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SHOULDER

Anterior-superior internal impingement of the shoulder: an evidence-based review

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Abstract
Purpose Internal impingement syndrome is a painful shoulder condition related to the impingement of the soft tissue, including the rotator cuff, joint capsule and the long head of the biceps tendon and glenoid labrum. Two types of internal impingement syndrome can be differentiated: posterior-superior impingement and anterior-superior impingement (ASI). The aetiology of ASI in particular is not clear. The purpose of this paper is to discuss the different aetiological theories relating to ASI, try to clarify the clinical, radiological and arthroscopic findings and, finally, suggesting treatment for this complex shoulder syndrome.
Methods The article is based on own research and clinical experience, as well as a non-systematic search in the PubMed database.
Results The aetiology of ASI appears to be related to the pulley lesion and instability of the long head of the biceps tendon. It can be caused by trauma or degenerative factors, which produces anterior shoulder pain in middle-aged patients, particularly when performing overhead activities.
Conclusion The ASI is probably more frequent than previously reported. There is no evidence to prove the efficacy of a specific rehabilitative protocol, and the gold standard of surgical management has to be ascertained. However, in patients with a pulley lesion, there is some evidence that early surgical management, when minor soft injury lesions are present, produces better clinical outcomes.

Keywords Internal · Non-outlet · Impingement · Rotator cuff · Pulley · Instability · Anterior-superior

Introduction

Classic shoulder impingement, as described by Neer, is caused by the extrinsic compression of the subacromial bursa, the long head of the biceps tendon and the rotator cuff by the coraco-acromial arch. In recent years, the internal impingement phenomenon has been described as a clinical entity responsible for shoulder pain and discomfort [8].

The internal or non-outlet impingement syndrome is the result of an impingement between the rotator cuff and joint capsule on the glenoid, rotator cuff and glenoid rim itself or between the glenoid and humerus, where the glenoid contact may involve attached soft tissue (i.e. the labrum, anterior or posterior). Minor internal impingement is frequently seen in asymptomatic shoulders, without evidence of pathological changes, when the arm is brought into abduction and external rotation or flexion and internal rotation. Over time, the constant repetition of these movements may result in injury at the site of impingement, creating a need for treatment of the pathology and, more importantly, the underlying factors causing the impingement [5, 7, 8, 11, 17, 26]. Two different types of internal impingement syndrome have been recognised: posterior-superior impingement (PSI) and

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anterior-superior impingement (ASI). The precise description of these two entities varies in different studies.

Moreover, while there are several studies describing PSI in terms of aetiology, anatomical structures involved, the impingement and the guidelines for treatment. Anterior-superior impingement (ASI) is less frequently mentioned in the literature.

There is still some confusion about this syndrome, particularly when it comes to aetiology and nomenclature. It is related to the compression of the rotator cuff on the anterior glenoid and should be not confused with subcoracoid, external impingement, due to rubbing between the coracoid process and the humerus (usually the lesser tuberosity) [5, 6, 14, 17].

The aim of this review is to evaluate the different aetiological theories that may explain ASI. The different anatomical structures involved in this type of impingement are described; the clinical findings are presented and treatment guidelines are suggested.

Biomechanics and theories of pathology

As different from PSI, which is associated with posterior pain during abduction and external rotation, the main feature of ASI is that pain is generated during the follow-through movement, with the arm in position of internal rotation, flexion and adduction.

Gerber and Sebesta [7] first described ASI as a form of intra-articular impingement responsible for unexplained anterior shoulder pain. They studied 16 consecutive patients with chronic shoulder pain provoked by anterior elevation and internal rotation. Twelve of these patients were engaged in manual labour involving regular overhead activity. The authors described lesions of the humeral insertion of the superior glenohumeral (SGHL)/coracohumeral ligament (CHL) complex (the pulley) and/or the deep surface of the subscapularis tendon related to impingement against the anterior-superior glenoid rim in a position of flexion and internal rotation of the arm. The biceps pulley mechanism stabilises the long head of the biceps (LHB), as it passes through the rotator interval between the supraspinatus and subscapularis into the intertubercular groove [7]. The authors were able intra-operatively (during arthroscopy) to reproduce the impingement between the pulley/subscapularis tendon system and the anterior-superior glenoid rim. Moreover, they noted that changing the angle of flexion while maintaining the same internal rotation changed the site of impingement [7]. In an embedded cadaveric model used to establish an in vitro basis for ASI, Valadie et al. noted that both the lesser tuberosity and the subscapularis insertion were significantly closer to the glenoid in the Hawkins position than in the Neer position [25]. The authors suggested the possibility that this type of impingement could be responsible for shoulder pain reported by swimmers at the point of hand entry [25].

While the articular side of the posterior-superior rotator cuff is involved in PSI, the articular side tear of the subscapularis tendon is affected in ASI. Gerber and Sebesta reported a subscapularis tendon tear in 13 of 16 shoulders. In 10 of 16 shoulders, they observed an SLAP type I or II lesion. In 44% of patients, arthritis of the acromio-clavicular joint was also observed [7]. Struhl [23] studied 10 non-athletic patients with shoulder pain related to ASI. The author believed that the contact between the rotator cuff and the superior labrum is physiological when the arm is rotated in the forward, flexed position. In cases of partial rotator cuff defect, the contact may become pathological, as the abnormal, fragmented rotator cuff tissue is sheared and compressed between the superior humeral head and the glenoid. Arthroscopic observation revealed that there is direct contact between the humeral head and the anterior-superior labrum, with the arm in internal rotation and flexion. In all shoulders, the authors reported a partial-thickness rotator cuff tear, involving the supraspinatus, in most shoulders, anterior-superior labral fraying and, in only 2 of 10 cases, a partial subscapularis tear. They also found a biceps tear in several patients, even if it was not specifically a biceps pulley lesion.

Habermeyer et al. [9] reviewed 89 consecutive patients with an arthroscopic diagnosis of pulley lesion. In their series, they observed that 75% of patients with ASI were engaged in manual labour involving regular overhead activities. They developed a classification system for the pulley lesion based on the combination of lesions observed in patients with ASI: type I with an isolated lesion of the SGHL, type II with a lesion of the SGHL associated with a partial articular side supraspinatus tendon tear, type III with a lesion of the SGHL associated with a partial subscapularis tendon tear and type IV with a lesion of the SGHL associated with a partial tear of the supraspinatus and subscapularis tendon. The authors found that as the degree of soft-tissue injury about the pulley system increased, so too did the frequency of ASI. In that study, ASI was defined by the presence, during arthroscopic examination, of an anterior-superior labral lesion together with positive dynamic testing of impingement of the subscapularis and the lesser tuberosity against the anterior-superior glenoid rim and labrum. The test was carried out with the arm in flexion, horizontal adduction and internal rotation. According to this study, the anterior-superior labral tear could be the result of an impingement of the LHB tendon and the subscapularis tendon against the anterior-superior glenoid rim. Habermeyer et al. [9] believed that the cascade of ASI starts with the pulley lesion and instability of

the LHB tendon caused by degenerative changes, macro-trauma or repetitive microtrauma. The subluxated LHB tendon loses its anterior stabilising effect on the humeral head, which leads to an increased anterior translation [9]. Furthermore, Habermeyer et al. [9] concluded that the subluxated LHB tendon could be responsible for a partial articular tear of the subscapularis tendon that permits a further anterior-superior translation of the humeral head. In the series reported by Habermeyer et al. [9], a partial articular side subscapularis tendon tear was observed in 72% of the shoulders. Several authors have shown that a lesion at the level of the SGHL is strongly associated with partial articular side rotator cuff tears adjacent to the rotator interval [16, 22, 26].

Baumann et al. [1] reported on a retrospective study of the pulley lesion. They found an incidence exceeding 7% on 1,007 diagnostic shoulder arthroscopies. Unfortunately, they did not report information about ASI. However, they performed the ASI test as described by Gerber and Sebesta [7] in several patients, and they were not able to reproduce ASI in each case of pulley lesion, concluding that ASI is not the only pathomechanism for a pulley lesion [1]. They also found support for the association of pulley lesions and acromio-clavicular arthritis in 26.4% of patients. Other authors have described a lesion of the anterior-superior labral complex with or without involvement of the rotator cuff, caused by traumatic [21] or degenerative factors [4].

Clinical history, physical examination

ASI typically involves middle-aged patients who are often involved in overhead manual labour or are athletes [7, 9, 23] (Fig. 1). Patients often complain of an insidious anterior shoulder pain, especially at night, without any history of trauma [7, 9]. Habermeyer et al. [9] reported that several patients diagnosed with ASI recalled a history of minor trauma before they started to have symptoms. When Baumann et al. [1] evaluated the cases with a pulley lesion, a history of trauma was found in 43% of the subjects. The traumatic mechanism reported to be associated with a pulley lesion is a fall on the outstretched arm, in combination with full external or internal rotation, or a fall backwards onto the hand or elbow [13]. Sometimes, patients with ASI may also present with insidious symptoms similar to those associated with classic subacromial impingement [23]. Gerber and Sebesta [7] stated that all their patients complained of pain when using the arm overhead in front of the head.

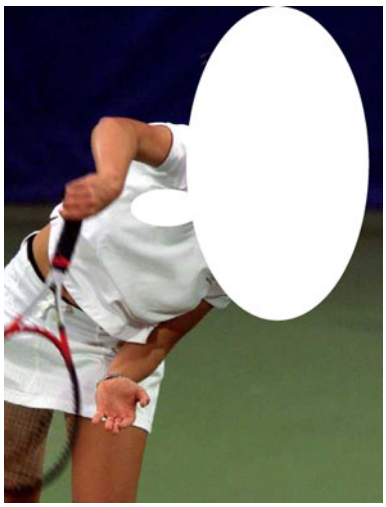

Fig. 1 Repetitive use of the arm in the position of adduction, elevation and internal rotation can produce the phenomenon of anterior-superior impingement

There are just a small number of *physical examination tests* that specifically address ASI; they are more frequently different tests that are used to evaluate the rotator cuff, biceps tendon or acromio-clavicular joint modification in patients with ASI.

Gerber and Sebesta [7] reported a modified impingement test that was positive in all patients. The test, similar to the Hawkins test [10], includes putting the arm in flexion, horizontal adduction and internal rotation (Fig. 2). In particular, they observed arthroscopically that internal rotation associated with an elevation of more than 120 degrees caused direct contact between the LHB tendon and the pulley region with the anterior-superior labrum, whereas decreasing the amount of flexion led to an impingement of a more distal part of the capsulo-tendinous complex and at an average 80-100 degrees of flexion, where the pulley was out of the contact zone of impingement (Fig. 3). The test is regarded as positive when, during this manoeuvre, the patient complains of pain [7]. In the series reported by Gerber and Sebesta [7], there was also tenderness of the acromion-clavicular joint and in some cases also in conjunction with the supraspinatus test and belly press test. The injection of 10 ml of Lidocaine 1% in the subacromial space failed to relieve pain in all patients. Baumann et al. [1] reported that neither subacromial nor acromion-clavicular joint injections induced pain relief in patients with a pulley lesion. They reported the presence of an O'Brien test [19] in 66.7%, a palm-up test in 66.7% and a Hawkins test in 56.9% of patients, concluding that the O'Brien test and the palm-up test were the most sensitive to pulley lesions [1].

Struhl et al. reported a positive Hawkins test in all their patients and a positive Neer test [18] in 90% of shoulders [23]. No other pathological clinical examination findings were made. Habermeyer et al. [9] reported a positive Hawkins test in 47 (53%) of 89 patients. In addition, clinical tests suggesting pathology of the LHB or of the biceps anchor, such as the palm-up test or the O'Brien test,

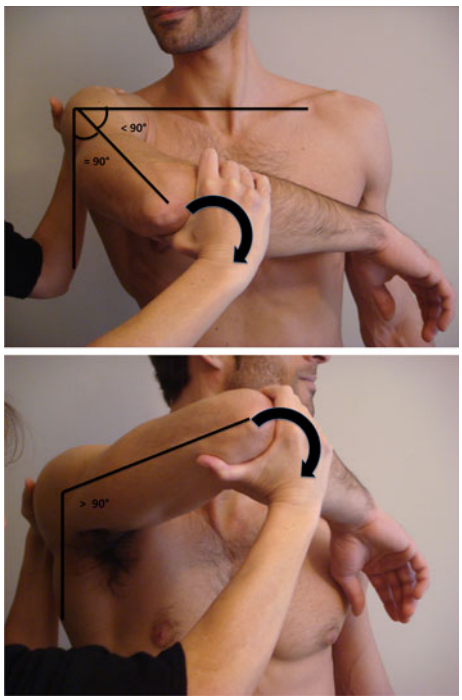

Fig. 2 Adduction, internal rotation with an elevation of the arm of less than or approximately 90 degrees, is the position of the arm that leads to the impingement of the deep surface of the subscapularis at the anterior-superior glenoid labrum. In this position, the pulley is not yet in contact with the anterior-superior labrum. With an associated anterior elevation of more than 90 degrees, the superior glenohumeral ligament and biceps are impingement against the anterior-superior glenoid rim

were found to be positive. No patients with ASI have been found to have a loss of shoulder range of motion, instability or increased laxity. Clinical tests are not sensitive or specific for ASI, and imaging has not been shown to be beneficial. On the other hand, ASI is best determined by dynamic evaluation at arthroscopy.

Imaging findings

In previous studies, we have not been able to make specific findings correlated with ASI. In the series reported by Habermeyer et al. [9], the only pathological but not specific ASI finding on *imaging* was the presence of osteoarthritis in the acromio-clavicular joint in 27% of patients. Ultrasound enables the evaluation of the stability of the LHB tendon through internal and external rotation [1, 20]. In this way, subluxation of the LHB tendon related to pulley injury is readily evident; moreover, the relationship between the LHB and the subscapularis tendon can also be assessed [1]. However, Teefey et al. [24] pointed out that, in the case of ASI, failure to detect small tears of the subscapularis and small partial-thickness tears are a source of inaccuracy in shoulder ultrasonography assessment.

Lesions of the LHB tendon, the SGHL and undersurface of the supraspinatus and subscapularis tendons [2, 12], as well as dislocation of the LHB tendon, when static [22], can be readily seen using MRI, but this is not enough to make a diagnosis of ASI. The MRI, however, fails to detect the recurrent subluxation of the LHB tendon.

The only findings on MRI reported by Struhl [23] were the presence of a partial or a complete rotator cuff tear in 3 of 10 patients in this series.

Several authors have demonstrated the efficacy of MR arthrography for assessing the structures of the rotator interval, which enables the demonstration of the components of the biceps pulley system [3, 15]. Moreover, tears in the rotator interval may not appear as a complete disruption of fibres but as thinning or focal discontinuity, so a routine MRI is unlikely to demonstrate interval tears and, in this sense, the arthro-MRI is of great value [3]. The free communication of contrast medium through the interval with the subacromial bursa in the absence of a full-thickness tear of

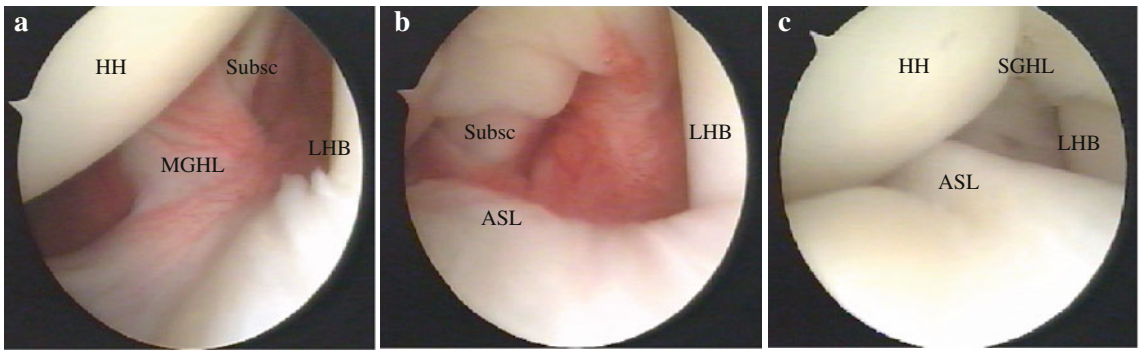

Fig. 3 **a** In the position of abduction and slight external rotation, no impingement can be observed between the structures of the pulley or the subscapularis tendon and the anterior-superior labrum. *HH* Humeral head, *Subsc* Subscapularis tendon, *MGHL* Middle gleno-humeral ligament, *LHB*. Long head biceps tendon. **b** In the position of internal rotation with an elevation of approximately 90 degrees, a slight impingement between the subscapularis tendon and the anterior-superior labrum can be observed. *Subsc* Subscapularis tendon, *LHB* Long head biceps tendon, *ASL* Anterior-superior labrum. **c** In the position of internal rotation with an elevation of more than 90 degrees, the humeral head and the superior glenohumeral ligament start to undergo an impingement with the antero-superior labral rim. *Subsc* Subscapularis tendon, *LHB* Long head biceps tendon, *ASL* Anterior-superior labrum, *HH* Humeral head

the rotator cuff tendons is a useful sign of interval disruption [8]. Gerber and Sebesta [7] performed an arthro-MRI in 13 patients and an arthro-CT scan in one patient with ASI, noting an alteration in the region of the pulley in parasagittal images in 8 shoulders, a suspicion of a lesion of this kind in 2 shoulders, while the MRI was read as normal in 3 shoulders.

Treatment

In contrast to the classical impingement syndrome or PSI, there are no published guidelines or treatment protocols for the conservative management of ASI. This is probably related to the rarity of this lesion.

Moreover, surgical treatment guidelines, especially for ASI, are not well established. It is usually treated as part of other associated injuries. Gerber and Sebesta performed the debridement of the partial tear of the subscapularis tendon, biceps tenotomy in 8 of 16 patients, SLAP repair in 1 patient and in 10 patients associated acromioplasty [7]. The authors reported excellent or good results in 10 of 16 patients.

Struhl performed the debridement of labral and rotator cuff partial tears in 7 patients and a labral repair in 3 patients. In one of these 3 patients, a thermal capsulorrhaphy was also performed [23]. Only short-term follow-up results (3–6 months) were reported. One patient was lost to follow-up. They found good results in six patients, while two patients reported pain in association with extreme activities and one patient experienced little benefit from the surgery. This was the only patient in the series who had evidence of osteoarthritis of the gleno-humeral joint.

Baumann et al. [9] reported on the surgical management of a group of 72 patients with a pulley lesion. Although the authors did not mention ASI, this syndrome is strongly associated with a pulley lesion, resulting in very important indirect evidence of the outcome of treatment of ASI [1]. The authors reported that, in 75% of patients, they performed an open tenodesis of the LHB tendon associated with a reconstruction of the rotator interval, using transosseous sutures or bioabsorbable screws [1]. This procedure was performed in patients who had a partial tear (articular side) of the rotator cuff and a partial tear of the LHB. In the other 25% of cases, the LHB was preserved and a pulley reconstruction was performed. In the 24% with an isolated SGHL elongation, the authors performed a thermal capsulorraphy of the SGHL. In 26.4% of patients, an open resection of the lateral clavicle was performed because of severe osteoarthritis of the acromion-clavicular joint. An arthroscopic subacromial decompression was performed in 32% of patients. The authors found better results in patients with an isolated lesion of the SGHL than in patients with combined partial surface tears. No other differences were observed when comparing tenodesis of the LHB versus no tenodesis, trauma versus no trauma and subacromial fraying versus no subacromial fraying [1].

Conclusion

ASI is a recently described type of internal impingement caused by trauma or degenerative factors, which produces anterior shoulder pain in middle-aged patients, particularly when performing overhead activities. This syndrome appears to be related to a lesion of the pulley system, but the LHB tendon is often involved, demonstrating synovitis, subluxation, dislocation or partial tearing. Different pathological findings are, however, associated with this syndrome, particularly at the level of the acromion-clavicular joint.

There is no evidence to prove the efficacy of a specific rehabilitative protocol, and the gold standard of surgical management has to be ascertained. However, in patients with a pulley lesion, there is some evidence that early surgical management, when minor soft injury lesions are present, produces better clinical outcomes.

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