

Management Options for Shoulder Impingement Syndrome in Athletes: Insights and Future Directions

This article was published in the following Dove Press journal:
Open Access Journal of Sports Medicine

Ioanna K Bolia 

Kevin Collon 

Jacob Bogdanov 

Rae Lan 

Frank A Petrigliano 

USC Epstein Family Center for Sports
Medicine at Keck Medicine of USC, 1520
San Pablo Street Suite 2000, Los Angeles,
CA, 90033, USA

Abstract: Athletes participating in overhead sports are at particularly high risk of shoulder impingement syndrome. Subcoracoid impingement is defined as impingement of the anterior soft tissues of the shoulder between the coracoid process and the lesser tuberosity. Subacromial impingement syndrome (SIS) occurs due to extrinsic compression of the rotator cuff between the humeral head and coracoacromial structures or intrinsic degeneration of the supraspinatus tendon and subsequent superior migration of the humerus. Internal impingement is a major cause of shoulder pain in overhead athletes, and it occurs due to repetitive impingement of the articular surface of the rotator cuff with the glenoid during maximum abduction and external rotation of the arm. When examining athletes with suspected impingement of the shoulder, it is important to discuss the sport-specific motion that regenerates the symptoms and perform a combination of physical examination tests to improve the diagnostic accuracy. Radiographic evaluation is recommended, and the extent of soft tissue abnormalities can be assessed on ultrasound or magnetic resonance imaging of the shoulder. Management of shoulder impingement syndrome can be conservative or operative, based on the severity and chronicity of symptoms and the associated structural abnormalities. This review provides an update on the management of SIS, subcoracoid impingement, and internal impingement in the athletic population.

Keywords: impingement syndromes, shoulder, subacromial impingement syndrome, joint, subcoracoid, internal, athletes

Introduction

Shoulder impingement syndrome is commonly diagnosed in athletes with shoulder pain especially those who participate in overhead and/or throwing activities.¹ Different types of shoulder impingement have been described including subacromial impingement, subcoracoid impingement, and internal impingement.² Subcoracoid impingement refers to the impingement of the anterior soft tissues of the shoulder (subscapularis tendon, long head biceps tendon, and biceps reflection pulley) between the coracoid process and the lesser tuberosity and mostly occurs with the arm in flexion, adduction, and internal rotation.³ Subacromial impingement syndrome (SIS) is a common cause of shoulder pain in the athlete.⁴ A partial or complete tear of the rotator cuff tendon often accompanies SIS and evaluation of rotator cuff integrity in these patients is a necessity.⁵ Freestyle swimmers have been reported to be at increased risk of SIS due to the repetitive microtrauma during the overhead-cyclic motion of the upper extremities in combination with shoulder

Correspondence: Frank A Petrigliano
USC Epstein Family Center for Sports
Medicine at Keck Medicine of USC, 1520
San Pablo Street Suite 2000, Los Angeles,
CA, 90033, USA
Tel +1 9703432813
Fax +1 818-658-5925
Email frank.petrigliano@med.usc.edu

hyperlaxity.⁶ Internal impingement (impingement of the undersurface of rotator cuff) conversely is rare in the general population and is almost exclusively encountered in athletes. Internal impingement is a major cause of shoulder pain in baseball players and occurs during the late cocking and early acceleration phases of throwing when the rotator cuff is compressed between the greater tuberosity and posterosuperior labrum.⁷

The diagnosis and treatment of shoulder impingement syndrome in athletes can be challenging, given that this condition (regardless of type) is multifactorial.² Athletes with a suspected diagnosis of shoulder impingement syndrome should be encouraged to demonstrate the specific motion(s) that trigger their symptoms. Apart from rotator cuff disease, other conditions that may accompany shoulder impingement should be ruled out. The last include but are not limited to glenohumeral instability, shoulder muscle imbalance, nerve entrapment syndromes, and scapular disorders.^{8,9} SICK (Scapular malposition, Inferior medial border prominence, Coracoid pain and malposition, and dysKinesis of scapular movement) scapula syndrome or scapulothoracic dyskinesis refers to the abnormal scapula motion that leads to shoulder impingement and dysfunction. Radiographic evaluation is often followed by ultrasound or magnetic resonance imaging (MRI) in athletes with suspected shoulder impingement syndrome.¹⁰ Conservative management with physical therapy, oral medication and/or subacromial injections remains the first-line therapy of impingement syndrome in athletes, while operative management is preserved for refractory cases. However, in cases of athletes with impingement syndrome accompanied by severe rotator cuff pathology and/or bony abnormalities, surgical treatment may be the first-line therapy.¹¹

The current review aims to provide a clinical update on the management of shoulder impingement syndrome in athletes. We focused on the diagnosis and treatment of subacromial impingement, internal impingement, and subcoracoid impingement syndromes, which are commonly encountered in the athletic population.

Subacromial Impingement Syndrome (SIS)

Subacromial impingement syndrome (SIS) is the most common cause of shoulder pain (accounting for 44–65% of all shoulder complaints) in the general population, and it is commonly diagnosed in athletes.⁴ The

pathophysiologic basis of SIS consists of subacromial space narrowing due to any etiology.¹² Similar to the internal impingement syndrome, the true incidence rate of SIS in athletes is hard to estimate due to the multifactorial character of the disease, and therefore it has not been reported. SIS has been traditionally classified into “structural” (primary SIS) or “functional” (secondary SIS) based on the underlying shoulder abnormalities.^{13,14} Structural SIS occurs due to bony or soft tissue abnormalities that result in the compression of the subacromial space structures including the rotator cuff tendon, long head of biceps, and the subacromial bursa.¹⁵ These anatomical structures can be compressed between the acromion, acromioclavicular joint, coracoacromial ligament, and the humeral head during the abduction of the humerus.¹⁴ In modern literature, “extrinsic compression” refers to the compression of the rotator cuff tendon, and specifically the supraspinatus tendon which is most likely to contact the acromion with the humerus in 90° of abduction and 45° of internal rotation of the arm.¹⁶

The “functional” type of SIS occurs due to muscle imbalance or rotator cuff disease (loss of the force couples around the shoulder) and/or glenohumeral instability that results in superior migration of the humeral head and narrowing of the subacromial space.¹⁷ For example, intrinsic degeneration of the rotator cuff tendon leads to decreased (downward) antagonizing force against the (upward) deltoid force with subsequent superior migration of the humerus.¹⁵ SIS represents a wide spectrum of shoulder diagnoses including rotator cuff disease, biceps tendinitis, and subacromial bursitis.¹⁴ The association between SIS and rotator cuff tears has been an era of controversy over the years between the theories of extrinsic compression and intrinsic tendon degeneration, as described above.⁵ Other conditions that may be associated with SIS include scapular dyskinesia, posterior capsular contracture, os acromiale, hook-shaped acromion, malunion of greater tuberosity fracture, and glenohumeral instability.^{2,15}

Previous studies have shown that functional SIS is more common in younger patients and overhead athletes, whereas structural SIS is more prevalent in older patients.¹⁴ When an athlete presents with shoulder pain, careful consideration of the sport-specific factors that may contribute to the development of structural lesions related to SIS is required.¹⁸

History and Physical Examination

The diagnostic process of SIS begins with obtaining a detailed history of the athlete's shoulder injury and performing physical examination. Typically, the athlete with SIS reports the insidious onset of shoulder pain (weeks to months) which is exacerbated by arm elevation and/or overhead activities.¹⁹ In most cases, the pain is located anteriorly and/or lateral to the acromion with or without radiation to the lateral aspect of the arm (deltoid tuberosity).^{4,15} Tenderness at the Codman point is another sign of possible SIS.²⁰ The presence of night pain should raise suspicion for partial or complete tear of the rotator cuff tendon.²¹ Shoulder stiffness or weakness are occasionally present.⁴ In athletes, it is extremely important to explore the sport-related maneuvers that elicit the SIS symptoms in order to determine the next steps in the diagnostic process. Freestyle swimmers have been reported to be at increased risk of function (secondary) SIS due to shoulder hyperlaxity and repetitive microtrauma of the subacromial structures, but also due to muscle imbalance.^{22,23} Throwing sports like baseball, tennis or water polo also place the athlete's shoulder at risk of SIS due to repetitive microtrauma of the subacromial structures.¹

Table 1 presents the physical examination tests that are commonly performed in patients with suspected SIS. The diagnostic performance of these tests has previously been investigated.^{20,24–26} The Neer sign is performed by flexing the arm forward while stabilizing the scapula with the opposite hand. In a meta-analysis, the pooled sensitivity of Neer sign for subacromial bursitis (indicative of SIS) was 72% and the specificity was reported as 60%.²⁷ According to the same study, the sensitivity of the Hawkins-Kennedy test for subacromial impingement was 79% and the specificity was 57%, while the painful arc test was 53% sensitive and 76% specific for this

condition.²⁷ The diagnostic performance of shoulder physical examination tests (including those related to SIS) can be improved by combining two or more tests during a physical examination, or by combining a test with specific patient characteristics or symptoms (such as age, shoulder clicking, and so on).^{24,28} Although the combination of SIS tests yielded only marginal improvement in their diagnostic performance (compared to that of an individual test) in previous studies, performing multiple diagnostic maneuvers is recommended in these patients.^{24,28}

Although the role of scapular kinematics in the pathophysiology of SIS is still under investigation, previous research has shown that scapular orientation may be related to this condition.²⁹ For example, some studies reported that SIS patients were more likely to present with upward rotation, increased anterior tilting, and medial rotation of the scapula compared to asymptomatic controls, while other studies found opposite results or no difference in the scapular motion between SIS and non-SIS patients.²⁹ Maenhout et al³⁰ investigated the changes in acromiohumeral distance on ultrasound and scapular position using electromagnetic motion-tracking system in 29 recreational overhead athletes who performed a shoulder muscle fatigue protocol. The authors found that muscle fatigue resulted in increased acromiohumeral distance at 45° and 60° of abduction and the scapula obtained a more externally rotated position. The authors concluded that muscle fatigue corresponded to an “impingement-sparing” situation.³⁰ In contrast, Silva et al³¹ found that tennis players with scapular dyskinesia had a smaller subacromial space on ultrasound compared to unaffected athletes. Laudner et al³² compared the subacromial joint space in baseball pitchers with various degrees of posterior shoulder tightness compared to asymptomatic

Table 1 Positive Interpretation of Commonly Performed Physical Examination Tests in Patients with Suspected Subacromial Impingement Syndrome (SIS)

Physical Examination Test	Positive Interpretation for the Diagnosis of SIS
Neer impingement sign	Shoulder pain with passive forward flexion of the shoulder > 90°
Neer impingement test	Negative Neer impingement sign following subacromial injection with local anesthetic± corticosteroid ^o
T sign	Shoulder pain with forced elevation of the arm (between flexion and abduction) between 70–110 °
Hawkins test	Shoulder pain with passive forward flexion of the shoulder to 90° with internal rotation
Jobe test (supraspinatus)	Shoulder pain with forward arm elevation to 90° and resisted pronation
Painful arc test	Shoulder pain with active arm abduction between 60°-120°

professional baseball pitchers, and found a significant correlation between excessive posterior shoulder tightness with reduced subacromial space on ultrasound.³² The evaluation of scapular motion and shoulder range of motion may be useful in athletes presenting with SIS in order to determine whether scapular stabilization exercises or shoulder stretching should be part of the physical therapy protocol.²⁹

Imaging

Radiographic evaluation is recommended in patients with suspected SIS in order to assess for potential bony abnormalities of the coracoacromial arch. Routine radiographs include the true shoulder anteroposterior (AP) view, 30° caudal tilt view, outlet supraspinatus view, and the axillary view.^{5,10} The 30° caudal view is useful to diagnose subacromial spurring. The supraspinatus outlet view allows for the evaluation of the acromial morphology.¹⁰ SIS is most commonly associated with type III (hooked) acromion (Bigliani classification).³³ Os acromiale is best seen on axillary view.⁵ Other radiographic findings may include coracoacromial ligament classification and/or cystic changes of the greater tuberosity.^{5,20} MRI is performed in the majority of patients with SIS in order to evaluate the structural integrity of the rotator cuff tendon, diagnose subacromial bursitis and/or identify additional soft tissue pathology. Ultrasound of the shoulder can also be useful for the same purpose, but MRI provides a more detailed visualization of the lesions and aids in surgical decision-making. However, musculoskeletal ultrasound may be useful in the athletic population given its low-cost and the ability to be performed on the field using a portable device.

Treatment

The management of SIS in athletes can be non-operative or operative, and it largely depends on the associated structural lesions of the shoulder at the time of diagnosis. In patients with SIS, a 3–6-month trial of conservative therapy is the mainstay of treatment. Non-operative therapy consists of the combination of physical therapy, oral anti-inflammatory medications and/or subacromial injections. Physical therapy should focus on strengthening of the rotator cuff muscles as well as scapular stabilization exercises especially in athletes with concomitant scapular dyskinesis. Athletes with the SICK scapular syndrome are at higher risk of shoulder instability and rotator cuff injury, compared to patients with normal scapular mechanics.³⁴

Physical therapy in athletes with SICK scapula syndrome should focus on core strengthening, as well as strengthening of the rotator cuff and scapula stabilizer muscle groups.³⁵ A sport-specific rehabilitation program that includes the teaching of proper throwing technique with emphasis on core-upper extremity coordination is important in order to prevent the progression of the shoulder pathology in athletes with SICK scapula syndrome.^{18,36} In the study by Kuhn et al, an exercise program resulted in decreased pain and improved shoulder function in patients with rotator cuff impingement; however, it did not have a significant effect on shoulder range of motion or muscle strength.³⁷ A recent systematic review examined the effect of clinical taping in addition to physical therapy in patients with SIS but failed to demonstrate a clear benefit of this intervention.³⁸

Subacromial injections with local anesthetic and/or corticosteroid are more commonly performed in patients with SIS for both diagnostic and therapeutic purposes. Subacromial platelet-rich plasma (PRP) injection has also been proposed as a potential treatment; however, recent studies have failed to demonstrate a significant benefit in SIS patients.^{39,40} According to Say et al, subacromial injection with corticosteroid in SIS patients resulted in greater improvement in shoulder function (Constant score) and pain (VAS) at 6 weeks and 6 months post injection, compared to a single dose of PRP injection.⁴⁰ It is important to note, that the above studies were not exclusively performed in physically active patients and more research is needed in order to determine the optimal treatment of SIS in athletes.¹¹

Surgical therapy consists of open or arthroscopic subacromial decompression with acromioplasty. Surgery is only indicated when the nonoperative measures (physical therapy) fail to improve the patient's symptoms. Although acromioplasty and subacromial decompression are routinely performed in patients who undergo rotator cuff repair in order to prevent future impingement of the tendon to the coracoacromial complex, the clinical benefit of this procedure has been debated in the literature.⁴¹ Lahdeoja et al showed no difference in outcomes of adult patients with SIS who underwent subacromial decompression versus placebo surgery or exercise therapy.⁴² Similarly, no difference in patient-reported outcomes was detected following arthroscopic rotator cuff repair with versus without acromioplasty in a meta-analysis of 4 randomized trials and 373 patients.⁴³ Therefore, physical therapy is the gold standard treatment for SIS in athletes.

Fewer studies have investigated the effect of subacromial decompression in athletes. Roye et al reported a higher percentage of satisfactory outcomes following subacromial decompression in nonthrowing athletes compared to throwing athletes (90% and 86%, respectively), but the clinical significance of this difference (4%) is questionable.⁴⁴ In the same study, only 50% of the competitive baseball and softball players reported successful results.⁴⁴ Payne et al⁴⁵ reported the outcomes of surgical management of partial rotator cuff tears in a group of 40 athletes, and 21 of these athletes had subacromial inflammation. The rate of return to sport in this last patient subgroup was 50%, regardless of the presence of concomitant glenohumeral instability.⁴⁵ Based on the above, the clinical benefit of subacromial decompression in athletes is not fully supported by clinical evidence and sports surgeons should carefully evaluate the need for this procedure when performing shoulder arthroscopy in athletes.

Internal Impingement of the Shoulder

History and Physical Examination

Nearly 30 years after Walch et al published the first series on internal impingement in athletes, clinical diagnosis remains challenging.⁴⁶ Due to the wide range of concomitant intra- and extra-articular pathology often encountered with this syndrome, the true incidence has not been defined, and the clinical presentation is often nonspecific.⁴⁷ Internal impingement is typically seen in patients under the age of 40, and it is most often associated with the overhead throwing athlete.⁷

As Jobe emphasized in his 1995 “expanded spectrum” of internal impingement, a thorough social and occupational history is critical to raising clinical suspicion for this entity.⁴⁸ In athletes, a predisposition may be more apparent as high rates of internal impingement have been widely documented in baseball players, volleyball players, tennis players, and swimmers.^{49,50} The most common complaint among athletes presenting with internal impingement is posterior shoulder pain which is aggravated by positions of abduction and external rotation – classically the late cocking and early acceleration phases in throwers.⁵¹ Additionally, the overhead athlete will frequently report stiffness, the need for a prolonged warm-up or a gradual decline in throwing velocity and control.⁵⁰

A presentation consistent with rotator cuff disease in the overhead athlete should also alert the clinician to the

potential for an internal impingement mechanism, which has been associated with articular-sided rotator cuff tears.⁵² Additionally, anterior instability is occasionally encountered on clinical presentation in patients with internal impingement.⁵³ Due to the variability and non-specific nature of symptoms obtaining a definitive diagnosis of internal impingement based on clinical presentation alone is difficult. A thorough physical exam and diagnostic imaging are crucial in diagnosing this condition.

Physical examination findings in the patient with internal impingement are often nonspecific.⁷ Findings on inspection may be unremarkable; however, the clinician should pay attention to asymmetry with respect to glenohumeral and scapular positioning compared with the unaffected side. Burkhart et al described a relationship between scapular dyskinesis and internal impingement in the throwing shoulder.³⁶ The authors documented common associated physical exam findings of apparent inferior positioning of the affected shoulder and inferior tilt of the clavicle, as well as scapular protraction and medial scapular winging. On palpation, posterior glenohumeral joint line tenderness is the most common physical finding.⁴⁷ Anterior shoulder tenderness secondary to capsular or biceps pathology, or tenderness laterally over the greater tuberosity related to rotator cuff disease can also be seen.

Range of motion (ROM) testing is critical in the athlete with suspected internal impingement. Posterior shoulder tightness and glenohumeral internal rotation deficit (GIRD) are associated with the development of internal impingement in overhead athletes.⁵⁴ While GIRD of 10°–15° is common in the asymptomatic throwing shoulder, higher degrees of internal rotation deficit have been shown to have a significant correlation with symptomatic internal impingement.⁵⁵ Myers et al compared posterior shoulder tightness and internal rotation deficit between asymptomatic throwing athletes and those with symptomatic internal impingement, and found a significant increase in internal rotation deficit in symptomatic patients (19.7° and 11.1°, respectively), as well as increased posterior shoulder tightness in the symptomatic group.⁵⁵

Jobe’s apprehension and relocation tests are important to evaluate for both gross anterior instability and pseudolaxity or microinstability of the shoulder.⁵⁴ Specifically, the examiner should pay attention to the recreation of posterior shoulder pain when performing the apprehension test (now referred to as the posterior impingement sign, described by Meister et al⁵⁶), and relief of pain with

relocation, as these findings have been shown to be more specific for internal impingement than the subjective apprehension seen with gross anterior instability.^{7,50} O'Brien's active compression test may also be useful to diagnose concomitant SLAP tears.^{7,47,50} The classic Neer and Hawkins impingement tests can also be performed to distinguish from external outlet impingement.^{7,47,50} Arm positions in which the shoulder is placed in the Neer and Hawkins impingement tests can potentially recreate posterosuperior impingement as well, potentially decreasing the specificity of these tests.⁵⁷ There remains a relative lack of literature describing specific physical examination tests for the diagnosis of internal impingement. Meister et al⁵⁶ described the posterior impingement sign, as noted above, which is frequently used to assess for internal impingement and carries a sensitivity and specificity of 95% and 100%, respectively, for noncontact injuries.⁷ Zaslav described the internal rotation resistance strength test in 2001,⁵⁸ for which he documented an 88% sensitivity and 96% specificity for the diagnosis of internal impingement, though this examination maneuver was never adopted by the orthopaedic community. Ultimately, an exhaustive physical examination may be necessary in the athlete with a presumed internal impingement in order to make an accurate diagnosis.

Imaging

While radiographs are often unremarkable in the evaluation of the young athlete with internal impingement, they are the first-line imaging modality in patients with shoulder pain. A complete shoulder series consisting of a standard AP, axillary, and scapular Y views should be obtained. Stryker notch and West Point views may be useful in demonstrating certain pathologic findings associated with internal impingement, such as posterior/inferior glenohumeral exostoses, or anterior glenoid bony abnormalities.⁴⁷ The clinician should pay particular attention to potential cystic changes in the humeral head or "geodes" which may represent osteochondral lesion associated with internal impingement; bony exostoses near the inferior glenoid – historically referred to as the Bennett lesion.⁴⁷ These lesions, while often found in both symptomatic and asymptomatic athletes and which have questionable clinical significance, are important to alert the clinician to pathophysiologic changes in the shoulder associated with internal impingement.

Noncontrast MRI is the gold standard diagnostic imaging modality for the patient with suspected internal

impingement. Alternatively, some shoulder surgeons may opt to obtain magnetic resonance arthrography (MRA), which has been demonstrated to have slightly improved sensitivity in the diagnosis of the glenoid labral injury.⁵⁹ MRI aides the surgeon in the visualization of lesions associated with internal impingement, such as partial articular sided rotator cuff tears and fraying, as well as glenoid labrum injuries, such as posterior fraying and SLAP tears. The abduction and external rotation (ABER) sequence on MRI is useful for the evaluation of the articular surface of the supraspinatus tendon, the anterior inferior glenohumeral ligament, and the anteroinferior part of the glenoid labrum.⁶⁰ Given that shoulder internal impingement partially originates from the tightness of the inferior glenohumeral ligament and is associated with articular-sided tears of the rotator cuff tendon and SLAP tears, the ABER view may be used to better depict these abnormalities.⁶¹

Treatment

Non-Operative Management

Conservative management is the preferred initial treatment strategy for athletes with internal impingement.⁴⁷ Rest, cryotherapy, and anti-inflammatory medications, followed by a structured rehabilitation program, are the standard of care. Several studies have demonstrated the therapeutic potential of glenohumeral internal rotation deficit (GIRD) correction,⁵⁴ and periscapular strengthening in patients with internal impingement.³⁶ Physical therapy (PT) is typically centered on these two goals, and can even be initiated pre-emptively in throwers and overhead athletes to prevent the development of symptoms. Burkhart et al⁵⁴ conducted a prospective study evaluating tennis players over a two-year period who were randomized to a daily "sleeper stretch" program versus no stretching. At 2 years of follow-up, the sleeper stretch group exhibited significantly increased internal rotation and total rotation, as well as a 38% decrease in the incidence of shoulder problems compared to the control group. Similarly, employing a physical therapy regimen focused on GIRD correction and periscapular stretching, Tyler et al⁶² demonstrated a significant association between correction of posterior shoulder tightness and resolution of symptoms in athletes with symptomatic internal impingement.

Some studies have described a relationship between internal impingement and anterior microinstability, also commonly referred to as pseudolaxity.^{47,54,63} This refers to a slight attenuation, with repetitive overhead motion, of the anterior capsule leading to mild pathologic anterior

translation of the humeral head. This subsequently places strain on the rotator cuff and scapular stabilizing musculature, leading to fatigue and increased posterosuperior glenolabral contact pressures.⁶⁴ If diagnosed early before significant structural damage has occurred, anterior micro-instability – much like concomitant GIRD and posterior shoulder tightness – is typically responsive to PT. Ultimately, rehabilitation of the overhead athlete with internal impingement should be focused on correcting the individual pathologies involved (scapular dyskinesis, posterior shoulder tightness, anterior instability).

Operative Management and Current Concepts

In 1992, Walch et al documented the posterosuperior glenoid impingement mechanism during the arthroscopic examination of 17 overhead athletes.⁴⁶ The earliest evidence published on the results of surgical management of internal impingement showed promising rates of return to sport in athletes undergoing anterior capsulolabral reconstruction or anterior capsulorrhaphy.^{52,65,66} While anterior laxity is still believed to play an important role, the notion that this is the primary driver of posterosuperior impingement is no longer widely accepted.^{7,47} In a study by Sonnery-Cottet et al,⁶⁷ none of the overhead athletes had any evidence of anterior instability, yet all had symptomatic internal impingement requiring arthroscopic intervention, suggesting other important factors at play. Burkhart et al suggested the importance of multiple changes in the throwing shoulder which contribute to the pathophysiology of internal impingement, including glenohumeral internal rotation deficit (GIRD) and contracture of the posterior inferior glenohumeral ligament (PIGHL), as well as scapular dyskinesis.⁵⁴ This group described a “peel-back” mechanism on the superior labral complex related to posterosuperior humeral head migration as a result of PIGHL contracture and subsequent allowance of supraphysiological abduction and external rotation, leading to a high rate of concomitant SLAP tears.⁶⁸

Currently, surgical treatment of the throwing shoulder with internal impingement is aimed at addressing the individual anatomic abnormalities encountered. An understanding of the complex pathomechanism behind this clinical entity is crucial to maintain an index of suspicion for all potential lesions including rotator cuff tears, labral tears, and posterior capsular contracture. A preoperative bilateral examination under anesthesia is also essential to

rule out any potential concomitant laxity and to aid in decision-making for appropriate operative treatment. Paley et al⁶⁹ described the pathologies commonly encountered on arthroscopy in patients with internal impingement. This study found that 93% of the included athletes had undersurface rotator cuff fraying, 88% demonstrated posterosuperior labral injury, and 36% had evidence of anterior labral injury or fraying. Bankart lesions and SLAP tears occurred at a rate of 10%, and all patients with SLAP tears had concomitant undersurface rotator cuff fraying.

While detailed management of the individual pathologies that may be encountered in patients with internal impingement lies outside the scope of this review, we will briefly discuss their management in the specific context of the overhead athlete with a diagnosis of internal impingement.

Rotator Cuff Pathology

Many shoulder surgeons tend to follow the general rule that rotator cuff tears involving greater than 50% tendon thickness should be repaired, while those under 50% should simply be debrided. However, very few studies have evaluated the results of rotator cuff repairs in young athletes. In the case series of 28 tennis players by Sonnery-Cottet et al,⁶⁷ all athletes had evidence of partial articular sided rotator cuff tears and all patients underwent simple debridement. This group reported a 79% rate of return to the preinjury level of sport. Reynolds et al⁷⁰ reported an 82% return to play rate in 82 elite overhead throwers with internal impingement undergoing debridement of partial articular sided rotator cuff tears, though only 55% were able to return to the same preinjury level or higher. In a study of 16 professional baseball players (80% were pitchers) who underwent mini-open repair of a full-thickness rotator cuff tear, only 1 player returned to professional baseball.⁷¹ Even with debridement alone, return to preinjury level in athletes with internal impingement and rotator cuff tears is challenging. Further studies would be needed in order to determine a role for rotator cuff repair in this population.

Labral Lesions

Posterosuperior labral injury in overhead athletes with internal impingement is common. Treatment of these lesions historically has been limited to labral debridement; however, clinical results have been mixed. Nourissat et al⁷² evaluated the outcomes of nine recreational overhead

athletes undergoing arthroscopic articular sided rotator cuff debridement, glenoidplasty, and posterior labral fixation for symptomatic internal impingement and reported a return to preinjury level of sport in 7/9 (78%) patients. It is important to keep in mind that opinions on management, as well as the frequency of diagnosis of internal impingement, vary significantly between international orthopaedic communities.⁷³ While prior studies have not evaluated operative SLAP tear management specifically in patients with internal impingement, treating surgeons should closely evaluate the anterosuperior labrum and biceps anchor on diagnostic arthroscopy. When encountered, repair should be considered, especially as these lesions have been shown to contribute to shoulder microinstability.⁶⁸

Anterior Instability

Anterior instability has been demonstrated to play an important role in the pathophysiology of internal impingement.⁶⁷ In a study of 25 overhead athletes with pain in the throwing position who underwent anterior capsulolabral reconstruction (ACLR), Jobe et al⁶⁵ reported a 72% rate of return to preinjury level of sport. In 2001, Levitz et al⁶⁶ compared the outcomes of baseball players with internal impingement between those who underwent debridement and labral repair alone, versus those who had a simultaneous anterior thermal capsulorrhaphy. The anterior capsulorrhaphy group had a significantly improved rate of return to play at the preinjury level at 30 months following surgery – 90% versus 67% in the group without capsulorrhaphy. In this last study, there was significant variability in the concomitant intra-articular pathology between the groups as well as the proportion of major league, minor league, and recreational players. Further, thermal capsulorrhaphy should be undertaken with caution given multiple case reports of significant complications.⁷⁴ Jones et al⁷⁵ published a case series on 20 overhead athletes undergoing anterior capsular plication for refractory shoulder pain with a preoperative diagnosis of anterior microinstability. Twenty percent of patients had concomitant rotator cuff fraying, which was debrided. They documented an 85% return to sport at the preinjury level.

Subcoracoid Impingement

The impingement of the rotator cuff by the coracoid process was firstly described by Goldthwait, in 1909.⁷⁶ Subcoracoid impingement is defined as the compression of the anterior soft tissues of the shoulder (mainly the

subscapularis, but also the long head of the biceps tendon, and the biceps reflection pulley) between the coracoid process and the lesser tuberosity of the humerus.³ Subcoracoid impingement can be idiopathic due to structural abnormalities of the coracoid process (long coracoid or excessively lateral position of the coracoid). Calcification of the subscapularis tendon or the presence of a ganglion cyst can also lead to subcoracoid impingement. One case of subcoracoid impingement caused by an accessory coracobrachialis muscle has been reported.⁷⁷

Apart from idiopathic, subcoracoid impingement may be iatrogenic or post-traumatic. Subcoracoid impingement has been associated with posterior capsular tightening and subsequent limitation of the internal rotation of the arm.^{78,79} Athletes with multidirectional instability who undergo shoulder capsulorrhaphy may be at risk of this condition. Additional procedures that may lead to subcoracoid impingement include coracoid transfer, posterior glenoid neck osteotomy, and acromionectomy.³ Post-traumatic causes of subcoracoid impingement include fractures of the proximal humerus (head or neck), scapular neck fractures, glenoid fractures, or sternoclavicular dislocations. Existing literature on subcoracoid impingement in athletes is limited compared to the other two types of shoulder impingement mentioned in this article; however, this condition has been recognized as a possible cause of anterior shoulder pain in throwing and overhead athletes.^{77,79,80}

Physical Examination and Imaging

Patients with subcoracoid impingement will often present with anterior shoulder pain, which is exacerbated with the arm in flexion, adduction, and internal rotation (subcoracoid impingement position).³ During physical examination, maximal pain occurs between 120°-130° degrees of forward flexion and internal rotation of the arm, with or without tenderness over the coracoid process. The standard shoulder radiographic views should be obtained in patients with suspected subcoracoid impingement. Obtaining a Computed Tomography (CT) examination with the arm crossed on the chest is useful, and a coracohumeral distance of <6 mm has been defined as subcoracoid stenosis.⁸¹ Further, increased coracoid index (a measure of coracoid size) has been associated with subcoracoid impingement.^{78,82} MRI should also be performed to assess the integrity of the rotator cuff tendon, and the condition of the glenoid labrum and capsule of the shoulder. Increased signal in subscapularis and/or lesser tuberosity of the

humerus may be seen on the MRI of these patients.⁷⁸ In cases of failure to identify the cause of shoulder pain, surgical exploration may be necessary. Mestdagh et al⁷⁷ identified an accessory coracobrachialis muscle as the cause of subcoracoid impingement in an alpinist via surgical exploration using the deltopectoral approach.

Treatment

Conservative treatment should be the first-line therapy in athletes with subcoracoid impingement. This may consist of rest, ice, activity modification, physical therapy, oral medication, and/or corticosteroid injections. Physical therapy should focus on shoulder muscle stretching and strengthening, as well as a range of motion exercise. In cases of failure of the conservative measures, surgical management may be necessary. Open or arthroscopic coracoplasty should be considered in patients with structural abnormalities of the coracoid causing impingement. Repair of the subscapularis tendon should be performed if a tear is identified. The goal of coracoplasty is to create a 7-mm interval between the coracoid and subscapularis and prevent future impingement. Adequate pain relief and significant improvement in function has been reported in patients who underwent acromioplasty to correct subacromial impingement,³ but the rate of return to sport in athletes receiving conservative and/or surgical treatment for this condition remains unknown.

Conclusion

Shoulder impingement syndrome is commonly diagnosed in athletes with shoulder pain. Performing multiple shoulder physical examination tests is necessary during the initial evaluation, and knowledge of the diagnostic performance of each of these tests is critical to differentiate between the various types of impingement. A course of conservative therapy, followed by surgical treatment in refractory cases, remains the gold standard approach for the management of shoulder impingement syndrome in athletes, regardless of type. Evaluation of the outcomes and return to sport rate is challenging, due to the broad spectrum and different combination of shoulder structural lesions identified in each athlete.

Funding

There is no funding to report.

Disclosure

The authors report no conflicts of interest in this work.

References

- Allen H, Chan BY, Davis KW, Blankenbaker DG. Overuse injuries of the shoulder. *Radiol Clin North Am*. 2019;57(5):897–909. doi:10.1016/j.rcl.2019.03.003
- Creech JA, Silver S. Shoulder impingement syndrome. In: *StatPearls*. Treasure Island (FL): StatPearls Publishing Copyright © 2020, StatPearls Publishing LLC; 2020. PMID: 32119405.
- Martetschläger F, Rios D, Millett PJ. Coracoplasty: indications, techniques, and outcomes. *Tech Shoulder Elbow Surg*. 2012;13(4):177–181. doi:10.1097/BTE.0b013e31825574ea
- Dhillon KS. Subacromial impingement syndrome of the shoulder: a musculoskeletal disorder or a medical myth? *Malays Orthop J*. 2019;13(3):1–7. doi:10.5704/MOJ.1911.001
- Harrison AK, Flatow EL. Subacromial impingement syndrome. *J Am Acad Orthop Surg*. 2011;19(11):701–708. doi:10.5435/00124635-201111000-00006
- Matzkin E, Suslavich K, Wes D. Swimmer's shoulder: painful shoulder in the competitive swimmer. *J Am Acad Orthop Surg*. 2016;24(8):527–536. doi:10.5435/JAAOS-D-15-00313
- Heyworth BE, Williams RJ 3rd. Internal impingement of the shoulder. *Am J Sports Med*. 2009;37(5):1024–1037. doi:10.1177/0363546508324966
- Lubiatowski P, Kaczmarek PK, Ślęzak M, et al. Problems of the glenohumeral joint in overhead sports – literature review. Part II – pathology and pathophysiology. *Pol Orthop Traumatol*. 2014;79:59–66.
- Patel DR, Breisach S. Evaluation and management of shoulder pain in skeletally immature athletes. *Transl Pediatr*. 2017;6(3):181–189. doi:10.21037/tp.2017.04.06
- Pesquer L, Borghol S, Meyer P, Ropars M, Dallaudière B, Abadie P. Multimodality imaging of subacromial impingement syndrome. *Skeletal Radiol*. 2018;47(7):923–937. doi:10.1007/s00256-018-2875-y
- Escamilla RF, Hooks TR, Wilk KE. Optimal management of shoulder impingement syndrome. *Open Access J Sports Med*. 2014;5:13. doi:10.2147/OAJSM.S36646
- Koester MC, George MS, Kuhn JE. Shoulder impingement syndrome. *Am J Med*. 2005;118(5):452–455. doi:10.1016/j.amjmed.2005.01.040
- Neer CS II. Anterior acromioplasty for the chronic impingement syndrome in the shoulder: a preliminary report. *JBJS*. 1972;54(1):1. doi:10.2106/0004623-197254010-00003
- Page P. Shoulder muscle imbalance and subacromial impingement syndrome in overhead athletes. *Int J Sports Phys Ther*. 2011;6(1):51–58.
- Garving C, Jakob S, Bauer I, Nadjar R, Brunner UH. Impingement syndrome of the shoulder. *Dtsch Arztebl Int*. 2017;114(45):765–776. doi:10.3238/arztebl.2017.0765
- Michener LA, McClure PW, Karduna AR. Anatomical and biomechanical mechanisms of subacromial impingement syndrome. *Clin Biomech*. 2003;18(5):369–379. doi:10.1016/S0268-0033(03)00047-0
- Mackenzie TA, Herrington L, Horlsey I, Cools A. An evidence-based review of current perceptions with regard to the subacromial space in shoulder impingement syndromes: is it important and what influences it? *Clin Biomech*. 2015;30(7):641–648. doi:10.1016/j.clinbiomech.2015.06.001
- Seroyer ST, Nho SJ, Bach BR Jr, Bush-Joseph CA, Nicholson GP, Romeo AA. Shoulder pain in the overhead throwing athlete. *Sports Health*. 2009;1(2):108–120. doi:10.1177/1941738108331199
- Holmes RE, Barfield WR, Woolf SK. Clinical evaluation of nonarthritic shoulder pain: diagnosis and treatment. *Phys Sportsmed*. 2015;43(3):262–268. doi:10.1080/00913847.2015.1005542
- Cotter EJ, Hannon CP, Christian D, Frank RM, Bach BR Jr. Comprehensive examination of the athlete's shoulder. *Sports Health*. 2018;10(4):366–375. doi:10.1177/1941738118757197

21. Gumina S, Candela V, Passaretti D, Venditto T, Mariani L, Giannicola G. Sleep quality and disturbances in patients with different-sized rotator cuff tear. *Musculoskelet Surg.* 2016;100(S1):33–38. doi:10.1007/s12306-016-0405-4
22. Brushøj C, Bak K, Johannsen H, Faunø P. Swimmers' painful shoulder arthroscopic findings and return rate to sports. *Scand J Med Sci Sports.* 2007;17(4):373–377.
23. Allegrucci M, Whitney SL, Irrgang JJ. Clinical implications of secondary impingement of the shoulder in freestyle swimmers. *J Orthop Sports Phys Ther.* 1994;20(6):307–318. doi:10.2519/jospt.1994.20.6.307
24. O'Kane JW, Toresdahl BG. The evidenced-based shoulder evaluation. *Curr Sports Med Rep.* 2014;13(5):307–313. doi:10.1249/JSR.0000000000000090
25. Myer CA, Hegedus EJ, Tarara DT, Myer DM. A user's guide to performance of the best shoulder physical examination tests. *Br J Sports Med.* 2013;47(14):903–907.
26. Wright AA, Wassinger CA, Frank M, Michener LA, Hegedus EJ. Diagnostic accuracy of scapular physical examination tests for shoulder disorders: a systematic review. *Br J Sports Med.* 2013;47(14):886–892.
27. Hegedus EJ, Goode AP, Cook CE, et al. Which physical examination tests provide clinicians with the most value when examining the shoulder? Update of a systematic review with meta-analysis of individual tests. *Br J Sports Med.* 2012;46(14):964–978. doi:10.1136/bjsports-2012-091066
28. MacDonald PB, Clark P, Sutherland K. An analysis of the diagnostic accuracy of the hawkins and neer subacromial impingement signs. *J Shoulder Elbow Surg.* 2000;9(4):299–301. doi:10.1067/mse.2000.106918
29. Ratcliffe E, Pickering S, McLean S, Lewis J. Is there a relationship between subacromial impingement syndrome and scapular orientation? A systematic review. *Br J Sports Med.* 2014;48(16):1251–1256. doi:10.1136/bjsports-2013-092389
30. Maenhout A, Dhooze F, Van Herzele M, Palmans T, Cools A. Acromiohumeral distance and 3-dimensional scapular position change after overhead muscle fatigue. *J Athl Train.* 2015;50(3):281–288. doi:10.4085/1062-6050-49.3.92
31. Silva RT, Hartmann LG, Laurino C, Biló JPR. Clinical and ultrasonographic correlation between scapular dyskinesia and subacromial space measurement among junior elite tennis players. *Br J Sports Med.* 2010;44(6):407–410. doi:10.1136/bjsm.2008.046284
32. Laudner K, Wong R, Latal J, Meister K. Posterior shoulder tightness and subacromial impingement characteristics in baseball pitchers: a blinded, matched control study. *Int J Sports Phys Ther.* 2020;15(2):188–195. doi:10.26603/ijsp20200188
33. Tangtrakulwanich B, Kapkird A. Analyses of possible risk factors for subacromial impingement syndrome. *World J Orthop.* 2012;3(1):5. doi:10.5312/wjo.v3.i1.5
34. Edmonds EW, Dengerink DD. Common conditions in the overhead athlete. *Am Fam Physician.* 2014;89(7):537–541.
35. Tonin K, Stražar K, Burger H, Vidmar G. Adaptive changes in the dominant shoulders of female professional overhead athletes: mutual association and relation to shoulder injury. *Int J Rehabil Res.* 2013;36(3):228–235. doi:10.1097/MRR.0b013e32835d0b87
36. Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology Part III: the SICK scapula, scapular dyskinesis, the kinetic chain, and rehabilitation. *Arthroscopy.* 2003;19(6):641–661. doi:10.1016/S0749-8063(03)00389-X
37. Kuhn JE. Exercise in the treatment of rotator cuff impingement: a systematic review and a synthesized evidence-based rehabilitation protocol. *J Shoulder Elbow Surg.* 2009;18(1):138–160. doi:10.1016/j.jse.2008.06.004
38. Saracoglu I, Emuk Y, Taspinar F. Does taping in addition to physiotherapy improve the outcomes in subacromial impingement syndrome? A systematic review. *Physiother Theory Pract.* 2018;34(4):251–263. doi:10.1080/09593985.2017.1400138
39. Lin M-T, Chiang C-F, Wu C-H, Huang Y-T, Tu Y-K, Wang T-G. Comparative effectiveness of injection therapies in rotator cuff tendinopathy: a systematic review, pairwise and network meta-analysis of randomized controlled trials. *Arch Phys Med Rehabil.* 2019;100(2):336–349. e315. doi:10.1016/j.apmr.2018.06.028
40. Say F, Gürlür D, Bülbül M. Platelet-rich plasma versus steroid injection for subacromial impingement syndrome. *J Orthop Surg.* 2016;24(1):62–66. doi:10.1177/230949901602400115
41. Papadonikolakis A, McKenna M, Warme W, Martin BI, Matsen FA 3rd. Published evidence relevant to the diagnosis of impingement syndrome of the shoulder. *J Bone Joint Surg Am.* 2011;93(19):1827–1832. doi:10.2106/JBJS.J.01748
42. Lähdeoja T, Karjalainen T, Jokihaara J, et al. Subacromial decompression surgery for adults with shoulder pain: a systematic review with meta-analysis. *Br J Sports Med.* 2020;54(11):665–673. doi:10.1136/bjsports-2018-100486
43. Song L, Miao L, Zhang P, Wang WL. Does concomitant acromioplasty facilitate arthroscopic repair of full-thickness rotator cuff tears? A meta-analysis with trial sequential analysis of randomized controlled trials. *Springerplus.* 2016;5(1):685. doi:10.1186/s40064-016-2311-5
44. Royce RP, Grana WA, Yates CK. Arthroscopic subacromial decompression: two- to seven-year follow-up. *Arthroscopy.* 1995;11(3):301–306. doi:10.1016/0749-8063(95)90007-1
45. Payne LZ, Altchek DW, Craig EV, Warren RF. Arthroscopic treatment of partial rotator cuff tears in young athletes: a preliminary report. *Am J Sports Med.* 1997;25(3):299–305. doi:10.1177/036354659702500305
46. Walch G, Boileau P, Noel E, Donell S. Impingement of the deep surface of the supraspinatus tendon on the posterosuperior glenoid rim- an arthroscopic study. *J Shoulder Elbow Surg.* 1992;1:238–245. doi:10.1016/S1058-2746(09)80065-7
47. Spiegl UJ, Warth RJ, Millett PJ. Symptomatic internal impingement of the shoulder in overhead athletes. *Sports Med Arthrosc Rev.* 2014;22(2):120–129. doi:10.1097/JSA.000000000000017
48. Jobe C. Posterior superior glenoid impingement – expanded spectrum. *Arthroscopy.* 1995;11:530–536. doi:10.1016/0749-8063(95)90128-0
49. Sein ML, Walton J, Linklater J, et al. Shoulder pain in elite swimmers: primarily due to swim-volume-induced supraspinatus tendinopathy. *Br J Sports Med.* 2010;44(2):105–113. doi:10.1136/bjsm.2008.047282
50. Corpus KT, Camp CL, Dines DM, Altchek DW, Dines JS. Evaluation and treatment of internal impingement of the shoulder in overhead athletes. *World J Orthop.* 2016;7(12):776–784. doi:10.5312/wjo.v7.i12.776
51. Drakos MC, Rudzki JR, Allen AA, Potter HG, Altchek DW. Internal impingement of the shoulder in the overhead athlete. *J Bone Joint Surg Am.* 2009;91(11):2719–2728. doi:10.2106/JBJS.I.00409
52. Davidson P, Elattrache N, Jobe C, Jobe F. Rotator cuff and posterior-superior glenoid labrum injury associated with increased glenohumeral motion: a new site of impingement. *J Shoulder Elbow Surg.* 1995;4:384–390. doi:10.1016/S1058-2746(95)80023-9
53. Chambers L, Altchek DW. Microinstability and internal impingement in overhead athletes. *Clin Sports Med.* 2013;32(4):697–707. doi:10.1016/j.csm.2013.07.006
54. Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology part I: pathoanatomy and biomechanics. *Arthroscopy.* 2003;19(4):404–420. doi:10.1053/jars.2003.50128
55. Myers JB, Laudner KG, Pasquale MR, Bradley JP, Lephart SM. Glenohumeral range of motion deficits and posterior shoulder tightness in throwers with pathologic internal impingement. *Am J Sports Med.* 2006;34(3):385–391. doi:10.1177/0363546505281804
56. Meister K. Injuries to the shoulder in the throwing athlete: part two, evaluation/treatment. *Am J Sports Med.* 2000;28:587–601. doi:10.1177/03635465000280042701

57. Leschinger T, Wallraff C, Muller D, Hackenbroch M, Bovenschulte H, Siewe J. Internal impingement of the shoulder: a risk of false positive test outcomes in external impingement tests? *Biomed Res Int*. 2017;2017:2941238. doi:10.1155/2017/2941238
58. Zaslav KR. Internal rotation resistance strength test: a new diagnostic test to differentiate intra-articular pathology from outlet (Neer) impingement syndrome in the shoulder. *J Shoulder Elbow Surg*. 2001;10(1):23–27. doi:10.1067/mse.2001.111960
59. Smith TO, Drew BT, Toms AP. A meta-analysis of the diagnostic test accuracy of MRA and MRI for the detection of glenoid labral injury. *Arch Orthop Trauma Surg*. 2012;132(7):905–919. doi:10.1007/s00402-012-1493-8
60. Aydingöz U, Maraş Özdemir Z, Ergen FB. Demystifying ABER (ABduction and External Rotation) sequence in shoulder MR arthrography. *Diagn Interv Radiol*. 2014;20(6):507–510. doi:10.5152/dir.2014.14117
61. Iyengar JJ, Burnett KR, Nottage WM. The abduction external rotation (ABER) view for MRI of the shoulder. *Orthopedics*. 2010;33(8):562–565. doi:10.3928/01477447-20100625-17
62. Tyler TF, Nicholas SJ, Lee SJ, Mullaney M, McHugh MP. Correction of posterior shoulder tightness is associated with symptom resolution in patients with internal impingement. *Am J Sports Med*. 2010;38(1):114–119. doi:10.1177/0363546509346050
63. Cools AM, Declercq G, Cagnie B, Cambier D, Witvrouw E. Internal impingement in the tennis player: rehabilitation guidelines. *Br J Sports Med*. 2008;42(3):165–171. doi:10.1136/bjsm.2007.036830
64. Mihata T, McGarry MH, Neo M, Ohue M, Lee TQ. Effect of anterior capsular laxity on horizontal abduction and forceful internal impingement in a cadaveric model of the throwing shoulder. *Am J Sports Med*. 2015;43(7):1758–1763. doi:10.1177/0363546515582025
65. Jobe F, Giangarra C, Kvitne R, Glousman R. Anterior capsulolabral reconstruction of the shoulder in athletes in overhand sports. *Am J Sports Med*. 1991;19:428–434. doi:10.1177/036354659101900502
66. Levitz CL, Dugas J, Andrews JR. The use of arthroscopic thermal capsulorrhaphy to treat internal impingement in baseball players. *Arthroscopy*. 2001;17(6):573–577. doi:10.1053/jars.2001.24853
67. Sonnery-Cottet B, Edwards TB, Noel E, Walch G. Results of arthroscopic treatment of posterosuperior glenoid impingement in tennis players. *Am J Sports Med*. 2002;30:227–232. doi:10.1177/03635465020300021401
68. Burkhart SS, Morgan CD. The peel-back mechanism: its role in producing and extending posterior type II SLAP lesions and its effect on SLAP repair rehabilitation. *Arthroscopy*. 1998;14(6):637–640. doi:10.1016/S0749-8063(98)70065-9
69. Paley K, Jobe F, Pink M, Kvitne R, Elattrache N. Arthroscopic findings in the overhand throwing athlete – evidence for posterior internal impingement of the rotator cuff. *Arthroscopy*. 2000;16:35–40. doi:10.1016/S0749-8063(00)90125-7
70. Reynolds SB, Dugas JR, Cain EL, McMichael CS, Andrews JR. Debridement of small partial-thickness rotator cuff tears in elite overhead throwers. *Clin Orthop Relat Res*. 2008;466(3):614–621. doi:10.1007/s11999-007-0107-1
71. Mazoué CG, Andrews JR. Repair of full-thickness rotator cuff tears in professional baseball players. *Am J Sports Med*. 2006;34(2):182–189. doi:10.1177/0363546505279916
72. Nourissat G, Provost J, Vigan M, Cammas C. Glenoidplasty with posterior labral reattachment for posterosuperior glenoid impingement. *Orthop J Sports Med*. 2020;8(3):2325967120907892.
73. Chelli M, Grimberg J, Lefebvre Y, et al. Internal impingement of the shoulder: an international survey of 261 orthopaedic surgeons. *Orthop Traumatol Surg Res*. 2019;105(8s):S207–S212. doi:10.1016/j.otsr.2019.09.007
74. Good CR, Shindle MK, Kelly BT, Wanich T, Warren RF. Glenohumeral chondrolysis after shoulder arthroscopy with thermal capsulorrhaphy. *Arthroscopy*. 2007;23(7):797 e791–795. doi:10.1016/j.arthro.2007.03.092
75. Jones KJ, Kahlenberg CA, Dodson CC, Nam D, Williams RJ, Altchek DW. Arthroscopic capsular plication for microtraumatic anterior shoulder instability in overhead athletes. *Am J Sports Med*. 2012;40(9):2009–2014. doi:10.1177/0363546512453299
76. Goldthwait JE. An anatomic and mechanical study of the shoulder-joint, explaining many of the cases of painful shoulder, many of the recurrent dislocations, and many of the cases of brachial neuralgias or neuritis. *JBJS*. 1909;2(4):579–606.
77. Mestdag H, Maynou C, Cassagnaud X. Accessory coracobrachialis muscle as a cause of anterior impingement syndrome of the rotator cuff in an athlete. *Eur J Orthop Surg Traumatol*. 2002;12(2):96–98. doi:10.1007/s00590-002-0021-x
78. Dines DM, Warren RF, Inglis AE, Pavlov H. The coracoid impingement syndrome. *J Bone Joint Surg Br*. 1990;72-B(2):314–316. doi:10.1302/0301-620X.72B2.2312576
79. Jobe CM, Coen MJ, Screnenar P. Evaluation of impingement syndromes in the overhead-throwing athlete. *J Athl Train*. 2000;35(3):293.
80. Friedman RJ, Bonutti PM, Genev B. Cine magnetic resonance imaging of the subcoracoid region. *Orthopedics*. 1998;21(5):545–548.
81. Nové-Josserand L, Boulahia A, Levigne C, Noel E, Walch G. Coraco-humeral space and rotator cuff tears. *Rev Chir Orthop Reparatrice Appar Mot*. 1999;85(7):677–683.
82. Ferrick MR. Coracoid impingement. A case report and review of the literature. *Am J Sports Med*. 2000;28(1):117–119. doi:10.1177/03635465000280010501

Open Access Journal of Sports Medicine

Publish your work in this journal

Open Access Journal of Sports Medicine is an international, peer-reviewed, open access journal publishing original research, reports, reviews and commentaries on all areas of sports medicine. The

Submit your manuscript here: <http://www.dovepress.com/open-access-journal-of-sports-medicine-journal>

manuscript management system is completely online and includes a very quick and fair peer-review system. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Dovepress