Current Concepts Review

Subacromial Impingement Syndrome*

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In the last two decades, subacromial impingement syndrome has become an increasingly common diagnosis for patients who have a painful shoulder. However, subacromial impingement syndrome is a specific diagnosis and is not the only cause of pain in the anterosuperior aspect of the shoulder. Impingement may be difficult to diagnose because the clinical presentation may be confusing. It is important to differentiate subacromial impingement syndrome from other conditions that may cause symptoms in the shoulder, such as glenohumeral instability, cervical radiculitis, calcific tendinitis, adhesive capsulitis, degenerative joint disease, isolated acromioclavicular osteoarthrosis, and nerve compression. This is particularly true when examining younger patients, especially athletes who perform overhead motions with use of the upper extremity, in whom the diagnosis of impingement should be made with caution. In many cases, the primary diagnosis is subtle glenohumeral instability even though impingement and subacromial bursitis are evident.

In the past, many authors noted abnormal contact between the coracoacromial arch and the rotator cuff tendons, but the exact etiology was not clearly understood. Meyer, in 1931, proposed that tears of the rotator cuff occurred secondary to attrition as a result of friction with the undersurface of the acromion. He described corresponding lesions on the undersurface of the acromion and the greater tuberosity, although he did not implicate the acromion directly. Codman, in 1934, defined the critical zone, where most degenerative changes occur, as a portion of the rotator cuff located one centimeter medial to the insertion of the supraspinatus on the greater tuberosity. Armstrong, in 1949, introduced the term supraspinatus syndrome and proposed that the condition should be treated with a total acromioplasty. Diamond also noted the role of the acromion as a cause of symptoms in the shoulder and suggested acromioplasty as a solution. McLaughlin and Asherman developed the lateral acromioplasty to relieve impingement on the rotator cuff. However, this procedure does not involve removal of the anterior portion of the acromion, which is responsible for impingement, and it necessitates detachment of a substantial portion of the deltid origin.

The disappointing results of complete acromioplasty and lateral acromioplasty led Neer to focus on the undersurface of the acromion as the offending area. In 1972, Neer described subacromial impingement syndrome as a distinct clinical entity. He hypothesized that the rotator cuff is impinged upon by the anterior one-third of the acromion, the coracoacromial ligament, and the acromioclavicular joint rather than by just the lateral aspect of the acromion. He also suggested that the portion of the rotator cuff that is impinged upon (the impingement zone) is centered on the insertion of the supraspinatus tendon on the greater tuberosity. Finally, he postulated that the formation of spurs in the substance of the coracoacromial ligament leads to chronic wear and to tears of the rotator cuff. Neer described three stages of impingement. Stage-I impingement is characterized by edema and hemorrhage of the bursa and cuff and is typically found in patients who are less than twenty-five years old. Stage-II impingement represents irreversible changes, such as fibrosis and tendinitis of the rotator cuff, and is typically found in patients who are twenty-five to forty years old. Stage-III impingement is marked by more chronic changes, such as partial or complete tears of the rotator cuff, and usually is seen in patients who are more than forty years old. Later, impingement was divided into outlet and non-outlet lesions. Outlet impingement occurs when the coracoacromial arch encroaches on the supraspinatus outlet. Non-outlet impingement occurs secondary to thickening or hypertrophy of the bursa or the rotator cuff tendons.

Neer developed the anterior acromioplasty, which includes acromioclavicular arthroplasty when indicated, to correct impingement by decompressing the subacromial space. Anterior acromioplasty involves débridement of the inflamed subacromial bursa, resection of the coracoacromial ligament and any spurs that are present, resection of the anteroinferior aspect of the acromion, and resection of overhanging osteophytes from the acromioclavicular joint or of the entire joint if there is preoperative tenderness. This procedure has become an accepted method for the treatment of impingement and has been associated with a high percentage of satisfactory results. In recent years,
however, excessive removal of acromial bone has been associated with complications and unsatisfactory clinical results\textsuperscript{10,13,17}. Recently, Ellman\textsuperscript{2} described arthroscopic anterior acromioplasty as an alternative to open acromioplasty. In the last ten years, the arthroscopic procedure has produced results that are similar to those of the open procedure\textsuperscript{3,5,6,15,28,36,39,51,55,61,67,70,75,95,107}.

**Etiological Factors**

Many causes\textsuperscript{4,9,12,13,16,18,22,26,45,52,54,66,67,69,71-73,78,82,89,97,98,104,106,130,111-115} have been proposed for subacromial impingement syndrome. These factors can be broadly classified as intrinsic (intratendinous) or extrinsic (extratendinous), and they can be further characterized as primary or secondary. A primary etiology — either intrinsic or extrinsic — causes the impingement process. A secondary etiology is the result of another process, such as instability or neurological injury.

To understand the etiology of subacromial impingement, it is important to understand the unique anatomical characteristics of the subacromial space. Within this space, a number of soft-tissue structures are situated between two rigid structures that move. The superior border (the roof) of the space is the coracoacromial arch, which consists of the acromion, the coracoacromial ligament, and the coracoid process. The acromioclavicular joint is directly superior and posterior to the coracoacromial ligament. The inferior border (the floor) consists of the greater tuberosity of the humerus and the superior aspect of the humeral head. The height of the space between the acromion and the humeral head ranges from 1.0 to 1.5 centimeters as seen on radiographs\textsuperscript{2}. However, interposed between these two osseous structures are the rotator cuff tendons, the long head of the biceps tendon, the bursa, and the coracoacromial ligament. Therefore, the true height of this space is considerably less than that seen on radiographs. Normally, the bursa facilitates the motion of the rotator cuff beneath the arch. Any abnormality that disturbs the relationship of these subacromial structures may lead to impingement\textsuperscript{13,104}.

**Intrinsic Factors**

**Muscle Weakness**

Nirschl\textsuperscript{10} reported that impingement occurs as a result of weakness of the muscles of the rotator cuff and that the pathological change in the supraspinatus tendon occurs primarily as a result of tension overload. When the arm is in the overhead position, eccentric contraction of the supraspinatus decelerates internal rotation and adduction of the arm, causing an overload in tension. Although this phenomenon is most dramatic in patients who swim or who participate in racquet or throwing sports, it also can occur in carpenters, mechanics, plumbers, and other manual laborers who use overhead motions in their work. Proximal migration of the humeral head has been associated with muscle fatigue, injury, and degenerative changes in the tendons\textsuperscript{9,61,111}. Jerosch et al.\textsuperscript{4} studied eight cadaveric specimens and found that muscle imbalance can cause impingement; on the basis of their findings, those authors suggested that impingement should be treated with muscle-strengthening exercises instead of acromioplasty. Wickiewicz\textsuperscript{11} studied twelve volunteers who had no history of problems in the shoulder and found radiographic evidence of proximal migration of the humeral head as the muscles became fatigued. We think that resection of the coracoacromial ligament should be avoided in this situation because it may not relieve the impingement but may allow for additional proximal migration of the humeral head.

**Overuse of the Shoulder**

Subacromial impingement also may develop as a result of inflammation and thickening of the rotator cuff tendons or the subacromial bursa. The primary cause is soft-tissue inflammation resulting from overuse of the shoulder, which increases the area occupied by the soft tissues in the subacromial space and leads to friction and wear against the coracoacromial arch\textsuperscript{5,50,106}. Inflammation also can result from a variety of systemic diseases.

The overuse syndrome, which is caused by repetitive microtrauma, is another source of intrinsic tendinitis, bursitis, and impingement\textsuperscript{5,62}. Before this diagnosis is made, it is important to rule out any extrinsic factors related to the coracoacromial arch that may be contributing to the process. The overuse syndrome commonly occurs in young competitive athletes who perform forceful repetitive tasks that involve overhead motion. The most common of these activities include throwing, racquet sports, and swimming. Minor changes in the technique that an athlete uses to perform a motion can disturb the equilibrium of the forces across the shoulder, allowing the tolerance level of the soft tissues to be exceeded and injury to occur.

**Degenerative Tendinopathy**

Ogata and Uhthoff\textsuperscript{62} showed that intrinsic degenerative tendinopathy may play an important role in impingement syndrome. In a radiographic and histological study of seventy-six cadaveric shoulders, those authors analyzed the degenerative changes that were found on the undersurface of the acromion. They suggested that tendon degeneration is the primary etiology of partial tears of the rotator cuff. These partial tears allow proximal migration of the humeral head, which results in impingement and leads to complete tears of the rotator cuff.

**Extrinsic Factors**

Hamilton\textsuperscript{46}, in 1875, identified acromial morphology as a potential source of symptoms in the shoulder and noted that the acromial epiphysis could limit motion because of its slight downward displacement. In 1909,
Goldthwait described differences in the shape and slope of the acromion. Although several operations were devised to remove various parts of the acromion, it was not until 1972 that Neer finally focused on the cause-and-effect relationship between acromial morphology and subacromial impingement. On the basis of his own clinical observations as well as the findings revealed by dissection of more than 100 cadaveric scapulae, Neer proposed that variations in the shape and slope of the anterior aspect of the acromion were responsible for subacromial impingement and associated tears of the rotator cuff. Furthermore, a spur that apparently had been caused by tensile forces on the coracoacromial ligament often was found to be protruding into the subacromial space. Eburnation with erosion of the acromion was noted in several specimens and was thought to be a later manifestation of impingement. One of us (L. U. B.) and colleagues studied 139 shoulders from seventy-one cadavers and identified three types of acromial morphology on the basis of direct observation and lateral radiographs. Twenty-four acromions (17 per cent) were type I (flat), sixty (43 per cent) were type II (curved), and fifty-five (40 per cent) were type III (hooked). A substantially higher prevalence of full-thickness tears of the rotator cuff was noted in association with type-III acromions. In another study, Morrison and one of us (L. U. B.) evaluated the supraspinatus outlet radiographs of 200 consecutive patients and found that sixty-six (80 per cent) of the eighty-two patients who had a tear of the rotator cuff as seen on an arthrogram had a type-III acromion.

Nicholson et al., in a recent study of 420 cadaveric scapulae from individuals who had been twenty-one to seventy years old at the time of death, found that acromial morphology is a primary anatomical characteristic that does not change with age. The distribution of the different acromial types remained consistent in the five different age-groups that were studied. However, the prevalence of spur formation significantly increased after fifty years of age (p < 0.05).

Whitney and Snyder modified the classification system of one of us (L. U. B.) and colleagues by addressing the thickness as well as the shape of the acromion. Acromial thickness was measured at the junction of the anterior and middle thirds of the acromion, which corresponds clinically with the area of proposed operative decompression. Three types of acromion were identified: type A (less than eight millimeters thick), type B (eight to twelve millimeters thick), and type C (more than twelve millimeters thick). This modification allows for the preoperative assessment of acromial thickness, which helps to minimize the chance of an iatrogenic acromial fracture.

Although the classification system described by one of us (L. U. B.) and colleagues has been cited widely in the literature, recent investigators have questioned its reliability. Jacobson et al. reported low interobserver reliability when the system was used to evaluate acromial morphology as seen on supraspinatus outlet radiographs and questioned the correlation between acromial morphology and tears of the rotator cuff. The classification of acromial morphology on the basis of a subacromial outlet radiograph may be difficult because of overlying bone, such as the clavicle, ribs, or scapular spine. Classification may be complicated further by the presence of thoracic kyphosis, which may cause the scapula to tilt.

Toivonen et al. recently confirmed the hypothesis, previously reported by Morrison and one of us (L. U. B.), that there is an association between type-III acromions and tears of the rotator cuff. Those authors also showed that magnetic resonance imaging offered no additional benefit over a properly made supraspinatus outlet radiograph in the determination of acromial shape.

Aoki et al. studied 130 cadaveric shoulders and found that acromions with spur formation had a flatter slope and were associated with increased pitting on the surface of the greater tuberosity. They also showed that the prevalence of spurs in the subacromial space increased with advancing age and noted a decreased alpha angle in patients who had impingement. They defined the alpha angle as the angle formed by the intersection of a line connecting the superior and inferior aspects of the acromion and a line connecting the inferior aspect of the acromion and the coracoid process. The spine of the scapula, which is another variable that affects impingement, is taken into consideration when measuring the alpha angle. Acromial slope and length also were studied by Edelson and Taitz, who found that the more horizontal the acromion is, the greater the degenerative changes are. Those authors also noted that increased degenerative changes were associated with increased length of the acromion.

Rockwood and Lyons emphasized the importance of the anterior prominence of the acromion in impingement syndrome. In the years preceding that study, a number of patients who had had a poor result after a standard Neer acromioplasty were managed with a revision procedure. At the time of the revision, it was noted that the anterior aspect of the acromion remained and extended beyond the anterior edge of the clavicle. During flexion of the arm, the rotator cuff and the subacromial bursa impinged on the remaining anterior aspect of the acromion. In response to this observation, the authors developed a two-step acromionectomy that involves, first, the resection of the anterior aspect of the acromion at the level of the clavicle and, second, the removal of bone from the inferior aspect of the acromion. The findings of Zuckerman et al. support the theory that the anterior projection of the acromion is an important factor in the production of tears in the rotator cuff. In an anatomical study of 140 cadaveric shoulders, those authors found that the supraspinatus outlet was 22.5 per cent smaller, and the anterior projection of the
Acromion was substantially larger, in the cadavera that had such a tear.

**Glenohumeral Instability**

When managing young competitive athletes who have symptoms of impingement, it is imperative to rule out underlying glenohumeral instability as the primary source of the problem. Subtle glenohumeral subluxation may cause an adjustment in the mechanics of the overhead motion, which may lead to secondary impingement. Some investigators have stressed that this concept may explain why certain throwing athletes do not show improvement after an anterior acromioplasty. The interrelationship between instability and impingement in such patients is poorly understood. However, although these patients often have symptoms of impingement, the underlying instability needs to be treated either with an exercise program designed to strengthen the dynamic stabilizers or with operative intervention if the exercise program fails.

**Degeneration of the Acromioclavicular Joint**

Neer proposed that degeneration of the acromioclavicular joint may contribute to subacromial impingement, and a number of other authors have supported this hypothesis. Osteophytes that protrude inferiorly from the undersurface of a degenerative acromioclavicular joint can contribute to impingement when the cuff passes beneath the joint. In 1977, Kessel and Watson brought additional attention to the acromioclavicular joint as a cause of subacromial impingement. They found that patients who had so-called painful arc syndrome could be divided into three categories. Approximately two-thirds of the ninety-seven patients in the study had lesions of either the posterior or the anterior aspect of the rotator cuff. All of these patients had resolution of the symptoms after subacromial injection of a local anesthetic and a steroid or division of the cuff. Soslowsky et al. recently showed, in a rat model, that the healing process was slowed dramatically when both intrinsic and extrinsic factors were present. Rats that had either an intrinsic injury alone or an extrinsic injury alone showed better healing after twelve weeks than did rats that had both types of injury.

**Coracoid Impingement**

Coracoid impingement along the more medial aspect of the coracoacromial arch is less common, but it has been reported. Goldthwait, in 1909, apparently was the first to suggest coracoid impingement as a source of pain in the shoulder. It remains unclear whether coracoid impingement should be considered as a separate entity or as a more medial component of subacromial impingement syndrome. However, it is important to differentiate these entities clinically because the treatment differs. In patients who have coracoid impingement, the pain usually is located on the anteromedial aspect of the shoulder and is referred to the arm and the forearm. Pain can be elicited by forward elevation and internal rotation. In addition, there may be an abnormal relationship between the coracoacromial ligament and the undersurface of the acromion.
coracoid process and the lesser tuberosity.

In a recent study, Friedman et al. used cine magnetic resonance imaging to measure the interval between the coracoid process and the lesser tuberosity in seventy-five patients who had clinical signs and symptoms of coracoid impingement as well as in fifty normal individuals who served as controls. In the control group, the average interval between the coracoid process and the lesser tuberosity was eleven millimeters. In all seventy-five symptomatic patients, the interval measured six millimeters or less. That study was a preliminary report on the imaging technique, and no clinical data were provided with regard to treatment or outcome.

It is important to realize that coracoid impingement can be iatrogenic. This complication may develop after an osteotomy of the coracoid for the treatment of anterior glenohumeral instability or an osteotomy of the glenoid neck for the treatment of posterior instability. Folliasson reported that coracoacromial clearance decreases with forward elevation and internal rotation of the shoulder.

**Os Acromiale**

Os acromiale is an unfused distal acromial epiphysis and was first described, in 1863, by Gruber. Folliasson classified the lesion into four distinct types on the basis of its anatomical location, with the mesoacromion being the most common type. The prevalence of os acromiale, as reported in both radiographic and anatomical studies, has varied a great deal, with a range of 1 to 15 per cent. It is difficult to detect an os acromiale on a routine anteroposterior radiograph; thus, an axillary radiograph may be needed. Impingement may occur because the unfused epiphysis on the anterior aspect of the acromion may be hypermobile and may tilt anteriorly as a result of its attachment to the coracoacromial ligament. An association between os acromiale and impingement syndrome has been reported in at least two clinical studies.

**Impingement on the Posterosuperior Aspect of the Glenoid**

Recently, investigators have described another form of impingement seen in athletes who engage in overhead activities. When the arm is placed in the throwing position (extension, abduction, and external rotation), the rotator cuff is impinged on the posterosuperior edge of the glenoid. None of the patients in the studies cited had evidence of anterior instability, and the only abnormal finding at arthroscopy was impingement on the posterosuperior aspect of the glenoid. Although this impingement is probably physiological, it becomes pathological in these athletes because of the repetitive nature of the overhead activities and the potential for increased contact secondary to fatigue of the muscles of the rotator cuff. Jobe recently reported on eleven patients (including six non-athletes) who were diagnosed with impingement of the rotator cuff on the posterosuperior aspect of the glenoid. He suggested that anterior instability may contribute to impingement syndrome in patients who have more severe involvement, especially athletes who engage in overhead activities.

**Biomechanical Considerations**

A number of studies have been performed to investigate the biomechanical factors related to subacromial impingement. Nasca et al. used anatomical specimens to investigate the contact areas of the subacromial joint; however, the use of such specimens did not allow for direct clinical correlation. Wuelker et al., with use of dynamic models of the shoulder, found that peak forces under the acromion occurred between 85 and 136 degrees of elevation. This range closely corresponds with the so-called painful arc sign (pain that occurs at intermediate levels of elevation and recedes when maximum elevation is achieved). Flatow et al., with use of stereophotogrammetric analysis, demonstrated that the main area of increased contact is the anteroinferior part of the acromion. This finding lends support to the original recommendation of Neer with regard to the use of anterior acromioplasty for the treatment of impingement. Zuckerman et al., with use of three-dimensional computer-modeling, showed that the volume of the subacromial space was decreased when the anterior aspect of the acromion was more prominent.

**Evaluation and Diagnosis**

**Diagnosis**

Subacromial impingement syndrome is a common diagnosis, but it is probably overdiagnosed as the primary etiology of pain in the anterosuperior part of the shoulder. Therefore, it is imperative to make an accurate diagnosis. However, this may be difficult because the anatomy and function of the shoulder are complex and the clinical presentation may be highly variable.

**History**

The history of the patient is an integral component in the accurate diagnosis of subacromial impingement syndrome. Pain is the most common symptom. Weakness and stiffness of the shoulder also may be elicited, but those symptoms are usually secondary to pain. When the pain is eliminated, the weakness and stiffness should resolve. If the weakness persists, the patient should be evaluated for a tear of the rotator cuff or a neurological problem secondary to cervical radiculitis or entrapment of the suprascapular nerve. If the stiffness persists, the patient should be evaluated for conditions that may be associated with a frozen shoulder, such as adhesive capsulitis, inflammatory arthritis, and calcific tendinitis. A complete history is essential in order to identify any predisposing factors, such as participation in sports or work-related activities that involve overhead motion. In addition, qualification of
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the characteristics of the pain can be quite helpful. It is important to establish the position of maximum pain, the quality of the pain (dull or severe), the timing of the pain (during the day or at night), and the association between pain and activity (that is, the presence or absence of pain during rest and during movement). The duration of symptoms also should be documented. Most symptoms of impingement begin insidiously and have a chronic component that progresses gradually during a period of several months. However, acute traumatic bursitis may not completely resolve and may develop into an impingement lesion. Therefore, the patient may recall a specific event that precipitated the symptoms. Finally, it is important to document all interventional modalities, including changes in lifestyle, physical therapy regimens, non-steroidal anti-inflammatory medications, subacromial injections, and operative procedures on the shoulder. Impingement syndrome is more common in patients who are more than forty years old, and a thorough history often is quite helpful in confirming the diagnosis. In patients who are less than forty years old, however, the diagnosis of impingement syndrome must be made with caution because these patients may have subtle glenohumeral instability. These two processes cannot be differentiated on the basis of an accurate history alone.

Physical Examination

The physical examination should help to clarify the initial diagnosis that is made on the basis of the history. A careful examination of the neck should be performed to rule out abnormalities of the cervical spine, such as radiculitis and degenerative disease, that may cause symptoms in the shoulder. Subacromial impingement and cervical radiculitis may exist concomitantly, and therefore it is important to document both abnormalities. After the shoulder has been inspected and palpated and the muscle strength as well as the range of motion have been assessed, several specific tests may be helpful in making the diagnosis of impingement syndrome. The impingement sign, as described by Neer, is elicited by standing behind the patient and passively elevating the arm in the scapular plane while stabilizing the scapula. Pain usually is elicited in the arc between 70 and 120 degrees. Flatow et al. reported that the acromiohumeral distance is decreased substantially in this range of motion as the greater tuberosity passes under the acromion. This distance is diminished further by internal rotation of the humerus, spur formation, or the presence of a type-III acromion. Therefore, it may be difficult to elicit the impingement sign in a patient who has a stiff shoulder that is unable to pass through this range of motion. Hawkins and Kennedy modified the maneuver by forcibly internally rotating the arm after passively elevating the arm to 90 degrees. A recent study of cadavers showed this modified maneuver to be a more specific test for the identification of impingement under the coracoacromial arch.

The impingement test, as described by Neer, can be a useful adjunct in the diagnosis of impingement. After sterile injection of ten milliliters of Xylocaine (lidocaine) into the subacromial space, the test for the impingement sign is repeated. When the abnormality is confined to the subacromial space, the injection eliminates the pain in most patients. Abnormalities of the acromioclavicular joint should be identified by direct palpation of the joint, internal rotation of the extended arm, and adduction of the arm across the chest. However, these maneuvers also may cause impingement in the subacromial space and therefore may not be specific for the identification of abnormalities of the acromioclavicular joint. Selective injections into both the acromioclavicular joint and the subacromial bursa are helpful in identifying the source of symptoms. It is also important to evaluate the patient for a rupture of the long head of the biceps tendon, which occurs secondary to an impingement lesion. This tendon may rupture at the superior aspect of the bicipital groove, just adjacent to the insertion of the supraspinatus tendon. Therefore, all patients who have a rupture of the long head of the biceps tendon and pain in the proximal part of the shoulder should be evaluated for an impingement lesion and a possible tear of the rotator cuff.

The difficulty of making the diagnosis in younger patients who have signs and symptoms of impingement syndrome has been reported by many investigators. These patients may have secondary impingement due to subtle glenohumeral instability. Therefore, the apprehension test and the relocation test described by Jobe et al. also should be performed when examining such patients. The apprehension test is performed first. With the patient in the supine position and the involved shoulder in 90 degrees of abduction, the arm is externally rotated beyond 90 degrees. The test is positive when the patient is apprehensive as the humeral head begins to subluxate anteriorly. The relocation test then is performed by directing a posterior force on the proximal aspect of the humerus, thereby relieving the sensation of apprehension.

Radiographic Evaluation

Routine radiographs are extremely helpful in making the diagnosis of subacromial impingement. Anteroposterior radiographs may show subchondral cysts or sclerosis of the greater tuberosity with corresponding areas of sclerosis or spur formation on the anterior edge of the acromion. In addition, anteroposterior radiographs may help in identifying other abnormalities, such as osteoarthrosis of the acromioclavicular joint, calcific tendinitis, evidence of glenohumeral instability (an osseous Bankart lesion or a Hill-Sachs lesion), and osteoarthrosis of the glenohumeral joint. An axillary radiograph may be needed to diagnose an unfused acromial epiphysis. The subacromial space, however, is not well...
visualized on anteroposterior radiographs because of the superimposition of the scapular spine and body. As a result, a number of specialized radiographs have been developed. Neer and Poppen, in 1987, described the supraspinatus outlet radiograph, which is a lateral radiograph that is made in the plane of the scapula with the x-ray beam directed 10 degrees caudally. Morrison and one of us (L. U. B.) used this radiograph to confirm the findings of an earlier study on cadavers in which type-II or type-III acromions were found to be associated with abnormalities of the rotator cuff. The supraspinatus outlet radiograph is widely used in the diagnosis of subacromial impingement. However, the findings may be difficult to reproduce consistently because of thoracic kyphosis or superimposition of adjacent osseous structures such as the clavicle, ribs, or scapular body.

Ono et al. described a 30-degree caudal tilt anteroposterior radiograph that demonstrates the anteroinferior projection of the acromion. Andrews et al., in 1991, suggested the use of a profile radiograph to facilitate evaluation of the lateral aspect of the acromion. Special radiographs may be necessary in order to evaluate the acromioclavicular joint properly. As the setting that is used to make routine anteroposterior radiographs results in overpenetration of this joint, the number of kilovolts should be reduced by one-third. Also, an anteroposterior radiograph made with 10 degrees of cephalic tilt facilitates the evaluation of inferiorly protruding osteophytes. Finally, a silicone pillow is used at our institution for additional delineation of the acromioclavicular joint when making routine radiographs.

Other Imaging Modalities

If the history, physical examination, and radiographs are consistent with subacromial impingement syndrome and an intact rotator cuff, additional imaging studies may not be needed. However, if a tear of the rotator cuff is suspected, additional imaging studies may be indicated. Recent studies have shown that ultrasound may be useful in identifying moderate or large full-thickness tears. However, ultrasound is less helpful in diagnosing small tears and its overall accuracy in delineating lesions of the rotator cuff is less than that of other modalities. Magnetic resonance imaging of the shoulder has gained popularity during the last decade. The use of magnetic resonance imaging has increased the ability to diagnose partial tears and small full-thickness tears, although it remains difficult to differentiate these lesions from rotator cuff tendinitis. Magnetic resonance imaging is also helpful in evaluating the acromioclavicular joint, fused acromial epiphysis, and lateral acromial morphology. Finally, arthroscopy may be useful for the evaluation of the rotator cuff and the glenohumeral joint because it allows for direct visualization. However, arthroscopy is an invasive, operative procedure. If a patient is having an arthroscopic decompression, the rotator cuff and the glenohumeral joint can be evaluated at that time and the operative procedure can be modified accordingly.

Treatment Options

Non-Operative Treatment

Our review of the literature indicated that most patients who have impingement syndrome eventually recover with non-operative intervention. The most common interventional modalities include modification of activity, the use of non-steroidal anti-inflammatory medications, subacromial injections of steroids, and physical therapy programs. Morrison et al. recently reported the results of non-operative treatment in a study of 616 patients who had isolated subacromial impingement syndrome. All of the patients were managed with non-steroidal anti-inflammatory drugs and a specific physical therapy regimen that included isometric and isotonic muscle-strengthening exercises. The patients were followed for an average of twenty-seven months. Four hundred and thirteen patients (67 per cent) had a satisfactory result, 172 patients (28 per cent) had an unsatisfactory result and were managed with decompression, and thirty-one patients (5 per cent) had an unsatisfactory result but declined operative intervention. Patients who had a type-I acromion were more likely to have a satisfactory result than those who had a type-II or type-III acromion.

The duration of non-operative treatment has varied widely in the literature, but it has ranged from twelve to eighteen months in several studies. The use of newer arthroscopic procedures to decompress the subacromial space has decreased the morbidity associated with operative treatment, suggesting that a shorter period of non-operative treatment may be appropriate before operative intervention is attempted. As this issue has not been investigated in controlled clinical trials, it is impossible to make any scientifically based recommendations. The duration of non-operative treatment is a clinical decision that should be based on the specific set of circumstances associated with the individual patient. However, on the basis of the findings of most reports, a minimum six-month trial of non-operative intervention seems to be justified.

Operative Treatment

If non-operative treatment fails to reduce symptoms, operative intervention may be indicated. Anterior acromioplasty with resection of the coracoacromial ligament is the preferred treatment. Removal of the lateral portion of the acromion is unnecessary and has been associated with complications and unsatisfactory results. Resection of the acromioclavicular joint is not routinely performed as part of a subacromial decompression and is indicated only when the joint is tender or when inferiorly protruding excrescences or osteophytes are contributing to the impingement. Currently, anterior acromioplasty can be performed with use of either the...
Traditional open technique described by Neer\textsuperscript{14} or the arthroscopic method described by Ellman\textsuperscript{29}.

The results of open acromioplasty are difficult to interpret, partly because the criteria for publication had not been carefully delineated at the time that many of the earlier studies were conducted. Consequently, direct comparisons among earlier reports or between early reports and more recent reports involving arthroscopic techniques are virtually impossible. In our review of the literature, we took into account the shortcomings of previous reports and attempted to draw conclusions on the basis of an overview of the results.

**Open Acromioplasty**

Open anterior acromioplasty was first described by Neer\textsuperscript{14}, in 1972. In that study, the result was considered to be satisfactory if the patient was satisfied with the operation, had no pain, and had less than 20 degrees of limitation of overhead elevation and at least 75 per cent of normal strength. Symptoms had to persist for a minimum of nine months, despite appropriate non-operative therapy, before operative treatment was attempted. Fifteen patients had a satisfactory result, and one had an unsatisfactory result. The patient who had an unsatisfactory result had concomitant acromioclavicular osteoarthrosis, which was not addressed at the time of the index procedure. The duration of follow-up was not noted.

A number of other investigators have reported a high percentage of satisfactory results in association with anterior acromioplasty. Ha’eri and Wiley\textsuperscript{40} reported that nineteen (90 per cent) of twenty-one patients were satisfied with the result of the procedure at the one-year follow-up examination, but those authors did not indicate the specific criteria for postoperative evaluation or document the preoperative symptoms. Post and Cohen\textsuperscript{40} reported the results of anterior acromioplasty in a study of seventy-two patients who had been followed for an average of twenty-three months (range, five to forty-eight months). Sixty-four patients (89 per cent) had postoperative relief of pain. Strength and range of motion also were modestly improved postoperatively. However, no standardized system of evaluation was used to assess the results. In the study by Hawkins et al.\textsuperscript{101}, 108 patients had an anterior acromioplasty for the treatment of chronic impingement without a tear of the rotator cuff. The average duration of symptoms before operative intervention was eighteen months (minimum, twelve months), and the average duration of follow-up was five years (range, two to eight years). According to the criteria described by Neer\textsuperscript{14}, ninety-four patients (87 per cent) had a satisfactory result. Although statistical analyses were not reported, the patients who were receiving Workers’ Compensation had a higher percentage of unsatisfactory results. This was one of several reports to suggest that outcome may be related to Workers’ Compensation status or pending litigation\textsuperscript{19,30}.

In the study by Daluga and Dobozi\textsuperscript{21}, forty-eight patients (fifty shoulders) who had stage-II or stage-III impingement were managed with an open anterior acromioplasty. Thirteen shoulders had a concomitant resection of the distal aspect of the clavicle in addition to the acromioplasty. The average duration of follow-up was forty-five months (range, fourteen to eighty-four months). Seventeen of the eighteen shoulders that had an isolated anterior acromioplasty had an excellent or good result. Resection of the distal aspect of the clavicle did not appear to have a negative impact on the outcome, as all thirteen patients in that group had an excellent or good result. That study was perhaps the first to demonstrate that full recovery can be quite lengthy; the patients returned to work after an average of eight months.

Frieman and Fenlin\textsuperscript{46} recently reported the results of open anterior acromioplasty in a study of seventy-four patients (seventy-five shoulders). The average duration of follow-up was seventeen months (range, twelve to forty-eight months). An excellent or good result was reported for seventy-two patients (97 per cent), including thirty-five (97 per cent) of the thirty-six patients who had filed a Workers’ Compensation claim, twenty-nine (95 per cent) of the twenty-one patients who had litigation pending, and all seventeen patients who had no apparent or potential financial gain associated with the impingement syndrome. However, patients who had filed a Workers’ Compensation claim took longer to return to work. The longer time needed for rehabilitation often was due to the heavy labor that these patients performed and not just to the potential for secondary gain as has been suggested in other reports\textsuperscript{15,30}.

A higher percentage of unsatisfactory results has been reported in several other studies\textsuperscript{40,96,102}. Thorling et al.\textsuperscript{102} reported on fifty-one patients who had an open anterior acromioplasty for the treatment of impingement syndrome. The average duration of follow-up was twenty months (range, six to forty-two months). Thirty-nine patients (76 per cent) were satisfied with the result. Eleven patients who had a tear of the rotator cuff also were included in that study and, of these, only seven had a satisfactory result. On the basis of this finding, the authors concluded that the prognosis is worse for patients who have a concomitant resection of the acromioclavicular joint. This tendency was not reported in another study\textsuperscript{11} in which resection of the acromioclavicular joint had been performed.

Sahlstrand\textsuperscript{46} reported the results of open anterior acromioplasty in a study of fifty-two consecutive patients who had impingement syndrome. The average duration of follow-up was only eleven months (range, six to twenty-four months). Thirty-five patients (95 per cent) of the twenty-one patients who had file a Workers’ Compensation claim, twenty-nine (95 per cent) of the twenty-one patients who had litigation pending, and all seventeen patients who had no apparent or potential financial gain associated with the impingement syndrome. However, patients who had filed a Workers’ Compensation claim took longer to return to work. The longer time needed for rehabilitation often was due to the heavy labor that these patients performed and not just to the potential for secondary gain as has been suggested in other reports\textsuperscript{15,30}.

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study of fifty-six patients (sixty shoulders) who had been followed for an average of forty-eight months (range, twenty-four to ninety-six months). Forty-one patients (73 per cent) had an excellent or satisfactory result, according to the functional assessment of Neer. As specific categorization of the patients was not provided, further analysis of the results was not possible.

In 1982, Neviaser et al.93 described the so-called four-in-one arthroplasty and reported the results of the procedure for eighty-nine patients who had been followed for two to eight years. The procedure consists of the anterior acromioplasty described by Neer,1 excision of the coracoacromial ligament, acromioclavicular arthroplasty, and biceps tenodesis. All patients had relief of pain; however, the study had few objective criteria, and patient satisfaction, function, and strength of the involved extremity were not assessed. Biceps tenodesis has not been advocated routinely. Instead, it has been reserved for shoulders in which the tendon has dislocated or has more than 50 per cent attenuation. Resection of the acromioclavicular joint also has not been advocated routinely and usually is indicated only for symptomatic patients. In the study by Rockwood and Lyons,37 thirty-seven patients who had chronic subacromial impingement syndrome and an intact rotator cuff had a modified two-step acromioplasty. In this procedure, the anterior part of the acromion is resected to the level of the clavicle and then the undersurface of the acromion is removed. The procedure shortens the acromion and necessitates the use of bone sutures in the anterior aspect of the acromion to ensure secure reattachment of the anterior aspect of the deltoid. After an average duration of follow-up of nearly four years (minimum, two years), thirty-three (89 per cent) of the thirty-seven patients had an excellent or good result, according to a modification of the system described by Neer.

The impingement syndrome in athletes has been associated with both diagnostic and treatment dilemmas. Tibone et al.105 reported the results of anterior acromioplasty in a study of thirty-three athletes (thirty-five shoulders) who were less than forty years old. The average duration of follow-up was thirty-seven months. Although twenty-four patients (73 per cent) were satisfied with the result, twenty-five (76 per cent) still had difficulty throwing overhead. The result was considered to be excellent or good for only fourteen patients (42 per cent) overall. The outcome was even worse for the athletes who were involved in pitching or throwing; only four of eighteen such patients had an excellent or good result. In that retrospective study, the result of the apprehension test was not documented, which made it difficult to determine if glenohumeral instability had contributed to the symptoms. Subsequent studies have shown that, in patients who are less than forty years old, the symptoms of impingement syndrome may be secondary to subtle glenohumeral instability; thus, acromioplasty may prove to be unsuccessful because it does not address the primary abnormality.

The poor results reported by Tibone et al.105 were not reproduced in a study by one of us (L. U. B.) and colleagues11, who retrospectively reviewed the cases of twenty-six patients who were less than forty years old and had an anterior acromioplasty for the treatment of subacromial impingement syndrome. None of the patients, however, were high-performance athletes, and only ten participated in recreational sports. The average duration of follow-up was thirty-three months (range, twelve to eighty months). Twenty-five patients (96 per cent) reported subjective improvement after the procedure. Twenty-one patients (81 per cent) had a satisfactory result (ten had an excellent result and eleven, a good result) and were able to return to the preinjury level of employment or participation in sports. Seven of the ten recreational athletes had a satisfactory result.

**Complications of open acromioplasty**

The rate of complications after open acromioplasty is predictably quite low. Reported complications have included acromial fracture, persistent pain, postoperative glenohumeral stiffness, lengthy rehabilitation, delayed return to work, weakness, superficial or deep wound infection, detachment of the deltoid, and dysfunction. McShane et al., in a study of twenty-nine patients who had an acromioplasty for the treatment of impingement syndrome, reported a high percentage of complications (including acromial fracture and prolonged convalescence) after procedures involving detachment of the deltoid. Most of the problems were related to technical errors. Ogilvie-Harris et al. evaluated sixty-seven shoulders in fifty-six patients who had had persistent pain for more than two years after an open anterior acromioplasty. Although the total number of acromioplasties performed at their institution was not documented, twenty-one of the failed acromioplasties had been performed by the authors and the other forty-six had been performed elsewhere. All patients had a thorough examination to determine the reason for failure. Arthroscopy revealed that the original diagnosis had been incorrect for twenty-seven shoulders (40 per cent), that an error had been made during the operation on twenty-eight shoulders (42 per cent), and that only twelve shoulders (18 per cent) had had the correct diagnosis and procedure. Even after the appropriate procedure had been performed, however, only thirty-one (60 per cent) of fifty-two shoulders that had a reoperation had a good result. No explanation was provided for this disappointing finding.

**Arthroscopic Subacromial Decompression**

Arthroscopic subacromial decompression was first described as an alternative to open acromioplasty in 1987 by Ellman.28 Since its introduction, there has been a proliferation of reports on the use of this technique for the treatment of subacromial impingement; overall, more than 700 arthroscopic acromioplasties have been performed for this purpose. Most
of the results have been found to be satisfactory.

Ellman reported the results for forty-nine patients who had been followed for at least one year after arthroscopic subacromial decompression. However, ten of those patients had a full-thickness tear of the rotator cuff. The average duration of preoperative symptoms was twenty-nine months (range, six to sixty months), and the average duration of follow-up was seventeen months (range, twelve to thirty-six months). Overall, forty-three patients (88 per cent) had a satisfactory result; specifically, twenty-one patients had an excellent result and twenty-two had a good result. Range of motion, function, and ability to participate in sports improved postoperatively in most patients. Six patients had an unsatisfactory result. Two of these patients had had a previous open acromioplasty and continued to have pain after arthroscopic subacromial decompression, two subsequently had an open acromioplasty that led to a satisfactory result, and two had either a large or a massive tear of the rotator cuff.

Although Ellman introduced the technique of arthroscopic subacromial decompression, Gartsman et al. performed the first anatomical study to compare this technique with open acromioplasty. Arthroscopic subacromial decompression was performed on seven fresh cadaveric specimens, and open acromioplasty was done on seven others. Several points on the acromion then were measured, and the findings were compared with the recommendations of Neer regarding proper open acromioplasty. The results of this study suggested that arthroscopic subacromial decompression is at least as good as the open technique for the treatment of impingement.

Gartsman later reported the results of arthroscopic subacromial decompression in a clinical study of 126 patients (129 shoulders) who had stage-II impingement. In that report, Gartsman further classified stage-II impingement on the basis of the severity of the lesion. Stage-IIa impingement is equivalent to stage-II impingement as originally described by Neer; that is, it represents milder lesions that are characterized by fibrosis and inflammation without any evidence of a rotator cuff tear. Stage-IIb impingement is characterized by more severe lesions, including partial-thickness tears but not full-thickness tears. Eighty-six patients (eighty-nine shoulders) had no tear of the rotator cuff (group 1), and forty patients (forty shoulders) had a partial-thickness tear (group 2). The average duration of follow-up was twenty-nine months (range, twenty-four to forty-eight months). Seventy-five (87 per cent) of the patients in group 1 had a satisfactory result according to the rating system of the American Shoulder and Elbow Surgeons. The procedure failed in the other eleven patients in that group; eight failures were due to a technical problem, two were due to an incorrect diagnosis, and one could not be explained. Both of the patients who had an incorrect diagnosis were less than forty years old and were thought to have symptomatic instability. In group 2, thirty-three patients (83 per cent) had a satisfactory result. In both groups, the only factor that appeared to be associated with the failure of treatment was the patient's Workers' Compensation status: seven of the eleven failures in group 1 and four of the seven failures in group 2 were in patients who were receiving Workers' Compensation. Gartsman stressed that the indications for arthroscopic subacromial decompression were identical to those for open acromioplasty and emphasized that they should not be made less stringent simply because arthroscopic decompression is a less extensive procedure.

Esch et al. reported the results of arthroscopic subacromial decompression for seventy-one patients who had been followed for an average of nineteen months (range, twelve to thirty-six months). The preoperative duration of symptoms was not specifically documented, but one indication for the procedure was pain for more than six months. Overall, fifty-five patients (77 per cent) had an excellent or good result, and sixty (85 per cent) patients were satisfied with the outcome of the procedure. The type and duration of non-operative treatment, the number of subacromial injections, and the findings on physical examination were not specifically documented. Twenty-eight of the seventy-one patients were less than forty years old, which raises the possible diagnostic dilemma of differentiating between impingement syndrome and instability, as already described.

Paulos and Franklin reported on sixty-six patients who had arthroscopic acromioplasty after six months of unsuccessful non-operative treatment. The average duration of follow-up was thirty-two months (range, twelve to fifty-four months). No standardized form of evaluation was used. Fifty-seven patients (86 per cent) were satisfied with the outcome of the procedure. However, fourteen patients (21 per cent) continued to have pain at night. Altchek et al. reviewed the cases of thirty patients with stage-II impingement who had arthroscopic acromioplasty after at least six months of unsuccessful non-operative treatment. Twenty-four patients had no tear of the rotator cuff (stage-IIa impingement), and six patients had a partial-thickness tear (stage-IIb impingement). The average duration of symptoms before the arthroscopy was twenty-eight months (range, six to 120 months), and the average duration of follow-up was seventeen months (range, twelve to thirty-six months). Twenty of the twenty-four patients who had no tear of the rotator cuff had a good or excellent result, compared with only four of the six patients who had a partial-thickness tear.

Ryu retrospectively reviewed the cases of fifty-three patients who had been managed with arthroscopic acromioplasty. All of the patients had had six months of unsuccessful non-operative treatment. The average duration of follow-up after the operation was twenty-three months (range, twelve to fifty months). An excellent or good result was reported for forty-two patients (79 per cent) overall, including six of the seven patients who
had a normal or slightly irritated rotator cuff, thirty of the thirty-five patients who had a partial tear of the cuff, and six of the eleven patients who had a complete tear of the cuff. A small subgroup of patients, however, had a partial tear of the undersurface of the rotator cuff, which was thought to be secondary to subtle instability. This finding illustrates the difficulty in making the diagnosis of impingement, as the author deliberately attempted to exclude patients who had glenohumeral instability on preoperative physical examination.

Adolfsson and Lysholm\textsuperscript{1} reported on seventy-nine patients who were managed with arthroscopic acromioplasty for the treatment of subacromial impingement syndrome. All patients had instability testing and diagnostic arthroscopy. The rating scale that was used to evaluate the results was heavily weighted toward postoperative pain. The average duration of follow-up was only seventeen months (range, nine to twenty-four months). Fifty-three patients (67 per cent) had an excellent or good result according to these stringent criteria. The findings of that study cannot be compared with those of any of the other arthroscopic studies, most of which involved the use of the rating scale of the University of California at Los Angeles\textsuperscript{9}. In a study by Schneider et al.\textsuperscript{8}, fifty-two patients who had stage-I or stage-II impingement syndrome had arthroscopic acromioplasty after at least six months of unsuccessful non-operative treatment. The patients were followed for only one year. In addition, all patients had ultrasonography postoperatively to document the extent of passive inferior shift of the humeral head. Forty patients (77 per cent) had a satisfactory result. The twelve patients who had an unsatisfactory result had a significant increase in passive inferior shift of the humeral head (p < 0.001). However, as no preoperative physical examination or ultrasonography had been performed for these patients, it was difficult to interpret these data. Despite these shortcomings, however, the findings of this study support the theory of Jobe et al.\textsuperscript{6} that glenohumeral instability causes secondary impingement.

Olsewski and Depew\textsuperscript{86} reported the results of arthroscopic acromioplasty for forty-eight patients who had stage-II impingement syndrome. Twenty-seven patients had no tear of the rotator cuff (stage-IIa impingement), and twenty-one patients had a partial-thickness tear (stage-IIb impingement). All patients were managed non-operatively for a minimum of six months before the operation, and all were followed for at least two years. Twenty-two (81 per cent) of the twenty-seven patients who had no tear of the rotator cuff had a satisfactory result. The five patients in that group who had an unsatisfactory result were involved in Workers’ Compensation claims. Seventeen (81 per cent) of the twenty-one patients who had a partial-thickness tear also had a satisfactory result. This study is important because it showed that the results for patients who had a partial-thickness tear were comparable with those for patients who had no tear. Many arthroscopic studies have suggested that patients who have a partial-thickness tear have clinical symptoms that are more similar to those of patients who have a full-thickness tear (stage-III impingement) than to those of patients who have no tear (stage-IIa impingement)\textsuperscript{93,94,95}.

Royle et al.\textsuperscript{93} recently reported the results of arthroscopic acromioplasty for eighty-eight patients (ninety shoulders) who had stage-II impingement syndrome. The average duration of follow-up was forty-one months (range, twenty-four to eighty-two months). Forty-six patients (forty-seven shoulders) had no tear of the rotator cuff (stage-IIa impingement), and forty-two patients (forty-three shoulders) had a partial-thickness tear (stage-IIb impingement). The result was rated as satisfactory for seventy-two shoulders (80 per cent). No difference was found between the patients who had a tear of the rotator cuff and those who did not. A satisfactory result was reported for only twenty-three (68 per cent) of the thirty-four throwing athletes compared with fifty (89 per cent) of the fifty-six non-throwing athletes; this difference was significant (p < 0.05). In addition, only six of the twelve baseball pitchers had a satisfactory rating. As the average age of the patients was thirty-five years, the diagnostic dilemma of differentiating between instability and impingement may have been a factor, especially for the athletes who used overhead motions. Instability testing was not performed for any of the patients before the operation.

The worst results that have been achieved to date with use of the arthroscopic technique were reported by Hawkins et al.\textsuperscript{94}. Those authors reviewed the results of 110 consecutive arthroscopic acromioplasties in patients who had been followed for at least two years. The criteria for a satisfactory result were identical to those described in their previous report of 108 patients who had been managed with open acromioplasty\textsuperscript{95}. The result was considered to be satisfactory for only fifty-one (46 per cent) of the 110 patients overall and for only fourteen (32 per cent) of the forty-four patients who were involved in a Workers’ Compensation claim. The authors could not identify any factors that may have been associated with these poor results and therefore suggested that open decompression yields superior results.

Complications of arthroscopic acromioplasty: Overall, few complications have been associated with arthroscopic acromioplasty. Perhaps the most common complication has been inadequate removal of bone necessitating a revision operation. Matthews et al.\textsuperscript{63}, however, recently reported on six patients in whom an acromial fracture developed after arthroscopic acromioplasty. This finding emphasizes the need for proper anatomical identification of the anterior aspect of the acromion before acromioplasty. Although initially there was great concern about the possibility of neurological injury resulting from traction while the patient is in the lateral decubitus position, this has not proved to be a
major problem. Many surgeons now use the beach-chair position, further reducing the risk of neurological injury during arthroscopic procedures.

Comparison of Open and Arthroscopic Acromioplasty

Norlin\textsuperscript{8}, in 1989, reported the results of a study in which arthroscopic decompression was compared with open decompression. Only twenty patients were included, and the method of randomization was not documented. The average duration of symptoms before the operation was five years for the group that had operative arthroscopy and nearly four years for the group that had an open procedure. No scoring system was used to evaluate the results, and the duration of follow-up was only three months. Therefore, it is difficult to draw conclusions from this study. The same twenty patients were reevaluated twenty-four months postoperatively in a follow-up study by Lindh and Norlin\textsuperscript{9}. Although the rating scale of the University of California at Los Angeles\textsuperscript{28} was used, the results were not specifically classified as excellent, good, fair, or poor.

In a study by Van Holsbeeck et al.\textsuperscript{28, 29}, two groups of patients were evaluated concurrently. Fifty-three patients had open decompression, and fifty-three patients had arthroscopic decompression. The patients were not randomized; the choice of the procedure was based on the preference of the surgeon. The preoperative duration of symptoms was similar for both groups and averaged twenty-six months (range, two to 168 months) overall. The average duration of follow-up was twenty-four months (minimum, one year). Both groups had a high percentage of satisfactory results. Statistical analyses were not performed on these data. Those authors also found that associated abnormalities, such as acromioclavicular osteoarthrosis, adhesive capsulitis, calcific tendinitis, and small tears of the rotator cuff, did not influence the result.

Sachs et al.\textsuperscript{29} reported the results of their well controlled, prospective, randomized clinical trial in which twenty-two patients who had open acromioplasty were compared with nineteen patients who had arthroscopic acromioplasty. All patients had stage-II impingement, and all had had a minimum of six months of nonoperative treatment before the operation. No arthroscopic data were provided, which made it impossible to subclassify the impingement on the basis of the presence or absence of a tear of the rotator cuff. The patients were evaluated at two, six, twelve, twenty-six, and fifty-two weeks postoperatively. Various parameters, including patient satisfaction, pain, range of motion, strength, return to activity, and duration of hospitalization, were compared; however, no specific rating scale was used. Of the twenty-two patients who had had an open acromioplasty, twenty-one had either complete or moderate improvement and one had only mild improvement. Of the nineteen patients who had had an arthroscopic acromioplasty, seventeen had either complete or moderate improvement, one had only mild improvement, and one had worsening. The evaluation of satisfaction was not well described, and it is unclear what criteria were used to distinguish moderate improvement from mild improvement. Although patients who had been managed with an open procedure used narcotic medications for a slightly longer period of time initially, the treatment of pain was similar in both groups by two weeks after the operation. No differences in range of motion were observed from three months postoperatively to the completion of the study, although the patients who had been managed arthroscopically had an earlier return to normal function. No substantial differences in strength or return to activity were noted at the one-year evaluation. The patients who had the open procedure had a longer duration of hospitalization because the patients who had the arthroscopic procedure were admitted and discharged on the same day. All three patients who had an unsatisfactory result (one of whom had had the open procedure and two of whom had the arthroscopic procedure) were receiving Workers’ Compensation.

The most recent comparison of the two procedures was reported by Lazarus et al.\textsuperscript{29}, who retrospectively reviewed the results of acromioplasty in a study of sixty-eight patients (seventy shoulders). Twenty-four shoulders were treated with open acromioplasty, and forty-six were treated with arthroscopic acromioplasty. The patients were not randomized; the procedure was chosen on the basis of the preference of the surgeon. The average duration of non-operative treatment was fourteen months for the patients who had an open procedure and nine months for the patients who had an arthroscopic procedure. The minimum duration of follow-up was twelve months in both groups. The average scores for the two groups were similar, but there was a higher percentage of excellent results in the group of patients who had been managed with an open procedure (54 compared with 42 per cent) and a higher percentage of worse results in the group of patients who had been managed arthroscopically (28 compared with 17 per cent). Patients who were receiving Workers’ Compensation tended to have worse results than those who were not. An additional finding, not previously reported, was calcification within the subacromial space but not within the tendons of the rotator cuff. This calcification was not noted on preoperative radiographs, prompting the authors to theorize that it was caused by bone dust that had been produced by the arthroscopic burr. Patients who had subacromial calcification tended to have worse results than patients who did not (p = 0.06).

Overview

Subacromial impingement syndrome is a common problem that causes pain in the anterosuperior part of the shoulder. The etiology can be either extrinsic or
intrinsic. Non-operative treatment is often successful; however, if symptoms persist for more than six months, operative treatment with either open or arthroscopic acromioplasty may be indicated. Both of these procedures have been associated with a high percentage of successful results and a low rate of complications.

References
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