Full-Thickness Rotator Cuff Tears: Factors Affecting Surgical Outcome

Joseph P. Iannotti, MD, PhD

Abstract

Eighty-five percent to 95% of patients who undergo primary surgical repair of full-thickness rotator cuff tears have a significant decrease in shoulder pain and improvement in shoulder function. The results of surgery are dependent on the surgical technique, the extent of pathologic changes in the rotator cuff, and the postoperative rehabilitation protocol. Preoperative factors associated with a less favorable result are the size of the tear, the quality of the tissues, the presence of a chronic rupture of the long head of the biceps tendon, and the degree of preoperative shoulder weakness. Surgical factors associated with a less favorable result include inadequate acromioplasty, residual symptomatic acromioclavicular arthritis, inadequate rotator cuff tissue mobilization, deltoid detachment or denervation, and failure of rotator cuff healing. Clinical evaluation and preoperative imaging of the shoulder will improve patient selection and counseling. Meticulous surgical technique and postoperative rehabilitation will optimize the final result.

J Am Acad Orthop Surg 1994;2:87-95

Disorders of the rotator cuff constitute the most common source of shoulder pain. The wide spectrum of pathologic conditions includes rotator cuff tendinitis, partial- and full-thickness tears, and calcific tendinopathy. Many etiologic factors underlie these conditions, but the pathogenesis remains controversial. Important factors include age-related degeneration of the tendons, mechanical impingement on the rotator cuff by subacromial and acromioclavicular joint spurs, and changes in the vascularity of the rotator cuff tendon. However, the natural history and progression of rotator cuff disease from simple tendinitis to partial- and full-thickness rotator cuff tears remain poorly understood and are an area of considerable debate.

In this article I will review the preoperative evaluation of full-thickness rotator cuff tears, the surgical management of primary rotator cuff repair, and the factors that influence the postoperative functional outcome.

Preoperative Evaluation

History

The presence of preinjury rotator cuff symptoms correlates with the degree of tendon degeneration and can be an important factor in predicting the outcome of surgical management. The combination of long-standing rotator cuff symptoms and a large full-thickness cuff tear following low-velocity trauma is generally indicative of an acute extension of a chronic degenerative rotator cuff defect. The acute extension is usually associated with pain and weakness. Tears often are associated with fair- or poor-quality degenerative tissue, a significant degree of tendon retraction, peritendinous adhesions, and soft-tissue capsular contracture.

Full-thickness rotator cuff tears associated with high-velocity trauma, particularly in younger individuals, are rarer. When younger patients are treated with early surgery, degenerative changes in the tendons usually do not occur. The prognosis is also better, as measured by greater active postoperative elevation of the arm compared with that after late repair.[1]

Physical Examination

The physical examination should assess the range of motion and the degree of weakness of the rotator cuff musculature. The disparities in active and passive arcs of shoulder elevation are measured. Rotator cuff weakness is then defined by evaluation of muscle strength in both external rotation and internal rotation. The degree of muscular atrophy of the supraspinous and infraspinous fossae is also noted. External rotation strength can be tested in various positions of arm elevation but is least affected by pain when tested

Dr. Iannotti is Associate Professor of Orthopaedic Surgery and Chief, Shoulder Service, Department of Orthopaedic Surgery, University of Pennsylvania School of Medicine, Philadelphia.

Reprint requests: Dr. Iannotti, 3400 Spruce Street, Philadelphia, PA 19104.

with the arm placed at the side. Internal rotation is evaluated by the lift-off test.

Significant weakness (grade 3 or less) of external rotation and significant muscular atrophy are associated with larger chronic full-thickness tears, which extend well into the infraspinatus tendon and are, on average, more difficult to repair. Not surprisingly, these tears are associated with a higher occurrence of persistent postoperative full-thickness defects of the rotator cuff and postoperative weakness.[2,3]

A less favorable prognosis for functional recovery following surgery also should be anticipated in patients with the constellation of large chronic rotator cuff defects, chronic rupture of the long head of the biceps tendon, marked weakness of forward flexion, chronic atrophy of the deltoid, and cephalic migration of the humeral head when active elevation of the arm is attempted. These clinical findings often are associated with massive chronic ruptures of the rotator cuff that are not reparable by primary suturing techniques. These cases may require reconstructive procedures using local or distant tendon transfer to achieve coverage of the humeral head.

Local Anesthetic Injections

The response to local anesthetic injections into the subacromial space or acromioclavicular joint has diagnostic and prognostic value. A marked temporary decrease in shoulder pain associated with the impingement signs helps to confirm the diagnosis of an intrinsic shoulder disorder localized to the rotator cuff and is usually a reflection of the level of pain improvement that can be expected following rotator cuff surgery.[4] In some cases, improvement of active arcs of shoulder motion is also observed.

A significant decrease in shoulder pain with local anesthetic injection is also helpful in distinguishing between true weakness of external rotation or elevation and weakness due to pain. Pain in the acromioclavicular joint that persists following subacromial injection of a local anesthetic suggests significant concomitant acromioclavicular arthropathy and is an indication to assess pain relief by means of a subsequent anesthetic injection into the acromioclavicular joint. If a further significant decrease in shoulder pain is observed and the imaging studies demonstrate significant degenerative changes in the acromioclavicular joint, primary distal clavicular resection is indicated. Lack of improvement with either injection test suggests that an alternative cause for the shoulder pain should be considered.

Imaging Studies

The plain radiographic examination should include an anteroposterior (AP) view in the plane of the scapula and an axillary view of the shoulder. Specialized views are taken to evaluate the degree of acromioclavicular arthritis and supraspinatus outlet narrowing. These include the AP coronal 30-degree caudal-tilt view (Fig. 1, A), the supraspinatus outlet view (10- to 15-degree caudal-tilt lateral scapular view) (Fig. 1, B), and the AP coronal 10- to 30-degree cephalic-tilt view to evaluate the acromioclavicular joint (Fig. 1, C). When properly obtained, these views can be used to define the degree of anterior extension of the acromion beyond the anterior border of the clavicle (Fig. 1, A), the morphology and size of the spur associated with the undersurface of the acromion (Fig. 1, B), and the presence of cystic and degenerative changes in the acromioclavicular joint (Fig. 1, C).

Additional imaging studies useful in the diagnosis of a full-thickness tear of the rotator cuff include arthrography, ultrasonography, and magnetic resonance (MR) imaging. Arthrography has been considered the standard study, with a reported accuracy greater than 95% in the diagnosis of full-thickness cuff tears[5] (Fig. 2), but it has not been universally reported to have a high degree of accuracy in determining the size of a full-thickness tear or the presence of a partial-thickness tear. Arthrography of the shoulder is easily performed and interpreted but is an invasive procedure associated with transient synovitis and a very small potential for infection.

Ultrasonography of the shoulder has been reported to be an accurate and cost-effective noninvasive screening tool for the diagnosis of full- thickness rotator cuff tears[6,7] (Fig. 3). The accuracy of ultrasonography is highly dependent on the experience of the ultrasonographer and the type of equipment used. Its accuracy is significantly improved by obtaining dynamic images through the range of shoulder motion. Using only static images results in decreased accuracy in the diagnosis of full-thickness rotator cuff tears. Ultrasonography has been used to measure the size of the tear and the degree of tendon retraction. Ultrasonography has not yet achieved widespread use in North America as a routine imaging study of the rotator cuff and is most likely to be used in the centers with the most experience in its performance and interpretation.

Magnetic resonance imaging of the shoulder has also been shown to be highly accurate for the diagnosis of full-thickness rotator cuff tears[8] (Fig. 4). The advantages of MR imaging, in addition to its noninvasiveness, include the capacity to accurately measure the size of the cuff defect, the magnitude of tendon retraction, and the degree of supraspinatus and infraspinatus muscular atrophy. The presence of acromioclavicular joint arthritis and acromial spur formation can be determined. Magnetic resonance imaging is also helpful in defining

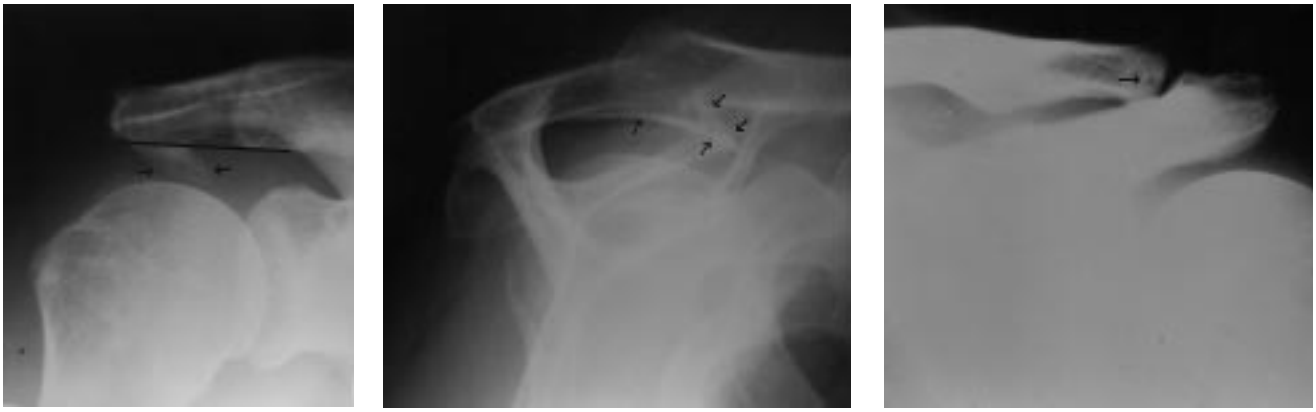


Fig. 1 Specialized radiographic views of the shoulder. **A,** An AP coronal 30-degree caudal-tilt (Rockwood tilt) view demonstrating anterior extension of the acromion (arrows) beyond the anterior border of the clavicle (line). **B,** Supraspinatus outlet view demonstrating a large anteroinferior acromial osteophyte (arrows). (Reproduced with permission from Iannotti JP [ed]: *Rotator Cuff Disorders: Evaluation and Treatment*. American Academy of Orthopaedic Surgeons Monograph Series. Rosemont, Ill: American Academy of Orthopaedic Surgeons, 1991, p 15.) **C,** An AP coronal 15-degree cephalic-tilt view (Zanca view) demonstrating cystic changes at the distal end of the clavicle (arrow).

other associated pathologic conditions, including glenohumeral arthritis, capsular and labral pathologic changes, rupture of the long head of the biceps tendon, and ganglion cysts. Ganglion cysts can simulate the clinical findings of a chronic full-thickness rotator cuff tear by extrinsic compression of the suprascapular nerve. The accuracy of MR imaging is dependent on the experience of the reader, the technique of MR sequencing, and the equipment utilized.

Certain anatomic findings that can be depicted on MR imaging studies correlate with less favorable functional outcomes following rotator cuff repair, among them large tears involving the subscapularis and the infraspinatus and teres minor, chronic rupture of the long head of the biceps tendon, cephalic migration of the humeral head, early degenerative changes of the glenohumeral articulation, and moderate to severe atrophy of the supraspinatus and infraspinatus musculature. These pathologic findings are easily identified by experienced MR imagers and often correlate well with the clinical findings.[8]

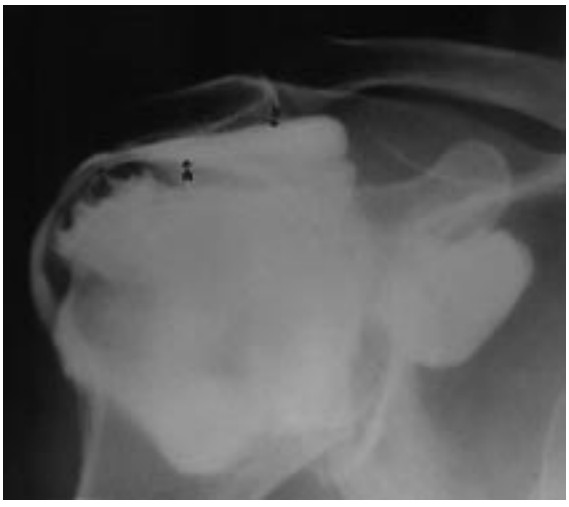


Fig. 2 An AP single-contrast arthrogram demonstrating a full-thickness rotator cuff tear with contrast material within the subacromial space (arrows). (Reproduced with permission from Iannotti JP [ed]: *Rotator Cuff Disorders: Evaluation and Treatment*. American Academy of Orthopaedic Surgeons Monograph Series. Rosemont, Ill: American Academy of Orthopaedic Surgeons, 1991, p 19.)

Goals and Indications for Surgical Intervention

The primary goal of surgical intervention for the vast majority of patients with rotator cuff tears is to decrease pain, including rest pain, night pain, and pain with activities of daily living. Additional goals of surgery are to improve shoulder function and to limit the progression of rotator cuff tendinopathy.

The indications for surgical intervention must be individualized and are dependent on the patient's age and physical demands, the size of the rotator cuff tear, the mechanism of injury, and the progression of pain. It is my preference to advise initial nonoperative treatment for patients who

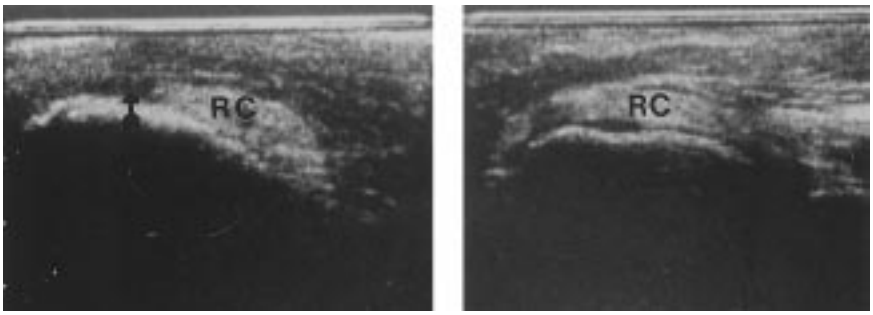


Fig. 3 Longitudinal sonograms of both shoulders. **A,** Image of the right shoulder depicts a full-thickness tear (arrow) of the rotator cuff (RC). **B,** Image of the left shoulder shows an intact rotator cuff.

have good active arcs of shoulder motion and strength at the time of their initial presentation and who have either a chronic rotator cuff tear or an acute extension of a small tear superposed on chronic symptoms. Such patients generally have minimal involvement of the posterior aspect of the rotator cuff (infraspinatus and teres minor). For patients with less severe symptoms, nonoperative treatment may simply be modification of activity and a home exercise program. For patients with more severe symptoms, nonoperative treatment includes oral anti-inflammatory medication, occasional subacromial injection of corticosteroids, and supervised physical therapy.

The length of nonoperative treatment must be individualized on the basis of the pathologic changes, the patient's response to treatment, and his or her functional demands and expectations. If pain persists despite compliance with a well-supervised nonoperative treatment program, surgical intervention can be recommended, provided the pain level and functional limitations are sufficiently serious. Early surgical intervention is indicated in patients who sustain acute trauma associated with significant weakness of the shoulder and posterior cuff involvement, particularly in younger patients with higher functional demands. Patients with acute tears or large extensions of chronic cuff tears can be included in this group.

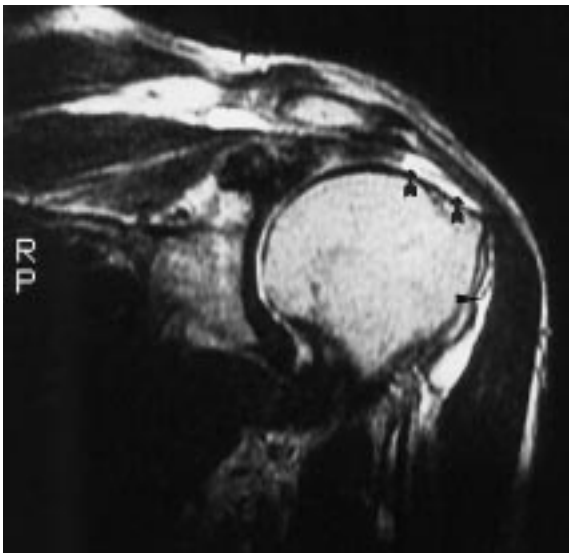


Fig. 4 Coronal oblique T2-weighted (repetition time = 2,000 msec; echo time = 80 msec) MR image (16-cm field of view, 4-mm section thickness) depicts synovial fluid within a full-thickness defect of the supraspinatus tendon (arrows). Synovial fluid extends into the subdeltoid space (arrowhead). There is minimal atrophy of the supraspinatus muscle belly.

Primary Open Repair

With a few exceptions, all operative procedures described in the recent literature for primary repair of chronic rotator cuff tears include the use of an anteroinferior acromioplasty to provide adequate decompression of the subacromial space.[9-17] Almost all patients with chronic full-thickness rotator cuff tears have significant subacromial outlet narrowing, and an adequate acromioplasty has been shown to be an important element in the subsequent relief of shoulder pain.[14-16]

The presence of clinically significant acromioclavicular joint arthritis, as defined by clinical examination, injection testing, and imaging studies, serves as the indication for concomitant formal distal clavicle resection. Informal surveys of shoulder surgeons indicate that 5% to 20% of patients meet this criterion. Without this primary indication for distal clavicle resection, an adequate decompression of only the undersurface of the acromioclavicular joint is generally performed when there is significant impingement in this area. Anterior acromioplasty may not be necessary in the rare case of a young patient with an acute traumatic rotator cuff tear, but it is sometimes performed to aid in surgical exposure. In patients with massive tears and a proximally migrated humerus, preservation and repair of the coracoacromial ligament is con-

sidered, and distal clavicle resection and aggressive acromioplasty are avoided.

Technique

Most surgeons prefer an anterosuperior approach to the shoulder performed within Langer's lines (Fig. 5). The approach is usually performed in association with detachment of a small portion of the anterior deltoid from the acromioclavicular joint to the anterolateral corner of the acromion, with splitting of the fibers of the middle deltoid for a distance of 3 to 4 cm. An anteroinferior acromioplasty is performed as described by Neer.[4]

Mobilization of the cuff tendons requires release of all adhesions in the subacromial space, the coracohumeral ligament at the base of the coracoid, and occasionally the intraarticular portion of the capsule when it is contracted (Fig. 6). To avoid injury of the suprascapular nerve, dissection of the supraspinatus and infraspinatus musculature medial to the glenoid margin should not exceed 1.5 to 2.0 cm. Debridement of the edges of the rotator cuff tendon should remove only tissue that is mechanically unsound. Relaxing incisions at the rotator interval may also improve lateral mobilization of the tendon for repair to a bone trough with the arm held at the patient's side (Fig. 7).

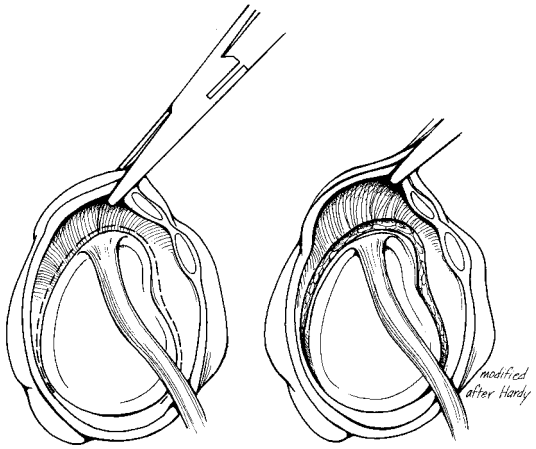


Fig. 6 Technique of capsular advancement in patients with fixed, retracted rotator cuff tears.

Most tears require direct suturing of the tendon edge to a bone trough in the greater tuberosity. A shallow bone trough is made to expose the bleeding cancellous bone of the tuberosity, and care is taken to preserve the cortical bone of the lateral portion of the greater tuberosity (Fig. 8, A). The primary repair of the rotator cuff tear is performed utilizing heavy nonabsorbable suture (No. 2 or larger). The technique for repair is dictated by the configuration of the tendon tear.

Horizontal mattress sutures are placed through drill holes in the tuberosity and passed through the lateral edge of the cuff tendon (Fig. 8, B and C). In most cases, tendon-to-tendon repair is also performed along with suturing of the lateral tendon edge to a bone trough. The deltoid is sutured back to the acromion through drill holes and to the deltotrapezius aponeuroses. Routine skin closure includes subcuticular suturing.

Postoperative management after primary repair of full-thickness cuff tears must be individualized to

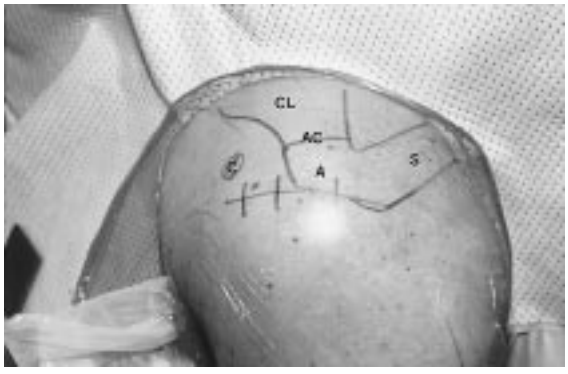


Fig. 5 Anterosuperior incision for open acromioplasty and rotator cuff repair. A = acromion; AC = acromioclavicular joint; C = coracoid; CL = distal clavicle; S = spine of the scapula.

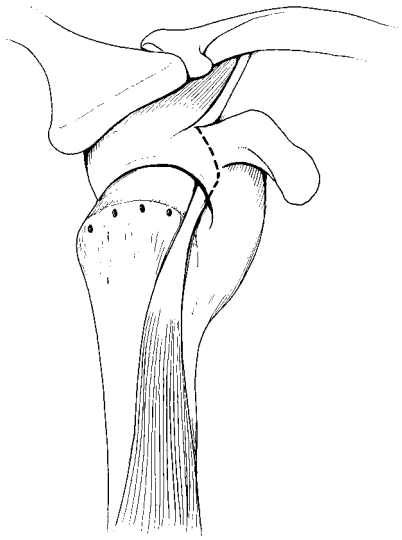
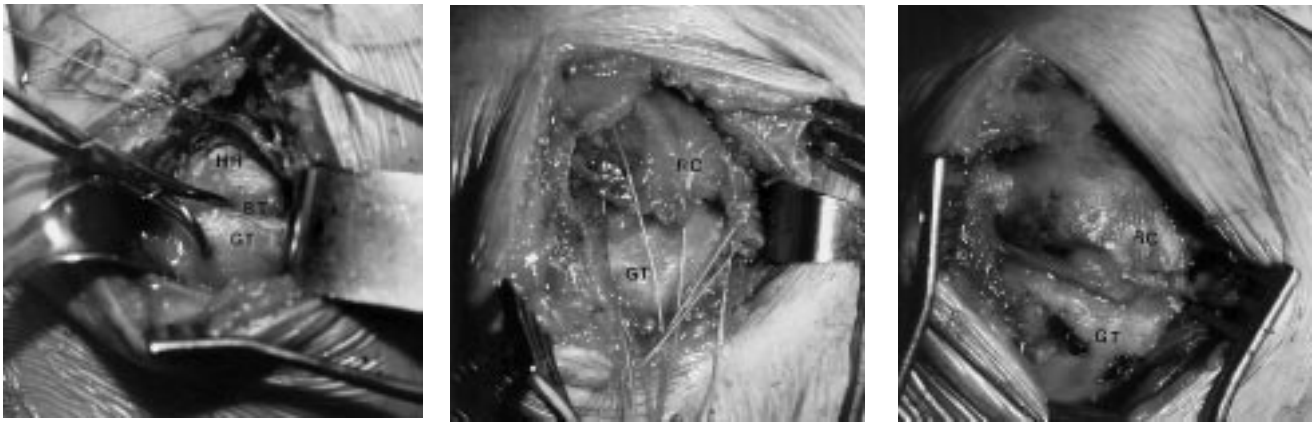


Fig. 7 Incision in the rotator cuff interval from the edge of the tear to the base of the coracoid releases the coracohumeral ligament and supraspinatus tendon as a unit, allowing lateral mobilization of tissue toward the greater tuberosity.



A B C

Fig. 8 Suturing procedure. **A,** Bone trough (BT) between the humeral head (HH) and the greater tuberosity (GT). The hole made by passing a towel clip from the bone trough through the lateral wall of the greater tuberosity is used to pass suture for tendon-to-bone repair. **B,** Traction sutures placed within the rotator cuff (RC) are used to mobilize the tendon edges and then pulled laterally to the bone trough within the greater tuberosity. **C,** Horizontal mattress sutures are passed from the greater tuberosity through the rotator cuff and tied over a bone bridge in the greater tuberosity.

account for the size of the tear, the quality of the tissues, the difficulty of repair, and the patient's goals. In general, supine active assisted motion is started on the first postoperative day. Waist-level use of the hand can in most cases be started immediately after surgery. Active range-of-motion exercises and isotonic strengthening are usually started 6 to 8 weeks after surgery. Progression of the strengthening program must be individualized; the period required for full rehabilitation ranges from 6 to 12 months after surgery.

Results

The overall clinical results with respect to shoulder pain have been reported to be satisfactory in 85% to 95% of patients who have undergone open repair of full-thickness tears.[2-4,9-13] If an early satisfactory result is obtained, the pain relief and functional improvement appear to be lasting. Analysis of the 7- to 15-year follow-up of patients who underwent primary rotator cuff repair demonstrates maintenance of satisfactory clinical results without significant deterioration of function or recurrence of shoulder pain.[9,18,19] Improvement in pain level is highly correlated with patient satisfaction.

Several recent retrospective studies of rotator cuff repair also report that 85% to 95% of patients have significant improvement in shoulder function following primary rotator cuff repair.[2,3,9-13] The degree of functional improvement reported is difficult to compare among these studies due to the wide variation in techniques utilized to define function and to measure shoulder strength and functional outcome. Most reports indicate that improvement in pain level correlates with the adequacy of acromioplasty and subacromial decompression.[14-17] Improvement of function is correlated with improvement in pain level as well as adequacy of the rotator cuff repair and healing of the rotator cuff defect.[2,16] Postoperative strength and function correlate with the preoperative size of the tear, the quality of the tendon tissue, and the ease of tissue mobilization.[3]

Significant postoperative weakness on forward flexion and difficulty with use of the arm at or above shoulder level are usually seen in the following circumstances: (1) failure of repair of a full-thickness cuff tear or a postoperative tear, particularly when the tear involves the posterior aspect of the rotator cuff (infraspinatus and teres minor); (2) deltoid detachment or denervation; and (3) rupture of the long head of the biceps tendon.[20-22]

It may still be possible to achieve active elevation of the arm above shoulder level in the presence of a postoperative full-thickness cuff tear as long as there is significant improvement in the postoperative pain level, full rehabilitation of the deltoid, and sufficient anterior and posterior rotator cuff musculature to maintain containment of the humeral head within the glenoid fossa during elevation of the arm.[2] In such cases, however, patients often have decreased strength of external rotation and abduction. Despite the persistence of weakness in patients with postoperative rotator cuff defects, improvement of the pain level and concomitant improvement of shoulder function often result in a high level of patient satisfaction.[2,23]

Arthroscopic Repair

The preliminary results and short-term follow-up after arthroscopic subacromial decompression in conjunction with arthroscopic rotator cuff repair or arthroscopically assisted rotator cuff repair have recently been reported.[23,24] The principles of arthroscopically assisted rotator cuff repair and subacromial decompression are the same as those of open procedures. An adequate decompression must be carried out beneath the acromion and the acromioclavicular joint. When indicated, arthroscopic resection of the distal clavicle may be necessary. Mobilization of rotator cuff tissue, release of adhesions and scar tissue, and repair of the tendon to a well-prepared bleeding bone trough are required.

Arthroscopic techniques appear to provide acceptable clinical results, particularly in patients with small rotator cuff tears involving a single tendon with good- to excellent-quality tissue and minimal tissue retraction and scarring. The challenge of arthroscopic surgery for rotator cuff repair lies in proper patient selection and improvement of the techniques for tendon-to-bone repair.

Technique

After adequate arthroscopic subacromial decompression, the anterolateral portal is utilized for preparing a bone trough for tendon repair. The techniques for arthroscopic rotator cuff repair to a bone trough include percutaneous insertion of absorbable tacks and metallic staples. Use of single- or double-point fixation, tacks, or staples carries the potential for loss of fixation, particularly in patients with soft cancellous bone. Loss of fixation can result in failure of tendon repair as well as mechanical irritation caused by these devices in the subacromial space. An alternative technique is arthroscopically assisted rotator cuff repair using standard suture techniques through a lateral deltoid-splitting incision.[24,25] This technique requires an open procedure to split the deltoid, but generally does not require detachment of the deltoid from the acromion, particularly in patients with small cuff tears of the supraspinatus tendon.

Results

The recently reported results of arthroscopically assisted techniques have been favorable.[24,25] However, the results are not directly comparable with the results of traditional open surgery because studies involving open techniques include larger numbers of patients, many of whom have large chronic tears requiring extensive soft-tissue mobilization. Arthroscopically assisted techniques for cuff repair have not been thoroughly evaluated for these more difficult cases. Further refinement of arthroscopic techniques for rotator cuff repair and analysis of long-term follow-up data will facilitate definition of the appropriate indications for arthroscopic rotator cuff repair. At the present time, arthroscopic techniques for rotator cuff repair remain an area for further development and careful consideration.

Repair of Massive Tears Not Amenable to Primary Repair

Surgical options for treatment of patients with massive full-thickness rotator cuff tears that are not amenable to primary repair include subacromial decompression and debridement of nonviable rotator cuff tissue without attempts at rotator cuff reconstruction, the use of autogenous or allograft tendon grafts, and the use of active tendon transfers.

Rockwood et al[23] analyzed the data on a large group of patients treated by subacromial decompression and debridement of mechanically nonviable rotator cuff tissue. The results were satisfactory in 85% of their patients, as measured by excellent improvement in pain level and active elevation of the arm above shoulder level. The patients with the best results had a well-compensated and well-rehabilitated deltoid, an intact long head of the biceps tendon, and significant improvement in pain level. Quantitative measurements of shoulder strength were not reported in this series; therefore, these results cannot be compared with those in patients who underwent rotator cuff repair.

The use of prosthetic materials or allograft tissue for rotator cuff repair has been reported to have variable results.[26,27] Improvement in pain level and function has been reported with the use of freeze-dried allograft in selected cases.[27] Use of these materials will require further experimental and clinical evaluation and cannot be strongly advocated at this time.

Tendon transfers may involve the subscapularis, latissimus dorsi, deltoid, or trapezius. Transfer of the upper two thirds of the subscapularis tendon is a commonly performed tendon transfer and is particularly useful for irreparable defects of the supraspinatus tendon.[28] It is best performed in patients with an intact or reparable posterior rotator cuff and an intact long head of the biceps tendon. Transfer of the subscapularis requires maintenance of the inferior glenohumeral capsular ligaments and the inferior third of the subscapularis muscle. This procedure can be performed for isolated reconstruction of the rotator cuff and is also used in prosthetic shoulder replacement associated with rotator cuff tears and deficient superior coverage of the humeral head.

Latissimus dorsi transfer is a difficult and extensive operative procedure, which is primarily indicated for patients with loss of external rotational power and irreparable defects of the posterior portion of the rotator cuff involving the infraspinatus and teres minor tendons.[29,30] The best results occur in patients with an intact subscapularis and long head of the biceps tendon and well-compensated deltoid function. Latissimus dorsi transfer is a demanding operative procedure, and at the present time there is limited experience in the United States.

Use of a portion of the middle deltoid as a tissue transfer in patients with irreparable rotator cuff tears also has been reported.[31] This technique has had limited use in Europe and has not yet been widely accepted in the United States, nor has it been adequately evaluated.

Trapezius transfers for repair of massive rotator cuff tears are now of purely historic interest and are no longer performed.

Summary

Clinical evaluation of patients with full-thickness rotator cuff tears can define many of the prognostic factors that influence the long-term functional outcome of rotator cuff repair. Plain radiographs remain the most important diagnostic tool for evaluating the degree of subacromial outlet narrowing and acromioclavicular joint disease. Although arthrography, ultrasonography, and MR imaging are all accurate for the diagnosis of full-thickness rotator cuff tears in specific clinical settings, MR imaging appears to be the most useful in evaluating the prognostic factors that influence the functional outcome following surgical repair.

A carefully conducted trial of nonoperative treatment should generally precede surgery. Surgical treatment of full-thickness rotator cuff tears yields patient satisfaction in a large percentage of patients and significant improvement in pain and function levels, which appear to be maintained over a 7- to 15-year follow-up period. Subacromial decompression and appropriate management of clinically significant acromioclavicular disease will, in most cases, decrease pain associated with impingement. Successful repair and healing of full-thickness cuff tears are highly correlated with improvement in shoulder strength.

Clinical, radiographic, and operative factors that are associated with a higher incidence of less favorable results include the presence of large and massive rotator cuff tears involving the infraspinatus and teres minor, significant preoperative weakness of external rotation and abduction, chronic rupture of the long head of the biceps tendon, anterior deltoid denervation or detachment, poor-quality tendon tissue, and difficulty with intraoperative tissue mobilization. These factors are interrelated and can be helpful both in the diagnosis and in preoperative patient counseling.

References

1. Bassett RW, Cofield RH: Acute tears of the rotator cuff: The timing of surgical repair. *Clin Orthop* 1983;175:18-24.
2. Harryman DT II, Mack LA, Wang KY, et al: Repairs of the rotator cuff: Correlation of functional results with integrity of the cuff. *J Bone Joint Surg Am* 1991;73:982-989.
3. Iannotti JP, Bernot M, Kuhlman J, et al: Prospective evaluation of rotator cuff repair. *J Shoulder Elbow Surg* 1993;2:S9.
4. Neer CS II: Anterior acromioplasty for the chronic impingement syndrome in the shoulder: A preliminary report. *J Bone Joint Surg Am* 1972;54:41-50.
5. Mink JH, Harris E, Rappaport M: Rotator cuff tears: Evaluation using double-contrast shoulder arthrography. *Radiology* 1985;157:621-623.
6. Crass JR, Craig EV, Thompson RC, et al: Ultrasonography of the rotator cuff: Surgical correlation. *J Clin Ultrasound* 1984;12:487-491.
7. Mack LA, Nyberg DA, Matsen FR III, et al: Sonography of the postoperative shoulder. *AJR* 1988;150:1089-1093.
8. Iannotti JP, Zlatkin MB, Esterhai JL, et al: Magnetic resonance imaging of the shoulder: Sensitivity, specificity and predictive value. *J Bone Joint Surg Am* 1991;73:17-29.
9. Bigliani LU, Cordasco FA, McIlveen SJ, et al: Operative repair of massive rotator cuff tears: Long term results. *J Shoulder Elbow Surg* 1992;1:120-130.
10. Gore DR, Murray MP, Sepic SB, et al: Shoulder-muscle strength and range of motion following surgical repair of full-thickness rotator cuff tears. *J Bone Joint Surg Am* 1986;68:266-272.
11. Ellman H, Hanker G, Bayer M: Repair of the rotator cuff: End result study of factors influencing reconstruction. *J Bone Joint Surg Am* 1986;68:1136-1144.
12. Björkenheim JM, Paavolainen P, Ahovuo J, et al: Surgical repair of the rotator cuff and surrounding tissues: Factors influencing the results. *Clin Orthop* 1988;236:148-153.
13. Hawkins RJ, Misamore GW, Hobeika PE: Surgery for full-thickness rotator cuff tears. *J Bone Joint Surg Am* 1985;67:1349-1355.
14. Ogilvie-Harris DJ, Demaziere A: Arthroscopic debridement versus open repair for rotator cuff tears. *J Bone Joint Surg Br* 1993;75:416-420.
15. Packer NP, Calvert PT, Bayley JI, et al: Operative treatment of chronic ruptures of the rotator cuff of the shoulder. *J Bone Joint Surg Br* 1983;65:171-175.
16. Rockwood CA Jr, Williams GR: The shoulder impingement syndrome: Management of surgical treatment failures. *Orthop Trans* 1992;16:739-740.
17. Flugstad D, Matsen FA, Larry I, et al: Failed acromioplasty: Etiology and prevention. *Orthop Trans* 1986;10:229.
18. Neer CS II, Flatow EL, Lech O: Tears of

the rotator cuff: Long term results of anterior acromioplasty and repair. *Orthop Trans* 1988;12:673-674.
19. Adamson GJ, Tibone JE: Ten year assessment of primary rotator cuff repairs. *J Shoulder Elbow Surg* 1993;2: 57-63.
20. Bigliani LU, McIlveen SJ, Cordasco FA, et al: Operative management of failed rotator cuff repairs. *Orthop Trans* 1988;12:674.
21. DeOrio JK, Cofield RH: Results of a second attempt at surgical repair of a failed initial rotator cuff repair. *J Bone Joint Surg Am* 1984;66:563-567.
22. Neviaser RJ, Neviaser TJ: Re-operation for failed rotator cuff repair: Analysis of 50 cases. *J Shoulder Elbow Surg* 1992;1:283-286.
23. Rockwood CA Jr, Williams GR, Burkhead WZ Jr: Debridement of irreparable degenerative lesions of the rotator cuff. *Orthop Trans* 1992;16:740.
24. Paletta GA Jr, Warner JJP, Altchek DW, et al: Arthroscopic rotator cuff repair: Evaluation of results and a comparison of techniques. Presented at the 60th Annual Meeting of the American Academy of Orthopaedic Surgeons, San Francisco, Feb 18-23, 1993.
25. Weber SC, Schaefer RK: Mini open versus traditional open technique in the management of tears of the rotator cuff. Presented at the 60th Annual Meeting of the American Academy of Orthopaedic Surgeons, San Francisco, Feb 18-23, 1993.
26. Nasca RJ: The use of freeze-dried allografts in the management of global rotator cuff tears. *Clin Orthop* 1988; 228:218-226.
27. Neviaser JS, Neviaser RJ, Neviaser TJ: The repair of chronic massive ruptures of the rotator cuff of the shoulder by use of a freeze-dried rotator cuff. *J Bone Joint Surg Am* 1978;60:681-684.
28. Cofield RH: Subscapular muscle transposition for repair of chronic rotator cuff tears. *Surg Gynecol Obstet* 1982;154: 667-672.
29. Gerber C, Vinh TS, Hertel R, et al: Latissimus dorsi transfer for the treatment of massive tears of the rotator cuff: A preliminary report. *Clin Orthop* 1988; 232:51-61.
30. Gerber C: Latissimus dorsi transfer for the treatment of irreparable tears of the rotator cuff. *Clin Orthop* 1993;275: 152-160.
31. Augereau B: Rekonstruktion massiver Rotatorenmanschettenrupturen mit einem Deltoidlappen. *Orthopade* 1991; 20:315-319.