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Rotator Cuff Disorders

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Introduction

Disorders of the rotator cuff tendons were first recognized early in the 19th century. An account of J.G. Smith (1835) described a tear that occurred as a result of a "severe blow, strain, or dislocation" of the shoulder [1]. The first surgical procedure to repair the injured rotator cuff tendon was described by Codman in 1911 [2]. Techniques were further modified by McLaughlin, and later by Neer [3–7]. Recent advances have emphasized minimally invasive techniques for subacromial decompression and rotator cuff repair, including arthroscopic and "mini-open" approaches.

Despite the advances in both diagnosis and surgical management of rotator cuff disorders, the exact etiology of rotator cuff tendinopathy is not fully understood. Both intrinsic and extrinsic theories of tendon injury have been proposed. Meyer suggested an extratendinous theory in 1922 where "tendon and capsular tears" were thought to be "secondary to frictional contact of the greater tuberosity on the acromion [8]." This theory was contrary to that proposed by Lindblom in 1939, where injury was thought to be secondary to "tension in the fascicles of the tendon aponeurosis [9]." Codman later emphasized the contribution of trauma to tendon injury. Finally, Neer turned the focus of etiology back to the acromion when he described "impingement syndrome" in 1972 [6]. More recent research has implicated the subacromial bursa as part of the pathology, with increased inflammatory mediators, afferent nerve endings and their products in inflamed subacromial bursa [10–14]. Currently, rotator cuff tendinopathy is considered to be multifactorial in etiology, and the relative contributions of these factors remain to be determined.

Rotator cuff tears are common, and their incidence increases with advancing age. Major and minor trauma can be associated in up to 58% of patients, and the incidence is particularly high in overhead athletes (30%) and laborers (23%) [15]. Nonoperative management is successful in the majority of patients, although these results are highly variable and depend upon several patient factors including patient age, tear size, and functional level [16–18]. Surgical principles of rotator cuff repair are much the same as those proposed by McLaughlin in 1944: reestablish the continuity of the cuff mechanism, obtain a tension-free repair, and create a smooth acromial surface to limit extrinsic impingement [4]. With current operative techniques, recent series have reported good to excellent results in both functional improvement (70% to 95%) and pain relief (85% to 100%) [19–28].

Patient Evaluation

Pain is the most common complaint in patients with rotator cuff disease. While sudden trauma can cause acute rotator cuff tears, especially in association with shoulder dislocation, the pain of rotator cuff disease often occurs insidiously, and usually cannot be related to a specific inciting event. The pain may often radiate down the arm, but does not localize below the elbow. This radiation of pain is attributed to the subacromial and subdeltoid bursa, which is rich in nerve endings and extends down to the deltoid insertion on the arm. Pain is usually aggravated by overhead activities, but rest pain and night pain may also be present. In addition to pain, the patient may also complain of weakness and inability to raise the arm. These complaints are often indicative of a larger size tear.

Physical examination should include visual inspection to determine the presence of deltoid or spinati muscle atrophy. Rupture of the biceps tendon may be manifest by a bulge in the proximal arm, while the presence of a "fluid sign" may indicate a massive rotator cuff tear consistent with rotator cuff tear arthropathy. Ecchymosis may be present in the setting of acute injury. Palpation should be performed to determine the presence of tenderness over the greater tuberosity and also to assess associated acromioclavicular joint tenderness.

Both passive and active range of motion should be examined. While passive range of motion is usually preserved with rotator cuff tears, mild stiffness from posterior capsular tightness can exacerbate impingement symptoms, while a secondary adhesive capsulitis may also rarely occur. In patients with severe impingement, an "arc of pain" will be present with passive motion. Provocative tests should be performed, including both the Neer and Hawkins impingement signs. The Neer impingement sign is elicited with passive forward elevation of the arm in the scapular plane. A positive Hawkins impingement sign is present when internal rotation of the arm when abducted to 90 degrees produces pain in the subacromial space.

While strength may be normal in some patients with small full-thickness rotator cuff tears, weakness is usually present with larger tears. Occasionally, pain will complicate the clinical exam and a subacromial lidocaine injection may be useful to distinguish pain from true weakness. Strength in forward elevation and external rotation should be closely examined. Patients with large tears have a positive "lag" or "drop" sign, indicating weakness of external rotation. A positive drop sign—inability to maintain neutral rotation with the arm at the side—usually indicates a tear of the infraspinatus and teres minor. Often patients with massive tears cannot actively elevate the arm above 90 degrees. Patients with nonpainful weakness require an expanded differential diagnosis. Neurologic lesions, including cervical radiculopathy, brachial neuritis, suprascapular neuropathy, or syringomyelia must be considered. Specific attention should be paid to potential tears of the subscapularis tendon, which often are undiagnosed. These are more common in the setting of acute trauma and anterior shoulder dislocation, although they may also occur in chronic massive rotator cuff tears. The "lift-off" and "belly-press" tests are useful in diagnosing subscapularis tears [29].

Radiographic Evaluation

Routine radiographic evaluation should include supraspinatus outlet, axillary, and anteroposterior (AP) radiographs in neutral, and in internal and external rotation. The supraspinatus outlet view is performed with a 10 degrees caudal tilt to the X-ray beam, and is particularly useful for assessing acromial morphology and the presence of an acromial spur (Figure 13-1). Three distinct acromial shapes have been described by Bigliani [30]. Type I, or "flat" acromions and type II "curved" were rarely associated with rotator cuff tears, while type III "hooked" acromions are associated with rotator cuff tears in 70% of postmortem specimens. The outlet view should also be examined for the presence of acromial "spurs," which indicate coracoacromial ligament degenerative changes and osteophyte formation, which are distinct from the acromial shape.

The axillary view is important to rule out the presence of os acromiale, which is present in 1% to 3% of the population, and is bilateral in 60% of patients. The AP view is particularly helpful in estimating the acromiohumeral interval, typically 1 to 1.5 cm [31]. Patients with large or massive tears have a decreased acromiohumeral distance. In our series of massive tears, the average acromiohumeral interval was 7.1 mm. Early signs of cuff tear arthropathy must be considered in patients with superior migration of the humeral head, superior glenoid wear, and erosion into the acromioclavicular joint [32]. AP views in internal and external rotation can also be helpful in identifying calcific tendonitis, which can be missed on a single AP view.

Further imaging may be necessary in the patient who has not responded to non-operative management.

FIGURE 13-1. The "outlet view" is taken with the X-ray beam tilted 10 degrees caudally. This view is important in determining acromial morphology and the presence of "spur" formation in the coracoacromial ligament.

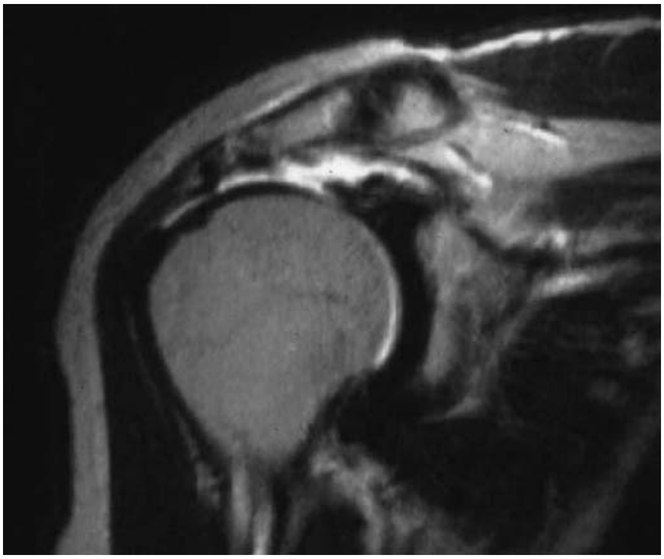

FIGURE 13-2. The MRI scan is the most useful test for evaluating rotator cuff tears. A large tear of the supraspinatus is evident on this oblique coronal image.

Arthrography, ultrasonography, and magnetic resonance imaging (MRI) can confirm the presence or absence of a rotator cuff tear. MR imaging is the preferred modality, as information regarding tear size, tear location, and tissue quality can be more clearly elucidated [33] (see Figure 13-2). It is important to obtain MR images in the scapular plane to evaluate the infraspinatus attachment and more proximal cuts to determine muscle atrophy [34]. Atrophy of the spinati muscles may predict the inability to obtain complete repair of the rotator cuff. Axillary images are needed to evaluate the subscapularis tendon and subluxation, dislocation, or rupture of the long head of the biceps. MR imaging is also useful in assessing the quality and size of the coracoacromial ligament, as thickening of the anteromedial band can be associated with impingement syndrome and rotator cuff tears in some patients [35].

Classification

The size of the rotator cuff tear is usually determined at the time of surgery, but can also be estimated on the MRI scan. The size of the tear is measured by the width of the tear at its insertion to the greater tuberosity or by its greatest diameter in any direction. Small tears are less than 1 cm wide; medium tear are 1 to 3 cm; large tears 3 to 5 cm, and massive tears greater than 5 cm wide [36]. The number of tendons involved can also characterize the tear, although this system may be unreliable due to confluence of the tendons at their insertion into the greater tuberosity [37]. Large and massive tears typically involve two or more tendons.

Management

Nonoperative

Nonoperative management of rotator cuff tears and impingement syndrome can be successful in 33% to 92% of patients. Management consists of rest and avoidance of provocative activities. A trial of nonsteroidal anti-inflammatory medication should be attempted if not contraindicated. Physical therapy can be very helpful in maintaining motion, increasing rotator cuff strength, and decreasing inflammation and pain. Passive range of motion exercises should be combined with resistive exercises with the arm below the horizontal. Therapeutic modalities, such as heat, ultrasound, ionophoresis, and phonophoresis can also be of value.

When these nonoperative management modalities are unsuccessful, consideration should be given to subacromial injection of steroid medication. Usually no more than three injections should be performed before the patient is counseled to have surgical management. Injections have also been found to be less helpful in the presence of large or massive rotator cuff tears.

Surgical Management

Indications

Because rotator cuff tears can be present in the general population in the absence of symptoms or functional deficits, the presence of a documented rotator cuff tear alone does not require surgery. However, when a rotator cuff tear is identified in combination with pain or functional deficit that is not responsive to conservative management, surgery is indicated. Nonoperative management is typically continued for 3 to 6 months before surgery is contemplated. More urgent surgery may be necessary in young patients with acute tears and in older patients who have acute extensions of chronic tears. The ability to repair the cuff may be improved in these patients when surgery is performed within the first 3 weeks after injury [38].

Arthroscopic Management

Arthroscopic acromioplasty and rotator cuff repair is advantageous due to the improved cosmesis and preservation of the deltoid origin. It is also useful in identifying the presence of associated pathology which can occur in up to 60% of patients [39]. Arthroscopy is performed with the patient in the beach-chair position so that conversion to an open procedure is possible. The glenohumeral joint is entered from a posterior portal and the rotator cuff insertion is inspected. Partial-thickness tears may be identified on either the articular or bursal side of the tendon. If the partial thickness tear is found to be less than 50% of the tendon width, no repair is needed and a subacromial decompression alone will suffice. However, if the tear is greater than 50%, debridement of the tear and primary repair either through arthroscopic or mini-open techniques is recommended.

Impingement may occur from the anteroinferior acromion, a hypertrophied coracoacromial ligament, or hypertrophic changes at the acromioclavicular joint. Bursectomy is performed through one or two lateral portals, and the coracoacromial ligament is detached from its insertion along the undersurface of the acromion. Arthroscopic acromioplasty creates a smooth undersurface to the acromion, with care to avoid detachment of the deltoid origin. Once acromioplasty is complete, the bursal side of the rotator cuff is inspected for full thickness tears (see Figure 13-3). When a tear is identified, the remaining rotator cuff must be mobilized by releasing intra-articular and subacromial adhesions.

Multiple techniques have been described for suturing the tendon and securing it to the tuberosity [40,41]. We prefer to use the absorbable suture anchors because of their ease of insertion. A spinal needle is used to determine the appropriate location at the tuberosity for anchor insertion, and a drill hole for the suture anchor is made through a small stab wound at this location. The Caspari suture punch is then used to create a passing suture (double limbed #2–0 Prolene or a shuttle relay device) (see Figure 13-4). The suture anchor is placed in the hole and one limb of the suture is passed through the tendon and back out the lateral hole with the passing suture (see Figure 13-5). Both limbs of the anchors are then withdrawn from the lateral portal and the sutures may then be tied down using the surgeon's arthroscopic knot of choice.

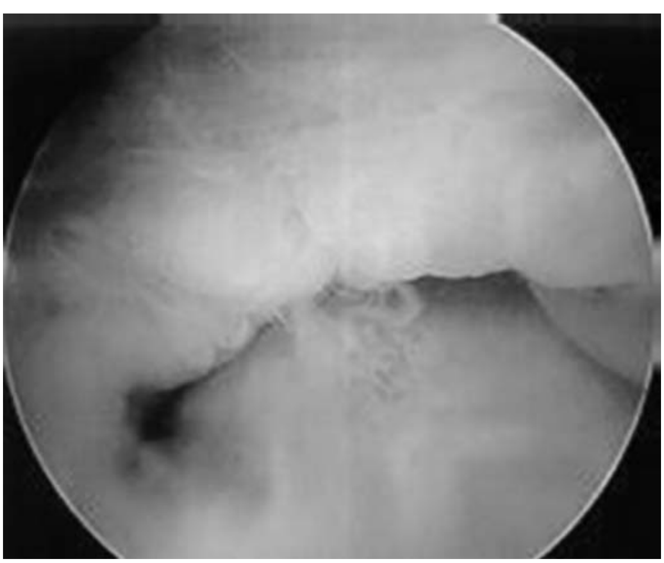

FIGURE 13-3. A full thickness tear of the supraspinatus tendon is seen with the 30-degree arthroscope in the subacromial space.

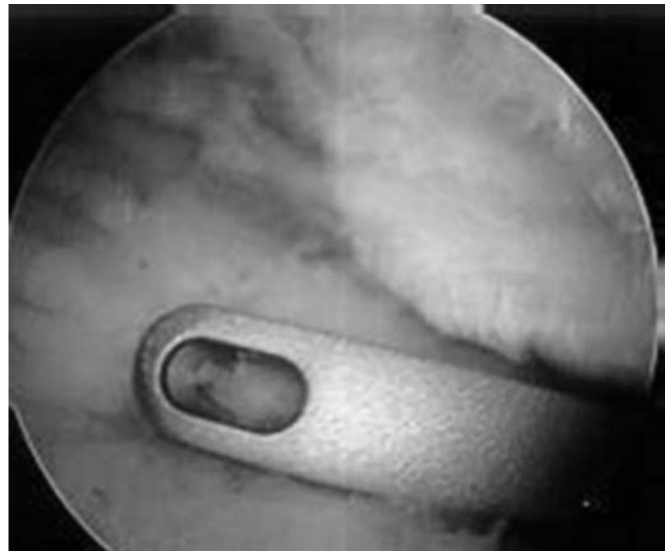

FIGURE 13-4. The tendon edge is grasped with the Caspari suture punch, and a passing suture is advanced through the tendon.

The results of arthroscopic management of rotator cuff tears are still being determined. Various techniques have been advocated for successful repair, with early good to excellent results reported in 84% to 92% of patients [42,43]. However, the technique is technically demanding and these results may not be reproducible for all orthopedic surgeons.

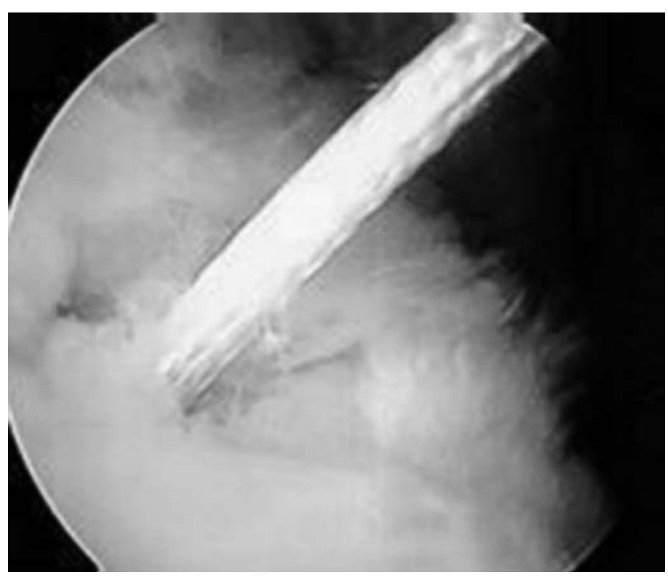

FIGURE 13-5. An absorbable suture anchor is placed in the anchor hole, and one suture limb is passed through the tendon edge with the passing suture.

Mini-Open

Mini-open rotator cuff repair has combined the advantages achieved by arthroscopic acromioplasty with the advantages of open rotator cuff repair. The incision is smaller than the standard open cuff incision, and the deltoid origin is preserved. Cuff mobilization can also be performed arthroscopically before the mini-open incision is made. Unlike the arthroscopic repair, direct visualization can then be achieved, thus assuring that complete mobilization of the rotator cuff to the tuberosity is performed.

Small or medium-sized rotator cuff tears are approached through a mini-open portal extending incision of approximately 3 cm following an arthroscopic anterior acromioplasty. The deltoid is then split in line with its fibers to the lateral edge of the acromion and 3 to 5 cm laterally. Richardson retractors and manipulation of the arm allows the entire cuff tear to be seen (see Figure 13-6). Repair of the tendon to the tuberosity can then be a done with either suture anchors or with transosseous bone tunnels and non-absorbable suture. Despite the excellent application of this technique to small and medium sized tears of the supraspinatus and infraspinatus tendons, access to the subscapularis and teres minor is difficult and open repair is recommended for larger-sized tears.

Open Repair

The repair of large and massive tears remains a technical challenge. Significant tendon retraction, bursal scarring, and adhesions to adjacent structures often accompany massive tears [44,45]. While local tendon transposition, tendon transfers, and tissue grafting with autograft, allograft, and synthetic material have all been described as potential options in repairing or augmenting the cuff repair, greater satisfactory results have been attained in studies using mobilization or transposition of existing rotator cuff tissue [46–52]. An anterosuperior approach to the shoulder is used with a deltoid split of less than 3 to 4 cm. The coracoacromial ligament is released but preserved in order to prevent postoperative anterosuperior humeral head subluxation [53,54]. While lateral or radical acromioplasty should be avoided to prevent deltoid dysfunction, an anterior acromioplasty should be performed as part of the procedure [55–60]. A complete acromioclavicular arthroplasty or distal clavicle resection is reserved for patients who are symptomatic on clinical exam with associated tenderness and pain with cross-body adduction. The resection should allow for preservation of the superior acromioclavicular ligaments to maintain anterior-posterior stability of the joint.

The rotator cuff is mobilized by releasing any adhesions on both the articular and bursal side. An "interval slide"—a complete longitudinal release of the rotator interval and coracohumeral ligament to the superior aspect of the coracoid—may be performed to improve tendon excursion [61,62]. A similar interval release can be performed between the posterior tendons to allow supraspinatus advancement. A satisfactory repair will allow the tendons to extend past the anatomic neck of humerus with the arm in a functional position of 10 to 15 degrees of forward flexion, abduction, and internal rotation. While no debridement of the tendon edge is required for rotator cuff healing, we perform minimal debridement of the cortical bone on the superficial aspect of the greater tuberosity before placing sutures [63–66]. Suture anchors or transosseous non-absorbable sutures are placed in the hard bone distal to the tuberosity utilizing a wide bridge of bone [67–70]. The insertion site may be augmented with a plastic or metal button in rare cases where the bone is of poor quality [71,72].

FIGURE 13-6. A deltoid split is made for the mini-open approach. Retractors are placed, and the arm is manipulated to expose the rotator cuff tear. A tear of the supraspinatus tendon is identified.

Deficient Rotator Cuff

Many procedures have also been proposed to augment a deficient rotator cuff. Although we strongly advise against rotator cuff debridement alone for "irreparable tears" due to the complication of anterosuperior humeral head migration, we do not advocate the routine use of allografts or synthetic grafts in this setting [73,74]. Instead, we have used partial repair of the rotator cuff with good success. Burkhart initially described this technique in fourteen patients with "irreparable" rotator cuff tears, with the goal of restoring force couples and converting the defect to a functional cuff tear [75]. Complete coverage of the defect was not essential, and average residual defect size measured 2.9 square cm. With this technique, forward elevation improved from 59.6 degrees preoperatively to 150.4 degrees postoperatively. We have used a modification of this partial repair technique, leaving the posterolateral aspect of the head uncovered, with good success.

When the subscapularis tendon is deficient, transfer of the upper one-third of the tendon can be considered. However, Burkhart has recently demonstrated that this transfer may lead to superior migration of the humeral head by destabilizing force couples. We prefer partial repair to transfer of the subscapularis tendon, as even partial transfer of an intact subscapularis may further destabilize the shoulder and adversely affect active motion. Pectoralis major transfer may be used for a deficient subscapularis in rare cases [76,77]. Rockwood has reported successful transfer of the pectoralis major, pectoralis minor, or both in ten of thirteen patients with subscapularis deficiency. Resch has recently modified this technique, using a sub-conjoined tendon transfer of the pectoralis major, with good or excellent results in 9 of 12 patients.

In the case of posterior cuff deficiency where partial repair cannot be performed, transfer of either the latissimus dorsi or teres major tendons may be considered in rare cases [78,79]. Gerber performed latissimus dorsi transfer in 16 patients with irreparable rotator cuff tears and achieved restoration of 80% normal shoulder function in these patients. Range of motion in forward flexion improved from an average of 83 to 135 degrees. Poor outcome was associated with a deficient subscapularis tendon, and the authors advised against this transfer if the subscapularis is not functioning. With the tendon mobilization techniques described here and with the partial repair technique described by Burkhart, we have found few truly irreparable rotator cuff tears, and therefore have seldom had to utilize the latissimus or teres major tendon transfer for this indication.

Rehabilitation

While rehabilitation varies based on the size of the rotator cuff tear and the adequacy of repair, some general principles can be stated. In all cases, rehabilitation begins with passive-assisted range of motion exercises on the first postoperative day. Patients with small tears or no tears may begin pulleys on the first operative day, while, in patients with medium or large tears, pulley exercises are avoided for first 6 weeks in order to protect the cuff repair. Patients with large or massive tears undergo a modified Neer phase I protocol for 6 weeks that includes pendulum exercises, passive-assisted forward elevation to 140 degrees, and passive-assisted external rotation (supine) to 30 degrees.

Strengthening with isometric exercises is initiated at 6 weeks accompanied by active-assisted range of motion. Use of weights is avoided for at least 3 months in the rehabilitation period to avoid cuff re-tearing. Resistance exercises with light weights (1 to 3 pounds) can be initiated at 12 weeks, progressing to dynamic strengthening exercises at 6 to 8 months. Patients should be aware that full return of strength may require 12 to 18 months.

Results

While the results of rotator cuff repair vary depending upon the size of the tear and other patient factors, the results reported for arthroscopic, mini-open, and open techniques have been consistently successful for primary repairs. The results for arthroscopic repair are still being determined and there are currently no long-term studies evaluating their outcome. Two recent studies have found 84% and 92% good to excellent results for arthroscopic repair of full thickness rotator cuff tears. The results of mini open rotator cuff repair have also been excellent, with satisfactory results reported in 83% to 96% of patients [80–83].

The results of open repair for large to massive rotator cuff tears can be more variable depending on the size and chronicity of the tear. However, with close attention to the principles outlined in this chapter, we have found excellent long-term results for repair of large and massive rotator cuff tears. In a 7-year average follow-up study of 61 patients with repair of massive rotator cuff tears, 85% excellent or satisfactory results were achieved by Neer's criteria [20]. Also, 92% of patients had adequate pain relief and the ability to raise the arm above the horizontal. Only two re-tears occurred, and these were secondary to significant trauma.

A more recent study at the New York Orthopaedic Hospital of 231 shoulder massive rotator cuff tears demonstrated a 90% rate of satisfactory results with primary rotator cuff repair [15]. Function was improved postoperatively, with average active forward elevation 160 degrees, external rotation 55 degrees and internal rotation to T9. This represented an average improvement of 46 degrees elevation, 22 degrees external rotation, and internal rotation of 2 vertebral levels. External rotation power was improved from an average of 3.1 to 4.7. Satisfactory results were slightly less (76.5%) in patients with 4-tendon involvement. These results support the role of open primary rotator cuff repair for patients with large to massive rotator cuff tears.

Summary

While the pathophysiology of rotator cuff tendinopathy continues to be investigated, current management of rotator cuff disorders emphasizes traditional principles. Inflammation and bursitis are an important component of the pathology and initial management is focused on relief of these symptoms. The majority of patients will have satisfactory results with nonoperative management, including physical therapy and anti-inflammatory medication. The cause of rotator cuff tendinopathy remains unknown. Surgical management is directed at both relieving the subacromial impingement (extrinsic cause) and restoring continuity and function of the rotator cuff tendons (intrinsic cause).

With current operative techniques, rotator cuff repair can provide significant functional improvement and pain relief in the majority of patients. Important principles include performing anterior acromioplasty, bursal resection, rotator cuff mobilization, and tension-free repair to the greater tuberosity with nonabsorbable sutures. These principles are important whether the repair is performed through arthroscopic or open techniques. In cases of large or massive tears where the deltoid must be taken down, a meticulous deltoid repair must be performed, and the coracoacromial ligament should be repaired to prevent anterosuperior instability. Partial repair of the rotator cuff is recommended over performing transfer procedures. Postoperative rehabilitation requires avoidance of active exercises for 6 weeks and weights for 3 months. With these techniques, 84% to 96% satisfactory results can be expected.

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