Nonsurgical Treatment of Rotator Cuff Tears

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Introduction

Rotator cuff injury is common in older patients. In younger individuals, this injury is associated with a sudden, violent, eccentric episode. This chapter will discuss a clinical method to evaluate rotator cuff injuries and explore the benefits of various imaging studies. Nonsurgical treatment and its indications with specific rehabilitation protocols and modalities will also be reviewed.

Patient history and physical examination are of paramount importance in the diagnosis of rotator cuff pathology. The purpose of the history is to help the clinician to perform a directed clinical examination. Likewise, the purpose of the clinical examination is to redirect the clinician to key points of the history that will lead to an appropriate treatment.

History

The overwhelming majority of patients with rotator cuff tears are older than age 40. The incidence of full-thickness cuff tears in patients younger than age 40 is between 2% and 4%. Assuming that most older individuals are less likely to sustain a sudden shoulder injury, it can be theorized that most rotator cuff pathology is a result of repetitive microtrauma. However, in some studies, more than 60% of patients can recall an exact incident after which their shoulder was affected. Teleologically, it makes sense then that rotator cuff tears result from some macrotraumatic event superimposed on age-related microtrauma to the cuff. In fact, patients with cuff tears usually have a history of recurrent episodes of "tendinitis" or "bursitis." These transient episodes usually consist of a period of shoulder soreness that abates following a period of rest, nonsteroidal anti-inflammatory drug administration, and/or steroid injection.

The majority of rotator cuff tears affect the dominant extremity. Hawkins found the dominant extremity to be affected 78% of the time. The symptomatology of rotator cuff pathology is extremely variable. Patients with full-thickness tears may have no signs or symptoms, whereas patients with small tears may have marked weakness and significant loss of motion.

Pain, especially with overhead activity, is a frequent complaint of patients with rotator cuff tears. Patients may complain of pain at night with an inability to sleep on the affected side.

Weakness of the affected shoulder during abduction and external rotation is another frequent complaint. Full-thickness tears may produce crepitus when the supraspinatus is below the acromion, prompting patients to complain of "crackling." Loss of motion is a variable complaint. The ability to assess true loss of motion versus loss of motion secondary to pain is very difficult. This important clinical distinction will be discussed in further detail below.

Physical Examination

The physical examination can be separated into four parts: general inspection, palpation, range of motion/strength testing, and special tests. None of these components are mutually exclusive of one another, so the entire physical examination should flow smoothly.

The astute clinician's examination begins when the patient enters the room. Age, body habitus, and any obvious systemic diseases that may affect the shoulder should carefully be noted. The general "attitude" of the upper extremities should also be noted. Male patients should remove all clothing above the waist whereas female patients may be gowned to a level just proximal to the breasts. This seemingly trivial point is very important in preserving the modesty of the female patient, because a tense, uneasy patient is very difficult to examine. General inspection of the shoulder with a rotator cuff tear may reveal a prominence of the scapular spine—an indication of supraspinatus and/or infraspinatus wasting. Wasting of the infraspinatus is a frequent finding of a chronic massive tear, but may also be seen with a less common suprascapular nerve palsy. Deformity of the biceps muscle usually indicates a rupture of the long head of the biceps tendon. This finding is more pronounced with elbow flexion and is indicative of a biceps rupture, a condition often associated with rotator cuff disease.

Palpation over the greater tuberosity may elicit tenderness. The greater tuberosity is easily palpated with the shoulder extended, allowing it to be free from the cover of the acromion. Tenderness may be present in the bicipital groove when there is associated biceps involvement. Attention should be paid to any tenderness in the region of the acromioclavicular joint because this may help to distinguish cuff pathology from degenerative disease of the acromioclavicular joint.

Patients with full-thickness cuff tears may have a palpable defect posteriorly. In a recent study by Lyons and Tomlinson, rotator cuff tears were divided into four groups according to the estimated size of the tear as determined by clinical examination. At surgery, each tear was measured and the results compared to the preoperative estimate. The investigators concluded that preoperative clinical evaluation of a rotator cuff defect had a sensitivity of 91% and a specificity of 75%.

Range of motion and strength testing may be carried out simultaneously. The current recommendation of the American Shoulder and Elbow Surgeons is that four functionally necessary arcs of motion be recorded: total elevation (forward flexion), external rotation at neutral, external rotation at 90° of abduction, and internal rotation.

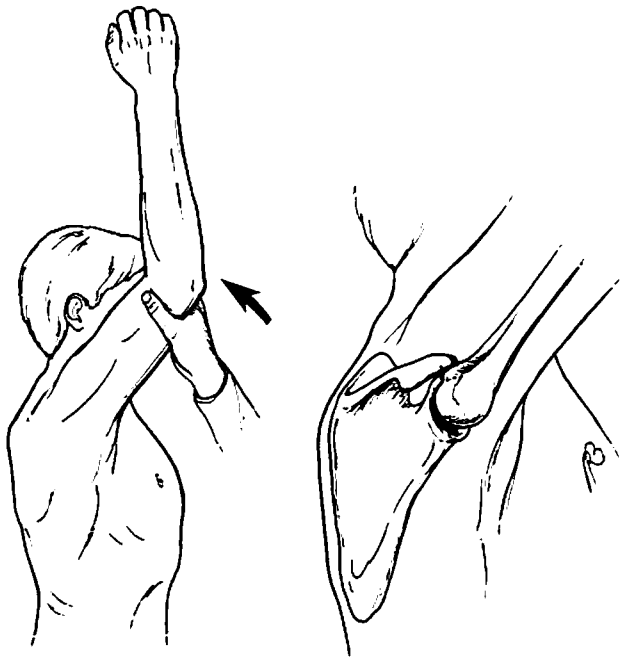

Fig. 1 A demonstration of the Neer impingement sign. (Copyright © 1997 Kevin D. Plancher, MD, Bronx, NY.)

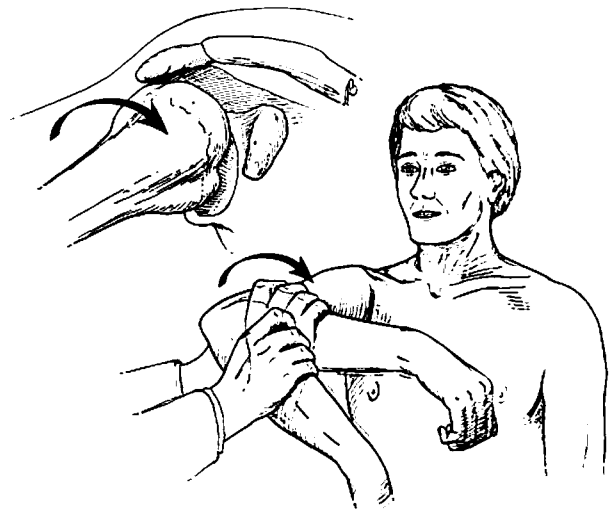

Fig. 2 Hawkins sign demonstrated with internal rotation in an arm elevated 90° and forward flexed. (Copyright © 1997 Kevin D. Plancher, MD, Bronx, NY.)

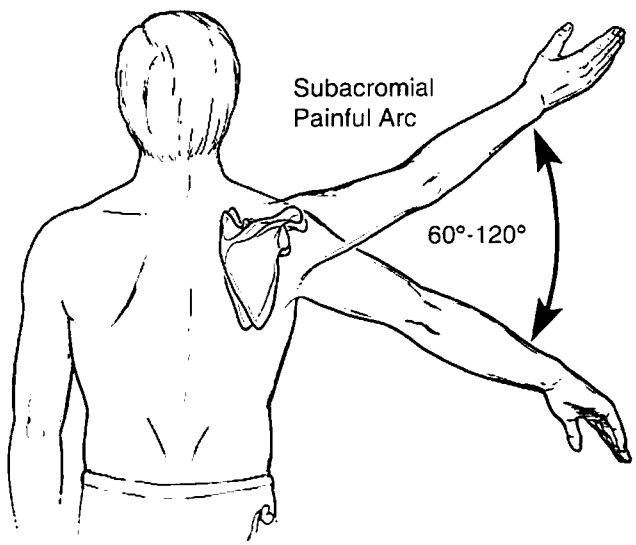

Fig. 3 Diagram showing a painful arc of abduction. (Copyright © 1997 Kevin D. Plancher, MD, Bronx, NY.)

Active and passive motion is assessed in these four planes. The patient is asked to flex the arms in a comfortable plane that is somewhere between the sagittal and coronal planes. After maximal active elevation is achieved, passive range is assessed by stressing the elevated arm into pure forward flexion. The impingement sign as described by Neer is positive if the patient experiences pain with greater than 120° of forward flexion (Fig. 1). The cause of true impingement is a result of the rotator cuff impinging against the anterior edge of the acromion with forced forward flexion. However, many disorders may present with similar findings. Therefore, to delineate isolated subacromial impingement, 10 cc of 1% lidocaine is injected into the subacromial space. The injection may be performed from either anterior or posterior. We prefer an anterior injection with the patient supine. The needle is placed directly into the subacromial space in the area of the pathology. An alternative is to place the needle 1 cm inferior to the posterolateral corner of the acromion, directing the needle toward the coracoid. The impingement test(s) are then repeated. Abatement of pain after injection strongly suggests the diagnosis of subacromial pathology.

Two other impingement tests have also been described. The Hawkins sign is performed with the arm flexed 90° and placed into internal rotation. The rotator cuff impinges on the coracoacromial ligament in this position (Fig. 2). Pain with this maneuver as described by Hawkins is a positive impingement sign. A third impingement sign is the painful arc of motion in the coronal plane with the arms abducted a maximum of 120° (Fig. 3). The pain is often exacerbated with added resistance as the supraspinatus is stressed. When all three signs are positive, the clinician can be certain that a diagnosis of impingement is appropriate.

External rotation is assessed in both neutral and 90° of abduction. The rotator cuff contributes only 30% to 40% of power in forward elevation, but accounts for 80% to 90% of external rotation strength. In a retrospective analysis of 100 patients operated on for full-thickness tears, Hawkins and associates found that shoulder strength in abduction and in external rotation at neutral were the only variables that had a statistically significant correlation with the size of the tear.

Other parameters that were correlated were preoperative pain, motion, and function.

In another recent study by Norwood and associates, 103 patients with known complete rotator cuff tears documented by arthrography were divided into two groups (those with single tendon tears and those with multiple tendon tears) to determine if cuff tear size could be predicted on the basis of history, physical examination, and radiographic findings. The patients with single tendon involvement demonstrated good active abduction and external rotation, measuring 116° and 61°, respectively. The patients with multiple tendon tears had an arc of motion of 52° and 36°, respectively. Furthermore, 75% of patients in the single tendon group could actively abduct the affected shoulder at least 90°, whereas only 16% of the patients with multiple tendon involvement could do the same. The difference in the range of abduction was the only statistically significant parameter between the physical examination of both groups. Neither pain, tenderness, nor weakness were useful in estimating cuff tear size. Nevaiser, in 1980, found the opposite to be true when he reported that middle-aged to elderly patients with chronic symptoms of rotator cuff disease did not have significant loss of motion.

A battery of special clinical tests help in the diagnosis of specific cuff pathology. The impingement signs have already been mentioned. Biceps tendon involvement may be evaluated by the Yergason or Speed tests. Yergason in 1931 described the supination sign, that is, pain localized to the bicipital groove when the examiner resists active supination with the elbow flexed to 90° and the forearm pronated. Yergason thought this pain represented wear and tear of the long head of the biceps. Speed's test is performed with the shoulder flexed, elbow fully extended, and hand supinated. Resistance is applied by the examiner (Fig. 4). Pain in the bicipital groove is suggestive of biceps pathology.

Jobe described the supraspinatus test in which the arms are extended at the elbows, flexed in the scapular plane, and the thumbs point toward the floor. The patient attempts to resist downward pressure applied to the arms by the examiner. Weakness is reported to be specific for evaluating the supraspinatus tendon. In this position, the infraspinatus, subscapularis, and teres minor are electrically silent when compared to the supraspinatus.

Gerber and Krushell described the lift-off test, a physical finding that has been shown to be both sensitive and specific for a subscapularis tendon tear. Patients with subscapularis tears have an increase in passive external rotation and weakness of internal rotation. The original lift-off test was positive if the patient was unable to move his/her hand off the small of the back. In this position, the arm is extended and internally rotated (Fig. 5). Gerber later described the modified lift-off test, reported to be even more sensitive. The upper extremity is placed into the same position as in the originally described test. The examiner passively lifts the hand off the small of the back, placing the arm in maximal internal rotation. The test is positive when the hand falls onto the back because of the inability of the subscapularis to maintain internal rotation. Greis and associates were able to validate the lift-off test with electromyographic testing. They concluded that performing the lift-off test required substantial subscapularis activity and was a rigorous challenge to the muscle, requiring approximately 70% of maximal activity to perform.

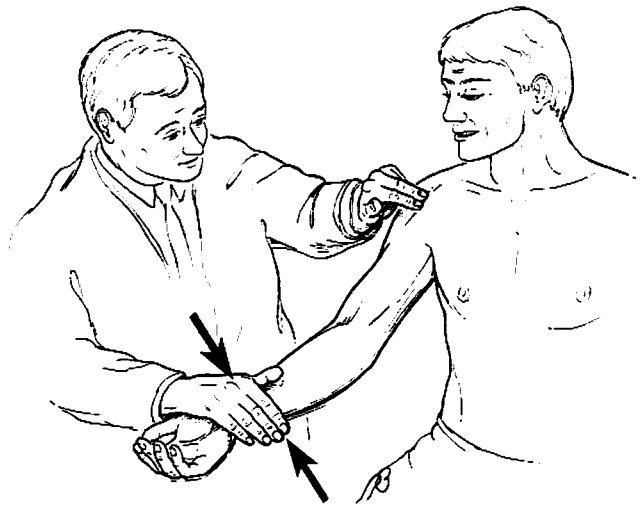

Fig. 4 Speed's test with pain in the bicipital groove. (Copyright © 1997 Kevin D. Plancher, MD, Bronx, NY.)

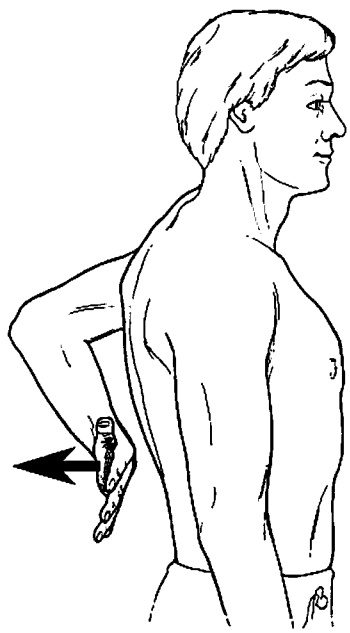

Fig. 5 The lift-off test demonstrated clinically. (Copyright © 1997 Kevin D. Plancher, MD, Bronx, NY.)

Recently, Hertel and associates described three new clinical tests to assess the integrity of the rotator cuff. These lag signs include the external rotation lag sign (ERLS), the drop sign, and the internal rotation lag sign (IRLS). The external rotation lag sign is used to assess the supraspinatus and infraspinatus tendons. It is performed by passively flexing the

elbow to 90° with the shoulder elevated in the scapular plane 20° and near maximally externally rotated. The examiner then lets go of the wrist while maintaining support of the elbow. The test is positive if the patient cannot maintain position and a drop or lag occurs. The magnitude of the lag is recorded to the nearest 5°. The drop sign, specific for the infraspinatus, is performed as follows: the examiner maintains the affected arm in 90° elevation and in near maximal external rotation with the elbow flexed 90°. Again, elbow support is maintained while the wrist is released. The infraspinatus is mainly responsible for the maintenance of external rotation in this position. Failure to maintain this position is seen as a drop or lag when the wrist is released. The lag should again be recorded to the nearest 5°. The internal rotation lag sign is specific for the subscapularis tendon. The patient's elbow is passively flexed to 90° and the shoulder is held at 20° of elevation and 20° of extension. The hand is then passively lifted off the small of the back, thereby placing the shoulder in near-maximal internal rotation. The wrist is released while supporting the elbow, and any lag is recorded to the nearest 5°. A slight lag is indicative of a partial tear, whereas an obvious drop represents a complete tear of the subscapularis tendon.

The ERLS was found to be less sensitive, but more specific, than the Jobe sign. Similarly, the drop sign had poor sensitivity but high specificity. For evaluation of the subscapularis tendon, the IRLS was more sensitive but as specific as the lift-off sign.

A cursory neurologic assessment is performed as part of our range of motion/strength testing. Gross motor skills and muscle mass are noted. Reflexes of the biceps and brachioradialis may be performed as well as evaluation of any dermatomal sensory changes. Distal pulses are recorded. Cervical spine evaluation should also be recorded for all patients with shoulder pain. Spurling's test is a clinical finding that is useful in distinguishing cervical spine radiculopathy from intrinsic shoulder pathology. The neck is extended and rotated to each side, vertically compressing the skull to the left and right. Pain, and more specifically, radiculopathy down the arm with this maneuver may indicate the need for a more extensive neurologic/cervical spine examination.

Physical findings in rotator cuff disease may be minor with an asymptomatic patient or may be significant with a completely disabled patient. The extent of the tear is often manifested by the extent of findings on physical examination. The presence of a massive tear is frequently confirmed by a physical examination, but subtle pathology requires a more involved diagnostic workup.

Imaging of the Rotator Cuff

Plain Radiographs

In early rotator cuff disease, plain films are usually normal. Calcific deposits in the cuff tendons, bony cysts at the greater tuberosity, concavity of the undersurface of the acromion, or acromial spurs are often found with more advanced disease. Degenerative changes may be present in the greater tuberosity, acromioclavicular joint, or anterior acromion. An acromiohumeral interval of less than 7 mm on a true anteroposterior (AP) plain radiograph of the shoulder is considered abnormal and suggests the presence of a chronic tear (Fig. 6). The shape of the acromion is an important radio-

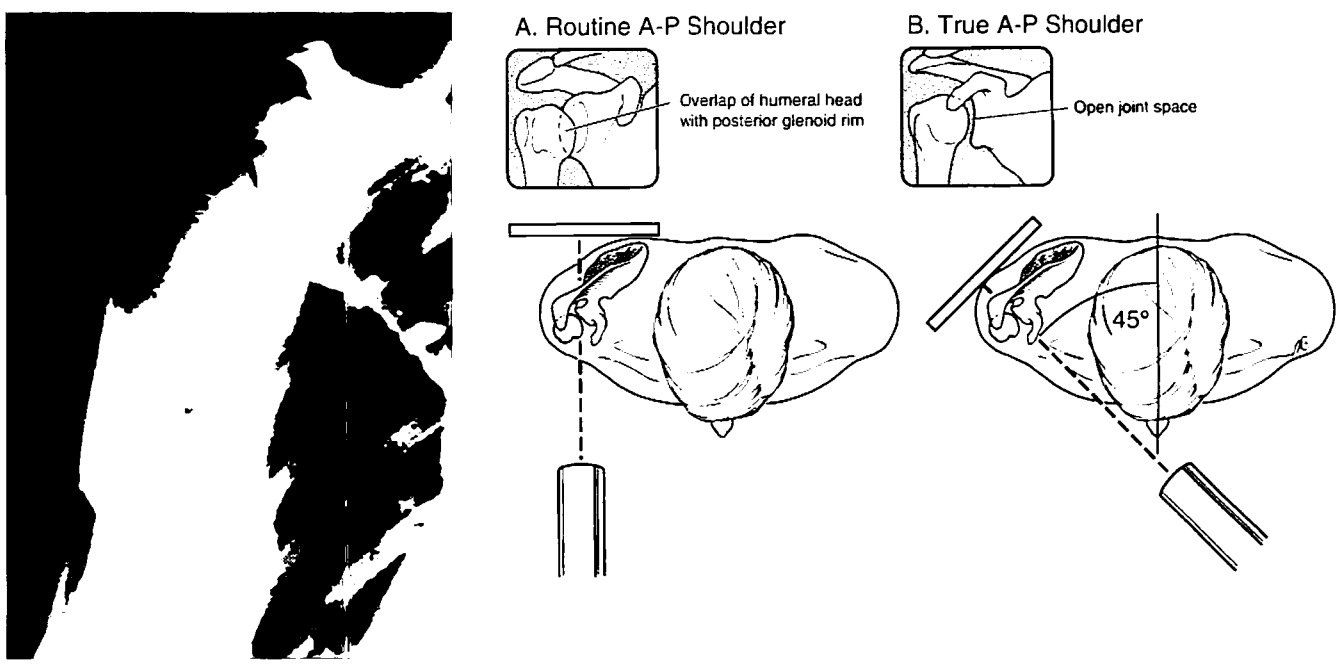

Fig. 6 Left, A plain radiograph demonstrating the acromiohumeral interval less than 7 mm on a true anteroposterior (AP) radiograph implying a rotator cuff tear. **Right,** Difference between true AP and routine AP radiographs of the shoulder. (Adapted with permission from Rockwood CA, Szalay EA, Curtis RJ, et al: X-ray evaluation of shoulder problems, in Rockwood, CA, Matsen FA III (eds): *The Shoulder.* Philadelphia, PA, WB Saunders, 1990, p 180.)

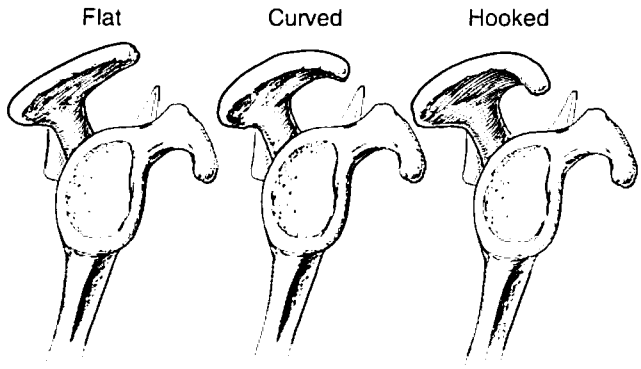

Fig. 7 Diagram of the type III acromion. (Copyright © 1997 Kevin D. Plancher. MD. Bronx. NY.)

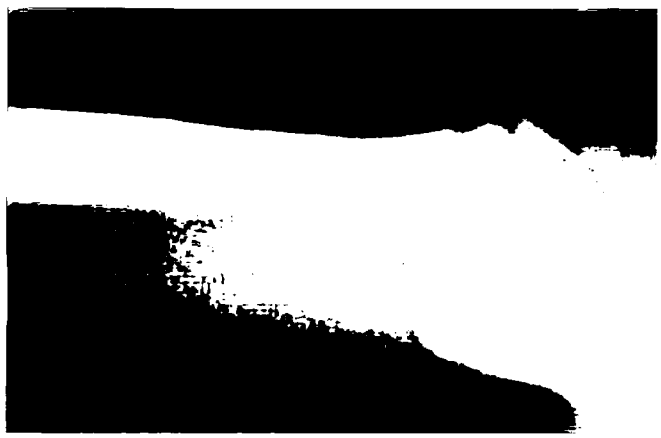

Fig. 8 A normal axillary view of the shoulder.

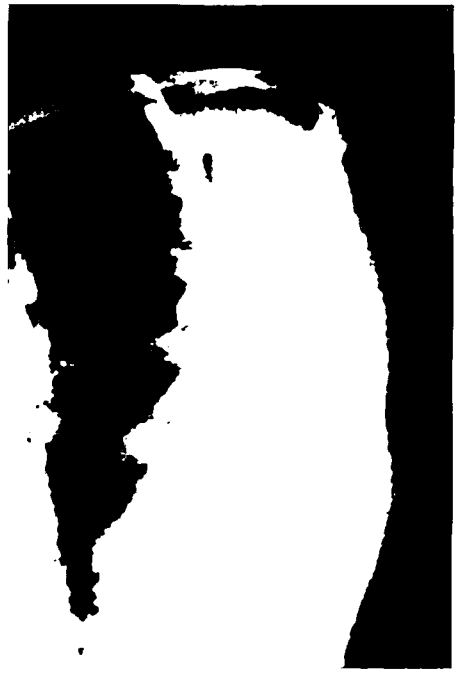

Fig. 9 A scapular outlet view.

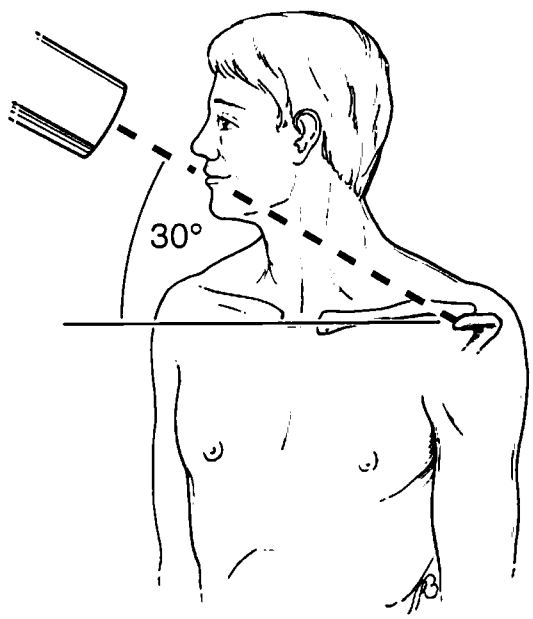

Fig. 10 Diagram of anteroposterior caudal tilt view. (Adapted with permission from Rockwood CA, Szalay EA, Curtis RJ, et al: X-ray evaluation of shoulder problems, in Rockwood CA, Matsen FA III (eds): *The Shoulder.* Philadelphia, PA, WB Saunders, 1990, p 197.)

graphic feature. A majority of rotator cuff tears occur in patients with a hooked (type III) acromion (Fig. 7), an anterior acromial spur, or an os acromiale. The latter finding is best visualized on the axillary view (Fig. 8). In addition to the standard AP, scapulothoracic, and axillary views, there are several other views that help assess the rotator cuff. The scapular outlet view is a true scapulolateral with the x-ray tube angled caudally 5° to 10°. This view will reveal deformities of the anteroinferior acromion (Fig. 9). An AP view of the shoulder with the tube angled 30° caudally (the AP caudal tilt view) also allows demonstration of an anteroinferior acromial spur or coracoacromial ligament calcification (Fig. 10).

Kitay and associates recently examined the interobserver reliability and the correlation of preoperative measurements with surgical findings for four different roentgenographic views. All patients had a diagnosis of impingement and were refractory to nonsurgical treatment. Prior to open acromioplasty, all patients had standard AP and axillary radiographs as well as supraspinatus outlet and 30° caudal tilt views. The 30° caudal tilt view had the highest interobserver reliability; the axillary view had the lowest. The interobserver reliability of the supraspinatus outlet view was found to be less than that of the caudal tilt view but greater than the axillary view. The authors found that the distance from the acromial cortex to the end of the spur, as measured on the 30° caudal tilt view, significantly correlated with intraoperative spur length

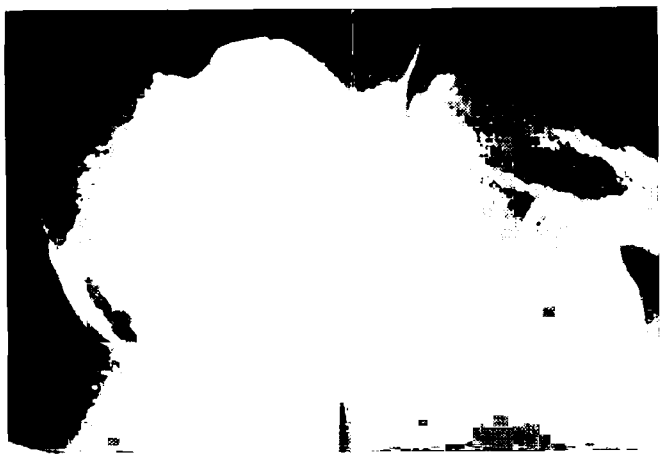

Fig. 11 The Fisk view used to image the bicipital groove.

Outline 1 Radiographic findings

Acromiohumeral interval less than 7 mm
Subacromial calcification
Greater tuberosity sclerosis or irregularity
Cysts at greater tuberosity
Subacromial spur
Concave acromion
Degenerative changes at the acromioclavicular joint
Distally pointing acromioclavicular spur greater than 2 mm in diameter
Degenerative changes at the glenohumeral joint
Exaggerated groove between the greater tuberosity and the humeral articular surface

(Reproduced with permission from Norwood LA, Barrack R, Jacobson KE: Clinical presentation of complete tears of the rotator cuff. *J Bone Joint Surg* 1989;71A:499–505.)

calculation. Additionally, acromial slope, measured on the supraspinatus outlet view, correlated significantly with anterior acromial thickness as measured intraoperatively. The authors therefore concluded that these two views offer distinct information about the morphology of the acromion and anteroinferior spur. We routinely obtain these two views in the evaluation of patients with impingement/rotator cuff symptoms prior to acromioplasty.

The Fisk view is used to image the bicipital groove. In this projection, the x-ray machine is superior to the shoulder. The bicipital groove is projected onto the cassette, which is held by the patient leaning on the table (Fig. 11).

A recent study by Norwood and associates reviewed ten separate plain radiographic findings in patients with a single tendon rotator cuff tear, multiple tendon tears, and patients with symptoms of rotator cuff disease but normal arthrograms. The ten radiographic findings were recorded as being either present or absent (Outline 1). The authors found that a significantly higher number of abnormal findings were present in the multiple tendon group when compared to the control group. However, when the single tendon group was compared to the controls, there were only two abnormal findings that occurred with a significantly higher frequency. When the two tendon tear groups were compared, half of the abnormal radiographic findings showed statistically significant differences. The authors concluded that in the appropriate clinical setting, a patient with five or more plain radiographic findings listed in Outline 1 is more likely to have a tear involving multiple tendons. Patients with three findings or less are likely to have single tendon involvement.

Arthrography

For years, the arthrogram has been considered the gold standard to evaluate full-thickness rotator cuff tears. Known complications such as infection, allergic reaction, and synovial effusions are rare; however, it must be remembered that the arthrogram is an invasive procedure and not without risk. Arthrography exposes the patient to radiation and its usefulness may be limited by the technical skill of both radiologist and technologist. Despite these drawbacks, arthrography remains an excellent imaging modality for full-thickness tears. Double contrast arthrography (using dye and air) or arthrotomography may enhance resolution. The latter technique uses tomograms taken with contrast material in the shoulder.

Fig. 12 Normal shoulder arthrogram.

The fundamental reason that arthrography works is inherent to normal shoulder anatomy. Contrast material injected into the normal glenohumeral joint should only communicate with the subscapularis bursa and biceps sheath as dye extends beneath the transverse humeral ligament. The normal rotator cuff prevents passage of contrast into the subacromial-subdeltoid bursa. In a full-thickness tear, contrast will either fill this bursa or extravasate into the substance of the tendon. AP views in internal and external rotation should be taken after brief exercise to fully evaluate the rotator cuff (Fig. 12). Other views, especially the axillary and Fisk views, may aid

Fig. 13 The geyser sign, which is indicative of a large rotator cuff tear.

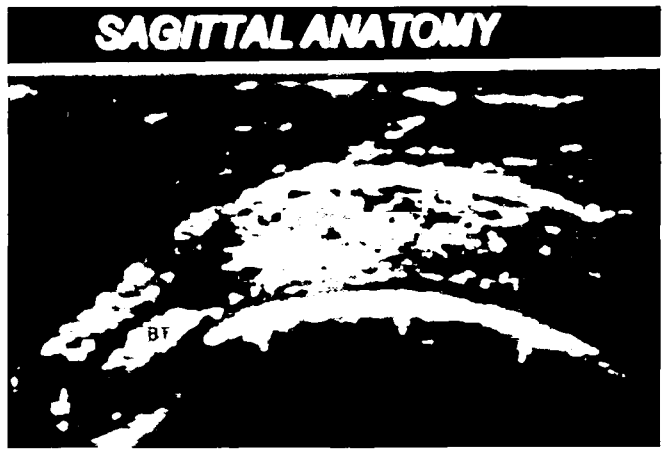

Fig. 14 Sonographic representation of a normal subacromial bursa. BT = biceps tendon; S = supraspinatus.

in evaluating associated pathology of the labrum or long head of the biceps tendon. Dye that is visualized in the acromioclavicular joint has been termed the geyser sign by Craig (Fig. 13). This sign is indicative of a large chronic tear in which contrast material has extravasated from the glenohumeral joint through the torn cuff to fill the acromioclavicular joint.

Arthrography has several limitations. Partial-thickness tears, by definition, will not allow extravasation of dye into the subacromial-subdeltoid bursa. Furthermore, bursal side tears are unable to be visualized with arthrography because there is no tendon discontinuity on the joint surface side to allow for the passage of dye. Arthrography is also unable to identify isolated midsubstance tears. Arthrography in the presence of a partial thickness tear is less accurate than when used to detect a full-thickness tear. The overall incidence of false-negative examinations (those with tears that were missed) in surgically documented tears (full and partial thickness) is between 0 to 8%, depending on which study is referenced.

Ultrasound

Shoulder ultrasonography has been used to diagnose rotator cuff pathology since the early 1980s. It is an inexpensive, noninvasive imaging modality that does not use radiation and is readily available at most centers, with very rapid results. Its main drawback is that ultrasound has been shown to be a tool that is highly technician-dependent.

High resolution, real-time equipment should be used. Most machines today use a 7.5 MHz linear array transducer. To further enhance signal resolution, the shoulder should be examined with the humerus hyperextended; this position allows the cuff to be free from the cover of the acromion.

The outer border of cortical bone covering the humeral head normally appears as a hyperechogenic line. The normal musculotendinous cuff appears homogenous with regard to echogenicity, without any focal changes. The subacromial bursa normally appears as a hypoechogenic focus less than 2 mm thick (Fig. 14). Visualization of the long head of the biceps tendon is made possible with ultrasound. The normal biceps tendon appears echogenic and sits deep in the intertubercular groove.

The most consistent ultrasound findings of a rotator cuff tear are nonvisualization, focal thinning, and discontinuity of the cuff. Hypoechogenic foci within the cuff may represent fluid whereas hyperechogenic foci may represent granulation tissue. These findings are nonspecific and should not be regarded as pathognomonic for a rotator cuff tear. Sonnabend and associates examined 117 patients who underwent shoulder ultrasound followed by surgical intervention for rotator cuff disease. The authors found that preoperative ultrasound assessment of cuff tear size was able to reliably predict full-thickness tears. Their data revealed a positive predictive value of 96%. However, in assessing partial thickness tears, ultrasound failed to detect a significant number of lesions. Diagnosis of subacromial impingement was found to have a positive predictive value of 94% but a negative predictive value of 66%. The authors concluded that ultrasound is reliable in the detection of full-thickness tears, but a negative study in the face of strong clinical findings should prompt further investigation, with methods such as arthrography or magnetic resonance imaging (MRI).

Matsen and associates examined the relationship between the presence of a joint effusion or fluid within the subacromial-subdeltoid bursa and the existence of a rotator cuff tear. A preoperative shoulder sonogram was performed

on all patients studied. One hundred sixty-three shoulders were then operated on for a suspected rotator cuff tear. The presence of a joint effusion alone had a sensitivity of 22%, specificity of 79%, and a positive predictive value of 60%. Bursal fluid alone was only seen in ten patients and had a sensitivity of 7%, specificity of 96%, and a positive predictive value of 70%. However, when fluid was seen in both the joint and the bursa, the sensitivity was 22%, specificity 99%, and positive predictive value 95%. The integrity of the rotator cuff tendons was deliberately not assessed. The authors concluded that sonographic evidence of fluid in the subacromial-subdeltoid bursa with or without a joint effusion, is highly specific and has a high positive predictive value for a rotator cuff tear. Although the combined presence of fluid in the joint and the bursae has a low sensitivity, this finding necessitates a careful ultrasound evaluation of the rotator cuff for a tear.

The use of sonography in the postoperative shoulder has also been looked at recently. Because surgical intervention distorts the normal cuff architecture, it is imperative that the sonographer be familiar with normal postoperative changes and the appearance of persistent or newly damaged cuff.

After acromioplasty, sonographic evaluation may reveal distortion of the lateral aspect of the acromial shadow, irregular contour, or medial displacement of the acromial margin. Most commonly, the supraspinatus is reattached at the level of the greater tuberosity via a trough-in-bone procedure, and is sonographically visualized as a linear defect in the humeral head. However, frequently the cuff is retracted medially and mobilization does not permit the repair to take place at the level of the tuberosity. In these instances, the reimplanted tendon and trough are displaced medially, and visualization of the supraspinatus tendon may be difficult. Extension of the arm as well as abduction/adduction may facilitate visualization.

Normally, the postoperative tendon remains thinned and exhibits increased echogenicity. Therefore, unlike preoperative criteria, visualization of a cuff defect is necessary to make the diagnosis of a recurrent rotator cuff tear. If the subdeltoid bursa has been resected, the normal echogenic plane between the supraspinatus tendon and overlying deltoid will be absent. Additionally, sonography may be used postoperatively to diagnose those patients with cuff arthropathy. This is visualized as irregularity of the humeral head with loss of normal overlying hypoechoic cartilage.

In a study by Mack and associates, sonography was used to evaluate 60 symptomatic postoperative shoulders in 53 patients. In ten shoulders that had a previous acromioplasty alone, nine had subsequent surgical intervention; a correct diagnosis of intact rotator cuffs was made in eight of the nine shoulders. Of the 50 shoulders that had previous full-thickness cuff repairs, subsequent surgical procedures were performed on 27. In 26 of these 27, sonography was used to confirm large recurrent tears; the remaining shoulder had an intact cuff. The authors concluded that although the ability of sonography to rule out disease was not adequately tested, ultrasound was an excellent means of assessing the postoperative shoulder. Their results yielded a sensitivity of 100%, specificity of 90%, and overall accuracy of 98% for detecting postoperative rotator cuff tears.

Magnetic Resonance Imaging

The use of MRI represents a major advance in musculoskeletal imaging. Some believe it to be the imaging modality of choice following plain film evaluation of the shoulder. MRI is noninvasive and unlike arthrography does not use ionizing radiation. A significant advantage of MRI is its ability to detect midsubstance and bursal side tears, which allows for detection of cuff pathology earlier in the disease process. These partial thickness tears are very difficult to diagnose using other modalities. MRI is significantly more expensive to use than the previously discussed modalities; this is its major disadvantage. Contraindications to the use of MRI include noncompatible aneurysm clips, cardiac pacers, neurostimulatory devices, and some types of prosthetic heart valves. Morbidly obese patients may not fit into the scanner. With the advent of "open" MRI machines, claustrophobia has become less of a problem and resolution has improved.

MRI changes seen in rotator cuff tendons are the principal means of diagnosing a tear. The grading system of these changes is based on changes in signal intensity and morphology of the cuff tendons. Low signal intensity is black and high signal intensity is white regardless of pulse sequence. A grade 0 tendon has normal signal intensity (low) and normal morphology (Fig. 15, *top left*). Grade 1 is a tendon with diffusely increased signal on short recovery time/echo time (TR/TE) (T1-weighted) and long TR/short TE (proton density-weighted) images but with normal morphology (Fig. 15, *top center* and *top right*). A grade 2 tendon has increased signal intensity on these same pulse sequences but, in addition, has some alteration in tendon morphology, ie, thinning, and/or surface irregularity (Fig. 15, *bottom left*). This group may be further classified into 2A or 2B depending on the degree of morphologic alteration. A grade 3 tendon will exhibit increased signal intensity on T2-weighted images. In this group there is an obvious tendon defect (Fig. 15, *bottom right*) This defect is the most specific finding of a full-thickness tear.

Changes in the subacromial-subdeltoid bursa and peribursal fat plane are clues to presence of a cuff tear. Significant fluid in the bursa, although not pathognomonic, is highly suggestive of a cuff tear. The most commonly offered explanation for this finding is that the complete tear allows the extension of intra-articular fluid into the bursa. This fluid is seen as high signal intensity within the bursa on T2-weighted images. Loss of the normal high signal of the peribursal fat plane is also highly suggestive of a tear. These two findings are present in over 90% of patients with full-thickness tears (Fig. 16).

The bony pathology associated with rotator cuff pathology may also be identified using MRI. The hooked type III acromion is best visualized on the coronal or sagittal oblique cuts. Subacromial spurs are also easily demonstrated. Small spurs (cortical bone) appear black on T2-weighted images. Larger spurs may contain marrow and thus appear as high signal on both T1- and T2-weighted images. Degenerative changes of the acromioclavicular joint may be visualized as hypertrophy of the joint capsule, seen as a medium intensity signal surrounding the acromioclavicular joint on pulse sequences with short TR and short TE (Fig. 17).

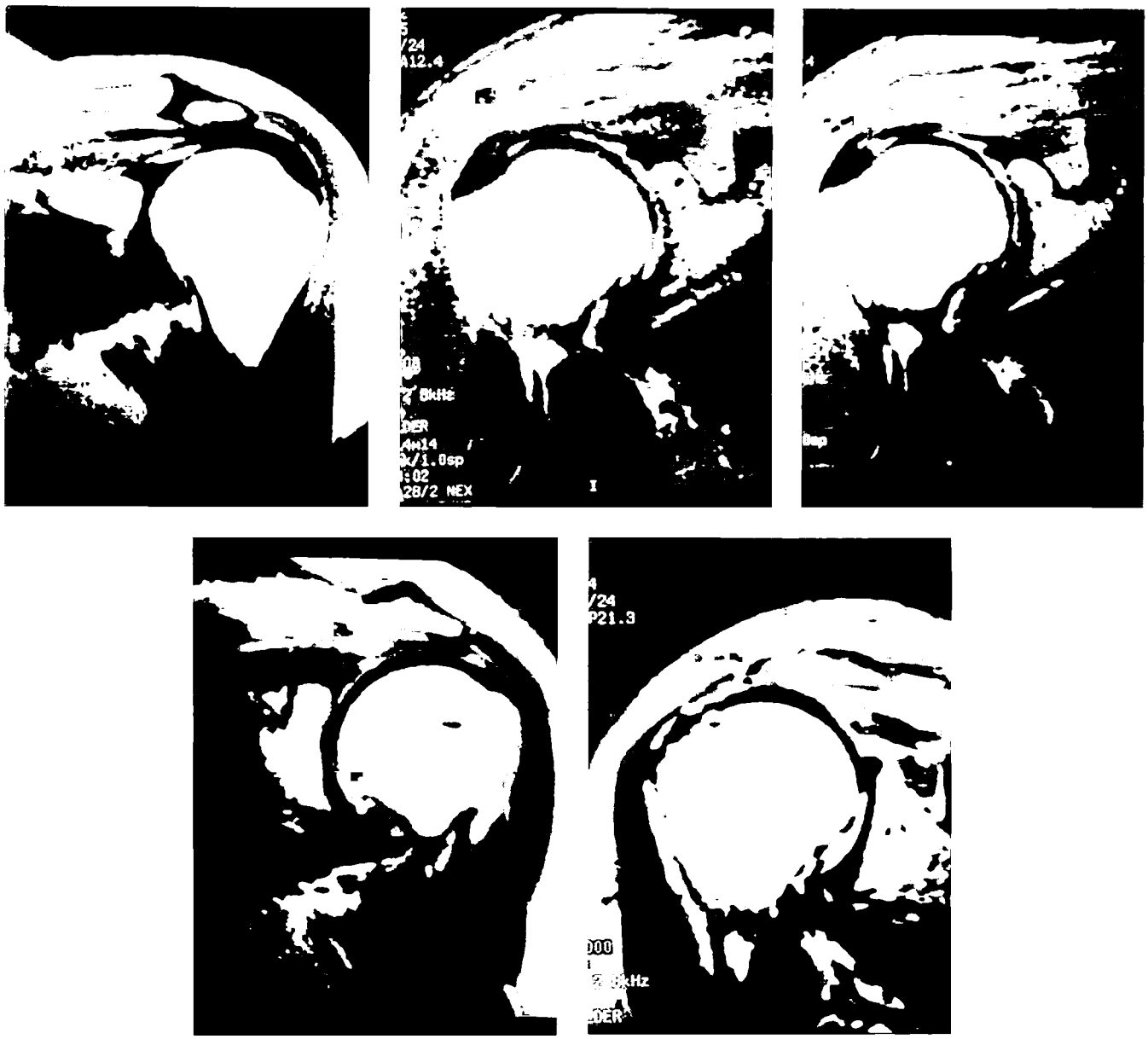

Fig. 15 **Top left,** A normal supraspinatus tendon grade 0. **Top center,** Grade 1 tendon on T1. **Top right,** Grade 1 tendon on proton density. **Bottom left,** Grade 2 tendon with some alteration of morphology. **Bottom right,** Grade 3 tendon on T2-weighted image.

MRI offers information regarding cuff tear size, specific tendon involvement, and the degree of retraction. It can identify torn tendon edges and frequently delineate whether those edges are frayed to the point of irreparability. By predicting the size of the cuff defect, MRI may aid the surgeon in deciding preoperatively whether to attempt a repair alone, repair with a local tissue transfer, or debridement of the cuff tear.

Iannotti and associates used MRI to preoperatively assess the integrity of the rotator cuff in 91 patients. In 33 patients, the presence of a complete tear of the rotator cuff was confirmed with MRI. The size of the tears was calculated and compared with the findings at operation. Of the 33 complete tears seen at operation, the size of all but two had been correctly assessed by MRI. These two large tears had been incorrectly assessed as being moderate in size. Small tears were those less than 2 cm in diameter, moderately sized tears were 2 to 4 cm, and large tears were 5 cm or larger.

The authors found a correlation between the degree of supraspinatus wasting seen on MRI and the size of the cuff tear at operation. In general, larger tears were seen at surgery in patients whose scans demonstrated a significant amount of supraspinatus wasting on MRI.

Fig. 16 Fluid in the subacromial bursa and peribursal fat plane on T2-weighted image, which is representative of a full-thickness rotator cuff tear.

Fig. 17 Degenerative changes of the acromioclavicular joint on a T1-weighted image.

The same authors correlated preoperative MRI assessment with findings seen at open acromioplasty or diagnostic arthroscopy. In 31 shoulders with clinical impingement and radiographically intact tendons, there were four false-positive and three false-negative results. The authors found that in the diagnosis of a complete tear of the rotator cuff, MRI had a sensitivity of 100% and a specificity of 95%. The positive predictive value was 92% and the negative predictive value 100%. The sensitivity and specificity of MRI in differentiating degeneration or partial thickness tears versus tendinitis was found to be 82% and 85%, respectively. The positive and negative predictive values were also 82% and 85%. Finally, with respect to differentiating normal tendon from one affected by tendinitis secondary to impingement, MRI had a sensitivity and specificity of 93% and 87%. Here the positive and negative predictive values were also 93% and 87%.

MRI is best in its ability to detect complete tears of the rotator cuff. However, it is useful in localizing the site of a tear, estimating its size, and differentiating between the various stages of impingement in clinical diagnoses.

The use of MRI in the postoperative shoulder has also been recently studied. As expected, preoperative evaluation is more difficult than the evaluation of a patient who has not had prior surgical intervention. MRI can demonstrate cuff disruption when it is present postoperatively. However, in assessing symptomatic postacromioplasty patients, the criteria for making the diagnosis of a rotator cuff tear needs to be modified. The only consistent findings are definite discontinuity in the cuff with high signal within it on T2-weighted images and nonvisualization of the cuff. The secondary signs discussed above are not useful in assessing the postoperative shoulder.

In a recent study by Owen and associates, MRI was used to assess the postoperative shoulder in 31 patients before repeated surgical intervention. Using the above criteria, a correct diagnosis was made in six of seven patients who had a surgically proven tear. Additionally, MRI was able to rule out the presence of a tear in 22 of 24 patients who had no evidence of a full-thickness tear at surgery. The authors concluded that MRI is a valuable technique in the evaluation of the symptomatic postoperative shoulder. Sensitivity was found to be 86%, specificity 92%, and accuracy 90%. However, these data pertain to full-thickness tears and the appearance of a postoperative tendon-to-tendon repair is indistinguishable from that of a new or recurrent tear. Therefore, MRI is limited in its ability to detect partial or midsubstance tears after primary rotator cuff repair.

Nonsurgical Management

The indications for nonsurgical treatment of a rotator cuff tear are not clearly defined. Each patient needs to be individually assessed with regard to age, occupation, physical demands, size of cuff tear, loss of function, mechanism of injury, and most importantly, pain. Most authors recommend an initial trial of nonsurgical treatment; however, this regimen may not be beneficial to a younger patient who sustains a traumatic tear associated with significant functional impairment and weakness. The length of nonsurgical treatment will vary depending on the degree of cuff involvement and with the patient's response to treatment. If pain persists in the face of an adequate rehabilitation protocol, then surgical intervention should be considered.

Nonsteroidal Anti-Inflammatory Medication

Although there is a paucity of good data to support the fact that nonsteroidal anti-inflammatory drugs are of value in the treatment of impingement and rotator cuff pathology, they remain a mainstay of management. Teleologically, it makes sense that an anti-inflammatory/analgesic medication would work in a setting where the presumed etiology is a spectrum of chronic irritation and inflammation. No data exist that support the benefits of one brand over another, and all patients should be asked about any history of peptic ulcer disease or gastritis prior to initiating therapy.

Corticosteroid Injection

There are few studies in the literature that conclusively show that the subacromial injection of steroids is of any benefit in the treatment of impingement or rotator cuff tears. In a prospective, controlled, randomized, double-blind study, Zuckerman and associates examined the efficacy of subacromial corticosteroid injection. Patients with a diagnosis of impingement without evidence of a rotator cuff tear were randomized to receive a subacromial injection of either 1% lidocaine or 1% lidocaine with 80 mg triamcinolone. Eighty-four percent of patients in the steroid group reported improvement in pain compared to only 36% in the control group. Objectively, active range of motion improved in 74% of the patients who received steroids compared to 36% of the patients in the control group. Finally, 79% of the steroid group patients, compared to 18% of the control group patients, actually had relief of impingement sign on last follow-up examination.

The adverse effects of such injections are well known. Steroid injections in or around the rotator cuff may produce tendon atrophy and can actually impede the repair process. Watson has shown that repeated injections (more than five) have been shown to be associated with poor tissue quality at surgery. However, the use of corticosteroid injections remains widespread. If used, injections should be limited in number, well-spaced out in time, and never administered in the acute phase of injury or directly into the tendons of the rotator cuff.

Ultrasound, Phonophoresis, and Iontophoresis

Ultrasound has been used extensively as a physical therapy modality for over 30 years. Ultrasound waves are sound waves that are above the audible limit (> 20 kHz). The therapeutic effects of ultrasound are a result of both the thermal and nonthermal properties of these high frequency sound waves. The heat induced by ultrasound causes a local hyperemia and is therefore potentially beneficial to the healing process. The nonthermal or mechanical characteristics of ultrasound waves are believed to alter the cell membrane resting potential and thus alter cell permeability.

Phonophoresis is the use of ultrasound to enhance the delivery of topically applied drugs. The most commonly used topical drugs are anesthetics, counterirritants, and anti-inflammatories such as nonsteroidal or steroidal medications. Studies are still lacking that define typical drug doses and duration of sonication. These topically applied drugs avoid the risks and possible complications associated with the use of systemic medications. The first pass effect by the liver is also eliminated by this route of administration. There is less of a chance of underdosing or overdosing the drug.

The mechanism of action is related to the thermal and nonthermal properties of ultrasound waves. Increased heat causes an increase in the kinetic energy of the drug molecules, dilates points of entry in the stratum corneum such as hair follicles and sweat glands, and causes a local increase in blood flow to the sonicated area. At the same time, cell membrane characteristics are altered in such a way that all of these physiologic responses enhance the opportunity for the topically applied drug to traverse the skin. In a study by Griffin and associates, various orthopaedic diagnoses were treated blindly using phonophoresis with either hydrocortisone or placebo. Sixty-eight percent of the patients treated with hydrocortisone with ultrasound had decreased pain and increased range of motion compared to only 28% of those treated with placebo plus ultrasound. A recent study by Kleinkort and Wood revealed that a 10% preparation of hydrocortisone plus ultrasound was more effective than a 1% preparation in reducing the pain associated with a number of inflammatory conditions, including subdeltoid bursitis and epicondylitis.

Like the classic investigations cited above, the more recent literature on the efficacy of phonophoresis appears promising. However, few studies are scientifically sound. Most of the reports lack some element of a fundamentally scientific study such as a control group, small sample size, nonobjective documentation of effectiveness, and nonblinded observers.

Smith and associates compared five modalities for the treatment of shin splints: ice, ice massage, ultrasound, iontophoresis, and phonophoresis. The investigators found no difference among the various treatment groups although all methods decreased pain. In two other recent studies by McElnay and Williams, the authors independently found that phonophoresis had no increased effect on the percutaneous absorption of lidocaine and other topical anesthetics.

Iontophoresis is a process that uses electricity to introduce ions into the skin. It is used by physical therapists to deliver locally higher concentrations of medication while avoiding the potential complications associated with their systemic use. Corticosteroids are the most commonly used drugs with iontophoresis. Several water-soluble preparations are available to enable the drug to dissociate into the negatively charged steroid molecule and therefore move in an electric field. DeLacerda, using iontophoresis with dexamethasone, found rapid improvement in range of motion in patients with myofascial shoulder girdle syndrome when compared to treatment with ultrasound or muscle relaxants. In a group of patients with shoulder tendinitis, Bertolucci found that those treated with dexamethasone and lidocaine iontophoresis had less pain and increased range of motion compared to controls.

The use of iontophoresis has declined; however, this process is occasionally selected by therapists whose patients do not show improvement with more conventional therapy. Fear of chemical skin burns and the paucity of sound scientific data demonstrating the efficacy of this treatment are the reasons why iontophoresis is seldom used.

Exercise

The common denominator in all rehabilitative programs for impingement is adequate resting of acutely inflamed tissues followed by rotator cuff strengthening. One of the functions of the rotator cuff is to serve as a humeral head depressor.

With the rotator cuff strengthened, mechanical impingement and the patient's symptoms are alleviated.

Rockwood has coined the term "orthotherapy" to describe a nonsurgical, rehabilitative program that first focuses on improvement in range of motion and then concentrates on improving shoulder strength. The regimen is designed to permit immediate communication between physician and patient to allow quick adjustments in their rehabilitation protocol. This method facilitates patient compliance and minimizes the chance of a rehabilitation setback.

Orthotherapy should not be used for a select group of patients with injury to the shoulder. The first group is the young or middle-aged patient who, as a result of violent trauma, sustains a rotator cuff tear. The second group of patients are highly competitive athletes, especially those whose sport involves raising the arms overhead, who sustain a rotator cuff tear. It is believed that these patients are best served with early surgical repair.

The rehabilitation of the rotator cuff can be divided into three convenient stages. There should be defined goals for each stage of this process. Criteria must be carefully evaluated before a patient is allowed to progress to the next stage of rehabilitation.

Stage I is aimed at decreasing acute inflammation while maintaining shoulder range of motion. Initially, a short period of rest with avoidance of overhead activity is pursued. A number of adjunctive modalities such as nonsteroidal anti-inflammatory medications, steroid injections, phonophoresis, and iontophoresis may be used. In addition to allowing inflammation to subside, it is equally important to maintain mobility of the glenohumeral as well as the scapulothoracic, acromioclavicular, and sternoclavicular joints. Gentle pendulum exercises are begun and active assisted range of motion exercises are gradually added with the use of a rope and pulley system. This system is set up so that the shoulder is flexed by having the patient grasp one end of the rope with the supinated palm of the affected extremity. The unaffected extremity is used to gently elevate the affected shoulder by pulling downward on the other end of the rope (Fig. 18). Pain should be avoided with all of these exercises.

After achieving full flexion, stick exercise should be performed in flexion and external rotation. In a manner similar to that of the pulley exercises, the contralateral extremity is used to assist the affected shoulder into these positions (Fig. 19). Posterior capsule stretching exercises may be initiated at this point. Posterior glenohumeral capsule tightness has been implicated in the exacerbation of rotator cuff symptomatology. To stretch the posterior capsule, the affected extremity is brought into a position of cross-body adduction and internal rotation with the arm abducted 45° from the body (Fig. 20). After the goals for stage I have been met and there are no inflammatory signs, such as pain with rest or warmth of the affected shoulder, the patient may progress to stage II.

Stage II is characterized by progressive strengthening exercises of the rotator cuff. Strengthening of the deltoid and scapular stabilizers is emphasized. Capsular stretching as described above is continued with increasing degrees of abduction as tolerated. Surgical tubing connected to an eyelet or doorknob makes an inexpensive home gym and allows the patient to progress through the exercises with increasing resistance as tolerated. There are various companies that make commercially available kits, or a homemade version can be created. The patient should attempt five to ten repetitions each of external rotation, abduction, extension, internal rotation, and flexion. Pain should once again be avoided. Proximal stability of the shoulder girdle is fundamental to the rehabilitation

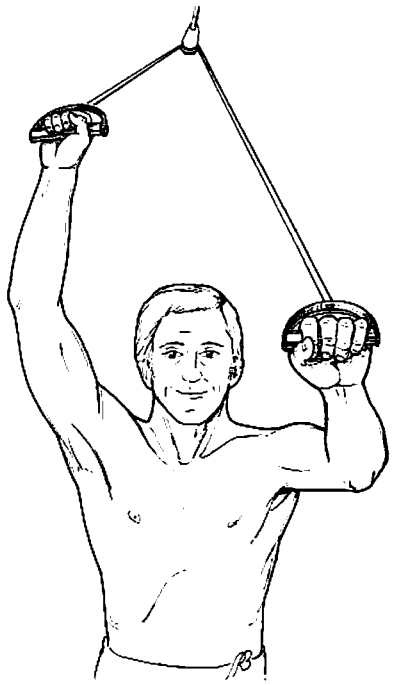

Fig. 18 A patient using a rope and pulley system for stretching of the shoulder capsule. (Copyright © 1997 Kevin D. Plancher, MD, Bronx, NY.)

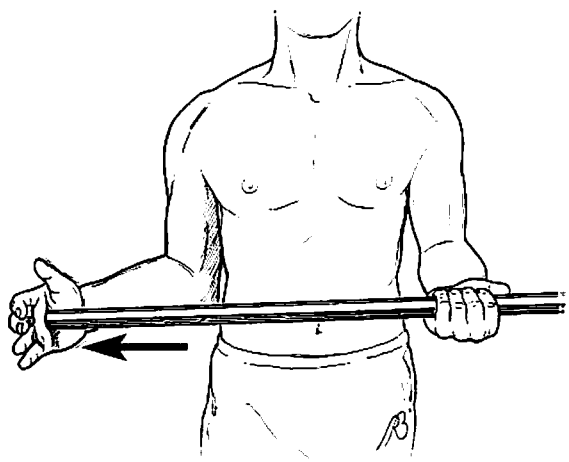

Fig. 19 Stick exercise used to stretch the shoulder in external rotation. (Copyright © 1997 Kevin D. Plancher, MD, Bronx, NY.)

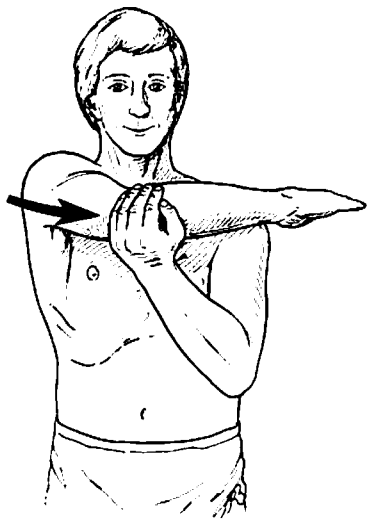

Fig. 20 Posterior capsular stretches in internal rotation and cross-body adduction. (Copyright © 1997 Kevin D. Plancher, MD, Bronx, NY.)

of a rotator cuff tear. Therefore, strengthening of the trapezius, serratus anterior, rhomboids, and levator scapulae is essential for full recovery. Wall push-ups and shoulder shrugs with weights of 15 to 20 lb are employed to isolate these muscles.

When the patient has progressed to the point where symptoms are minimal or absent, range of motion is excellent, and strength is adequate, phase III may be initiated. The goal of phase III is unrestricted symptom-free activity. This goal is accomplished with continued active range of motion and a gradual progression to overhead activities and sports-specific exercises. Early in this phase the sport or activity should be modified to avoid a recurrence of symptoms.

The success of nonsurgical treatment has been reported from less than 50% to greater than 90%. However, most studies to date do not have uniform criteria for nonsurgical management. The large disparity in success rates is in part attributed to the fact that different surgeons have different indications for nonsurgical therapy. Before the advent of MRI, arthrography and clinical examination were largely relied on to establish a diagnosis, and most study groups were heterogenous with results difficult to interpret.

Itoi and Tabata reported the results of 62 shoulders in 54 patients with full-thickness rotator cuff tears treated nonsurgically. Nonsurgical treatment was indicated in middle-aged (30 to 60 years old) and elderly patients (older than 60) who would not require strong muscle power and in those who had mild symptoms. Nonsurgical treatment was also selected for those patients who could not be operated on for medical reasons. The follow-up period averaged 3.4 years. Using a modified version of Wolfgang's criteria, the authors compared subjective findings (function and pain) and objective findings (strength and motion) on both initial and follow-up examinations. Their results showed that 82% of the shoulders had a satisfactory outcome and that scores for pain, motion, and function increased significantly at follow-up examinations. The authors also examined the relationship between length of follow-up and outcome and found that patients followed more than 6 years had significantly lower scores than those patients treated for less than 3 years or from 3 to 6 years. The authors concluded that nonsurgical treatment is effective when applied early during the onset of symptoms and yields satisfactory short-term (1 to 3 years) and midterm (3 to 6 years) results.

In a recent study, Morrison and associates examined the results of 616 patients with isolated subacromial impingement treated nonsurgically with a rotator cuff strengthening program and nonsteroidal anti-inflammatory medication. Sixty-seven percent of these patients had satisfactory results with a mean follow-up of 27 months. Treatment was unsuccessful in 28%, and arthroscopic subacromial decompression was necessary. Conservative treatment failed in an additional 5%, but these patients elected not to have surgery. These authors found that patients older than 60 years of age, those with a type II or III acromion, or those with acromioclavicular joint symptoms fared worse with conservative treatment.

Conclusion

Tears of the rotator cuff are common. A complete history and physical examination will help in the accurate diagnosis of partial and complete rotator cuff injuries. Radiography and its various modalities may be used in clarifying the disease staging process. A complete nonsurgical protocol, including a method to perform a subacromial injection, and rehabilitation protocol are useful. With these techniques, a successful outcome and avoidance of surgical intervention are often possible.

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A retrospective review of 100 patients who were surgically treated for a tear of the rotator cuff was performed. One goal of the study was to determine whether the size of the rotator cuff tear could be determined preoperatively by considering the degree of pain, motion, function, and strength. The authors found that the strength of the shoulder in abduction and in external rotation at neutral were the only parameters that had a statistically significant correlation with the size of the tear at operation.

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Kessel L, Watson M: The painful arc syndrome: Clinical classification as a guide to management. *J Bone Joint Surg* 1977;59B:166-172.

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Neviaser RJ: Tears of the rotator cuff. *Orthop Clin North Am* 1980;11:295-306.

Smith W, Winn F, Parette R: Comparative study using four modalities in shin splints treatments. *J Orthop Sports Phys Ther* 1986;8:77-80.

Physical Examination

Boublik M, Hawkins RJ: Clinical examination of the shoulder complex. *J Orthop Sports Phys Ther* 1993;18: 379-385.

This article provides a systematic and thorough approach to the physical examination of the shoulder. Clinical findings important in evaluating the athlete's shoulder and findings related to specific pathologic conditions of the shoulder are emphasized.

Hertel R, Ballmer FT, Lambert SM, et al: Lag signs in the diagnosis of rotator cuff rupture. *J Shoulder Elbow Surg* 1996;5:307-313.

Three newly described clinical signs for the evaluation of the rotator cuff were assessed in 100 patients. The external rotation and internal rotation lag signs independently examine the main components of the rotator cuff. Sensitivity and specificity values were compared to other, more common clinical signs.

Iannotti JP: Full-thickness rotator cuff tears: Factors affecting surgical outcome. *J Am Acad Orthop Surg* 1994;2: 87-95.

The author defines various clinical and radiographic findings that are prognostic of a good outcome in rotator cuff repairs. MRI appears to be useful in evaluating the clinical prognostic factors. Careful clinical examination and preoperative imaging will allow the orthopaedic surgeon to select those patients who are likely to have the best outcomes.

Lyons AR, Tomlinson JE: Clinical diagnosis of tears of the rotator cuff. *J Bone Joint Surg* 1992;74B:414-415.

Clinical examination of the shoulder in 42 patients was carried out to determine the presence and extent of a rotator cuff tear. The preoperative assessment was then compared to findings at operation. The authors found that clinical examination for the presence of a rotator cuff tear had a sensitivity of 91% and specificity of 75%. In 24 of 42 shoulders the type of tear found at operation agreed exactly with that of the preoperative assessment.

Silliman JF, Hawkins RJ: Clinical examination of the shoulder complex, in Andrews JR, Wilk KE (eds): *The Athlete's Shoulder.* New York, NY, Churchill Livingstone, 1994, pp 45-58.

Warner JJP, Allen AA, Gerber C: Diagnosis and management of subscapularis tendon tears. *Tech Orthop* 1994;9:116-125.

Rotator cuff tears that involve the subscapularis tendon are infrequent but not rare. The diagnosis may not always be immediately evident. In order to obtain the correct diagnosis, a careful physical examination is imperative. Even with a correct diagnosis and proper surgical management, these patients have a less favorable prognosis than those patients who undergo a surgical repair of the superior and/or posterior cuff.

Yergason RM: Supination sign. *J Bone Joint Surg* 1931; 13:160.

This case report is the first to describe the findings associated with "wear and tear" of the long head of the biceps tendon.

Imaging of the Rotator Cuff

Ahovuo J: Use of ultrasonography for the diagnosis of shoulder disease, in Vastamaki M, Jalovaara P (eds): *Surgery of the Shoulder.* Amsterdam, The Netherlands, Elsevier Science, 1995, pp 19-23.

The diagnostic performance of ultrasonography in lesions of the shoulder joint, along with the various ultrasound findings seen in the diagnosis of rotator cuff tears, are reviewed. The article concludes that distinctions between tendinitis, cuff degeneration, partial thickness tears, and small full-thickness tears are difficult.

Hollister MS, Mack LA, Patten RP, et al: Association of sonographically detected subacromial/subdeltoid bursal effusion and intraarticular fluid with rotator cuff tear. *Am J Roentgenol* 1995;165:605-608.

A retrospective study of 163 shoulder sonograms in patients who then went on to have surgery found a significant correlation between the presence of fluid in the glenohumeral joint and subacromial-subdeltoid bursa and the existence of a rotator cuff tear. These two findings, when present together, are highly specific for a rotator cuff tear. The specificity was found to be 99% and the positive predictive value was 95%.

Iannotti JP: MR imaging of the shoulder, in Vastamaki M, Jalovaara P (eds): *Surgery of the Shoulder.* Amsterdam, The Netherlands, Elsevier Science, 1995, pp 31-39.

MRI was responsible for major changes in the diagnosis or treatment of common shoulder disorders in approximately 10% of patients from several different studies. MRI was responsible for minor changes in 20% of the cases. The author found the most effective use of MRI to be during the preoperative assessment in the patient with a rotator cuff tear in whom nonsurgical management has failed.

Iannotti JP, Zlatkin MB, Esterhai JL, et al: Magnetic resonance imaging of the shoulder: Sensitivity, specificity, and predictive value. *J Bone Joint Surg* 1991;73A:17-29.

MRI was used to evaluate 91 patients and 15 asymptomatic volunteers. MRI was found to have a sensitivity of 100% and a specificity of 95% in the diagnosis of full-thickness rotator cuff tears. It also consistently predicted the size of the tear. In determining normal tendon from one affected by tendinitis, the sensitivity and specificity were 93% and 87%, respectively.

Jalovaara P, Paivansalo M, Myllyla V: Plain roentgenograms in the diagnosis of shoulder disorders, in Vastamaki M, Jalovaara P (eds): *Surgery of the Shoulder.* Amsterdam, The Netherlands, Elsevier Science, 1995, pp 3-11.

Plain anteroposterior and axillary radiographs are the essential basis for shoulder imaging. Supplementary projections may be implemented to demonstrate specific pathologic conditions about the shoulder complex. These additional views, the nature in which they are obtained, and the information derived from them are emphasized in this article.

Kitay GS, Iannotti JP, Williams GR, et al: Roentgenographic assessment of acromial morphologic condition in rotator cuff impingement syndrome. *J Shoulder Elbow Surg* 1995;4:441-448.

Standard anteroposterior and axillary views as well as supraspinatus outlet and 30° caudal tilt views were obtained preoperatively for patients with isolated impingement. Interobserver reliability and correlation of calculated radiographic measurements with acromial measurements obtained at surgery were highest for the supraspinatus and caudal tilt views.

Mack LA, Nyberg DA, Matsen FR, et al: Sonography of the postoperative shoulder. *Am J Roentgenol* 1988;150: 1089-1093.

Sonography was used to assess the rotator cuff in 60 symptomatic shoulders following either acromioplasty alone or in addition to a rotator cuff repair. In patients for whom postoperative follow-up was available, sonography correctly diagnosed a recurrent tear in all 26 shoulders. Likewise, an intact cuff was confirmed in ten of 11 cases.

Norwood LA, Barrack R, Jacobson KE: Clinical presentation of complete tears of the rotator cuff. *J Bone Joint Surg* 1989;71A:499-505.

Data from the histories and physicals of 103 patients with known rotator cuff tears was compared with radiographic and surgical findings to determine if the presence and extent of the tear could be predicted on the basis of history, physical examination, and radiographic findings. When patients with multiple tears were compared to patients with a single tendon tear, it was evident that the multiple tendon group had significantly more findings on their plain radiographs.

Owen RS, Iannotti JP, Kneeland JB, et al: Shoulder after surgery: MR imaging with surgical validation. Radiology 1993;186:443-447.

Thirty-one patients with persistent symptoms following shoulder surgery were examined with MRI prior to repeat surgical intervention. In patients examined with MRI, a correct diagnosis was made in six of seven full-thickness rotator cuff tears. However, partial tears were indistinguishable from repaired tendons. The accuracy of diagnosing impingement postoperatively was found to be 74%.

Sonnabend DH, Hughes JS, Giuffre BM, et al: Ultrasound assessment of shoulder pathology, in Vastamaki M, Jalovaara P (eds): *Surgery of the Shoulder.* Amsterdam, The Netherlands, Elsevier Science, 1995, pp 13-17.

In a series of 117 patients who underwent shoulder ultrasound followed by surgical management, ultrasound was found to be very reliable for the detection of full-thickness rotator cuff tears with a positive predictive value of 96%. In the diagnosis of partial thickness tears there were few false-positive studies but a significant number of false-negatives with a negative predictive value of 66%.

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Nonsurgical Management

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A prospective, randomized, controlled, double-blind study was undertaken in 41 patients with impingement. Patients that received 1% lidocaine with 80 mg triamcinolone had significant improvements in pain, range of motion, and relief of impingement sign when compared to patients who received 1% lidocaine alone.

Byl NN: The use of ultrasound as an enhancer for transcutaneous drug delivery: Phonophoresis. *Phys Ther* 1995;75:539-553.

This article reviews the basic principles of phonophoresis, summarizes the anatomy and physiologic principles that are pertinent to phonophoresis, and provides a critical examination of the most recent literature.

Costello CT, Jeski AH: Iontophoresis: Applications in transdermal medication delivery. *Phys Ther* 1995;75: 554-563.

This article provides an overview of the literature on iontophoresis and a discussion of the biologic and physical aspects that affect iontophoretic drug transfer. Clinical applications including the use of iontophoresis in the physical therapy of various musculoskeletal disorders are also presented.

Itoi E, Tabata S: Conservative treatment of rotator cuff tears. *Clin Orthop* 1992;275:165-173.

This study examined 62 shoulders in 54 patients with complete rotator cuff tears that were treated nonsurgically over an average period of 3.4 years. According to modified Wolfgang's criteria, the results were satisfactory (excellent or good) in 82% of the patients. Results were less satisfactory in those patients who initially had limited range of motion and decreased strength and in those patients who were followed for more than 6 years.

Seltzer DG, Kechele P, Basamania C, et al: Conservative management of rotator cuff tears, in Burkhead WZ (ed): *Rotator Cuff Disorders.* Baltimore, MD, Williams & Wilkins, 1996, pp 258-267.