Abstract

Subacromial impingement syndrome (SIS) represents a spectrum of pathology ranging from subacromial bursitis to rotator cuff tendinopathy and full-thickness rotator cuff tears. The relationship between subacromial impingement and rotator cuff disease in the etiology of rotator cuff injury is a matter of debate. Both extrinsic compression and intrinsic degeneration may play a role. Management includes physical therapy, injections, and, for some patients, surgery. There remains a need for high-quality studies of the pathology, etiology, and management of SIS.

Subacromial impingement syndrome (SIS) is a common cause of shoulder pain.1 Possible etiologies of shoulder pain related to SIS include a spectrum ranging from subacromial bursitis and rotator cuff tendinopathy to partial- and full-thickness rotator cuff tears. Localizing and addressing the etiology of shoulder dysfunction can be challenging due to the interplay of pathology in SIS. For example, the etiology of rotator cuff disease has long been debated and the cause is likely multifactorial, with contributions from external compression, age-related degeneration, trauma, and vascular compromise. Despite controversy regarding the importance of these factors, most investigators believe that external compression from the anterior acromion, coracoacromial ligament (CAL), and acromioclavicular joint plays a significant role in rotator cuff disease by the time treatment is considered. Secondary causes of impingement include tuberosity fracture nonunion or malunion, a mobile os acromiale, calcific tendinitis, instability, and iatrogenic factors. Accurate diagnosis and effective treatment requires a thoughtful and thorough history and physical examination as well as appropriate imaging.

History

Much of the early literature is difficult to interpret in the context of SIS because glenohumeral conditions, especially arthritis and frozen shoulder, were conflated with rotator cuff and bursal conditions. Duplay2 was likely focusing on glenohumeral disease when he described “périarthrite,” but he also spoke of the role of bursal inflammation under the acromion. Beginning in 1904, Codman3-15 wrote a series of articles that drew attention to the bursa and the adjacent rotator cuff tendons. In hindsight, Codman’s detailed writings can be interpreted in many ways; however, he generally favored a traumatic explanation for supraspinatus tears, whereas Meyer16-22 argued for “use attrition,” in which the rotator cuff tendon and biceps were “ground between the acromion and the humeral head.” Codman rejected this theory. In his description of supraspin-
natus tears, Codman noted that “Dr. Meyer finds similar lesions although he explains them as the result of attrition,” a mechanism that Codman found “unlikely” except as a secondary effect. He concluded, however, that “one is tempted to compromise by saying that many causes or combinations of causes may produce the same lesion” (ie, rotator cuff tear).

Theories

The connection between SIS and rotator cuff disease has been controversial. Some believe that rotator cuff disease is due to primary extrinsic compression, others think that the disease is generally due to intrinsic tendon degeneration, with subacromial impingement secondary to cuff weakness and humeral ascent against the overlying structures.

Extrinsic Compression

The theory of subacromial impingement has been dominated by debate regarding the precise location of an extrinsic compression source. Watson-Jones described impingement of the lateral acromion on the cuff in the midarc of abduction. The corrective surgery, lateral or even radical (ie, total) acromionectomy, caused deltoid damage; Neer and Marberry felt that the procedure was unnecessary. In his dissection of 100 cadaver scapulae, Neer identified spurs and excrescences on the undersurface of the anterior acromion. He proposed that these changes, resulting from impingement of the rotator cuff and humeral head against the undersurface of the anterior acromion, were primarily anterior, not lateral. This finding led Neer to propose the use of anterior acromioplasty to manage this pattern of impingement. Neer initially identified three stages of the impingement process. Stage I involves acute bursitis with subacromial edema and hemorrhage. If extrinsic compression continues, the bursa no longer lubricates the underlying rotator cuff, leading to tendinopathy of the rotator cuff tendons, which is classified as stage II (Figure 1). In this stage, the anterior fibers of the supraspinatus may become frayed and may progress to a partial-thickness tear. Stage III is characterized by progression of a partial-thickness tear to a full-thickness tear.

Variations in acromial morphology were originally described by Bigliani et al and classified into three types based on acromial shape: type I, flat; type II, curved; and type III, hooked. They also noted that a hook-shaped acromion was associated with cuff degeneration. Since then, others have reported a higher incidence of cuff tears with type III acromial impingement. It has been suggested that the spurs and excrescences are the result of ossification of the CAL insertion. Chambler et al proposed that this ossification is secondary to tensile forces on the ligament and demonstrated that shoulder abduction places a tensile force on the ligament. A recent cadaver study of contact and forces between the cuff and subacromial arch revealed that subacromial contact and CAL bending occurred in all motions in normal shoulders. The authors suggest that repetitive contact and bending of the CAL may lead to degenerative changes, including the proliferative acromial spurs.

Detailed anatomic studies of the CAL have further illustrated aspects of subacromial space anatomy that may play a role in the development of impingement. In a study of 56 cadaver shoulders, Fealy et al identified two distinct ligamentous bands: an anterolateral and a posteromedial band. Spurs were commonly found in the anterolateral band. Another anatomic study of CAL morphology demonstrated that variants with more than one band were associated with rotator cuff degeneration.

Confusion regarding whether acromial shape is a primary or secondary factor in cuff disease likely resulted from confusing acquired spurs with native acromial shape. Nicholson et al helped to reduce this confusion in a study of age cohorts of scapulae from a museum collection. They found that the incidence of spurs increased with age, whereas overall acromial shape remained unchanged.

Intrinsic Degeneration

Citing intrinsic characteristics of the rotator cuff, some authors assert that extrinsic compression is not the primary cause of rotator cuff disease. Proposed intrinsic etiologies include diminished vascular supply, aging,
and tensile forces leading to rotator cuff failure. Interestingly, Ogata and Uhthoff\(^3\) found that the incidence and severity of cuff tears increased with age, whereas acromial degeneration did not. The authors also identified degenerative changes on the acromial undersurface in 31 of 36 (86\%) shoulders with articular-sided partial cuff tears. They found that bursal surface tears were relatively uncommon, suggesting that cuff tendinopathy occurs primarily within the tendon.

It has been hypothesized that the hypovascular critical zone of the supraspinatus tendon is a possible intrinsic factor, causing tendon degeneration. In a cadaver study, Lohr and Uhthoff\(^7\) identified a zone of hypovascularity within the supraspinatus tendon and specifically noted that no vessels were present distally on the articular portion of the tendon. They proposed that such a region of hypovascularity is more susceptible to degenerative tendinopathy and rotator cuff tears. Recently, Benson et al\(^4\) reported evidence of apoptosis and hypoxic damage to the rotator cuff in shoulders with impingement and cuff tears. However, other studies have suggested that regions of impaired blood supply may be the result, not the cause, of tendon injury because injury to the tendon causes ischemia or necrosis through secondary damage of the vessels.\(^4\)

Proponents of the intrinsic theory do not refute that the acromion plays a role in SIS; rather, they argue that the primary, inciting factor in SIS stems from weakness and damage to the supraspinatus. In the intrinsic theory model, degenerative changes or trauma weaken the supraspinatus, and it is then no longer able to center the humeral head on the glenoid. When the humeral head migrates superiority, the subacromial space narrows, abutting the tuberosity and cuff against the undersurface of the acromion. Once this occurs, the changes commonly associated with SIS are seen: osteophytic spurring of the acromion and tuberosity erosion.

Supporters of the intrinsic theory cite results in patients with partial-thickness cuff tears treated with débridement without formal acromioplasty and the frequency of isolated articular-sided, partial-thickness tears.\(^4\) Based on results of their study of this management method, Budoff et al\(^1\) proposed that “primary failure of the rotator cuff most likely occurs by eccentric tension overload rather than by impingement from aberrant acromial morphology.”

### Diagnosis

Accurate diagnosis of impingement requires a thorough history and physical examination as well as appropriate imaging. Many patients with impingement report cuff-related symptoms such as anterolateral arm pain, as was reported by Gerber et al\(^3\) in their study of pain patterns caused by subacromial space irritation. Exacerbation of symptoms is frequently reported with shoulder elevation at or above 90° or with lifting items away from the body.

### Imaging

Radiographs should be obtained to evaluate for bony abnormality of the coracoacromial arch. Routine radiographs include AP and Grashey views (ie, AP radiograph of the shoulder in the plane of the scapula) as well as outlet and axillary views. Outlet and axillary views are of particular importance. The outlet view provides visualization of acromial morphology, and the axillary view best demonstrates evidence of os acromiale, which may lead to secondary impingement. Acromioclavicular osteoarthritis with inferior osteophyte formation, acromial enthesophytes or sclerosis, and cystic changes of the humeral head are the more common radiographic findings related to impingement. However, all of these findings may be present in asymptomatic subjects, making the relationship of such findings to the diagnosis of impingement controversial. A recent study found that acromiohumeral distance better reflected the clinical status of patients with subacromial impingement than did acromial shape.\(^4\)

MRI provides detail of potential sites of subacromial impingement through the supraspinatus outlet. Ossification of the CAL or the presence of a subacromial spur can be best identified in the sagittal oblique plane; however, differentiation of a pathologic spur and the normal CAL can be difficult. MRI also may demonstrate findings of subacromial subdeltoid bursitis. Findings that indicate this condition include bursal thickness >3 mm, the presence of fluid medial to the acromioclavicular joint, and the presence of fluid in the anterior aspect of the bursa.\(^4\) Typically, MRI is performed with the arm adducted; however, this position does not recreate the position of impingement.

These imaging modalities can be useful in identifying possible sources of mechanical impingement. Diagnosis of SIS is typically determined via a combination of physical examination and radiographic findings.

### Physical Examination

Physical examination of the patient with shoulder pain must include an evaluation of range of motion, rotator cuff strength, and provocative testing. Previous studies have demonstrated that these tests are commonly either very specific or very sensitive, which suggests that diagnosis should be determined based on
ings. All shoulders in the Neer positions demonstrated similar findings, placed in the Neer and Hawkins position. A cross-sectional analysis of nine cadaver specimens testing substantially decreased the distance from the supraspinatus insertion to the acromion and posterior glenoid. The Hawkins maneuver produced greater subacromial space narrowing and subacromial rotator cuff contact than did the Neer maneuver. In a study of 10 subjects with normal shoulders (average age, 32 years), Roberts et al\(^\text{50}\) found that the rotator cuff insertion was closest to the anteroinferior acromion at 90° of flexion (ie, Hawkins sign position) but not at full elevation (ie, Neer sign position). A cross-sectional analysis of nine cadaver specimens placed in the Neer and Hawkins positions demonstrated similar findings.\(^\text{21}\) All shoulders in the Neer position demonstrated contact between the soft tissues and the medial acromion. Shoulders in the Hawkins position had contact between soft tissues and the CAL. Although these studies were done in normal shoulders or cadavers, which may influence the results, these tests for subacromial impingement seem to demonstrate contact consistent with mechanical impingement.

**Nonsurgical Management**

The most appropriate and beneficial course of treatment for patients with SIS is widely debated. Management options include various types of injection and physical therapy as well as a variety of surgical options, such as bursectomy alone or subacromial decompression. In a recent study, Dorrestijn et al\(^\text{12}\) compared surgical and nonsurgical treatment in four randomized controlled trials (RCTs) in an effort to determine which treatment provided better outcomes. However, the authors could identify no high-quality RCTs that demonstrated differences in outcome; they concluded that, in terms of pain and shoulder function, no evidence exists for differences in outcome between nonsurgical and surgical treatment of SIS. Given the fact that few RCTs met the criteria to be included in this review, further high-quality research on the treatment of SIS is needed.

Nonsurgical management of SIS continues to be successful in most patients.\(^\text{23,53}\) In a recent prospective study, Cummins et al\(^\text{53}\) reported the results of 100 consecutive patients with SIS treated with a nonsurgical treatment protocol consisting of a subacromial cortisone injection and physical therapy. In this group, 79% of patients did not require surgery after two-year follow-up. Of the patients who did not require surgery, the average American Shoulder and Elbow Surgeons outcome score increased from 56 to 95, and the average pain score decreased from 4.8 to 0.6. The authors did not find evidence of any improvement beyond 1 year. The total number of subacromial steroid/lidocaine injections and patient response to the initial injection were predictors of future surgical intervention. Kuhn\(^\text{54}\) examined the role of exercise for the treatment of rotator cuff impingement in a systematic review of 11 RCTs. He found that exercise had both statistically and clinically significant effects in decreasing pain and improving function but did not have such effects on range of motion or strength. Although physical therapy is a critical component of nonsurgical treatment of SIS, subacromial injections also are frequently used in initial treatment of patients presenting with symptomatic SIS. In a study of 60 shoulders with impingement syndrome, Kang et al\(^\text{55}\) reviewed the accuracy and effectiveness of these injections. The shoulders were randomized to receive a subacromial injection of corticosteroids, local anesthetic, and contrast dye from one of three locations: anterolateral, lateral, or posterior. The authors evaluated the accuracy of the injection by obtaining three radiographic views of the shoulder and reported a 70% accuracy rate for each of the portals. Although clinical improvement did not correlate with accuracy in this study, an overall improvement in the University of California Los Angeles (UCLA) shoulder score and a decrease in the pain score at 3 months were noted. Another study reported that the accuracy of blind and ultrasound-guided injections was the same.\(^\text{56}\) In a double-blind RCT that compared the effectiveness of subacromial injections of tenoxicam, a nonsteroidal anti-inflammatory drug, with that of corticosteroid injections, the authors found that the outcomes were not equivalent when evaluated at time points between 2 and 6 weeks.\(^\text{57}\) Improvements in Constant and Disabilities of the Arm, Shoulder, and Hand scores were significantly greater in the steroid group than in the tenoxicam group at 6 weeks after injection (\(P < 0.020\)).

**Surgical Management**

Surgery is indicated in patients with persistent pain who fail a trial of nonsurgical treatment. Historically, open anterior acromioplasty, as described by Neer,\(^\text{10}\) has been performed in these patients. Neer noted...
that “it seems important that the rough surface on which the supraspinatus is rubbing be removed” and advised removing the undersurface of the anterior acromial edge and CAL. In patients with mechanical impingement, the goals of open anterior acromioplasty include pain relief, improvement of surgical exposure when cuff repair is necessary, and prevention of wear and degeneration of the rotator cuff and biceps tendon. Long-term results of this procedure have been good. In a study of 32 patients treated with open anterior acromioplasty, Chin et al\textsuperscript{59} reported an 88% patient satisfaction rate, and 23 shoulders (72%) had minimal or no pain at 25-year follow-up. Five shoulders required additional surgery, including distal clavicle excision (one patient), revision anterior acromioplasty (one patient), and repair of a new rotator cuff tear (three patients). These findings suggest good long-term results with this procedure and a relatively low reoperation rate.

With the evolution of arthroscopic shoulder surgery, open anterior acromioplasty has evolved toward arthroscopic subacromial decompression. The arthroscopic technique permits direct visualization of evidence of arch abrasion and allows the surgeon to manage possible sources of impingement (Figure 2). A meta-analysis of nine studies that compared open with arthroscopic subacromial decompression reported equivalent surgical times, complication rates, and clinical outcomes at a minimum 1-year follow-up.\textsuperscript{59} In addition, patients treated with arthroscopic acromioplasty returned to work sooner and had fewer hospital inpatient days than did those who underwent an open procedure. In a prospective cohort study, Odenbring et al\textsuperscript{60} reported on 31 shoulders treated with arthroscopic acromioplasty and 29 shoulders treated with open acromioplasty. They reported excellent or good results in 77% of shoulders in the arthroscopic acromioplasty cohort, and good results were maintained 12 to 14 years after surgery. Notably, long-term outcomes of arthroscopic acromioplasty, which were measured with the UCLA shoulder scoring system, were superior to those of open acromioplasty.

Other studies have reported good clinical results in patients who underwent arthroscopic acromioplasty. In a retrospective study, 162 patients treated with arthroscopic subacromial decompression without rotator cuff repair were evaluated at a 10- to 13-year follow-up (mean, 11.2 years).\textsuperscript{61} The authors found that isolated supraspinatus tears did not progress clinically, and they concluded that subacromial decompression for subacromial impingement yields good long-term results. Additionally, in a prospective study of 50 patients with SIS and persistent symptoms after 6 months of nonsurgical treatment, Bengtsson et al\textsuperscript{62} found a significant improvement in median Disabilities of the Arm, Shoulder, and Hand scores and visual analog scale scores 6 months after surgery ($P < 0.001$).

Although Neer\textsuperscript{24} and others who support the extrinsic compression theory recommend a formal acromioplasty, review of the literature reveals the ongoing controversy regarding the role of subacromial decompression for SIS. The debate has focused on the necessary components of subacromial decompression. Authors have described subacromial decompression as bursectomy alone as well as bursectomy and anterior acromioplasty. Much of the debate involves whether decompression is necessary in the setting of rotator cuff repair. Goldberg et al\textsuperscript{63} propose that acromioplasty is not necessary, reporting significant improvement in Medical Outcomes Study 36-Item Short Form comfort and Simple Shoulder Test functions in 27 full-thickness open cuff repairs done without acromioplasty. However, the authors note that they did make an effort to “reestablish the normal smoothness of the undersurface of the coraco-acromial arch,” which may reproduce some benefit of acromioplasty.

Budoff et al\textsuperscript{64} reported the long-term results (mean, 9.5 years) of 62 shoulders (60 patients) with partial-thickness tears treated with débridement without acromioplasty. The authors reported that 79% of shoulders had excellent or good results based on UCLA shoulder scores and that, of the 60 patients, 77% had no or only minimal pain. Paulos and Franklin\textsuperscript{65} reported the results of 80 arthroscopic subacromial decompressions in 76 patients. At an average follow-up of 32 months, patients had decreased pain with activity and at night and showed decreased impingement signs at final follow-up. Poorer results were seen in patients with full-thickness cuff tears. In a prospective randomized study, Garts-
man and O’Connor\textsuperscript{66} compared 47 patients treated with cuff repair and a formal subacromial decompression with 46 patients treated with cuff repair alone. All patients had a full-thickness supraspinatus tear and a type II acromion (patients with a type III acromion were excluded). The authors found no significant difference in American Shoulder and Elbow Surgeons scores between the groups, even when controlled for tear length.

Additional studies have directly compared various types of decompression. Henkus et al\textsuperscript{27} prospectively evaluated 57 patients with primary subacromial impingement without a rupture of the rotator cuff who failed nonsurgical management. Patients were randomized to treatment with either bursectomy alone or bursectomy with acromioplasty. At a mean follow-up of 2.5 years (range, 1 to 5 years) both bursectomy and acromioplasty demonstrated good clinical results without statistically significant differences between the two treatments. However, there was a trend toward better clinical results with acromioplasty; this trend did not reach significance, but the study was underpowered for this finding. The type of acromion and severity of symptoms were found to be more predictive of clinical outcome than was the type of treatment. Even when bone is taken, basic science studies suggest that modest anterior removal is all that is needed to reduce pathologic contact on the rotator cuff, and that complete flattening of the acromion is rarely needed.\textsuperscript{68-70}

### Summary

SIS is one of the most common causes of shoulder pain and is the subject of ongoing debate in the orthopaedic surgery community. Although debate persists regarding the etiology of impingement and rotator cuff disease, SIS is likely multifactorial and may involve both extrinsic compression and intrinsic degenerative factors. For most patients with SIS, nonsurgical treatment is successful. Surgical intervention is successful in patients who fail nonsurgical treatment. Surgeon experience and intraoperative assessment may guide the method of surgical treatment. Studies have shown that many surgical interventions, including débridement and open and arthroscopic acromioplasty, have been successful. However, there remains a need for high-quality clinical research on the diagnosis and treatment of SIS.

### References

**Evidence-based Medicine:** Levels of evidence are described in the table of contents. In this article, references 40, 47, 56, 57, and 66 are level I studies. References 48, 52-55, 58, 60, and 67 are level II studies. References 43, 46, and 59 are level III studies. References 11, 13, 15, 19, 20, 29, 30, and 61-65 are level IV studies. References 1-10, 12, 14, 16-18, 21-28, 31-39, 41, 42, 44, 45, 49-51, and 68-70 are level V expert opinion.

References printed in **bold** type are those published within the past 5 years.

20. Meyer AW: Spontaneous dislocation and destruction of tendon of long head of...


