# Shoulder Impingement Syndrome

Evan H. Horowitz, MD[a], William R. Aibinder, MD[b,*]

**KEYWORDS**

• Shoulder • Impingement • Subacromial • Acromion • Subcoracoid • Rotator cuff • Bursitis

**KEY POINTS**

- Shoulder pain has been cited as the third most common musculoskeletal pain complaint, with impingement syndrome as the most common diagnosis.
- The mainstay of treatment of shoulder impingement syndrome is nonoperative treatment.
- Refractory cases, or those with an objective or mechanical explanation for symptoms, may benefit from surgical intervention.

## INTRODUCTION/BACKGROUND/PREVALENCE

Shoulder pain has been cited as the third most common musculoskeletal pain complaint with a prevalence between 7% and 30%.[1–5] Impingement syndrome is the most common diagnosis when evaluating shoulder pain.[6] This concept was first theorized by Neer in 1972, referring to impingement of the tendinous rotator cuff by the coracoacromial (CA) ligament and the anterior aspect of the acromion, with occasional involvement of bone spurring and osteophyte formation.[7] Recently, the term "shoulder impingement syndrome" has been questioned, highlighting the simplicity and broadness of the diagnosis, which may affect the ability of physicians and therapists to communicate effectively.[8–10] Thus, the purpose of this review will be to describe the anatomic basis of subacromial impingement, internal shoulder impingement, and subcoracoid impingement. We will focus primarily on the evaluation and diagnosis, as well as common nonsurgical treatment modalities. Surgical intervention is reserved for patients who fail conservative measures.

[a] Department of Orthopaedic Surgery and Rehabilitation Medicine, SUNY Downstate Health Sciences University, 450 Clarkson Avenue, MSC 30, Brooklyn, NY 11203, USA; [b] Department of Orthopaedic Surgery, University of Michigan, 24 Frank Lloyd Wright Drive, Ann Arbor, MI 48106, USA
* Corresponding author.
*E-mail address:* Waibinde@med.umich.edu
Twitter: @EvanHorowitzMD (E.H.H.); @WillAibinderMD (W.R.A.)

Phys Med Rehabil Clin N Am 34 (2023) 311–334
https://doi.org/10.1016/j.pmr.2022.12.001 pmr.theclinics.com

## SUBACROMIAL IMPINGEMENT

Subacromial impingement is thought to be due to both extrinsic and intrinsic theories.[11,12] Some authors support one theory over the other; however, it is likely a combination of both factors that leads to the pathology. Extrinsic compression of the rotator cuff occurs due to limited space between the humeral head and the anterior acromion, CA ligaments, and acromioclavicular (AC) joint. Some have suggested that tension on the CA ligament during abduction causes acromial ossification and osteophyte formation at the ligament insertion site.[7,13] Other studies have shown that all planes of motion result in contact on the CA ligament resulting in proliferation of acromial spurs.[14] Acromial shape and morphology also play a role in extrinsic compression and is discussed later in this section. It has been shown that while acromial morphology does not change with age, increased age does lead to more proliferative acromial spur formation.[15]

In addition to extrinsic compression, it is hypothesized that intrinsic degradation of the rotator cuff through diminished vascular supply, tensile forces on the rotator cuff, and tendon aging lead to the constellation of symptoms related to subacromial impingement.[11,16–19] Advocates of the intrinsic theory propose that damage to the supraspinatus tendon initiates a cascade of events that leads to subacromial impingement.[11] Tendon impairment leads to eccentric tension overload of the rotator cuff, glenohumeral instability, and superior humeral head migration, which in turn creates the extrinsic contact that leads to spurring and perpetuates subacromial impingement.[11,20]

## PATIENT EVALUATION OVERVIEW—SUBACROMIAL IMPINGEMENT

Initial patient evaluation begins with a thorough subjective history, review of systems, physical examination, and relevant imaging. A careful subjective history of symptoms should focus on the duration of symptoms, mechanism of onset (traumatic vs atraumatic), aggravating and alleviating factors, character and severity of pain, location of pain, patient's activity level and goals, and treatment modalities that have been attempted, including physical or occupational therapy, orthotics/braces, creams/gels/ointments, medications, injections, and surgical procedures. For cases of subacromial, internal, and subcoracoid impingement, the history often contains an insidious and atraumatic onset of symptoms, pain in certain positions and at night, often without overt complaints of weakness. Once a thorough history is obtained, a complete shoulder examination should be performed with the focus to rule out any obvious signs of glenohumeral instability, full thickness rotator cuff tears, arthritic changes, scapular dyskinesia, or other structural causes of symptoms. Additionally, many of these may be present in the setting of impingement.

### *Physical Examination—Subacromial Impingement*

A complete shoulder physical examination should be performed. The examination starts with inspections of the shoulder, and it is imperative to appropriately visualize the entire shoulder girdle in order to first inspect the shoulder. This includes the "6 S's": skin, scars, swelling, size, symmetry, and scapula.

Skin: Skin examination will often be normal in isolated shoulder impingement cases; however, areas of hypopigmentation may be related to prior corticosteroid injection sites.

Scars: Prior surgical scars may be present. The location, size, and number of scars may give clues about prior procedures. However, without imaging or prior operative reports, such information must be used cautiously because it is not objective.

Swelling: Assess for swelling that may be a sign of acute injury, which is nonspecific and may be from either trauma, overuse, or tearing of muscles, tendons, intra-articular, or ligamentous structures.

Size: Assess for atrophy and hypertrophy of the rotator cuff musculature. Atrophy may be a sign of disuse, frailty, hyponutrition, or in some cases, chronic muscle or tendon tears. Unilateral atrophy should also raise suspicion for peripheral nerve compression.

Symmetry: Assess for symmetry of the shoulder girdle, particularly in cases of unilateral complaints.

Scapula: Assess for scapular symmetry, both at rest and with shoulder motion.[21] Scapular dyskinesia can be more common in athletes such as throwing athletes. Scapular dyskinesia has been found in as many as 68% of patients with rotator cuff abnormalities, 94% of patients with labral tears, and essentially 100% of patients with glenohumeral instability.[22–26] It can also be the primary cause of a patient's impingement and thus treatment, particularly physical therapy, should focus on the scapular dysfunction.

Next, careful palpation of the shoulder should be performed. Subacromial impingement often leads to diffuse pain; however, patients may report maximal tenderness at the rotator cuff insertion site on the greater tuberosity.

Passive range of motion (PROM) and active range of motion (AROM) should be evaluated. In all cases of shoulder impingement, extremes of motion are usually limited by pain at points of compression; however, PROM is typically normal.

A detailed examination of the rotator cuff should be performed as well to include an empty can test (**Fig. 1**A),[26] drop arm sign (**Fig. 1**B),[26] external rotation lag sign (**Fig. 1**C),[27] Hornblower's sign (**Fig. 1**D),[28] belly press (**Fig. 1**E),[27] bear hug test (**Fig. 1**F),[29] and lift off test (**Fig. 1**G).[30] Any concern for a full thickness rotator cuff tear with cross weakness in any plane, particularly with a positive lag sign should prompt obtaining advanced imaging.

A full distal neurologic examination should be performed and documented, including motor, sensory, and reflex testing. The authors recommend performing a Spurling's test in patients who report any periscapular and/or neck pain.[31] To do so, the patient's neck is extended and rotated to the affected side, the head is laterally bent to the affected side, and the examiner applies vertical compression to the top of the head. This is a positive test if it reproduces symptoms in the ipsilateral arm. This test is specific but has poor sensitivity.[31]

Provocative tests for impingement are extremely useful. Studies have shown excellent correlation between examination findings and MRI findings when evaluating supraspinatus tears.[32] Additional MRI studies proved that these tests cause true mechanical impingement that can be appreciated on imaging. These studies have found that the Hawkins test produced more subacromial space narrowing and impingement than the Neer test.[33,34] An additional study showed that shoulders in the Neer position demonstrated contact between the rotator cuff and the medial acromion, whereas shoulders in the Hawkins position produced contact between the rotator cuff and the CA ligament.[35]

### *Provocative Impingement Tests—Subacromial Impingement*

The Neer impingement sign helps to indicate rotator cuff or bursal impingement against the CA arch. It has been shown to have sensitivity 72% and specificity 60%.[36] False positives occur due to stiffness, arthritis, instability, or osseous lesions. To perform the maneuver, the examiner stabilizes the scapula, places the arm in the


**Fig. 1.** Multiple examination tests have been described to evaluating the rotator cuff. Tests for the supraspinatus include the empty can (Jobe) test (*A*) and the drop arm sign (*B*). The Jobe test is performed by abducting the arm in the plane of the scapula, internally rotating the shoulder and having the patient resist a downward force, and the drop arm sign is performed by passively elevating the arm in the scapular plane to the horizontal and asking the patient to slowly drop the arm. Both tests are positive if painful or weak. Tests for external rotation include the external rotation lag sign (*C*) and the Hornblower's sign (*D*). The external rotation lag sign is performed by passively externally rotating the shoulder with the elbow flexed to 90° and then asking the patient hold while letting go. This tests the infraspinatus and is positive if the arm drifts into internal rotation. The Hornblower's sign is performed by abducting and externally rotating the shoulder to 90° and asking the patient hold this position while letting go. This tests the teres minor and is positive if the arm drifts into internal rotation. Tests for the subscapularis include the belly press test (*E*), the bear hug test (*F*), and the lift off test (*G*). The belly press test is performed by asking the patient to press the palm into the abdomen and bring the elbow forward to the plane of the body. This can also be performed as a lag sign as demonstrated in the picture. The test is positive if weakness and inability to maintain the elbow in front of the plane of the body. The bear hug test is performed by placing the hand on the contralateral arm and asking the patient to resist while applying an anterior force. The test is positive with weakness or pain. The lift off test is performed by placing the patient's hand with the palm posterior on the lower back and asking the patient to lift the arm posteriorly off the back. This can also be performed as a lag sign as demonstrated in the figure. The test is positive if weakness and inability to move or keep the hand off the back.

plane of the scapula, and the arm is passively raised. The test is positive if pain is elicited because the greater tuberosity impinges against the acromion (between 70° and 110°; Fig. 2).

**Fig. 2.** Examiner performs the Neer impingement test with the right arm stabilizing the scapula while passively raising the arm.

The Neer impingement test is performed by repeating the impingement maneuver after injection of a local anesthetic into the subacromial space. If there is a decrease in pain, this is considered a positive sign.

The Hawkins test aims to cause impingement of the greater tuberosity underneath the CA ligament. It has been shown to have sensitivity of 79% and specificity of 59% for impingement.[36] To perform the maneuver, the examiner flexes the shoulder and elbow to 90°, and then internally rotates the arm. The test is considered positive if the symptoms of pain are recreated (**Fig. 3**).

### *Imaging Studies—Subacromial Impingement*

Initial evaluation should begin with plain radiographs, which are typically normal in cases of impingement syndrome. The senior author's standard series includes a Grashey view, anteroposterior internal rotation view, scapular Y, and axillary lateral. In subacromial impingement, acromion morphology may play a role in the process. In 1986, Bigliani and colleagues classified acromion morphology.[37] They described 3 distinct types of acromial morphology; a fourth type (convex distal acromion) was later described by Vanarthos and colleagues in 1995.[38] Acromial morphology does not change with time but increased spurring occurs with age.[15] The types of acromia include a Type I (flat), Type II (curved), Type III (hooked), and Type IV (convex) (**Fig. 4**).[39]

The significance of acromial morphology in relation to impingement and rotator cuff tears is debated. Several authors reported that type III acromion is associated with shoulder impingement syndrome and rotator cuff tears.[40–42] However, other authors

Fig. 3. Examiner performs the Hawkins test by passively applying an internal rotation force to the arm with 90° of forward flexion/abduction and the elbow flexed to 90°.

have contradicted these findings, and found instead that it is the acromial spurring that is associated with full-thickness rotator cuff tears but not partial tears.[43]

The critical shoulder angle (CSA) is a novel angle measured from the inferior pole of the glenoid and the glenoid plane to the lateral edge of the acromion (Fig. 5). In 2013, Moor and colleagues hypothesized that a smaller CSA would correlate with shoulder arthritis, and a larger CSA would correlate with rotator cuff tears.[44] They stated that the normal CSA range was between 30° and 35°.[44] Passaplan and colleagues in 2021 reported that the CSA measurement remains constant in patients and does not change over time.[45] Acceptance of the CSA as a predictor of rotator cuff tears has been inconsistent and its role in impingement syndrome has not been elucidated.[43,46–49]

Additional radiographic parameters for shoulder impingement syndrome diagnosis have been proposed. Amit and colleagues investigated the sharpened lateral acromion morphology (SLAM sign) (Fig. 6).[41] They measured the angle between the inferior and lateral borders of the acromion using the most inferolateral point as the apex and

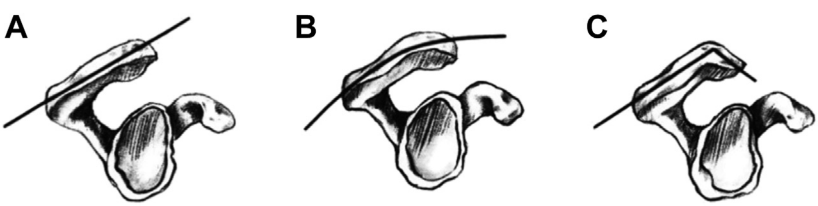


Fig. 4. The Bigliani Classification of acromial morphology, demonstrating a Type I or flat acromion (*A*), a Type II or curved acromion (*B*), and a Type III or hooked acromion (*C*). (*From* Bright, A., Torpey, B., Magid, D. et al. Reliability of radiographic evaluation for acromial morphology. Skeletal Radiol 26, 718–721 (1997).)

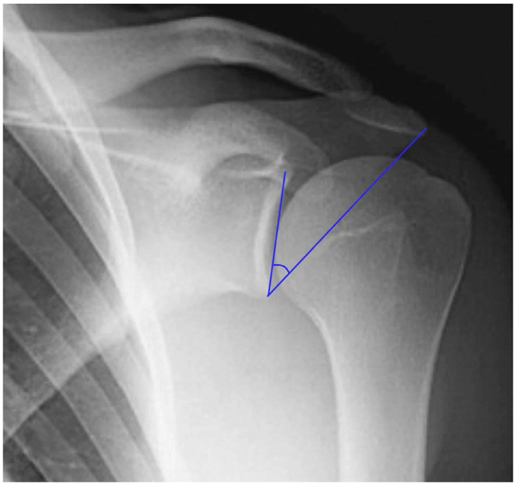

**Fig. 5.** Example of the CSA measured as the angle of the glenoid plane from the inferior pole of the glenoid to the lateral edge of the acromion.

termed this the “inferolateral acromion angle” (ILAA). If less than 90°, it was considered an SLAM sign. They compared this finding with acromial type III and the CSA greater than 35°. They found that all 3 imaging findings (acromial type, CSA, and SLAM sign) correlated to rotator cuff tears but the SLAM sign had the strongest correlation.[41]

Ultrasound is a useful and inexpensive imaging modality that has been shown to be accurate for full thickness rotator cuff tears, and bursitis of the subacromial or subdeltoid bursae. Early tendinitis changes are seen with high echogenicity and thickening. Bursitis is seen as a thickened bursa wall and anechoic effusion.[50–52] Thus, ultrasound may have some utility in the clinical setting with a well-trained operator.

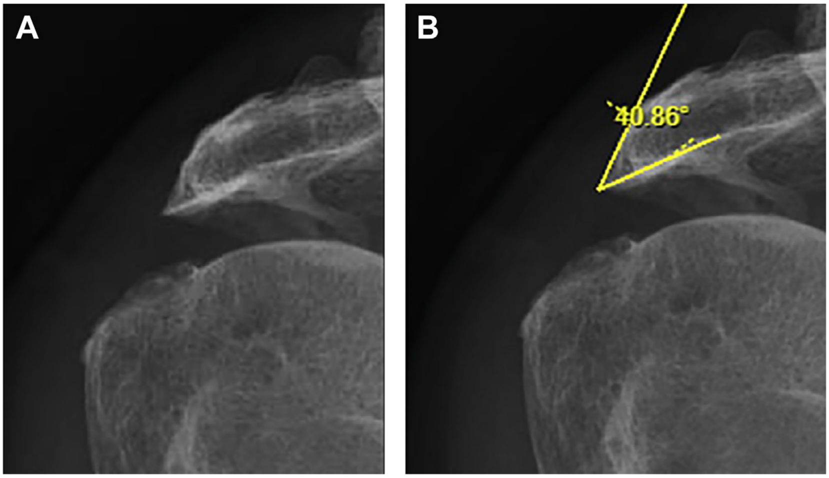


**Fig. 6.** Radiographic image of the sharpened lateral acromion morphology (*A*), with the ILAA measured at 40° (*B*), consistent with an SLAM sign. (*From* Amit P, Paluch AJ, Baring T. Sharpened lateral acromion morphology (SLAM sign) as an indicator of rotator cuff tear: a retrospective matched study. JSES Int. 2021 Jul 14;5(5):850-855. https://doi.org/10.1016/j.jseint.2021.05.013. PMID: 34505095; PMCID: PMC8411071.)

## CLASSIFICATION AND STAGING OF SUBACROMIAL IMPINGEMENT

Neer classified subacromial impingement into 3 stages.[53] Although rarely discussed in current clinical practices, the stages can help guide treatment. Stage 1 (edema and hemorrhage) is typically seen in patients aged younger than 25 years and managed conservatively. Stage II (fibrosis and tendinitis) is typically seen in patients aged between 25 and 40 years, which may require bursectomy or CA ligament division. Stage III (bone spurs and tendon rupture) is typically seen in patients aged older than 40 years, which may require anterior acromioplasty and/or rotator cuff repair.

## TREATMENT OPTIONS FOR SUBACROMIAL IMPINGEMENT SYNDROME

Nonoperative management of subacromial impingement syndrome remains the mainstay of treatment and is successful in most patients.[54,55] Initial modalities include non-opioid pain medication such as nonsteroidal anti-inflammatory drugs (NSAIDs), corticosteroid injections, and physical therapy. Cummins and colleagues produced a prospective study, in 2009, which included 100 patients with shoulder impingement syndrome treated nonoperatively.[55] Patients received a subacromial cortisone injection and physical therapy. 79% of patients avoided surgery at 2-year follow-up. ASES scores increased from 56 to 95, and visual analog scale pain score decreased from 4.8 to 0.6. Total number of injections and patient response to the initial injection were predictors of future surgical interventions. Overall, their findings demonstrate that nonoperative management yields good outcomes.

### *Pharmacologic or medical treatment options*

Several over the counter and prescription NSAIDs are commonly available. Given the longer half-life, the senior author prefers naproxen due to decreased dosing frequency.[56] Some NSAIDs have increased COX-2 selectivity over COX-1, which may lead to decreased gastrointestinal side effects; however, these medications have an increased risk of cardiovascular and clotting side effects.[57,58–60] Topical NSAIDs may decrease the risk of systemic side effects and may be considered.

Acetaminophen may be safer for use in patients with renal disease but should be avoided in patients with hepatic disease. It may provide symptom control in select patients but it does not decrease inflammation in the peripheral tissues. It inhibits the prostaglandin pathway within the central nervous system.[61] Although some patients and providers prefer acetaminophen for its lack of gastrointestinal and blood thinning side effect profile, it is not an anti-inflammatory medication.

### *Nonpharmacologic or surgical/interventional treatment options*

Physical therapy including a home exercise program is very effective. In a systematic review, Kuhn demonstrated that exercise improves pain symptoms and function but not range of motion or strength.[60] Steuri and colleagues showed that guided exercises lead to better results than generic exercises.[62] Thus, patients should be started on a supervised therapy program, and they can advance to home exercises once they can demonstrate the exercises on their own and are showing improvement. Patients who do not require manual therapy techniques, and who have developed proficiency in the protocol may progress to an unsupervised home exercise program.[63]

Similarly, in the postoperative setting, supervised physical therapy has been shown to be superior to unsupervised home exercise programs following arthroscopic acromioplasty for impingement syndrome.[64]

Yet, studies have shown that manual therapy in addition to isolated physical therapy improves outcomes in patients with shoulder impingement syndrome.[65] Some reports note improvement in strength and function and decreased pain. Manual therapy techniques included soft tissue massage and muscle stretching focusing on the pectoralis minor, infraspinatus, teres minor, upper trapezius, sternocleidomastoid, and scalenes.[66,67]

Kuhn also described a thorough, evidence-based rehabilitation protocol for the treatment of rotator cuff impingement.[63] A summary of his 5 distinct categories is presented here and is the preferred guidelines for the senior author:

1. Modalities: Heat or cold, or both, may be used. The literature does not support the use of ultrasound treatment because results were similar between test subjects and controls.
2. Manual therapy: Joint and soft tissue mobilization techniques are useful during a period of supervised exercise. Patients should be instructed on a home exercise program and once able, should transition to one.
3. Range of motion: Begin with postural exercises such as shrugs and shoulder retraction to stabilize the scapula. Glenohumeral motion should be initiated with pendulum exercises. This can be progressed to active assisted motion and then active motion as tolerated. Active assisted motion can be performed by the patient using a cane, pulleys, or the uninvolved arm.
4. Flexibility: Daily stretching should be performed, for both the anterior and posterior shoulder. Stretches should be held for 30 seconds and repeated 5 times, with a 10-second rest in between stretches.
5. Strengthening: The focus of strengthening is the rotator cuff and scapular stabilizing muscles. Rotator cuff strengthening should be focused on internal rotation with the arm adducted at the side, external rotation with the arm adducted at the side, and scaption exercises if there is no associated pain. Scapular stabilization exercises include chair presses, push-ups, and upright rows. Standing forward elevation and extension exercises can be performed with elastic bands. Each exercise should be performed as 3 sets of 10 repetitions and may increase with patient progression.

Corticosteroid injections into the shoulder capitalize on the anti-inflammatory effects of steroids, which have been used in treating degenerative joint disease in other joints in the body. Steuri and colleagues demonstrated that corticosteroid injections were superior to placebo in the treatment of shoulder impingement syndrome.[62] Cuomo and colleagues performed a prospective, double-blinded, randomized control trial comparing steroid injections with plain lidocaine injections and found that 84% of steroid injection patients reported significant improvement in pain, and only 36% of controls reported improvement.[68] Additionally, 76% of the steroid group had improvement in activities of daily living (ADLs), whereas this was seen in only 23% of the lidocaine group.[68] Dong and colleagues reported that corticosteroid injections should be used in conjunction with therapy for best results, and worse effects are noted when corticosteroid injections are performed alone.[69] Patients should be counseled on the risks of corticosteroid injections before administration. Diabetic patients should be counseled to monitor their glucose levels. A hemoglobin A1c greater than 7% has been postulated as a cutoff for higher risk of postinjection day 1 increases in glucose.[70] All patients should be counseled on the risk of tendon rupture, which although rare, has been described.[71] Patients should be counseled on the risk of the “flare phenomenon,” which is a paradoxic, short-term increase in pain following a corticosteroid injection, which is self-limiting in nature.[72] It should be discussed with the patient that shoulder surgery should be delayed after corticosteroid injection because risks of repair failure and postoperative infection may be increased.[73] Some authors advocate for a 6-month delay before performing shoulder tendon repair procedures following a local injection, although recent data may suggest that a shorter period is acceptable.[73] The risks of shoulder joint infection and local skin hypopigmentation should be discussed as well.

Hyaluronic acid is a long polysaccharide (glycosaminoglycan) chain with hydrophilicity, providing viscoelastic properties. It is theorized to provide mechanical properties similar to cartilage in the form of impact absorption, and synovial fluid in the form of joint lubrication.[74] Although hyaluronic acid injections have been studied and shown to demonstrate some success in the treatment of knee osteoarthritis, evidence is currently lacking in terms of replicating this success in the shoulder.[75] Penning and colleagues performed a randomized control trial, which demonstrated that hyaluronic acid injections for subacromial impingement syndrome did not provide improved results when compared with corticosteroid injections or placebo.[76] Hsieh redemonstrated this in a 2021 randomized control trial, showing that corticosteroid injections performed superior to hyaluronic acid injections; furthermore, they showed hyaluronic acid injections to be only marginally better than normal saline placebo injection.[77]

### *Additional Modalities*

Additional modalities that have been proposed in the treatment of shoulder impingement syndrome include ultrasound, laser therapy, pulsed electromagnetic field treatment, extracorporeal shockwave therapy (ECSWT), taping, and hyperthermia. Definitive evidence to support these is lacking. In a randomized control trial, Shakeri and colleagues demonstrated that kinesiological taping was able to demonstrate significant decreases in motion-related pain and nocturnal pain when compared with placebo taping,[78] and other authors demonstrated that taping may be effective in the early stages of shoulder impingement syndrome.[69] Steuri and colleagues used meta-analysis to compile low-quality evidence reporting that laser treatment, ECSWT, and taping may be superior to sham treatment.[62] An analysis of 2 systematic reviews and 10 randomized control trials evaluated the use of exercise therapy, ultrasound, laser, pulsed electromagnetic field, and hyperthermia for subacromial impingement syndrome.[79] Moderate evidence supported hyperthermia and exercise therapy in the short term; however, lasting effects were unable to be shown for any intervention aside from exercise therapy.

### *Surgical Options and Outcomes—Subacromial Impingement Syndrome*

Surgical intervention is reserved for patients who fail a trial of nonoperative treatment measures. The mainstay of operative intervention is open or arthroscopic subacromial decompression, which includes an acromioplasty with CA ligament release. In 1972, Neer introduced the idea of anterior acromioplasty with release of the CA ligament in the treatment of subacromial impingement.[7] Although his originally described procedure was open and not arthroscopic, the study reported good results in terms of pain relief in patients with chronic pain from subacromial impingement. The principles of anterior acromioplasty include removing the anterior edge and undersurface of the anterior acromion, the attached CA ligament, biceps tendon decompression and removal of groove osteophytes, and resection of hypertrophic spurring at the AC joint.[7]

Ellman described the arthroscopic subacromial decompression technique in 1987.[80] About 88% of patients had a satisfactory result with 88% also returning to their prior level of sporting activity. A 2010 meta-analysis showed equivalent outcomes, operative times, and complication rates between open and arthroscopic methods.[81] Additional studies have shown good results regarding pain relief in these patients.[11,82]

Potential complications include deltoid dysfunction and anterosuperior escape. Care should be taken to not resect an excessive amount of anterior acromion near the deltoid attachment. Preoperative imaging should be inspected for os acromiale because complete excision can cause deltoid dysfunction. Anterosuperior escape can occur if acromioplasty and CA ligament release are performed in patients with massive rotator cuff tears.

In a cadaveric study, Colman and colleagues found that flattening of the anterior ridge removed an average thickness of 1.9 + 0.5 mm of bone and only removed impingement in 50% of specimens, whereas flattening of the anterior third to the midline removed an average of 5.4 + 1.9 mm of bone and eliminated impingement in 100% of cases.[83] No further benefit was gained by the most aggressive resection or flattening of the entire acromion.

## INTERNAL IMPINGEMENT

Internal impingement, in contrast, is primarily an intra-articular pathologic condition that is characterized by excessive or repetitive impact of the greater tuberosity with the posterosuperior glenoid. This occurs with arm abduction and external rotation (ABER), the so-called late cocking phase of throwing.[84] Internal impingement results in articular-sided rotator cuff degeneration and posterior labral tears or fraying (**Fig. 7**). The pathoanatomy is thought to be multifactorial and includes glenohumeral instability, scapular dyskinesis, and posterior shoulder capsule tightness. Common findings include posterior glenohumeral joint line tenderness, decreased internal rotation, increased external rotation, and pain in the abducted and external rotation position.

## PATIENT EVALUATION OVERVIEW—INTERNAL IMPINGEMENT

Initial patient evaluation for internal impingement is similar to that of subacromial impingement and should begin with a thorough subjective history, review of systems, physical examination, and relevant imaging. This is detailed in the subacromial impingement section.

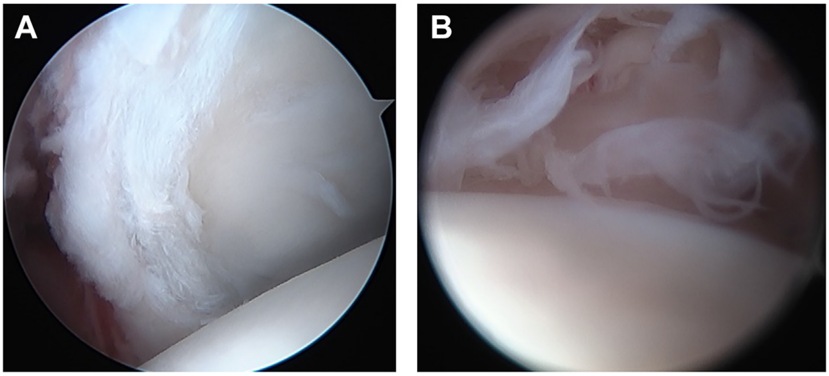


**Fig. 7.** Intraoperative arthroscopic view of the (*A*) posterior labrum fraying and the (*B*) articular side of the infraspinatus demonstrating fraying and degeneration in a patient with internal impingement. These are original images from the senior author.

### Physical examination—internal impingement

In the evaluation of internal impingement, a complete shoulder physical examination should be performed. The overall physical examination is similar to that of subacromial impingement. The "6 S's" as outlined above should be performed: skin, scars, swelling, size, symmetry, and scapula. PROM and AROM should be evaluated and may demonstrate pain at the extreme of ABER. A full distal neurologic examination and rotator cuff examination should be performed and documented and previously outlined.

Next, careful palpation of the shoulder should be performed. Posterior glenohumeral joint line tenderness is suggestive of internal impingement, most likely at the posterosuperior glenoid and labrum.[84]

### Provocative impingement tests for internal impingement

Provocative tests for impingement are extremely useful and include the internal impingement/posterior impingement sign and the relocation sign. Meister and colleagues studied the posterior impingement sign to attempt to reproduce posteriorly located pain.[85] The goal of the test is to cause impingement of the articular-sided rotator cuff and labrum between the glenoid and the greater tuberosity. Sensitivity was shown to be 75.5% and specificity was 85% for internal impingement.[85] When only noncontact athletes with posterior shoulder pain were included, sensitivity improved to 95% and specificity to 100%. Positive findings highly correlated with undersurface rotator cuff or posterior labrum tearing during arthroscopy, which were amenable to treatment. To perform this maneuver, the arm is placed in $90^\circ$ to $110^\circ$ of abduction and maximally externally rotated to recreate the late cocking phase. The arm is then extended $10^\circ$ to $15^\circ$, and pain in this position is considered a positive test. External rotation in forward flexion rather than abduction should resolve the pain (**Fig. 8**).

The relocation sign was described by Jobe and colleagues with the arm abducted to $90^\circ$ and maximally externally rotated (**Fig. 9**).[84,86,87] Pain in this position and resolution of pain with a posteriorly directed force on the proximal humerus is considered a positive test. During arthroscopic examination in 41 professional overhand throwing athletes with a positive test, the authors found 100% had either rotator cuff/posterosuperior glenoid contact, or osteochondral lesions.[88]

### Imaging studies—internal impingement

Similar to subacromial impingement, in the evaluation of internal impingement, the initial evaluation should begin with plain radiographs. On plain film radiographs, some radiographic findings may be seen with internal impingement to assist with the diagnosis.[84] These include exostosis of the posteroinferior glenoid rim (Bennett lesion), sclerosis of the greater tuberosity, posterior humeral head osteochondral lesions or cysts, and rounding of the posterior glenoid rim.[84,89]

However, in the evaluation of internal impingement syndrome, MRI plays a larger role. Studies have evaluated MRI in shoulders with arthroscopically diagnosed internal impingement syndrome and have defined 3 distinct findings that are consistent with the diagnosis: (1) undersurface tears of the supraspinatus or infraspinatus, (2) cystic changes in the posterior aspect of the humeral head, and (3) posterior superior labral pathologic condition (**Fig. 10**).[90]

Fessa and colleagues proposed that shoulder positioning plays an important role during MRI when evaluating internal impingement.[91] The authors proposed that the shoulder position of ABER, which allows the posterosuperior rotator cuff to relax and allows

**Fig. 8.** Examiner performs the posterior impingement test by placing the arm in 90° to 110° of abduction and maximally externally rotated to recreate the late cocking phase. The arm is then extended 10° to 15° and pain in this position is considered a positive test.

more contrast into the tear. This position also places the humeral head and glenoid impaction sites closer together, and approximates the potential pathologic sites.

### *Treatment Options for Internal Impingement Syndrome*

Similar to subacromial impingement, nonoperative management remains the mainstay of treatment. Initial modalities include nonopioid pain medication, corticosteroid injections, and physical therapy. Additional modalities that have been proposed in the treatment of shoulder impingement syndrome include ultrasound, laser therapy, pulsed electromagnetic field treatment, ECSWT, taping, and hyperthermia. These interventions are outlined in detail above, with inconclusive data.

For internal impingement, an intra-articular injection is preferred, and the authors' preferred technique is a posterior injection site located approximately 2 cm distal and medial to the posterolateral edge of the acromion. The injection can yield both therapeutic and diagnostic benefit.

### *Surgical options and outcomes—internal impingement*

Internal impingement is associated with a high rate of concomitant pathologic condition, including biceps tenosynovitis, labral tears, and arthritic changes.[92] ElAttrache and colleagues demonstrated concomitant pathologic condition arthroscopically in overhand throwing athletes, finding that 93% of internal impingement patients had undersurface rotator cuff fraying, and 88% had posterosuperior labral fraying.[88] Treatment of this concomitant pathologic condition should be addressed based on the severity of the individual pathologic condition. For example, the amount of rotator cuff tearing to warrant debridement versus repair is a topic of debate. In 1985, Andrews and colleagues published on 36 overhead athletes who underwent debridement for articular-sided partial tears and demonstrated that 85% returned to premorbid function.[93] To further complicate the picture, it is possible that microinstability in the glenohumeral joint contributes to internal impingement pathologic condition, which, if unaddressed, can lead to continued pain, as theorized by Levitz and colleagues[94] Some have proposed the importance of addressing osseous pathologic condition such as the Bennett lesion or even performing a humeral osteotomy to change humeral version in refractory cases that failed arthroscopic management.[95,96]

**Fig. 9.** Examiner performs the relocation sign by applying a posteriorly directed force on the proximal humerus, which should relieve pain.

Outcomes are difficult to study and vary based on the true intra-articular pathologic condition identified.

## SUBCORACOID IMPINGEMENT

Subcoracoid impingement refers to pain due to compression of the subscapularis between the lesser tuberosity and the coracoid. Pain is usually located anteriorly and tearing of the subscapularis may occur.[97] Symptoms are reproduced with the arm adducted, forward flexed, and internally rotated. Coracoid morphology, such as a more lateral projection and shorter distance may predispose patients to this condition.[98] Some authors suggest that rotator cuff integrity and humeral head stability also play a role in this rare condition that requires a high index of suspicion.[99]

## PATIENT EVALUATION OVERVIEW—SUBCORACOID IMPINGEMENT

Initial patient evaluation for internal impingement is similar to that of subacromial and internal impingement and should begin with a thorough subjective history, review of systems, physical examination, and relevant imaging.

### *Physical Examination—Subcoracoid Impingement*

In the evaluation of subcoracoid impingement, a complete shoulder physical examination should be performed. The overall physical examination is similar to that of subacromial and internal impingement. The “6 S’s” as outlined above should be performed: skin, scars, swelling, size, symmetry, and scapula. PROM and AROM should be

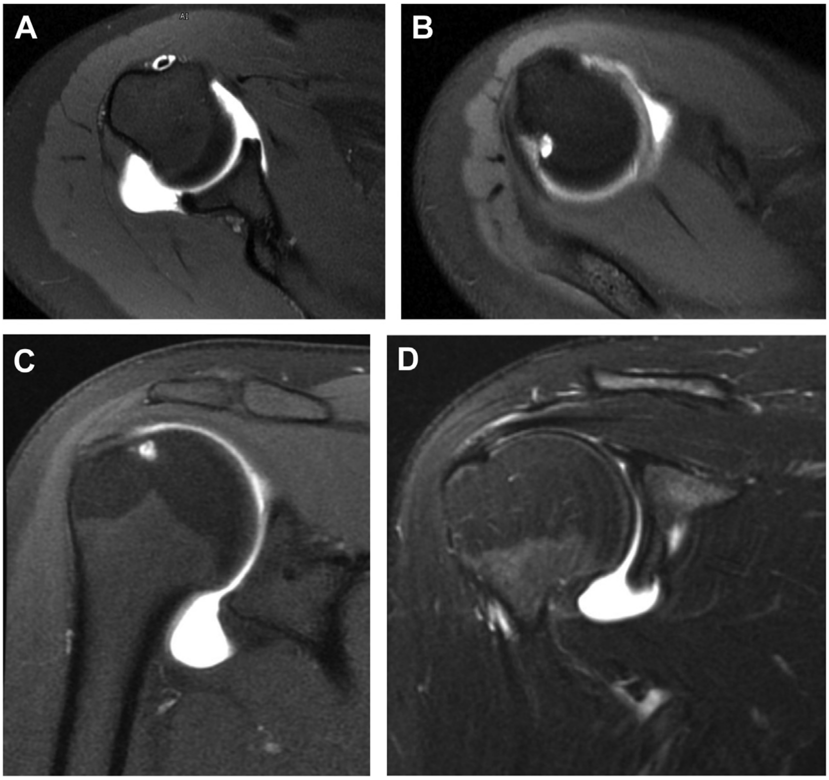


**Fig. 10.** MRI arthrogram of the patient in Fig. 2, which demonstrates (*A*) fraying of the posterior labrum on an axial slice, as well as (*B*, *C*) a posterosuperior osseous cyst seen on the axial and coronal slices, as well as (*D*) degenerative tearing of the posterosuperior rotator cuff tissue.

evaluated. A full distal neurovascular examination and rotator cuff examination should be performed and documented and previously outlined.

Next, careful palpation of the shoulder should be performed. Subcoracoid impingement patients may locate a single, focal point of tenderness anteriorly, at either the anterior coracoid or the lesser tuberosity.

### *Provocative Impingement Tests for Subcoracoid Impingement*

Provocative tests for subcoracoid impingement are extremely useful and include pain induced by forward elevation and internal rotation of the arm. It is greatest between 120° and 130° of flexion. This is a higher degree of flexion than what is expected in subacromial impingement.

The coracoid impingement test is performed by placing the shoulder passively in a position of cross-arm adduction, forward elevation, and internal rotation to bring the lesser tuberosity in contact with the coracoid (Fig. 11). A positive test produces a painful clicking in the anterior shoulder.[100]

### *Imaging Studies—Subcoracoid Impingement*

Similar to subacromial and internal impingement, in the evaluation of subcoracoid impingement, the initial evaluation should begin with plain radiographs.

**Fig. 11.** Examiner performs the coracoid impingement test by placing the shoulder passively in a position of cross-arm adduction, forward elevation, and internal rotation to bring the lesser tuberosity in contact with the coracoid. A positive test produces a painful clicking in the anterior shoulder.

MRI and computed tomography (CT) play a significant role in the diagnosis of subcoracoid impingement. Some authors have used cine, or dynamic, MRI imaging, which allows use of a shoulder rotating device for a series of images in progressive rotating positions of the shoulder.[101] One study demonstrated that cine MRI can be a very useful tool in the diagnosis of subcoracoid impingement when other methods are inadequate (**Fig. 12**).[97]

CT scans are obtained with the arms crossed on the chest. A coracohumeral distance less than 6 mm is consistent with subcoracoid impingement. A normal distance is 8.7 mm with the arm adducted and 6.8 mm with the arm flexed.[98] Nonetheless, subcoracoid impingement is a clinical diagnosis, and a normal coracohumeral distance does not rule out the condition.[102]

## TREATMENT OPTIONS FOR SUBCORACOID IMPINGEMENT SYNDROME

Similar to subacromial and internal impingement, nonoperative management is the mainstay of treatment and is similar to the other forms of impingement. In regard to injections, an ultrasound-guided injection is recommended to be performed by a trained specialist. Typically, this is performed with the arm at the side and external rotated to avoid subscapularis or biceps tendon involvement. Injection should be deep and lateral to the coracoid tip to maximize the therapeutic and diagnostic benefit.[97]

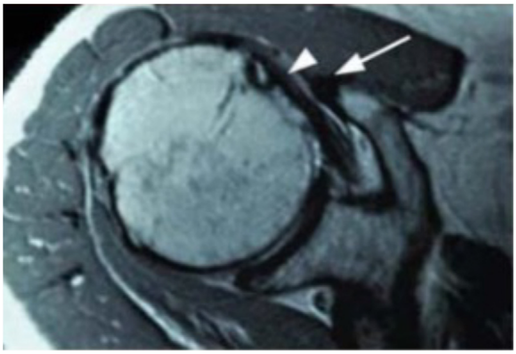

**Fig. 12.** Axial MRI image showing subcoracoid impingement. The arrowhead depicts the subscapularis with intrasubstance tendinosis, and the arrow demonstrates the elongated coracoid and decreased coracohumeral distance. (*From* Freehill, Michael Q. MD. Coracoid Impingement: Diagnosis and Treatment. American Academy of Orthopaedic Surgeon: April 2011 - Volume 19 - Issue 4 - p 191-197.)

### *Surgical options and outcomes—subcoracoid impingement*

Surgical management is rare but may include arthroscopic coracoplasty with or without subscapularis tendon repair if indicated. The posterolateral coracoid should be resected to create a minimum of 7 mm of clearance between the coracoid and the subscapularis. Care should be taken to be aware of the dangers during arthroscopy for subcoracoid impingement, which include the musculocutaneous nerve, which is an average of 2.74 cm from the coracoid, the axillary nerve, which is an average of 3.5 cm from the coracoid, and the cephalic vein, which is an average of 1.37 cm from the coracoid.[103] Another option includes open coracoplasty, which includes resected the lateral portion of the coracoid. Then, the conjoined tendon is reattached to the remaining medial coracoid.[100] Reported surgical outcomes have been good and can be recommended for patients who have failed nonoperative measures.[100]

## SUMMARY/DISCUSSION

Shoulder impingement syndrome has been cited as the most common cause of shoulder pain. The term “shoulder impingement syndrome” has been criticized as vague and nonspecific, and therefore misleading. Although shoulder impingement syndrome is likely multifactorial, the 3 most common subtypes would include subacromial impingement, internal impingement, and subcoracoid impingement. The mainstay of treatment is nonsurgical, as the majority of patients will improve with conservative measures. Surgical intervention is reserved for patients who fail conservative measures. Surgical intervention is most commonly in the form of decompression, with attention given to concomitant, associated pathologic condition of the shoulder, which commonly exists in the setting of impingement. The authors strongly emphasize that the specific subtype of shoulder impingement syndrome terminology be clearly communicated, as ambiguity can lead to misdiagnosis. Vague diagnoses such as “shoulder impingement syndrome” can lead to treatments that have a low likelihood of success because specific pathologic condition may go unaddressed.[104,105]

Finally, there is a clear need for future high-powered, high-quality, prospective randomized controlled trials in this arena in order to improve outcomes in patients with different impingement syndromes of the shoulder.

## CLINICS CARE POINTS

- Supervised physical therapy and exercises have been shown to improve pain and function in the setting of subacromial impingement syndrome.
- In the sertting of internal impingement refractory to nonoperative treatment, articular sided debridement yields a reasonable return to function.
- A coracohumeral distance of less than 6 mm is consistent with subcoracoid impingement.

## DISCLOSURE

E.H. Horowitz has nothing to disclose. W.R. Aibinder is a consultant for Exactech Inc, serves on the editorial board for EJOST.

## REFERENCES


1. Urwin M, Symmons D, Allison T, et al. Estimating the burden of musculoskeletal disorders in the community: the comparative prevalence of symptoms at different anatomical sites, and the relation to social deprivation. Ann Rheum Dis 1998;57(11):649–55. PMID: 9924205; PMCID: PMC1752494.
2. Feleus A, Bierma-Zeinstra SM, Miedema HS, et al. Incidence of non-traumatic complaints of arm, neck and shoulder in general practice. Man Ther 2008; 13(5):426–33. Epub 2007 Aug 2. PMID: 17681866.
3. gutiérrez-Espinoza H, Araya-Quintanilla F, Cereceda-Muriel C, et al. Effect of supervised physiotherapy versus home exercise program in patients with subacromial impingement syndrome: A systematic review and meta-analysis. Phys Ther Sport 2020;41:34–42. Epub 2019 Nov 6. PMID: 31726386.
4. van der Windt DA, Koes BW, de Jong BA, et al. Shoulder disorders in general practice: incidence, patient characteristics, and management. Ann Rheum Dis 1995;54(12):959–64. PMID: 8546527; PMCID: PMC1010060.
5. Luime JJ, Koes BW, Hendriksen IJ, et al. Prevalence and incidence of shoulder pain in the general population; a systematic review. Scand J Rheumatol 2004; 33(2):73–81.
6. Michener LA, McClure PW, Karduna AR. Anatomical and biomechanical mechanisms of subacromial impingement syndrome. Clin Biomech (Bristol, Avon) 2003;18(5):369–79. PMID: 12763431.
7. Neer CS 2nd. Anterior acromioplasty for the chronic impingement syndrome in the shoulder: a preliminary report. J Bone Joint Surg Am 1972;54(1):41–50. PMID: 5054450.
8. Lewis J. The End of an Era? J Orthop Sports Phys Ther 2018;48(3):127–9.
9. Papadonikolakis, Anastasios MD1, McKenna Mark MD1, et al. MD1. Published Evidence Relevant to the Diagnosis of Impingement Syndrome of the Shoulder. J Bone Joint Surg 2011;93(19):1827–32.
10. Ludewig PM, Lawrence RL, Braman JP. What's in a Name? Using Movement System Diagnoses Versus Pathoanatomic Diagnoses. J Orthop Sports Phys Ther 2013;43(5):280–3.
11. Harrison AK, Flatow EL. Subacromial Impingement Syndrome. Am Acad Orthopaedic Surgeon 2011;19(11):701–8.
12. Lewis JS. Rotator cuff tendinopathy. Br J Sports Med 2009;43(4):236–41. Epub 2008 Sep 18. PMID: 18801774.

13. Chambler AF, Bull AM, Reilly P, et al. Coracoacromial ligament tension in vivo. J Shoulder Elbow Surg 2003;12(4):365–7. PMID: 12934032.
14. Yamamoto N, Muraki T, Sperling JW, et al. Contact between the coracoacromial arch and the rotator cuff tendons in nonpathologic situations: a cadaveric study. J Shoulder Elbow Surg 2010;19(5):681–7. Epub 2010 Mar 19. PMID: 20303292.
15. Nicholson GP, Goodman DA, Flatow EL, et al. The acromion: morphologic condition and age-related changes. A study of 420 scapulas. J Shoulder Elbow Surg 1996;5(1):1–11.
16. Lohr JF, Uhthoff HK. The microvascular pattern of the supraspinatus tendon. Clin Orthop Relat Res 1990;254:35–8. PMID: 2323147.
17. Chansky HA, Iannotti JP. The vascularity of the rotator cuff. Clin Sports Med 1991;10(4):807–22. PMID: 1934098.
18. Fukuda H, Hamada K, Yamanaka K. Pathology and pathogenesis of bursal-side rotator cuff tears viewed from en bloc histologic sections. Clin Orthop Relat Res 1990;254:75–80. PMID: 2323150.
19. Ogata S, Uhthoff HK. Acromial enthesopathy and rotator cuff tear. A radiologic and histologic postmortem investigation of the coracoacromial arch. Clin Orthop Relat Res 1990;254:39–48. PMID: 2323148.
20. Budoff JE, Nirschl RP, Guidi EJ. Debridement of partial-thickness tears of the rotator cuff without acromioplasty. Long-term follow-up and review of the literature. J Bone Joint Surg Am 1998;80(5):733–48. PMID: 9611036.
21. Martin RM, Fish DE. Scapular winging: anatomical review, diagnosis, and treatments. Curr Rev Musculoskelet Med 2008;1(1):1–11. PMID: 19468892; PMCID: PMC2684151.
22. Kibler WB, McMullen J. Scapular dyskinesis and its relation to shoulder pain. J Am Acad Orthop Surg 2003;11(2):142–51. PMID: 12670140.
23. Warner JJ, Micheli LJ, Arslanian LE, et al. Scapulothoracic motion in normal shoulders and shoulders with glenohumeral instability and impingement syndrome. A study using Moiré topographic analysis. Clin Orthop Relat Res 1992;285:191–9. PMID: 1446436.
24. Paletta GA Jr, Warner JJ, Warren RF, et al. Shoulder kinematics with two-plane x-ray evaluation in patients with anterior instability or rotator cuff tearing. J Shoulder Elbow Surg 1997;6(6):516–27. PMID: 9437601.
25. Burkhart SS, Morgan CD, Kibler WB. Shoulder injuries in overhead athletes. The "dead arm" revisited. Clin Sports Med 2000;19(1):125–58. PMID: 10652669.
26. Balevi B.E., Sarikaya P.Z.B., Kaygisiz, M.E., et al., Diagnostic dilemma: which clinical tests are most accurate for diagnosing supraspinatus muscle tears and tendinosis when compared to magnetic resonance imaging?, *Cureus*, 14 (6), 2022, e25903.
27. Schmidt M., Enger, M., Prill A.H., et al., Interrater reliability of physical examination tests in the acute phase of shoulder injuries, *BMC Musculoskelet Disord*, 22 (1), 2021, 770.
28. Walch G, Boulahia A, Calderone S, et al. The 'dropping' and 'Hornblower's' signs in evaluation of rotator-cuff tears. JBJS Br 1998;80(4):624–8.
29. Barth JRH, Burkhard SS, De Beer JF. The bear-hug test: a new and sensitive test for diagnosing a subscapularis tear. *Arthroscopy* 2006;22(10):1076–84.
30. Gerber C, Krushell RJ. Isolated rupture of the tendon of the subscapularis muscle. Clinical features in 16 cases. JBJS Br 1991;73(3):389–94.
31. Jones S.J. and John-Mark M.M., Spurling test, In: StatPearls, 2021, StatPearls Publishing: Treasure Island; FL.

32. Yazigi Junior JA, Anauate Nicolao F, Matsunaga FT, et al. Supraspinatus tears: predictability of magnetic resonance imaging findings based on clinical examination. J Shoulder Elbow Surg 2021;30(8):1834–43. Epub 2021 Mar 4. PMID: 33675978.
33. Pappas GP, Blemker SS, Beaulieu CF, et al. In vivo anatomy of the Neer and Hawkins sign positions for shoulder impingement. J Shoulder Elbow Surg 2006;15(1):40–9.
34. Roberts CS, Davila JN, Hushek SG, et al. Magnetic resonance imaging analysis of the subacromial space in the impingement sign positions. J Shoulder Elbow Surg 2002;11(6):595–9.
35. Valadie AL 3rd, Jobe CM, Pink MM, et al. Anatomy of provocative tests for impingement syndrome of the shoulder. J Shoulder Elbow Surg 2000;9(1): 36–46.
36. Hegedus E.J., Goode A.P., Cook C.E.,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*, 46 (14), 2012, 964–978.
37. Bigliani LU, Morrison DS, April EW. The Morphology of the Acromion and Its Relationship to Rotator Cuff Tears. Orthopaedic Trans 1986;10:228.
38. Vanarthos WJ, Monu JU. Type 4 acromion: a new classification. Contemp Orthopaedics 1995;30(3):227–9. PMID: 10150316.
39. Bright AS, Torpey B, Magid T. Reliability of radiographic evaluation for acromial morphology. Skeletal Radiol 1997;26:718–21.
40. Epstein RE, Schweitzer ME, Frieman BG, et al. Hooked acromion: prevalence on MR images of painful shoulders. Radiology 1993;187(2):479–81.
41. Amit P, Paluch AJ, Baring T. Sharpened lateral acromion morphology (SLAM sign) as an indicator of rotator cuff tear: a retrospective matched study. JSES Int 2021;5(5):850–5. PMID: 34505095; PMCID: PMC8411071.
42. Toivonen DA, Tuite MJ, Orwin JF. Acromial structure and tears of the rotator cuff. J Shoulder Elbow Surg 1995;4(5):376–83.
43. Pandey V, Vijayan D, Tapashetti S, et al. Does scapular morphology affect the integrity of the rotator cuff? J Shoulder Elbow Surg 2016;25(3):413–21. Epub 2015 Dec 2. PMID: 26652696.
44. Moor BK, Bouaicha S, Rothenfluh DA, et al. Is there an association between the individual anatomy of the scapula and the development of rotator cuff tears or osteoarthritis of the glenohumeral joint?: A radiological study of the critical shoulder angle. Bone Joint J 2013;95-B(7):935–41.
45. Passaplan C, Hasler A, Gerber C. The critical shoulder angle does not change over time: a radiographic study. J Shoulder Elbow Surg 2021;30(8):1866–72. Epub 2020 Nov 4. PMID: 33160027.
46. Lin CL, Chen YW, Lin LF, et al. Accuracy of the Critical Shoulder Angle for Predicting Rotator Cuff Tears in Patients With Nontraumatic Shoulder Pain. Orthop J Sports Med 2020;8(5). 2325967120918995.
47. İncesoy MA, Yıldız KI, Türk ÖI, et al. The critical shoulder angle, the acromial index, the glenoid version angle and the acromial angulation are associated with rotator cuff tears. Knee Surg Sports Traumatol Arthrosc 2021;29(7):2257–63. Epub 2020 Jul 15. PMID: 32671437.
48. Kim JH, Min YK, Gwak HC, et al. Rotator cuff tear incidence association with critical shoulder angle and subacromial osteophytes. J Shoulder Elbow Surg 2019; 28(3):470–5. Epub 2018 Nov 12. PMID: 30429059.

49. Chalmers PN, Salazar D, Steger-May K, et al. Does the Critical Shoulder Angle Correlate With Rotator Cuff Tear Progression? Clin Orthop Relat Res 2017;475(6):1608–17. Epub 2017 Jan 24. PMID: 28120293; PMCID: PMC5406338.
50. Daghir AA, Sookur PA, Shah S, et al. Dynamic ultrasound of the subacromial-subdeltoid bursa in patients with shoulder impingement: a comparison with normal volunteers. Skeletal Radiol 2012;41(9):1047–53. Epub 2011 Oct 14. PMID: 21997670.
51. Kloth JK, Zeifang F, Weber MA. Klinische oder radiologische Diagnose des Impingements [Clinical or radiological diagnosis of impingement]. Radiologe 2015;55(3):203–10. German.
52. Garving C, Jakob S, Bauer I, et al. Impingement syndrome of the shoulder. Dtsch Arztebl Int 2017;114:765–76.
53. Neer CS 2nd. Impingement lesions. Clin Orthop Relat Res 1983;173:70–7. PMID: 6825348.
54. Bigliani LU, Levine WN. Subacromial impingement syndrome. J Bone Joint Surg Am 1997;79(12):1854–68. PMID: 9409800.
55. Cummins CA, Sasso LM, Nicholson D. Impingement syndrome: temporal outcomes of nonoperative treatment. J Shoulder Elbow Surg 2009;18(2):172–7.
56. Elliot V.H. and Raymond A.D., Ch 17 - Nonopioid analgesics, In: Frank J.D., Angelo J.M., et al., *Pharmacology and therapeutics for dentistry*, 7th edition, 2017, Mosby: St. Louis, MO, 257–275, 9780323393072.
57. Smith H.S., Nonsteroidal anti-inflammatory drugs; acetaminophen, In: Michael J.A. and Robert B.D., *Encyclopedia of the neurological sciences*, 2nd edition, 2014, Academic Press: USA, 610–613, 9780123851581.
58. Hawkey C, Kahan A, Steinbrück K, et al. Gastrointestinal tolerability of meloxicam compared to diclofenac in osteoarthritis patients. International MELISSA Study Group. Meloxicam Large-scale International Study Safety Assessment. Br J Rheumatol 1998;37(9):937–45. Erratum in: Br J Rheumatol 1998;37(10):1142. PMID: 9783757.
59. Stiller Carl-Olav, Paul Hjemdahl. Lessons from 20 years with COX-2 inhibitors: Importance of dose-response considerations and fair play in comparative trials. J Intern Med 2022;292(4):557–74.
60. Schmidt Morten, et al. Cardiovascular Risks of Diclofenac Versus Other Older COX-2 Inhibitors (Meloxicam and Etodolac) and Newer COX-2 Inhibitors (Celecoxib and Etoricoxib): A Series of Nationwide Emulated Trials. Drug Saf 2022;45(9):983–94.
61. Graham GG, Scott KF. Mechanism of action of paracetamol. Am J Ther 2005;12(1):46–55.
62. Steuri R, Sattelmayer M, Elsig S, et al. Effectiveness of conservative interventions including exercise, manual therapy and medical management in adults with shoulder impingement: a systematic review and meta-analysis of RCTs. Br J Sports Med 2017;51:1340–7.
63. 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):138–60.
64. Holmgren T, Oberg B, Sjöberg I, et al. Supervised strengthening exercises versus home-based movement exercises after arthroscopic acromioplasty: a randomized clinical trial. J Rehabil Med 2012;44(1):12–8.

65. Bang MD, Deyle GD. Comparison of supervised exercise with and without manual physical therapy for patients with shoulder impingement syndrome. J Orthop Sports Phys Ther 2000;30(3):126–37.
66. Hengeveld E, Banks K, Maitland GD. Maitland's peripheral manipulation. 5th edition. Edinburgh: Elsevier/Butterworth Heinemann; 2014. p. 142–260.
67. Olaf E& Jern H. Muscle Stretching in Manual Therapy: A Clinical Manual. Alfta Rehab. Volume I: The Extremities. 2002. ISBN 91-85934-02-X.
68. Cuom F, Blair B, et al. An Analysis of the Efficacy of Corticosteroid Injections for the Treatment of Subacromial Impingement Syndrome. J Shoulder Elbow Surg 1996;5(2):S8–9.
69. Dong W, Goost H, Lin XB, et al. Treatments for shoulder impingement syndrome: a PRISMA systematic review and network meta-analysis. Medicine (Baltimore) 2015;94(10):e510. Erratum in: Medicine (Baltimore). 2016 Jun 10;95(23): e96d5. PMID: 25761173; PMCID: PMC4602475.
70. Shin WY, An MJ, Im NG, et al. Changes in Blood Glucose Level After Steroid Injection for Musculoskeletal Pain in Patients With Diabetes. Ann Rehabil Med 2020;44(2):117–24.
71. Ford LT, DeBender J. Tendon rupture after local steroid injection. South Med J 1979;72(7):827–30.
72. Fawi HMT, Hossain M, Matthews TJW. The incidence of flare reaction and short-term outcome following steroid injection in the shoulder. Shoulder Elbow 2017; 9(3):188–94.
73. Lubowitz JH, Brand JC, Rossi MJ. Preoperative Shoulder Corticosteroid Injection Is Associated With Revision After Primary Rotator Cuff Repair. Arthroscopy 2019;35(3):693–4.
74. Chevalier X. Acide hyaluronique dans la gonarthrose : mécanismes d'action. In: Chevalier X, editor. Injection d'acide hyaluronique et arthrose. Paris: Masson; 2005. p. 9–39.
75. Vannabouathong C, Bhandari M, Bedi A, et al. Nonoperative Treatments for Knee Osteoarthritis: An Evaluation of Treatment Characteristics and the Intra-Articular Placebo Effect: A Systematic Review. JBJS Rev 2018;6(7):e5.
76. Penning LI, de Bie RA, Walenkamp GH. The effectiveness of injections of hyaluronic acid or corticosteroid in patients with subacromial impingement: a three-arm randomised controlled trial. J Bone Joint Surg Br 2012;94(9): 1246–52.
77. Hsieh LF, Lin YJ, Hsu WC, et al. Comparison of the corticosteroid injection and hyaluronate in the treatment of chronic subacromial bursitis: A randomized controlled trial. Clin Rehabil 2021;35(9):1305–16.
78. Shakeri H, Keshavarz R, Arab AM, et al. Clinical effectiveness of kinesiological taping on pain and pain-free shoulder range of motion in patients with shoulder impingement syndrome: a randomized, double blinded, placebo-controlled trial. Int J Sports Phys Ther 2013;8(6):800–10.
79. Gebremariam L, Hay EM, van der Sande R, et al. Subacromial impingement syndrome–effectiveness of physiotherapy and manual therapy. Br J Sports Med 2014;48(16):1202–8.
80. Ellman H. Arthroscopic subacromial decompression: analysis of one- to three-year results. Arthroscopy 1987;3:173–81.
81. Davis AD, Kakar S, Moros C, et al. Arthroscopic versus open acromioplasty: a meta-analysis. Am J Sports Med 2010;38(3):613–8.

82. Dorrestijn O, Stevens M, Winters JC, et al. Conservative or surgical treatment for subacromial impingement syndrome? A systematic review. J Shoulder Elbow Surg 2009;18:652–60.
83. Colman WW, Kelkar R, Flatow EL, et al. The Effect of Anterior Acromioplasty on Rotator Cuff Contact: An Experimental and Computer Simulation. JSES 1996;5(2):2.
84. Heyworth BE, Williams RJ 3rd. Internal impingement of the shoulder. Am J Sports Med 2009;37(5):1024–37.
85. Meister K, Buckley B, Batts J. The posterior impingement sign: diagnosis of rotator cuff and posterior labral tears secondary to internal impingement in overhand athletes. Am J Orthop (Belle Mead Nj) 2004;33(8):412–5.
86. Davidson PA, ElAttrache NS, Jobe CM, et al. Rotator cuff and posterior-superior glenoid labrum injury associated with increased glenohumeral motion: a new site of impingement. J Shoulder Elbow Surg 1995;4(5):384–90.
87. Edelson G, Teitz C. Internal impingement in the shoulder. J Shoulder Elbow Surg 2000;9(4):308–15.
88. Paley KJ, Jobe FW, Pink MM, et al. Arthroscopic findings in the overhand throwing athlete: evidence for posterior internal impingement of the rotator cuff. Arthroscopy 2000;16(1):35–40.
89. Bennett GE. Elbow and shoulder lesions of baseball players. Am J Surg 1959; 98:484–92.
90. Giaroli EL, Major NM, Higgins LD. MRI of internal impingement of the shoulder. *AJR Am J roentgenology* 2005;185(4):925–9.
91. Fessa CK, Peduto A, Linklater J, et al. Posterosuperior glenoid internal impingement of the shoulder in the overhead athlete: pathogenesis, clinical features and MR imaging findings. J Med Imaging Radiat Oncol 2015;59(2):182–7.
92. Walch G, Boileau P, Noel E, et al. Impingement of the deep surface of the supraspinatus tendon on the posterosuperior glenoid rim: An arthroscopic study. J Shoulder Elbow Surg 1992;1(5):238–45.
93. Andrews JR, Broussard TS, Carson WG. Arthroscopy of the shoulder in the management of partial tears of the rotator cuff: a preliminary report. Arthroscopy 1985;1(2):117–22.
94. Levitz CL, Dugas J, Andrews JR. The use of arthroscopic thermal capsulorrhaphy to treat internal impingement in baseball players. Arthroscopy 2001;17(6): 573–7.
95. Yoneda M, Nakagawa S, Hayashida K, et al. Arthroscopic removal of symptomatic Bennett lesions in the shoulders of baseball players: arthroscopic Bennettplasty. Am J Sports Med 2002;30(5):728–36.
96. Riand N, Levigne C, Renaud E, et al. Results of derotational humeral osteotomy in posterosuperior glenoid impingement. Am J Sports Med 1998;26(3):453–9.
97. Freehill MQ. Coracoid impingement: diagnosis and treatment. J Am Acad Orthop Surg 2011;19(4):191–7. PMID: 21464212.
98. Gerber C, Terrier F, Zehnder R, et al. The subcoracoid space. An anatomic study. Clin Orthop Relat Res 1987;215:132–8. PMID: 3802629.
99. Osti L, Soldati F, Del Buono A, et al. Subcoracoid impingement and subscapularis tendon: is there any truth? Muscles Ligaments Tendons J 2013;3(2):101–5.
100. Dines D.M., Warren R.F., Inglis A.E., et al., The coracoid impingement syndrome, *J Bone Joint Surg*, 72 (2), 1990, 314–316.
101. Friedman RJ, Bonutti PM, Genez B. Cine magnetic resonance imaging of the subcoracoid region. Orthopedics 1998;21(5):545–8.

102. Giaroli EL, Major NM, Lemley DE, et al. Coracohumeral interval imaging in subcoracoid impingement syndrome on MRI. AJR Am J Roentgenol 2006;186(1):242–6.
103. Kleist KD, Freehill MQ, Hamilton L, et al. Computed tomography analysis of the coracoid process and anatomic structures of the shoulder after arthroscopic coracoid decompression: a cadaveric study. J Shoulder Elbow Surg 2007;16(2):245–50.
104. Neer CS 2nd, Welsh RP. The shoulder in sports. Orthop Clin North Am 1977;8(3):583–91.
105. Tibone JE, Jobe FW, Kerlan RK, et al. Shoulder impingement syndrome in athletes treated by an anterior acromioplasty. Clin Orthop Relat Res 1985;198:134–40.