Partial-Thickness Rotator Cuff Tears

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Abstract

Partial-thickness rotator cuff tears are not a single entity; rather, they represent a spectrum of disease states. Although often asymptomatic, they can be significantly disabling. Overhead throwing athletes with partial-thickness rotator cuff tears differ with respect to etiology, goals, and treatment from older, nonathlete patients with degenerative tears. Pathogenesis of degenerative partial-thickness tears is multifactorial, with evidence of intrinsic and extrinsic factors playing key roles. Diagnosis of partial-thickness rotator cuff tears should be based on the patient's symptoms together with magnetic resonance imaging studies. Conservative treatment is successful in most patients. Surgery generally is considered for patients with symptoms of sufficient duration and intensity. The role of acromioplasty has not been clearly delineated, but it should be considered when there is evidence of extrinsic causation for the partial-thickness rotator cuff tear.

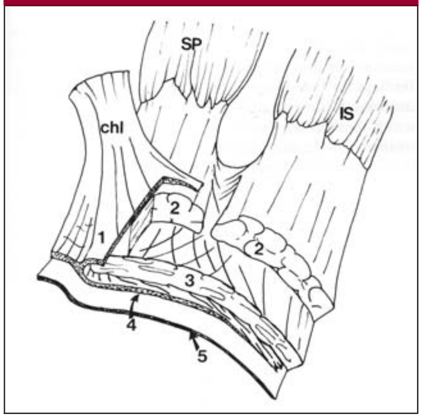
Advances in shoulder arthroscopy, basic science research, and imaging modalities continue to increase our understanding of and ability to treat rotator cuff disease. Compared to studies on full-thickness rotator cuff tears, limited published data are available regarding the optimum treatment of partial-thickness rotator cuff tears. In part, this is because of the emerging concept that partial-thickness rotator cuff tears are not a single entity with a single etiology. Similarly, treatment of symptomatic partial-thickness rotator cuff tears should be based on the patient's goals, injury site, and cause of the tear.

Anatomy and Classification

The rotator cuff represents the coalescence of the subscapularis, supraspinatus, infraspinatus, and teres minor tendons. Clark and Harryman[1] showed a significant amount of interdigitation of these tendons, as well as between the tendons, the shoulder capsule, and the coracohumeral ligament (Figure 1). Most partial-thickness rotator cuff tears in older patients occur on the articular side of the supraspinatus tendon; isolated involvement of the bursal side of the supraspinatus tendon or of the infraspinatus and subscapularis tendons is less common. In contrast, tears in younger overhead throwing athletes are articular-sided, partial-thickness tears of the dominant arm at the supraspinatus-infraspinatus interval.

Partial-thickness tears of the rotator cuff can be articular-sided, bursal-sided, intratendinous, or a combination thereof. Ellman[2] described a classification system that

Figure 1



Transverse section of the rotator cuff with the orientations of the fascicles indicated by the lines on their upper surfaces. Layer 1 is composed of superficial fibers that overlie the cuff tendons and form an extension of the coracohumeral ligament (chl). Layers 2 and 3 contain the fibers of the supraspinatus (SP) and infraspinatus (IS) tendons. The fibers in layer 2 are oriented parallel to the axes of the supraspinatus and infraspinatus tendons; the fibers of layer 3 are smaller and obliquely oriented compared with the fibers of layer 2. The fibers of layer 4 make up the deep extension of the coracohumeral ligament. Layer 5 is the joint capsule. (Adapted with permission from Clark JM, Harryman DT II: Tendons, ligaments, and capsule of the rotator cuff: Gross and microscopic anatomy. *J Bone Joint Surg Am* 1992;74:713-725.)

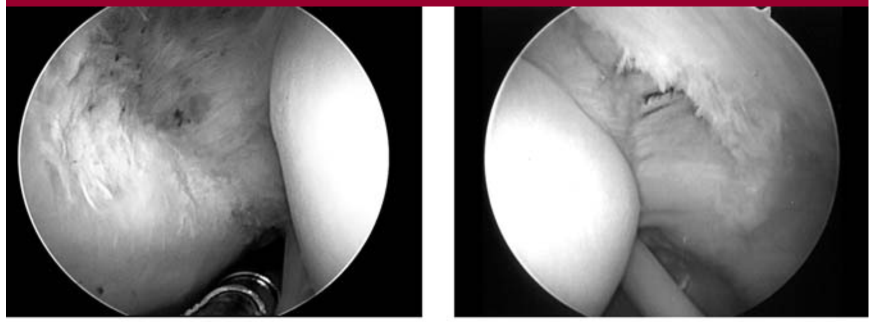
Table 1

Ellman's Classification of Partial-Thickness Rotator Cuff Tears

Location	Grade
A: Articular surface	1: <3 mm deep
B: Bursal surface	2: 3-6 mm deep
C: Interstitial	3: >6 mm deep

(Adapted with permission from Ellman H: Diagnosis and treatment of incomplete rotator cuff tears. *Clin Orthop Rel Res* 1990;254:64-74.)

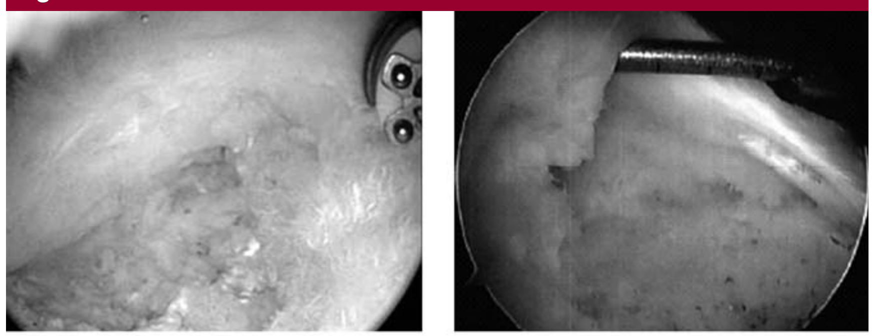
Figure 2



A B

A, Arthroscopic view through the posterior portal of a small partial-thickness tear of the articular side of the rotator cuff (Ellman grade A1). **B,** Arthroscopic view through the posterior portal of a deep partial-thickness tear of the articular side of the rotator cuff (Ellman grade A3).

Figure 3



A B

A, Arthroscopic view through the midlateral port of a small bursal-sided partial-thickness tear (Ellman grade B2) after débridement, showing intact anterior and posterior attachments of the rotator cuff. **B,** Arthroscopic view through the midlateral portal of a nearly full-thickness tear of the bursal side of the rotator cuff (Ellman grade B3).

differentiates between partial- and full-thickness tears of the rotator cuff based on findings at the time of arthroscopy. Partial-thickness tears are subdivided based on location and thickness of tear (Table 1) (Figures 2 and 3). Ruotolo et al[3] showed the mean thickness of the supraspinatus tendon to be 11.6 mm anteriorly, 12.1 mm at midtendon, and 12 mm posteriorly.

Incidence

Cadaveric and imaging studies have been performed in an attempt to define the incidence of rotator cuff tears. In 1934, Codman[4] noted a 32% prevalence of supraspinatus rupture. More recently, Fukuda et al[5] reported a prevalence of 7% full-thickness and 13% partial-thickness tears (of which 18% were bursal-sided, 27% articular-sided, and 55% intratendinous) in 249 cadavers. However, Fukuda later cautioned that "the statistics from cadaveric studies are skewed, because most of the specimens are from people older than the patients in clinical practice."[6]

Data from imaging studies show an increasing incidence with age. In a 1995 magnetic resonance imaging (MRI) study of 96 asymptomatic shoulders, Sher et al[7] reported no full-thickness and 4% partial-thickness tears in subjects 19 to 39 years of age. In contrast, among individuals older than 60 years of age, there was a 28% incidence of full-thickness and a 26% incidence of partial-thickness tears. Similarly, ultrasound studies of asymptomatic volunteers has demonstrated a 5% to 11% incidence of full- or partial-thickness tears in subjects in their fourth and fifth decades, increasing to 80% in the eighth decade.[8]

Throughout the literature, clinically noted articular-sided tears are approximately two to three times more common than bursal-sided tears.

Pathogenesis

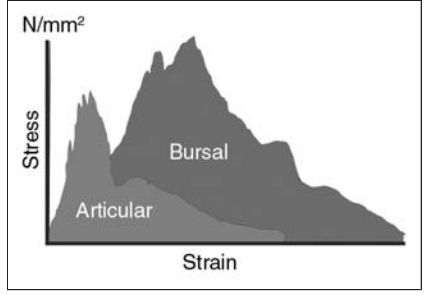
Bursal and articular surfaces of the rotator cuff differ with respect to their vascularity, biomechanical properties, and histologic composition. In 1965, Rothman and Parke[9] described the "critical zone" of hypovascularity near the insertion of the supraspinatus on the humerus. Rathbun and Macnab[10] histologically correlated areas of hypovascularity and degeneration of the rotator cuff in this region. Lohr and Uhthoff[11] found that the critical zone hypovascularity predominated on the articular side and extended from the musculotendinous junction to within 5 mm of the insertion.

Nakajima et al[12] reported differences in biomechanical and histologic properties in intact rotator cuffs taken from individuals at the time of autopsy. They found that the bursal side was composed mostly of tendon bundles, whereas the articular side was a complex of tendon, ligament, and capsule. Furthermore, they found that the bursal side was able to undergo a greater deformation and had a greater tensile strength (Figure 4). This offers a possible explanation for the increased incidence of articular-sided tears following a traumatic event.

The etiology of partial-thickness rotator cuff tears can be broadly differentiated into intrinsic, extrinsic, or traumatic causes. Evidence suggests that the pathogenesis of bursal-sided and articular-sided partial-thickness tears may differ. In 1934, Codman[4] postulated that the origin of rotator cuff tears was intrinsic and degenerative. In 1972, Neer[13] proposed that the etiology of rotator cuff tears was primarily extrinsic and secondary to subacromial impingement. Although the pathogenesis of rotator cuff tears is still the subject of debate, evidence suggests that both intrinsic and extrinsic factors play a role. The intrinsic tendinopathy from degenerative changes is most often thought to result in articular-sided tears in older patients. Similarly, most partial-thickness tears in young overhead throwing athletes are on the articular side. Bursal-sided tears may have a greater association with extrinsic factors such as coracoacromial arch narrowing or impingement from the distal clavicle.

In a cadaveric study, Ozaki et al[14] found that all bursal-sided tears were associated with attritional lesions on the coracoacromial ligament as well as the anterior third of the undersurface of the acromion; this was not true of articular-sided tears, in which the undersurface of the acromion was almost always intact. Similarly, Burkhead et al[15] reported that iatrogenic impingement of the rotator cuff in rats caused exclusively superior surface lesions on the cuff. The impingement observed in patients with bursal-sided cuff injuries still may be secondary to a primarily intrinsic cause that produces weakness of the rotator cuff. This weakness in turn may lead to superior migration of the humerus that causes increased impingement, initiating what Ozaki et al[14] described as a "vicious cycle."

Figure 4



Typical stress-strain curve for the supraspinatus tendon. Bursal and articular sides of the rotator cuff tendon show nonlinear deformation initially, followed by elastic elongation. The bursal side is able to undergo a greater deformation and has a greater tensile strength. (Adapted with permission from Nakajima T, Rokuuma N, Hamada K, Tomatsu T, Fukuda H: Histologic and biomechanical characteristics of the supraspinatus tendon: Reference to rotator cuff tearing. *J Shoulder Elbow Surg* 1994;3:79-87.)

Thus the differences in blood supply, biomechanical and histologic properties, associated changes of the acromion, and association with trauma suggest that the pathogenesis of articular- and bursal-sided partial-thickness tears of the rotator cuff may differ. Evidence points to intrinsic factors such as hypovascularity and decreased tensile strength putting the articular side of the rotator cuff in greater jeopardy, while both intrinsic and extrinsic factors subject the bursal side of the rotator cuff to greater wear.

Clinical Presentation

The most common reports by individuals with partial-thickness rotator cuff tears are pain and stiffness. Pain is the predominant symptom, often most troubling at night and with overhead activities. Many patients have a painful arc of motion with impingement signs, with or without apparent or real muscle weakness.

These partial tendon lesions are often much more painful than full-thickness tears.[6] In contrast to full-thickness tears, partial-thickness defects of the cuff have been theorized to give rise to stiffness and nonphysiologic tension on the remaining fibers. Halder et al[16] found that detachment of one or two thirds of the supraspinatus tendon from the crescent area had a negligible effect on the force transmission of the rotator cuff. These authors disputed the idea that nonphysiologic tension plays a role in symptomatology. They concluded that neighboring fibers composing the cables of the crescent-and-cable theory of rotator cuff function were sufficient for force transmission. However, Bey et al[17] reported significantly increased strain on the remaining supraspinatus tendon at arm abduction angles of 30°, 45°, and 60° in a cadaveric model after creation of a one-third thickness articular-sided partial-thickness tear of a supraspinatus tendon. They concluded that articular-sided tears predispose the remaining rotator cuff to further damage. Thus in vitro studies have shown that although mechanical strength may be preserved, strain on neighboring fibers is increased. This increased strain likely plays a role in the symptoms experienced by those with partial-thickness tears of the rotator cuff.

Fukuda[6] reported that 73.3% of patients with either subacromial bursitis or a partial-thickness rotator cuff tear reported "more than moderate" nocturnal pain, whereas only 50% of patients with full-thickness tears reported this much pain. Fukuda also found that bursal-sided tears produced notably more pain than did intratendinous or articular-sided partial-thickness tears.[6] Gotoh et al[18] reported significantly ($P < 0.01$) higher levels of substance P, an afferent nerve pain mediator, in the subacromial bursae of patients with partial-thickness rotator cuff tears than in the bursae of patients with full-thickness tears; the higher levels of substance P correlated with the significantly ($P < 0.001$) higher pain levels in the group of patients with partial-thickness tears. Gotoh et al[19] also found significantly higher levels of interleukin (IL)-1β and IL-1 receptor agonists (IL-1ra), which are inflammatory cytokine mediators, in the subacromial bursae of patients with rotator cuff pathology; the amount of these mediators correlated with patient pain levels. Furthermore, they found that increased IL-1β and IL-1ra in the glenohumeral joint did not correlate with pain in patients with rotator cuff pathology.[20]

Natural History

Although the natural history of partial-thickness tears of the rotator cuff is incompletely understood, evidence suggests that progression may occur over time.[7,14] Yamanaka and Matsumoto[21] reported on 40 patients with articular-sided tears diagnosed by arthrography repeated at a mean of 412 days. They found an enlargement of tear size in 21 patients (53%), progression to full-thickness tears in 11 patients (28%), reduction of tear size in 4 patients (10%), and disappearance of the tear in 4 patients (10%). This early study indicates that many articular-sided tears can progress over relatively short periods. It also suggests that although some patients become asymptomatic over time, few tears heal anatomically.

The limited healing potential of partial-thickness cuff tears is supported by histologic studies that have observed no active repair; proximal stumps of the cuff were rounded, retracted, and avascular. At the molecular level, cells at the tendinous margin of partial-thickness tears have been shown to contain α1 type-I procollagen mRNA, a precursor of type I collagen, thereby demonstrating the potential for repair.[22] However, other studies of tear specimens have shown macrophages and multinucleated giant cells, which exhibit strong immunoreactivity for IL-1β, cathepsin D, and matrix metalloprotease-1; none was found in intact tendons.[23] This led the authors to conclude that granulation tissue around the insertion of a torn supraspinatus tendon contributes to the progression of rotator cuff tears by weakening the insertion of the remaining tendon.

Although relatively few direct data are available on the natural history of partial-thickness rotator cuff tears, there is a substantial body of circumstantial evidence to suggest that most partial tears do not heal on their own. Patients may have waxing and waning symptoms, but the clinical, biomechanical, epidemiologic, and biologic data suggest that most of these tears progress to become larger rather than smaller with time.

Diagnostic Imaging

Various imaging modalities have been used to assist in the diagnosis of partial-thickness rotator cuff tears. Arthrography and bursography have been described, but these are of uncertain value given the wide ranges of reported accuracy in the literature—15% to 83% for arthrography[24,25] and 25% to 67% for bursography.[5,25] Sensitivity and specificity of preoperative ultrasound has been reported to be as high as 94% and 93% and as low as 41% and 91%, respectively, for arthroscopically confirmed partial-thickness tears.[26,27]

Other authors have reported a similarly variable accuracy level for MRI in the evaluation of partial-thickness tears, with sensitivity as low as 56%[28] and false-negative rates as high as 83%.[24] However, with improved technology and the increasing usage of MRI arthrography, the accuracy of MRI has improved. A recent study using magnetic resonance arthrograms with gadopentetate dimeglumine contrast agent and coronal oblique T1-weighted fat-suppression images yielded a sensitivity of 84% and a specificity of 96%.[29]

In comparing preoperative ultrasound to MRI in arthroscopically confirmed partial-thickness rotator cuff tears, Teefey et al[30] found that 13 of 19 tears were correctly identified by ultrasound, whereas 12 of 19 tears were correctly identified by MRI. Iannotti et al[31] found the preoperative diagnostic accuracy of ultrasound and MRI to be 70% and 73%, respectively.

Although ultrasound and MRI can be of similar utility in the diagnosis of partial-thickness tears, each has its limitations. Ultrasound can provide a less expensive and noninvasive alternative for evaluation of these tears, but it is highly operator-dependent and does not provide information regarding concomitant pathologies. In many patients with vague presenting signs and symptoms, MRI will offer a more complete evaluation of the shoulder. MRI evaluation of partial-thickness rotator cuff tears demonstrates alteration of the morphology, without discontinuity of the rotator cuff, on T1-weighted images in areas corresponding to increased signal on T2-weighted images.

For most patients with suspected partial-thickness cuff tears—especially young, overhead throwing athletes—magnetic resonance arthrography is the imaging modality of choice to best visualize these tears and assess for concomitant pathology. However, given the variable rates of accuracy and the high proportion of the population with asymptomatic partial-thickness tears, MRI should be considered in conjunction with clinical evaluation.

Treatment

Treatment of partial-thickness rotator cuff tears varies according to the cause and location of the pathology. Initially, these tears should be managed with rest, activity modification, and nonsteroidal anti-inflammatory drugs. Physical therapy for range of motion should then begin, with the goal of regaining any motion lost because of capsular contractures. Although recent reports have questioned the efficacy of corticosteroid injections,[32] we have found them to be a useful adjunct. Strengthening of the rotator cuff and periscapular musculature should be initiated after range of motion has improved and inflammation has subsided. Although there is a paucity of reliable reports on the clinical outcome of conservative treatment of partial tears, most patients will improve with conservative measures over 6 months; some continue to improve for up to 18 months.

Surgical intervention generally is considered for patients with symptoms of sufficient duration and intensity. According to the literature, the timing of surgery has ranged from a few months to 1.5 years, but it should be based on the patient's symptoms, improvement, and rate of improvement with nonsurgical therapy as well as on the goals of the patient. Many surgical procedures have been described to address the pathology and pathogenesis of partial-thickness tears; these include acromioplasty alone, débridement of tears with or without acromioplasty, and both mini-open and arthroscopic repair of tears, with or without acromioplasty.

Ogilvie-Harris and Wiley[33] reported that approximately half of 57 patients with partial-thickness tears had successful results with arthroscopic débridement without acromioplasty at a minimum of 1 year after surgery. Budoff et al[34] reported 89% good and excellent results at 2- to 5-year follow-up and 81% good and excellent results at >5-year follow-up; other authors have reported success rates of 50% to 89% after arthroscopic débridement without acromioplasty.[33-35]

In Neer's original article describing open anterior acromioplasty,[13] he noted that 15 of 16 patients with fraying of the bursal side of the supraspinatus who underwent anterior acromioplasty had satisfactory results at 9-month to 5-year follow-up. The articular side of the rotator cuff was not evaluated in these patients. Snyder et al[35] reported 84% satisfactory results with arthroscopic débridement of partial-thickness rotator cuff tears at 10 to 43 months. Bursoscopy was performed in 71% of these patients, with bursal-sided partial-thickness tears found in 82%; these patients underwent arthroscopic acromioplasty as well as débridement, resulting in an average postoperative University of California, Los Angeles (UCLA) score of 33 (range, 0-35). For patients found to have a normal bursal side of the rotator cuff, acromioplasty was not performed, resulting in an average UCLA score of 30.

Conclusions based on these studies are difficult to draw because most are small retrospective studies with short follow-ups and differing surgical techniques. Additionally, many studies combine data from patients with articular-sided and bursal-sided tears, traumatic and atraumatic tears, superficial fraying of the cuff and nearly full-thickness tears, and young overhead throwing athletes and older patients. From this group of reports it is difficult to define (1) the indications for surgery, (2) which aspects of the patients' pathologies were responsible for their symptoms, (3) why up to 50% of patients failed to achieve a satisfactory result, and (4) which aspect of the surgery (acromioplasty or débridement) was responsible for improvement after surgery.

In a 1999 study, Weber[36] compared the results at 2- to 7-year follow-up of 65 patients with grade 3A or 3B partial-thickness rotator cuff tears treated either with acromioplasty with mini-open repair or with acromioplasty and arthroscopic débridement. He reported a mean UCLA score of 31.6 for patients undergoing mini-open repair versus 22.7 for those undergoing arthroscopic débridement. For the bursal-sided tear subgroup, he reported a mean UCLA score of 33.0 for those treated with mini-open repair versus a UCLA score of 13.6 for those treated with arthroscopic débridement. Thus Weber concluded that débridement and acromioplasty was not adequate treatment of most grade 3 tears, with bursal-sided tears faring especially poorly.[36]

More recently, Park et al[37] reported 86% satisfactory results in 37 patients with partial-thickness cuff tears (24 articular-sided, 13 bursal-sided) 2 years after arthroscopic acromioplasty and débridement of articular- and bursal-sided tears of <50% thickness. They noted that bursal-sided tears fared significantly better with respect to pain score and function ($P < 0.05$ for both) at 6 months, but that the groups were not significantly different at 1-year and 2-year follow-ups.

Cordasco et al[38] reported results of arthroscopic subacromial decompression and débridement of partial-thickness tears that were in concordance with those of Weber[36] but differed from those of Park et al.[37] They demonstrated that patients with bursal-sided tears have a much higher rate of unsatisfactory outcomes than do patients with articular-sided tears at 2- to 10-year follow-up (mean, 4.5 years). The authors reported a 5% failure rate (2/44) for grade 2A tears versus a 38% failure rate (3/8) for patients with grade 2B tears ($P = 0.02$). When grade 1A and 1B tears were included, the overall treatment failure rate for bursal-sided tears was 29% (4/14), whereas the failure rate in the articular-sided tears was 3% (2/63) ($P = 0.008$). The authors stated that all of the patients in their study in whom the failure occurred garnered no benefits from surgery, and the failure was apparent immediately.[38] Thus the lack of concordance with the study of Park et al[37] cannot be explained by the longer follow-up in the work of Weber[36] and Cordasco et al.[38] Based on these data, Cordasco et al[38] stated that they have begun to repair grade 2B partial-thickness tears.

The literature thus suggests that repair of partial-thickness tears of the rotator cuff should be considered in articular-sided tears with a depth >6 mm and in bursal-sided tears with a depth >3 mm. Completion of the tear, followed by repair in the preferred manner (ie, all-arthroscopic, mini-open, or open), should be considered when the tear is near full-thickness and the remaining tissue is thin and tenuous, or when there is a concomitant tear on the opposite side of the rotator cuff. Alternatively, arthroscopic repair of the tear without creation of a full-thickness tear can be performed when the opposite side of the cuff is intact and tissue is of good quality.

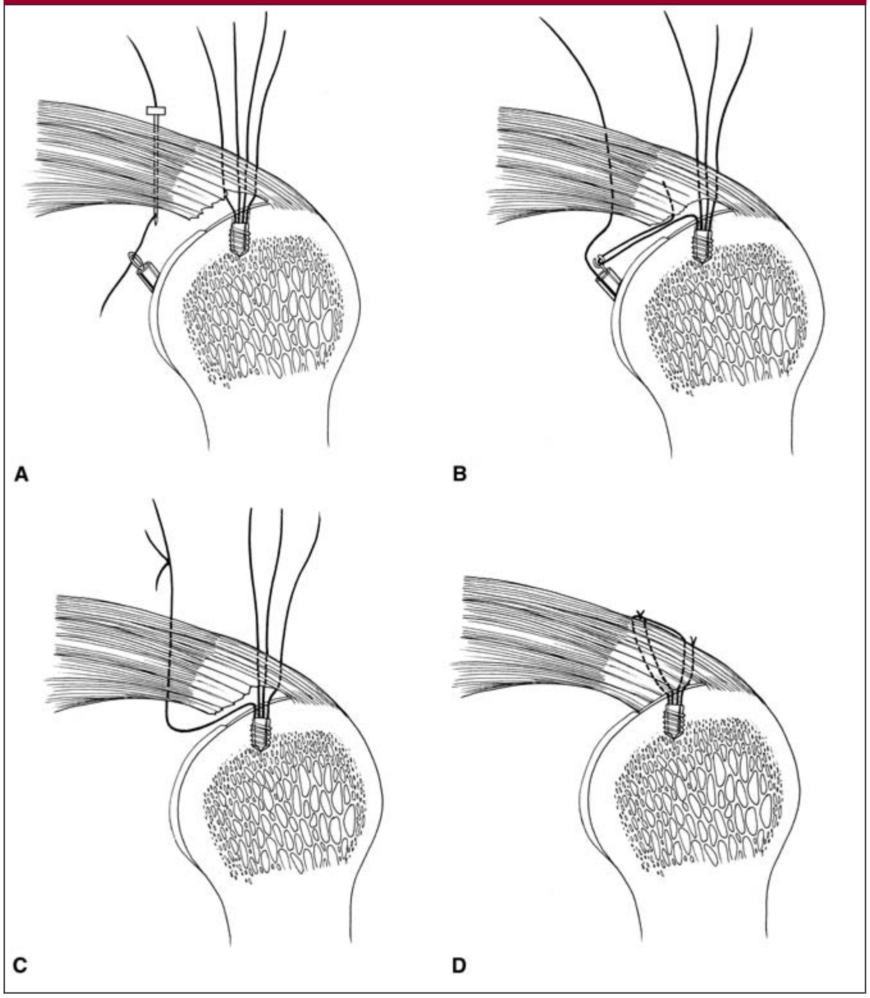
The role of acromioplasty has not been clearly delineated. Multiple studies demonstrate good results with and without acromioplasty in the treatment of partial-thickness rotator cuff tears.[34-38] We feel that, in all patients undergoing shoulder arthroscopy for a suspected partial-thickness tear, a comprehensive bursectomy should be performed to visualize completely the bursal side of the rotator cuff, as well as to remove any potential inflammatory mediators. Consideration should be given to performing an acromioplasty when an extrinsic etiology of a partial-thickness tear is suspected, as evidenced by damage to the bursal side of the rotator cuff and fraying of the coracoacromial ligament and/or anterior acromial osteophyte, or when there is evidence of impingement of the cuff on the undersurface of the acromion under arthroscopic visualization.

The goal of acromioplasty is the creation of a flat acromion that does not impinge on the rotator cuff. Torpey et al[39] demonstrated in a cadaveric model that a 4-mm and a 6-mm acromioplasty, respectively, would be expected to release 43% and 72% of the anterior and lateral surfaces of the deltoid tendon origin from the acromion; however, the clinical implications of this are unknown. Nevertheless, acromioplasty, when done, should be performed judiciously, with removal of no more bone than is necessary to achieve a flat acromion.

Snyder[40] originally described an arthroscopic transtendinous repair technique that does not involve completion of the tear. This technique has the theoretic advantage of retaining the lateral portion of the original footprint of the rotator cuff insertion and minimizing the length-tension mismatch of the repaired rotator cuff. Excellent results were recently reported by Ide et al,[41] who used this technique to repair grade 3A partial-thickness cuff tears. Of 17 patients, 14 were rated as excellent, 2 as good, and 1 as fair at an average 39-month follow-up (range, 25 to 57 months). Mean UCLA and Japanese Orthopaedic Association scores improved significantly (17.3 and 68.4 to 32.9 and 94.8, respectively; $P < 0.01$).

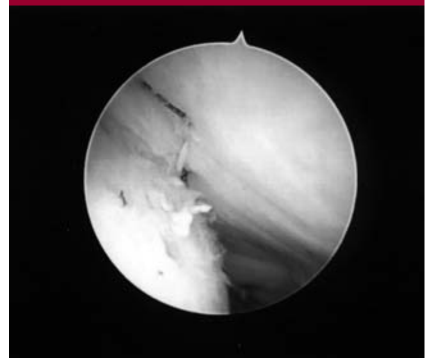
For articular-sided tears >1.5 cm in the anterior-to-posterior direction, two bioabsorbable suture anchors double-loaded with no. 2 nonabsorbable polyester are used. For tears <1.5 cm, only one suture anchor is used. For tears >1.5 cm, the suture anchors are placed through the rotator cuff at the lateral articular margin at the medial extent of the footprint after localization of the angle with a spinal needle. The spinal needle and suture anchors are passed just off the lateral aspect of the acromion to obtain an angle ≤45°. From the subacromial space, one limb from each anchor is grasped and pulled through the lateral portal, where it is tied over an instrument. Using the opposite ends of these sutures, the knot is pulled into

Figure 5



Arthroscopic repair of a partial-thickness articular-sided tear. **A,** A shuttle relay is passed through the spinal needle and retrieved through the anterior portal. **B,** One end of the suture is also retrieved through the anterior portal. **C,** One end of the suture is engaged in the eyelet of the shuttle relay and then pulled back out of the healthy portion of the partially torn tendon. **D,** A complete repair of an articular-sided partial-thickness rotator cuff tear. (Adapted with permission from Ide J, Maeda S, Takagi K: Arthroscopic transtendon repair of partial-thickness articular-side tears of the rotator cuff: Anatomical and clinical study. *Am J Sports Med* 2005;33: 1672- 1679.)

Figure 6



A large (>1.5 cm anterior to posterior) A3B0 (Ellman grade A3) articular-sided partial-thickness rotator cuff tear, as seen through a standard posterior portal after arthroscopic transtendinous fixation using two suture anchors.

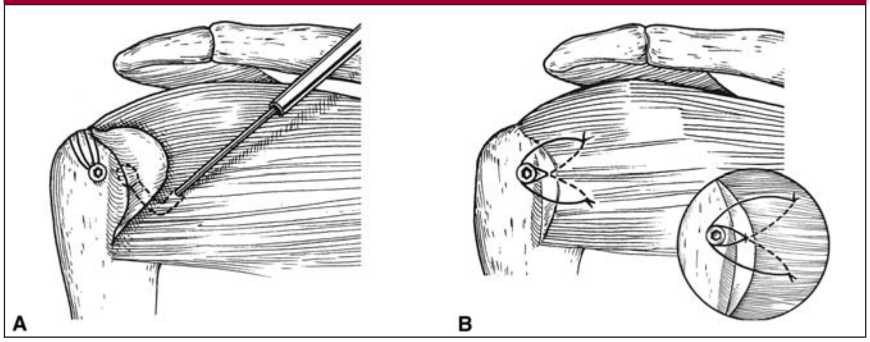
the subacromial space, cinching down the rotator cuff on top of the suture anchors, reestablishing the footprint. The opposite ends are then tied with static knots through a lateral subacromial portal. This process is repeated with the remaining suture limbs (Figure 5).

For articular-sided tears <1.5 cm in the anterior-to-posterior direction, the single double-loaded suture anchor is placed in the same manner as described above. However, because the entire suture is passing through the same puncture of the rotator cuff, a tissue bridge must be created. This is done either by a shuttle suture passed through a spinal needle or with a suture passer, such as the Suture Lasso (Arthrex, Naples, FL) or BirdBeak (Arthrex). In either manner, one limb of each suture is passed posteromedially through different percutaneous portals. Each suture is then retrieved and tied sequentially through the lateral subacromial portal (Figures 5 and 6).

For partial-thickness bursal-sided tears, bursectomy and acromioplasty are performed. The frayed edges of the bursal flap are then gently débrided, and the tuberosity is excoriated to bleeding bone using a round burr. One or two bioabsorbable double-loaded suture anchors are placed through the full thickness of the rotator cuff (one anterior, one posterior) using a percutaneous suture lasso (Figures 7 and 8).

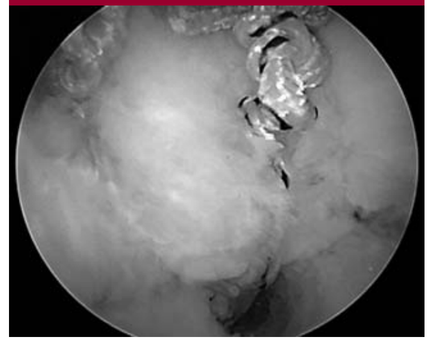
Based on the available literature, we propose the following treatment algorithm for patients with degenerative partial-thickness rotator cuff tears who are not overhead throwing athletes (Figure 9). At presentation, nonsurgical management should be the mainstay of treatment in most cases. When progress is lacking with nonsurgical therapy, surgical intervention can be considered as early as 3 months (but generally at 6 to 12 months) after initiation of nonsurgical management, depending on the patient's desires and goals.

Figure 7



Placement of bioabsorbable double-loaded suture anchors. **A,** The lasso is passed through the full thickness of the cuff through a percutaneous portal, which optimizes the angle required for repair. This is often accomplished through the Neviaser portal, the superior medial portal bordered by the clavicle, the acromioclavicular joint, and the spine of the scapula. The nitinol wire is shuttled out of a cannula, along with the more medial of the suture limbs, and then is pulled back out of the percutaneous portal along with the suture limb, passing the suture through the full thickness of the cuff. The procedure is repeated for the posterior limb of the suture after again passing a lasso through the full thickness of the rotator cuff in a more posterior position. **B,** After passing both the anterior and posterior sutures through the bursal-sided tear, both sutures are tied securely over the bursal side of the rotator cuff, thereby restoring the bursal side of the cuff to its anatomic location.

Figure 8



A small (<1.5 cm anterior to posterior) bursal-sided partial-thickness rotator cuff tear after repair with a single suture anchor.

Surgical treatment is based on location and depth of tear. Depth of tear can be determined either by examining the tear with a probe of a known length or, for articular-sided tears, by measuring the amount of bone lateral to the articular margin. A distance >7 mm represents a tear >50% (grade 3).[3] Ellman grade 1 tears (<3 mm deep) of either the articular or bursal side, and grade 1 and 2 tears (3 to 6 mm deep) of the articular side, should be treated with débridement of the tear, with or without acromioplasty. Although there is little evidence to suggest that débridement of partial-thickness tears stimulates a healing response or improves the biomechanics of the rotator cuff, it is vital in the assessment of the depth of the tear. Débridement also may relieve mechanical irritation in the subacromial space and the glenohumeral joint. In addition, débridement likely removes inflammatory cells and inflammatory mediators present in the torn rotator cuff tissue.[23]

Grade 2 tears of the bursal side (>3 mm deep) and grade 3 tears of the articular or bursal side (>6 mm deep) should be treated with repair, with or without acromioplasty. We prefer to complete articular-sided tears and perform double-arrow arthroscopic repairs because we have found longer convalescence and stiffness to occur with intratendinous repairs. In contrast, we arthroscopically repair bursal-sided tears without completion of the tear, using the articular footprint as an internal splint.

Partial-Thickness Rotator Cuff Tears in Overhead Throwing Athletes

Overhead throwing athletes represent a distinct population of individuals in whom partial-thickness tears of the rotator cuff develop. The etiology and pathogenesis of these injuries often differ from those in the non–overhead throwing population. Accordingly, the treatment of this subgroup can be very different as well, particularly when return to throwing is the goal. Partial-thickness tears in athletes are seen mostly in overhead throwing sports. Onset is usually insidious, with symptoms of pain at rest, loss of velocity, and "popping" or "catching" while throwing.

Most partial-thickness tears are articular-sided tears of the dominant arm that begin at the supraspinatus-infraspinatus interval, posterior to the location of tears commonly seen in the older population. Partial-thickness tears are often associated with other shoulder pathology. Superior labral injury, including posterosuperior labral injury and detachment, posteroinferior capsular contracture, anterior capsular attenuation, and internal rotation deficit, are frequently associated with articular-sided tears.[42]

The cause of partial-thickness rotator cuff tears in the overhead throwing athlete is a subject of considerable debate. Andrews et al[43] originally theorized that these articular-sided tears resulted from repetitive trauma of the massive eccentric traction force to the supraspinatus and infraspinatus tendons, which keep the humeral head in the correct position from the deceleration phase through the release phase of throwing. Davidson et al[44] espoused a theory of internal impingement from repetitive microtrauma of the rotator cuff resulting from anterior subluxation secondary to minor instability and fatigue of the dynamic stabilizers, which results in a secondary impingement of the rotator cuff on the posterior edge of the glenoid. Citing the association with posterior type 2 superior labrum anterior-posterior (SLAP) tears via a peel-back mechanism, Burkhart et al[42] have theorized that a combination of repetitive tensile loading of the cuff, and the subsequent partial-thickness tear, may be caused by posterosuperior subluxation of the humerus from posterior capsule contracture and by repetitive torsional and shear overload generated by hyperexternal rotation in throwing athletes.

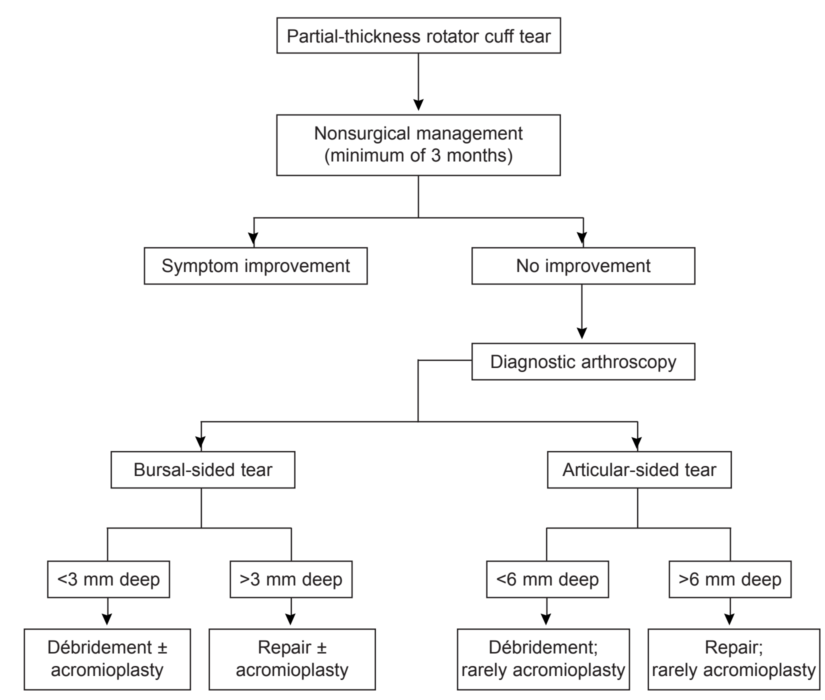
Treatment of partial-thickness cuff tears in the overhead throwing athlete should begin with nonsurgical measures. All of the following may be used to effect resolution of symptoms: stretching of the posterior capsular tissues to address loss of internal rotation, rotator cuff strengthening programs (including eccentric and plyometric exercises), trunk and lower extremity strengthening exercises, restoration of proper throwing mechanics, nonsteroidal anti-inflammatory drugs, and corticosteroid injections.

Surgical treatment is reserved for patients who fail to respond to nonsurgical management. Diagnostic arthroscopy often reveals concomitant pathology that may be the primary cause of the patient's symptoms. Débridement of the articular-sided tear and treatment of concomitant capsular or labral pathology should be the mainstay of surgical intervention; repair of the partial-thickness tear or acromioplasty is rarely indicated.

Summary

Partial-thickness rotator cuff tears are not a single entity but rather represent a spectrum of disease states affecting the rotator cuff. From asymptomatic to significantly dis-

Figure 9



Proposed treatment algorithm for partial-thickness rotator cuff tears.

Additional Resources

DVD/video: *Surgical Techniques in Orthopaedics:* "Arthroscopic Rotator Cuff Repair": http://www4.aaos.org/product/productpage.cfm?code=02640

Related clinical topics articles available on *Orthopaedic Knowledge Online:* "Glenohumeral Arthritis and the Rotator Cuff Deficient Shoulder," by Gregory P. Nicholson, MD, and Guido Marra, MD: http://www5.aaos.org/oko/shoulder_elbow/ga_rcdeficient/pathophysiology/pathophysiology.cfm

"Shoulder Arthroscopy," by Stephen J. Snyder, MD, and Petra Waldherr, MD: http://www5.aaos.org/oko/shoulder_elbow/arthroscopy/anatomy/anatomy.cfm

"Rotator Cuff Tears," by Evan Flatow, MD, and Leesa Galatz, MD: http://www5.aaos.org/oko/shoulder_elbow/rotator_cuff/pathophysiology/pathophysiology.cfm

Patient information: Free information for your patients about rotator cuff tears and treatment is available on Your Orthopaedic Connection at http://www.orthoinfo.com abling, partial-thickness tears of the rotator cuff can affect patients in different ways. Young overhead athletes presenting with partial-thickness tears differ with respect to etiology, goals, and treatment from older patients with degenerative tears.

Pathogenesis of degenerative tears is multifactorial. Articular-sided tears are more likely caused by primarily intrinsic factors, while both intrinsic and extrinsic factors may play roles in the development of bursal-sided tears. Diagnosis of clinically significant partial-thickness tears should be based on the patient's symptoms and clinical findings in conjunction with magnetic resonance arthrography.

Treatment should be based on the patient's goals, etiology, and depth of tear. Considerable thought should be given to differentiating between articular- and bursal-sided tears. Nonsurgical treatment is successful in most patients. Surgical treatment, when necessary, should consist of tear débridement in articular-sided tears <6 mm in depth and bursal-sided tears <3 mm in depth. Consideration should be given to repairing tears >6 mm in depth on the articular side and >3 mm of depth on the bursal side. The role of acromioplasty has not been clearly delineated, but it should be considered when there is evidence of extrinsic causation of the tear. To optimize future treatment of patients with partial-thickness tears of the rotator cuff, further research at the basic science and clinical levels is needed.

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Citation numbers printed in **bold type** indicate references published within the past 5 years.

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