

Impingement Lesions

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The anatomic rationale and technique of anterior acromioplasty for chronic impingement syndromes in the shoulder were described in 1972.³ The preliminary results of this procedure in 50 shoulders were included. Further observation of the original series, as well as additional experience with more than 400 anterior acromioplasties, has confirmed the postulates in that article. Certain points made in the original report have been further emphasized in subsequent publications.⁴⁻⁷ However, there remain many areas deserving of restatement and clarification. These points are clarified, and the author's view on the nature of impingement and an approach to its diagnosis and treatment are briefly described.

NATURE OF IMPINGEMENT

Further observations in the anatomy laboratory and at surgery give additional evidence that impingement occurs against the anterior edge and undersurface of the anterior third of the acromion, the coracoacromial ligament, and, at times, the acromioclavicular joint, rather than against the lateral acromion.³ As shown in Figure 1, the position in which most upper extremity functions are performed is with the hand in front of the shoulder, not lateral to it. The position in which the shoulder is subjected to the most

use is forward, not lateral. When the arm is raised, the supraspinatus passes under the anterior edge of the acromion and the acromioclavicular joint. The critical area for wear on the humeral side is centered on the supraspinatus tendon and may involve the long head of the biceps.⁴ This concept is thought to be important in the treatment of impingement lesions, both conservative and surgical. The posterior half of the acromion is not involved in the impingement process. Therefore, lateral acromionectomy or complete acromionectomy (removing the lateral edge without detachment of the middle deltoid) is thought to weaken the deltoid unnecessarily.⁶ Anterior acromioplasty (Figs. 2A-2C) has replaced these procedures for decompression of the rotator cuff from impingement wear, and since the author believes that 95% of tears of the rotator cuff are caused by impingement, this procedure is currently performed routinely in conjunction with a repair for a torn rotator cuff. This concept is also important in diagnosis, because an understanding of the close relationship between the anterior acromion, acromioclavicular joint, subacromial bursa, rotator cuff, and long head of biceps will explain many diagnostic dilemmas. Rather than thinking of each of these structures individually, it is more accurate to appreciate that two or more may be involved together.

THREE STAGES OF IMPINGEMENT LESIONS

It is useful when interpreting clinical problems to consider impingement lesions in three progressive stages,⁷ as summarized in

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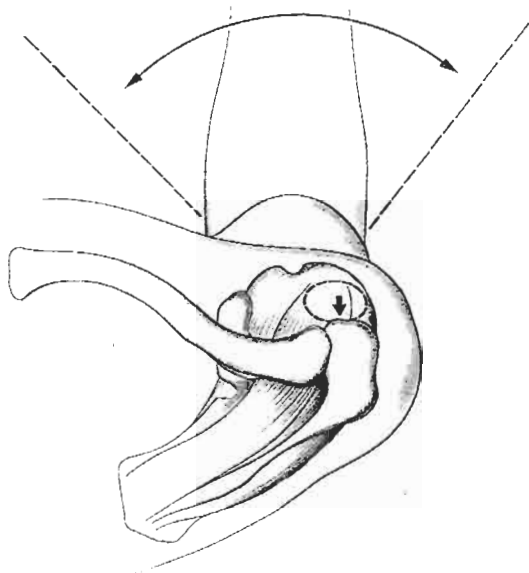
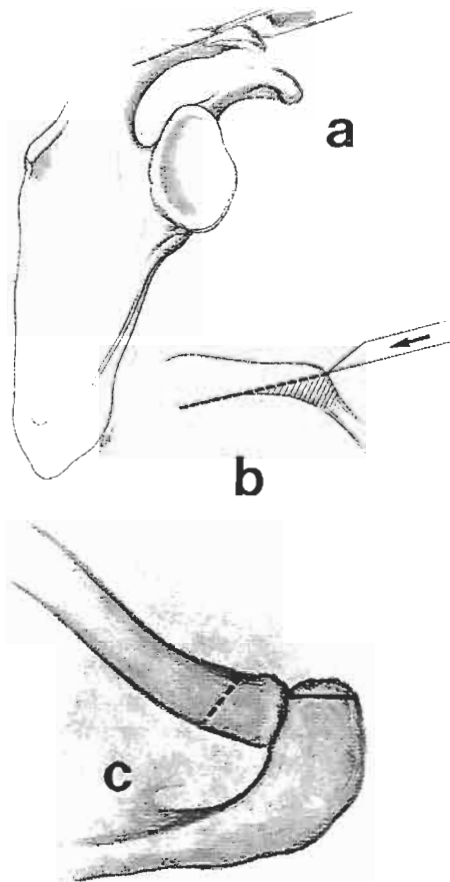


FIG. 1. Functional range. Most upper extremity activities are performed with the hand in front of the shoulder (not lateral to it). Impingement occurs against the undersurface of the anterior third of the acromion and, at times, the acromioclavicular joint, rather than laterally. Wear is centered on the supraspinatus.



FIGS. 2A-2C. The technique of anterior acromioplasty. (A) A 25.0-mm osteotome that is beveled on one side is used to remove the anterior edge and deep surface, including the attachment of the coracoacromial ligament and a traction spur if one has formed within this ligament. (B) The bevel of the blade is placed upward so that the blade is carried out of the acromion. Damage to the acromion is prevented also by having the assistant strike the osteotome with the mallet. This frees one of the surgeon's hands to palpate the superficial surface of the acromion as the other hand is used to direct the blade. The undersurface of the acromion frequently is visualized during this step. The objective is to render the undersurface flat (as shown), without overhang. (C) The full length of the acromion is preserved; only the anterior edge is removed. The acromioclavicular joint is excised when (1) it is painful and arthritic; (2) more exposure of the supraspinatus is needed; or (3) it is prominent and impinging on the supraspinatus (in which case the undersurface of the joint is usually beveled rather than completely excised).

Figure 3. The "impingement test" (Fig. 4) is useful in distinguishing these lesions from other causes of shoulder pain. The symptoms and physical signs in all three stages of impingement are almost identical, including the "impingement sign" (Fig. 4), arc of pain, crepitus, and varying weakness. In advanced Stage III with complete cuff tears, however, there tends to be less stiffness, more sub-acromial fluid, and more weakness.

STAGE I—EDEMA AND HEMORRHAGE

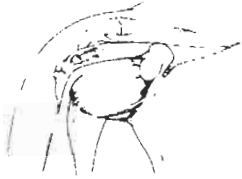
Edema and hemorrhage may result from excessive overhead use in sports or work. Characteristically, this is observed in patients younger than 25 years of age, as in a Little League baseball pitcher, but may occur at any age, as in a middle-aged weekend hedge clipper. Treatment is conservative, with a good prognosis for reversibility to normal. It is thought that this lesion accounts for much

Stage I:**Edema and Hemorrhage**

typical age	<25
diff. diagnosis	subluxation, A/C arthritis
clinical course	reversible
treatment	conservative

Stage II:**Fibrosis and Tendinitis**

typical age	25-40
diff. diagnosis	frozen shoulder, calcium
clinical course	recurrent pain with activity
treatment	consider bursectomy, C/A ligament division

Stage III:**Bone Spurs and Tendon Rupture**

typical age	>40
diff. diagnosis	cervical radiculitis; neoplasm
clinical course	progressive disability
treatment	anterior acromioplasty, rotator cuff repair

FIG. 3. Classification: progressive stages of impingement.

of the confusion in the literature regarding the prognosis and treatment of tears of the rotator cuff, because the signs and symptoms at this stage may be identical to those of Stage III. When the disability of the Stage I lesion resolves with conservative treatment, the inexperienced surgeon may erroneously believe that a tear of the rotator cuff has healed.

STAGE II—FIBROSIS AND TENDINITIS

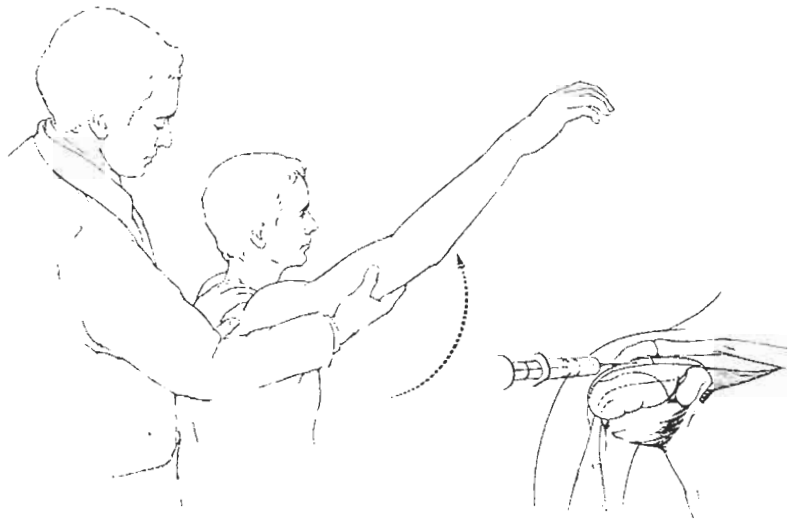
With repeated episodes of mechanical inflammation, the bursa may become fibrotic and thickened; hence, the problem magnifies. This lesion is less common and is characteristically found in athletes ranging from 25 to 40 years of age. The shoulder functions satisfactorily for light activity but becomes symptomatic after vigorous overhead use, e.g., in throwing sports. Surgery is considered

for this type of disability only when it has persisted in spite of conservative treatment (rest, oral anti-inflammatory medication, and exercise to eliminate stiffness) for 18 months. The procedure consists of removing the thickened subacromial bursa and dividing the coracoacromial ligament through a 5.0-cm deltoid-splitting approach. Anterior acromioplasty is not performed for simple impingement problems in patients younger than 40 years of age unless overhang and prominence of the undersurface of the anterior acromion are noted at the time of this procedure.

STAGE III—TEARS OF THE ROTATOR CUFF, BICEPS RUPTURES, AND BONE CHANGES

With further impingement wear, incomplete or complete tears of the rotator cuff,

FIG. 4. Impingement injection test. The "impingement sign" is elicited with the patient seated and the examiner standing. Scapular rotation is prevented with one hand while the other hand raises the arm in forced forward elevation, causing the greater tuberosity to impinge against the acromion. This maneuver produces pain in patients with impingement lesions of all stages. It also causes pain in many other shoulder conditions. In the case of the impingement lesions, however, the pain caused by this maneuver is relieved by the injection of 10.0 cc of 1.0% xylocaine beneath the anterior acromion. This test is useful in separating impingement lesions of all stages from other causes of shoulder pain. The most frequent lesions to be considered in the differential diagnosis are listed for each stage of impingement in Fig. 3.



Pain with forced forward elevation of the humerus against the acromion.

Relief of pain after 10cc injection of xylocaine into the subacromial space.

biceps lesions, and bone alterations at the anterior acromion and greater tuberosity may occur. These lesions are found almost exclusively in patients older than 40 years of age. Tears of the supraspinatus occur before biceps ruptures of a ratio of approximately 7:1. However, some mechanical inflammation of the long head of the biceps often accompanies these tears. Occasionally, the biceps ruptures first, possibly because the bicipital groove is shallow or more laterally placed, exposing the long head to greater impingement wear. Routine roentgenograms are often negative even though a tear of the rotator cuff is present. However, bone changes may eventually develop. The earliest bone changes evidenced roentgenographically include a slight prominence on the greater tuberosity at the point of insertion of the supraspinatus tendon and a traction spur at the anterior acromion, which is inside the coracoacromial ligament.³ Later bone changes include narrowing of the acromiohumeral

distance, ascent of the humeral head in relation to the glenoid, and erosion of the anterior acromion, which may involve the acromioclavicular joint.⁵ Since physical signs or roentgenographic changes are not reliable, and arthrogram is required for the early recognition of complete-thickness cuff tears and to distinguish them from the other impingement lesions.

ETIOLOGY OF CUFF TEARS

The author's experience indicates that 95% of the tears of the rotator cuff are initiated by impingement wear rather than circulatory impairment or trauma. The classic picture of a "cuff tear" depicted in the literature is somewhat misleading. Trauma may enlarge a tear but rarely seems to be the principal factor. Approximately 50% of the author's patients are unable to recall a definite injury. Heavy labor may be a predisposing factor. Forty percent of the patients are women who

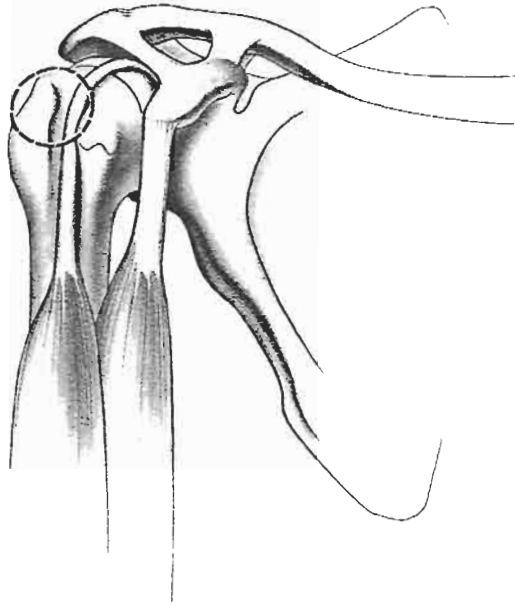


FIG. 5. Area of impingement. The vast majority of biceps ruptures occur at the proximal end of the bicipital groove in patients older than 40 years of age and are thought to be due to impingement wear. The supraspinatus tendon ruptures before the biceps more frequently, at a ratio of approximately 7:1. From this drawing it can be visualized how a laterally placed or shallow bicipital groove might expose the long head to unusual impingement wear.

have never done strenuous physical work. Many heavy laborers never develop cuff tears. The incidence of a second cuff tear developing in the opposite shoulder is much more frequent in patients who have had a tear. The incidence of complete cuff tears in more than 500 cadavers in the author's anatomy laboratory has been less than 5%. Perhaps others^{1,8} have reported a higher incidence because they have included fraying and incomplete lesions. Regardless of this difference, the fact remains that in many persons, tears of the supraspinatus never develop. Why tears develop in some people and not in others is best explained by the variations in shape and slope of the acromion. Marked differences can be observed in dried scapulae. An acromion with less slope and a prominent anterior edge on its undersurface should make the person more susceptible to impingement problems. If this pos-

tulate is true, it is logical to perform an anterior acromioplasty at the time of every cuff repair.

Approximately 50% of the author's patients who have tears of the rotator cuff give a history of injury (*e.g.*, a fall or dislocation of the glenohumeral joint) followed by loss of strength. This is referred to as an "acute extension" of a tear, which prior to the injury may have been only an incomplete-thickness tear. The injury involved is often trivial because little force is needed to extend the tear in worn and degenerated tendons. On careful questioning, many of these patients give a history of intermittent shoulder pain prior to the injury. This history, as well as the patients' age (average, 58 years) and the appearance of the tendons at surgery, all give good evidence that impingement wear almost always precedes the injury.

"IMPINGEMENT SIGN" AND "IMPINGEMENT TEST"

The impingement sign is elicited with the patient seated and the examiner standing, as shown in Figure 4. Scapular rotation is prevented by one hand as the other raises the arm in forced forward elevation (somewhere between flexion and abduction), causing the greater tuberosity to impinge against the acromion. This maneuver causes pain in patients with impingement lesions of all stages. It also causes pain in patients with many other shoulder conditions, including stiffness (partial frozen shoulder), instability (*e.g.*, anterior subluxation), arthritis, calcium deposits, and bone lesions. However, pain on this maneuver due to impingement can usually be completely eliminated or markedly reduced by the injection of 10 cc of 1.0% xylocaine beneath the anterior acromion. Pain due to the other causes enumerated, with the exception perhaps of some calcium deposits, is not relieved. This is the "impingement test," which has been helpful in distinguishing impingement lesions from the other causes of chronic shoulder pain. The most frequent lesions to be considered in the differential diagnosis are listed in Figure 3.

While the impingement test has been most useful in separating impingement lesions from other causes of shoulder pain, it does not identify the stage of the impingement lesion. An arthrogram is required for separating complete-thickness tears of the rotator cuff from the other impingement lesions.

INTERPRETATION OF BICEPS LESIONS

As previously discussed, most biceps tenosynovitis and ruptures are thought to be caused by subacromial impingement.⁴ Very rarely, rupture of the long head of the biceps is observed in a young adult who has sustained severe trauma, in which case the tear may occur at the musculotendinous junction and be amenable to direct suture. In the vast majority, however, the rupture occurs after the age of 40 years, at the superior edge of the bicipital groove. It is thought to be related to subacromial impingement in two ways: (1) Impingement may cause this type of biceps rupture. (2) Since the biceps is an important depressor of the humeral head against proximal migration, a rupture or dislocation of the long head may escalate impingement because its restraining action against ascent of the head is lost.

From these observations, it is noted that if the long head of the biceps is tenodesed for the type of biceps tenosynovitis caused by subacromial impingement, the operation may escalate the impingement process and worsen the patient's condition. This type of biceps tenosynovitis would be better treated by anterior acromioplasty for decompression, but avoiding tenodesis.

Patients with acute ruptures of the long head of the biceps and a history of previous shoulder pain are advised to have an arthrogram obtained. If the arthrogram shows a tear of the supraspinatus tendon, the patient is advised to have it repaired and decompressed by anterior acromioplasty, with tenodesis of the biceps in its groove. Transfer of the long head to the coracoid is not recommended, because this might act to further

escalate the impingement process. If the patient has not had shoulder pain, he is advised to return periodically for evaluation of possible future impingement problems, inasmuch as the stabilizing function of the long head has been lost.

INDICATIONS FOR ARTHROGRAPHY

Arthrography is the most reliable method for detecting a complete tear of the rotator cuff. The indications for it can be summarized as follows: (1) Patient older than 40 years of age with an impingement syndrome that has been unresponsive to conservative treatment for 12 weeks. (2) An "injury," regardless of how trivial, with sudden marked weakness of the shoulder. (Electromyography of the muscles supplied by C5-C6 root may be indicated concomitantly.) (3) Rupture of the long head of the biceps associated with shoulder symptoms. (4) Unstable glenohumeral dislocation, or a dislocation followed by shoulder symptoms in a patient older than 40 years of age.

Arthrography may also be helpful in evaluating fractures and prostheses. Arthroscopy has been less effective than arthrography in diagnosing cuff tears, and although it is considered by some to be helpful in the diagnosis of bursal-side, superficial, incomplete tears, the author has not found it to be an important aid. Bursagrams are used by some to identify superficial, incomplete tears, but they can be difficult to interpret. Double-contrast arthrography with and without laminography is being used in an effort to identify the size of the tear. This method appears to require special experience and seems to lack accuracy.

INDICATIONS FOR ANTERIOR ACROMIOPLASTY

The indications in patients who are good surgical risks and have reasonable life expectancies are as follows: (1) Positive arthrograms showing a complete-thickness tear of

the rotator cuff. The anterior acromioplasty is done routinely in conjunction with the repair of the rotator cuff. (2) Patients older than 40 years of age with negative arthrograms but persistent disability for one year, despite adequate conservative treatment (including efforts to eliminate stiffness), provided the pain can be temporarily eliminated during the "impingement test." (3) Carefully selected patients younger than 40 years of age with chronic Stage II impingement lesions observed at the time of bursectomy and noted to have a prominent anterior acromion. (4) Patients undergoing various other surgical procedures for conditions in which the rotator cuff and long head of the biceps are weak and less effective in preventing proximal migration of the head (as when a prosthesis is inserted in some patients with rheumatoid arthritis and old fractures). In these situations, however, weak muscles rather than the shape of the acromion seem to be the basis for the impingement problem.

TECHNIQUE OF ANTERIOR ACROMIOPLASTY

The procedure as described in 1972³ is used. Only a few points will be discussed for clarification. The range of motion of the shoulder is tested under anesthesia prior to the skin preparation. If motion is "restricted" ("frozen shoulder") even slightly, the shoulder is manipulated to regain full range. All elements of "frozen shoulder" must be eliminated at this time and prevented from recurring by heat and passive exercises after operation. The skin incision proceeds from a point just lateral to the anterior acromion toward a point one finger's breadth lateral to the coracoid. The length of the incision, varying with the size of the patient, is between 5 and 9.0 cm. A stay suture is placed at the lower end of the split in the deltoid to prevent further splitting. No more than 1.0 cm of deltoid origin is detached from the acromion. The undersurface of the acromion is then cleared of soft tissue for better visualization

during the osteotomy. The main cut into the acromion is made with a 25.0-mm AO osteotome used with the bevel up, as shown in Figure 2, so that the blade is carried out of the acromion rather than penetrating deeper. Damage to the acromion is also prevented by having the assistant strike the osteotome with the mallet, leaving one of the surgeon's hands free to palpate the superficial surface of the acromion. Using the osteotome, the anterior edge is removed and the undersurface of the acromion converted to a flat surface without overhang. Rongeurs and other small osteotomes usually are required to accomplish this. Great care is taken to remove all loose fragments of bone because they might reattach or enlarge to cause spurs later. The acromioclavicular joint is resected in three situations: (1) when the acromioclavicular joint is arthritic and has been symptomatic; (2) when more exposure of the supraspinatus is needed for mobilizing and repairing the rotator cuff; and (3) when the acromioclavicular joint is enlarged and impinges on the supraspinatus. In the latter situation, impingement often is relieved by beveling the edges of the undersurface of the acromioclavicular joint to create space and a tunnel for the supraspinatus without resection of the entire joint. This has the functional advantage of less deltoid detachment and the cosmetic advantage of less indentation.

The anterior acromioplasty approach has provided adequate exposure for the repair of 95% of tears of the rotator cuff. In less than 5%, those with the most massive tears, a second incision is made posteriorly for better mobilization of the infraspinatus superiorly (toward the top of the greater tuberosity). In repairing these massive tears, the author prefers to shift the infraspinatus and upper half of the subscapularis superiorly to close a defective supraspinatus. The lower half of the subscapularis, the teres minor, and the intervening capsule are left intact to aid in stabilizing and depressing⁹ the humeral head. A second posterior incision along the spine

of the scapula with detachment of the posterior deltoid is necessary for this shift of the infraspinatus.

UNFUSED ACROMIAL EPIPHYSIS

An unfused acromial epiphysis, which may be encountered at the time of anterior acromioplasty, alters the procedure. Grant² reported finding the anterior acromial epiphysis unfused after the age of 30 years in 7% of 319 cadavers. Small unfused centers are excised, leaving the fibrous surroundings for strong reattachments of the deltoid. If larger unfused centers are excised, however, the acromion is shortened excessively, weakening the deltoid as in a radical acromionectomy.⁶ Larger unfused epiphyses are, therefore, tilted up so that they no longer impinge, closed by curettage and local bone grafts, and internally fixed with screws or threaded wires.

Since the author believes that anatomic variation and abnormality in the shape of the acromion are the major etiologic factors in tears of the rotator cuff, it was expected that the incidence of unfused acromial epiphyses would be greater in patients with tears of the rotator cuff. This has not proved to be the case. However, this lesion is encountered with regularity and must be treated. On careful inspection, it can usually be identified prior to operation in axillary view films.

SUMMARY

Impingement lesions are considered in three progressive stages: I, edema and hemorrhage; II, fibrosis and tendinitis; III, tears of the rotator cuff, biceps ruptures, and bone changes. The physical findings in all of these stages are similar, accounting for some of the misconceptions about tears of the rotator cuff. The "impingement test" identifies these lesions. Arthrography is the most reliable method of identifying complete-thickness tears from other impingement lesions. Further observations confirm that impingement occurs anteriorly, not laterally. It is thought

that most supraspinatus and biceps lesions are due to impingement wear, usually caused in part by variations in the shape and slope of the acromion. When these tendons rupture, impingement may be escalated, because the head is allowed to migrate upward. Anterior acromioplasty is used routinely when tears of the rotator cuff are repaired, to decompress the supraspinatus from continuing wear. It is also used for chronic disability associated with incomplete tears but only occasionally in patients younger than 40 years of age. The approach offered by an anterior acromioplasty for repairing the rotator cuff offers three advantages over lateral acromionectomy: (1) less deltoid detachment; (2) better exposure of the supraspinatus; and (3) better decompression of the supraspinatus against continuing impingement. Small, unfused anterior acromial epiphyses are excised, whereas larger, unfused centers are tilted up and closed by curettage and local bone grafts, and internally fixed with screws or threaded wires.

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