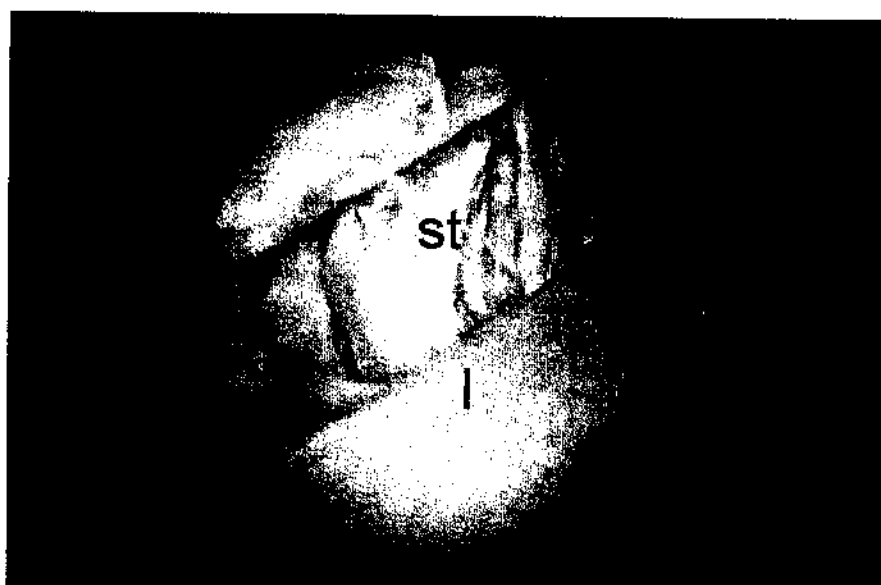
There were 5 women and 11 men; the average age was 45.3 years (range, 22-69 years). The dominant arm was affected in 12 cases, the nondominant arm in 4 cases. Twelve patients were engaged in manual professions involving regular overhead activity (eg, masonry, carpentry). Of the 4 patients not engaged in professional overhead work, one (a student) was a competitive pole vaulter and experienced pain when holding the pole fully overhead; another was a physician who suffered particularly during golf, when his leading arm was held across the chest during the backswing. The third of the patients considered not to be in a manual profession was a retired housewife, and the last was an office worker. All patients experienced night pain, and each complained of pain when using the arm overhead in front of the head, though not specifically about a painful arc during scapular plane abduction.<sup>9</sup>

Physical examination revealed tenderness of the acromioclavicular joint in 9 cases. The lift-off and belly press test<sup>3</sup> findings were weak without lag in 3 cases but normal in 13 cases. The supraspinatus test result<sup>8</sup> was slightly positive in 4 cases, painful without weakness in 6 cases, and normal in 6 cases. The palm-up test was painful in 7 cases. Active and passive ranges of glenohumeral motion were normal in 11 cases and painfully restricted by no more than 15 degrees for elevation and abduction in 5 cases. The modified impingement test was painful in all 13 of the patients in whom it was conducted. Subacromial injection of 10 mL of lidocaine 1% was carried out in 14 cases—into the subacromial space in 12 patients and into the acromioclavicular joint in 2 patients. The injections failed to relieve the pain in all 14 patients tested.

Thirteen patients underwent arthro-magnetic resonance imaging (MRI), and 1 patient underwent an arthro-computed tomography scan; 2 patients had only conventional radiographs followed by arthroscopy. On arthro-MRI, there was a suspicion of a SLAP (superior labrum, both anterior and posterior) lesion in 2 cases and biceps tendon signal alterations in 7 cases; a static subluxation of the biceps tendon was diagnosed in 1 case. The supraspinatus tendon showed a complete tear in 1 case, an articular side partial tear in 5 cases, and a bursal side partial tear in 1 case; the tendon was normal in 6 cases. An alteration in the region of the insertion of the pulley was diagnosed in parasagittal images in 8 cases, there was a suspicion of such a lesion in 2 cases, and the MRI was read as normal in 3 cases. Unequivocal lesions of the superior border of the subscapularis tendon near its insertion were diagnosed in 6 cases. Seven patients were diagnosed as having imaging signs of an additional acromioclavicular arthritis.



**Figure 4** Fraying of insertion of superior glenohumeral ligament insertion and of superior aspect of insertion of subscapularis tendon. Biceps tendon (*b*), superior glenohumeral ligament insertion (*asterisk*), subscapularis tendon (*st*), and humeral head (*h*) can also be seen.

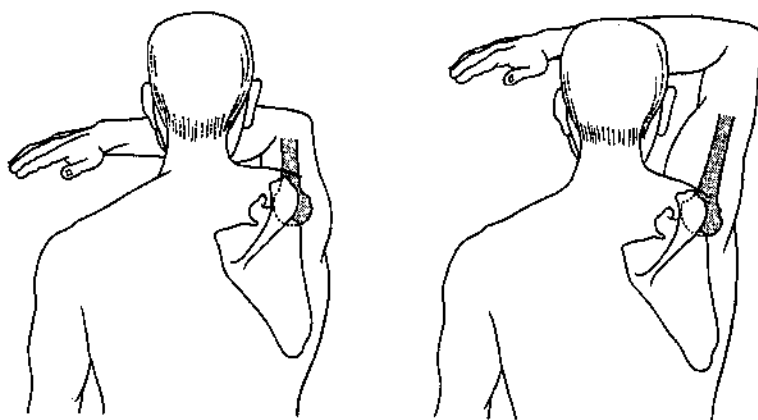


**Figure 5** Isolated lesion of deep surface of subscapularis tendon (*st*). Anterior labrum (*l*) can also be seen.

## RESULTS

Each patient underwent arthroscopy in the lateral decubitus position with the arm 30 degrees abducted under traction of 3 kg. After routine arthroscopy,

with special attention given to the pulley region (Figure 1), the weight was removed and the arm was brought into abduction and external rotation and into various degrees of anterior elevation—each with var-



**Figure 6** Positions of arm that lead to impingement of deep surface of subscapularis and pulley (*left*) or of insertion of superior glenohumeral ligament and biceps (*right*) at anterior glenoid labrum and rim are anterior (sagittal plane) elevation and maximal internal rotation. During intraoperative testing, arthroscope is left in posterior portal and anatomical relation between anterior glenoid and pulley and subscapularis insertion is studied.

ious degrees of horizontal adduction and full internal rotation.

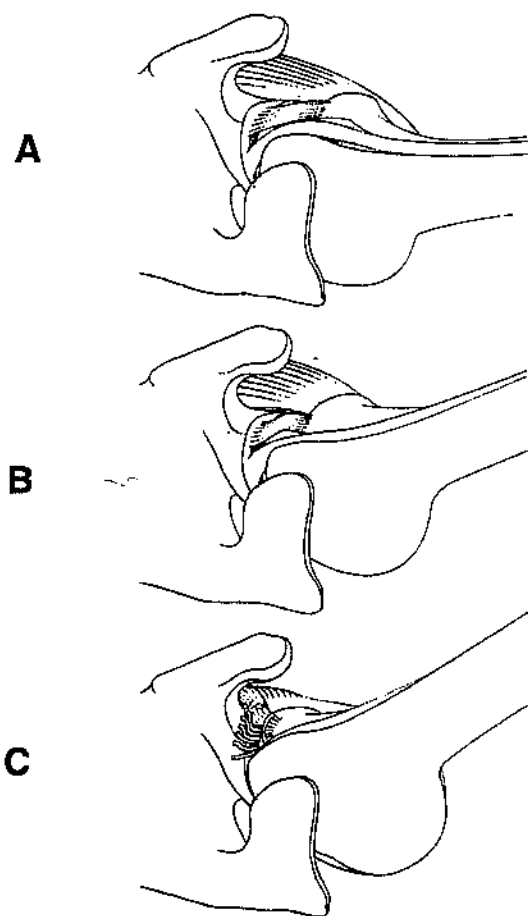
In 3 cases, an isolated lesion of the superior glenohumeral and coracohumeral ligament at the humeral insertion was identified (Figure 2). In 2 of these cases, the pulley lesion was associated with an undersurface lesion of the supraspinatus that was attributed to posterolateral glenoid impingement. The biceps anchor was normal in 1 case, showed a SLAP I lesion in 1 case, and showed a SLAP II in 1 case. The intraarticular portion of the biceps was normal in the 2 SLAP lesion cases and severely degenerated in the case with a normal anchor of the biceps. The biceps showed fraying and could be subluxated in 1 case (Figure 3).

In 10 additional cases, the pulley lesion was associated with a lesion of the superior, lateral aspect of the subscapularis tendon (Figure 4). In 7 of these 10 cases, there was an additional, minimal undersurface lesion of the supraspinatus. The biceps anchor was normal in 5 cases; it showed degenerative changes interpreted as SLAP I lesions in 4 cases and a SLAP II lesion in 1 case. The intraarticular biceps tendon was normal in 7 cases and showed degeneration in 3 cases. The biceps tendon could be subluxated in 4 cases and was considered to be stable in 6 cases.

Each of the last 3 cases had an intact pulley system. The biceps anchor showed degenerative lesions that were interpreted as SLAP I in all 3 cases. The intraarticular course of the biceps tendon was normal, and there was no subluxability at the sulcus. The deep surface of the superior aspect of the subscapularis was frayed and showed a marked partial undersurface tear, comparable to the ones seen in the 10 patients with combined pulley-subscapularis lesions (Figure 5). Two of these 3 patients had minimal, presumably degenerative undersurface lesions of the supraspinatus tendon.

To determine the mechanical situation of the affected structure in the most painful position, which was invariably that of anterior elevation with more or less forceful horizontal adduction and full internal rotation, the arm was brought into the sagittal plane, elevated, and fully internally rotated (Figure 6). In contrast with other pathoses, in which a mechanical impingement between the superior aspect of the middle glenohumeral ligament and the anterosuperior glenoid labrum and the deep surface of the pulley and the subscapularis generally could not be reproduced, a mechanical contact between these structures was demonstrable in all cases. It was obvious that the lesion on the pulley-subscapularis side was making contact with discrete alterations on the anterosuperior glenoid side (Figure 7). In the patients in this study, internal rotation in elevation of more than approximately 120 degrees caused direct contact between the biceps tendon and the pulley region and the anterosuperior labrum. Decreasing the amount of flexion led to an impingement of a more distal part of the humeral capsulotendinous insertion on the anterior glenoid. In the position of less than approximately 80 to 100 degrees of flexion, the pulley was out of the contact zone and the impingement occurred between the deep surface of the subscapularis and the anterior glenoid rim (Table). Thus, in the patients in this study, the invariably painful modified impingement test,<sup>6</sup> which is considered to reproduce subacromial impingement of the supraspinatus tendon, caused internal impingement—namely, of the deep surface of the subscapularis against the blade-like middle glenohumeral ligament and the anterosuperior glenoid labrum and anterior glenoid rim. This contact was associated with lesions on both contacting structures, exactly as was found in posterolateral glenoid impingement.<sup>22</sup>

In the absence of any established treatment for the



**Figure 7** Superior view shows anterosuperior glenoid, biceps, superior glenohumeral ligament, and subscapularis tendon. **A**, Arm is in approximately 100 degrees of elevation and in neutral rotation. **B**, With increasing internal rotation, lesser tuberosity and biceps tendon are brought close to anterosuperior glenoid rim and superior glenohumeral ligament becomes lax. **C**, In full internal rotation, superior glenohumeral ligament insertion is impinging against anterosuperior glenoid rim and middle glenohumeral ligament. If arm is in high degrees of flexion, impingement occurs between pulley and biceps and uppermost aspect of anterosuperior labrum and glenoid rim; if flexion is approximately 90 degrees, deep surface of subscapularis tendon is impinging against anterior glenoid rim and pulley is no longer in contact with rim without impingement of pulley.

condition and in the presence of associated lesions, it was difficult to determine the importance of each individual finding; accordingly, a standard form of treatment was not used in this series of patients. The undersurface lesion of the subscapularis tendon was debrided in the 11 cases in which it was frayed. A biceps tenotomy was carried out in 8 patients, a SLAP II was reinserted with a bioabsorbable tack in 1 patient, and an acromioplasty was added in 10 patients, each of whom had either concomitant superficial, velvetlike changes on the bursal surface of the supraspinatus tendon or a partial supraspinatus tendon tear.

At the completion of this study, which focused not on treatment results but on the description of a mechanism causing a lesion, 14 patients had a minimal follow-up of 6 months and an average follow-up of 11 months. Pain had been substantially improved in 11 patients and remained approximately the same as it was preoperatively in 3 patients. Each of 2 patients had developed a postoperative shoulder stiffness; all of the other patients had free and symmetric active and passive ranges of motion. The subjective overall result was excellent in 5, good in 5, fair in 3, and unsatisfactory in 1 of the patients.

## DISCUSSION

Lesions of the tendon of the long head of the biceps, the common insertion of the superior glenohumeral and coracohumeral ligaments (the pulley), and the subscapularis tendon are commonly associated.<sup>12,15,16,20,21</sup> For biceps subluxations to occur, the insertion of the pulley must be torn or stretched.<sup>12,15,20,24</sup> If a lesion involves only the pulley and leaves the subscapularis intact, the biceps can subluxate out of the groove or dislocate anterior to the subscapularis tendon, a rare but possible clinical entity.<sup>16,20,21</sup> External rotation of the abducted arm leads to a subluxation moment and can conceivably stretch the pulley region, leading to a sling formation with an extraarticular subluxation of the long biceps tendon.<sup>12,21</sup> Our findings do not exclude this potential mechanism of biceps subluxation. In clinical practice, however, minimal subluxations as frank dislocations of the tendon of the long biceps are most frequently intraarticular, the lesions originating invariably on the deep (articular) surface of the pulley and on the subscapularis, with an intact superficial tissue layer covering the pathology from the outside.<sup>1,4,14,16,18</sup>

The etiology of these lesions is unclear, but it appears reasonable to consider the same etiologies that apply to supraspinatus lesions:

- To our knowledge, subscapularis tears have never been thought to be caused by subacromial impingement, and observation of the position of the subscapularis tendon during movements of the shoulder does not suggest that the subscapularis could impinge under the anterior acromion.
- Degenerative changes caused by higher tension on the deep fibers in a relatively poorly vascularized deep portion of the tendon<sup>10,11</sup> could explain the deep surface lesions of the subscapularis tendon insertion. This etiologic hypothesis, however, cannot satisfactorily explain the lesions of the insertion of the superior glenohumeral ligament and the lesions of the biceps tendon, which are so often associated.

The present study showed that impingement of the undersurface of the pulley and of the subscapularis tendon occurs against the anterosuperior glenoid rim in a position of flexion and internal rotation of the arm. When lesions of the pulley or the subscapularis tendon

**Table** Arm position, observed structural contact and lesions

Position of arm	Observed structural contact	Observed structural lesions
<ul style="list-style-type: none"> <li>• Anterior elevation &gt; 120 degrees</li> <li>• Full internal rotation</li> <li>• Horizontal flexion &gt; 90 degrees (arm across sagittal plane)</li> </ul>	Intraarticular LHB with cuff superiorly and anterior biceps anchor region inferiorly	<ul style="list-style-type: none"> <li>• Anterosuperior labral fraying and detachment</li> <li>• Inflammatory changes and/or (rarer) fraying of LHB</li> <li>• Discrete fraying of humeral insertion of SGHL</li> </ul>
<ul style="list-style-type: none"> <li>• Anterior elevation &gt; 80 degrees and &lt; 120 degrees</li> <li>• Full internal rotation</li> <li>• Horizontal flexion &gt; 90 degrees (arm across sagittal plane)</li> </ul>	Humeral insertion of SGHL and inferior LHB at entrance into bicipital groove with anterosuperior and anterior glenoid labrum and MGHL (acting like a "plica")	<ul style="list-style-type: none"> <li>• Fraying of humeral insertion of SGHL</li> <li>• Bulging, fraying of superiormost insertion of subscapularis tendon (see Figure 4)</li> <li>• Fretting lesion of tendon of LHB immediately adjacent to insertion (see Figure 2)</li> <li>• Subluxation, subluxability of tendon of LHB (see Figure 3)</li> <li>• Fraying and/or instability of anterosuperior labrum</li> </ul>
<ul style="list-style-type: none"> <li>• Anterior elevation &gt; 50 degrees and &lt; 80 degrees</li> <li>• Full internal rotation</li> <li>• Horizontal flexion &gt; 90 degrees (arm across sagittal plane)</li> </ul>	Insertion of subscapularis tendon with anterior (anterosuperior) glenoid rim, labrum, and MGHL	<ul style="list-style-type: none"> <li>• Fraying of undersurface of subscapularis tendon (see Figure 5)</li> <li>• Fraying and/or instability of anterosuperior labrum</li> </ul>

SGHL, Superior glenohumeral ligament; MGHL, middle glenohumeral ligament; LHB, tendon of the long head of the biceps.

were present, they could be shown to contact corresponding lesions of the anterosuperior glenoid labrum in the flexion internal position of the arm. If the lesion was more cranial (biceps, pulley), more flexion was needed to recreate the mechanical conflict, but obvious encroachment of the lesional zone on the anterosuperior glenoid rim could be created in each case; it is therefore believed that this impingement is at least one of the etiologic factors in the development of these pathologic conditions.

The concept of anterosuperior glenoid impingement easily explains the various possible superior-inferior locations of the lesions of the biceps, pulley, and subscapularis tendons. Furthermore, this impingement explains why partial subscapularis tendon tears are not only always found proximally but also consistently affect the articular side of the tendon.<sup>14,16,18,24</sup> In analogy to posterolateral glenoid impingement, the described anterosuperior impingement should lead to articular side lesions<sup>22</sup> and not to bursal side tears, which are rather to be expected after subacromial<sup>19</sup> or subcoracoid impingement.<sup>5</sup> Thus, internal impingement can fully explain the topography of the clinically observed lesions.

For an impingement process to be a likely cause, it is hypothesized that the movement leading to the mechanical conflict would be painful. This was the case in every patient in this study. The fact that subacromial injection did not relieve pain in any patient essentially rules out subacromial impingement as a potential cause of the pain but is compatible with an intraarticular origin for it. For impingement to be a likely cause, the respective movement would also have to be carried out particularly frequently in a shoulder with this syndrome. The movement of flexion and internal rotation occurs

during overhead movements that are typical of racquet sports such as tennis (during follow-through), but it also occurs as a repetitive movement during overhead work, such as bricklaying. The vast majority of our patients were engaged in professions or sports activities that demand repetitive use of the involved arm in this position. Our study confirms that subscapularis tears are more frequently found in the dominant arm; this is contrast to supraspinatus tears, which occur as often in the dominant as in the nondominant arm.<sup>24</sup> These epidemiologic findings are at least compatible with the notion that impingement is the cause of the documented lesions.

The lesions of the subscapularis were usually found in combination with other intraarticular pathoses. An optimal form of treatment has not yet been defined, and the treatment results in the present series are preliminary and at best can be compared with the early results obtained after debridement of the supraspinatus tendon in posterolateral glenoid impingement. Longer follow-up is needed before treatment recommendations can be made. At this time, it appears important both to add the presented knowledge to our understanding of potential mechanisms that lead to painful structural pathoses of the shoulder and to encourage other surgeons to look for these lesions for the sake of contributing to the development of successful strategies for their prevention and treatment.

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