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Operative Techniques in
Sports Medicine

Arthroscopic Treatment of Partial Rotator Cuff Tears

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Partial rotator cuff tears can be a natural consequence of aging or can be caused by anatomic impingement or trauma. These tears can be asymptomatic or a potential source of shoulder dysfunction. We know very little about their natural history and whether they progress to full-thickness tears. With the advent of magnetic resonance imaging and shoulder arthroscopy, a more precise characterization of these tears is now possible. At the present time, there is no accepted classification system of partial-thickness rotator cuff tears. The optimal clinical approach to treating these tears is also controversial and ranges from simple debridement to open repair. The purpose of this article is to review partial-thickness rotator cuff tears, including the pathogenesis, diagnosis, nonoperative, and operative treatment options, and to create a rational treatment algorithm.
Oper Tech Sports Med 12:135-148 © 2004 Elsevier Inc. All rights reserved.

KEYWORDS partial rotator cuff tear, shoulder arthroscopy

Partial-thickness tears of the rotator cuff may involve either the articular surface, bursal surface, or both sides of the rotator cuff. They may be asymptomatic or a potential source of shoulder dysfunction.[1] With the advent of magnetic resonance imaging (MRI) and shoulder arthroscopy, more tears are being recognized. The optimal clinical approach to these tears has not been completely defined.[2] To gain a better understanding of these tears, we must first understand the anatomy and pathogenesis of these tears and then agree on a classification system to develop a rational approach to their treatment.

Anatomy

The suprascapular artery is the primary vascular supply to the supraspinatus tendon. The vascular studies of Rathbun and McNab[3] have shown that the articular side of the rotator cuff is hypovascular as compared with the bursal side. This finding has been suggested as a factor in the tendency for partial tears to occur on the articular surface of the cuff[4] (Fig. 1).

Collagen bundles located near the articular surface of the cuff are thinner and less uniform than the thick parallel bundles found closer to the bursal surface. The articular surface of the cuff has an ultimate failing stress only half as high as the bursal surface.[5] This lack of uniformity of the collagen bundles along with the hypovascularity of the articular surface of the cuff are contriebuting factors for partial tears to occur more commonly on the articular surface.[2]

The anatomic footprint of the rotator cuff is an important landmark for recognizing the degree of partial tearing of the articular surface of the rotator cuff.[6] In a cadaveric study, Curtis[6] studied the anatomic insertions of the rotator cuff musculature. He found the supraspinatus had a rectangular insertion from approximately the 11:30 position to 1 o'clock position with an average length of 23 mm (range 18-33 mm) and a width of 17 mm (range 12-24 mm) (Fig. 2). The infraspinatus wraps and interdigitates with the supraspinatus tendon. The infraspinatus frames the bare spot of the humeral head, has an average length of 28 mm (range 20-45 mm), and has a width of 18 mm (range 12-24 mm).

Pathogenesis

The pathogenesis of partial rotator cuff tears are multifactorial and may be classified as intrinsic, extrinsic, traumatic, or a combination of all of these. Intrinsic changes in the cuff are related to intrinsic tendinopathy with failure of collagen fibers within the cuff. This may be caused by a lack of uniformity of the collagen bundles especially on the articular side causing partial tearing on the articular side. The lack of cuff vascularity also contributes to weakness of the cuff on the articular side leading to degenerative tears associated with the aging process. These degenerative tears are often associated with extensive delamination or can remain entirely intratendinous.

Extrinsic impingement because of narrowing of the supraspinatus outlet caused by coracoacromial arch abnormalities can result in cuff irritation and may play a major role in many partial cuff tears.[2] Histological changes have been found on the undersurface of cadaveric acromion specimens

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1060-1872/04/$-see front matter © 2004 Elsevier Inc. All rights reserved.
doi.10.1053/j.otsm.2004.06.005

Figure 1 Coronal photomicrograph of the zone of diminished vascularity of the supraspinatus tendon. The arrow points to the critical zone of hypovascularity of the articular side of the tendon.

with bursal surface tears but not in those with articular surface tears.[7] This suggests that bursal-surface tears may be more likely to be related to abrasion of the cuff by the acromion.[2] Gartsman and coworkers[8] believes that extrinsic impingement because of coracoacromial arch narrowing can lead to partial tears on the articular side as well as the bursal surface of the cuff. A differential shear stress affecting the layered anatomy of the cuff has been proposed as one mechanism involved in the production of articular surface tears.[2]

Trauma is more often associated with articular surface tears than with bursal surface tears.[9] This may be because of a direct fall on the shoulder or to repetitive microtrauma seen in laborers or athletes with repetitive overhead activities. Partial degenerative tears can be seen in older individuals without a particular history of trauma.

Walch and coworkers[10] and Jobe[11] have described a subset of partial articular-sided rotator cuff tears that develop secondary to "internal impingement." Glenohumeral instability and traction stress on the rotator cuff in the throwing athlete can lead to undersurface tears in the absence of extrinsic impingement. Additionally, throwers and other overhand athletes may experience posterior shoulder pain when repetitive contact occurs between the undersurface of the supraspinatus and the posterosuperior glenoid during the late cocking phase of the throwing motion. Fatigue of the dynamic stabilizers and excessive external rotation secondary to overstretching of the anterior capsule may predispose individuals to development of internal impingement.[2] A subset of these patients may develop a glenohumeral internal rotation deficit with a significant loss of internal rotation on the affected side.

Natural History

The natural history and progression of these partial rotator cuff tears is a controversial topic. Codman[12] first described changes in the musculotendinous cuff as a rim rent (partial tear) in the undersurface of the supraspinatus tendon at the point of attachment near the articular surface of the humeral head. We know that partial tears of the articular surface are 2 to 3 times more common than bursal surface tears.[9,13-18] Most tears involve the supraspinatus tendon with the infraspinatus, subscapularis, and teres minor tendons much less commonly involved.[8,19] Intratendinous tears are intrasubstance and therefore have no communication with either surface.[20] As anticipated, cadaveric studies have shown a higher incidence of intratendinous tears than that reported in clinical studies since inspection is limited to the tendon surfaces.[21] Magnetic resonance imaging techniques have improved our ability to detect intrasubstance tears and tendon degeneration.[5]

Fukuda et al[21] reported a 13% incidence of partial rotator cuff tears in a cadaveric study of 249 anatomic specimens. The prevalence of these partial thickness tears increases with age. DePalma[22] studied 96 shoulders of patients aged 18 to 74 years without a history of shoulder dysfunction and found an incidence of partial ruptures of the supraspinatus tendon in 37%. Sher and coworkers,[23] in an MRI study of 96 asymptomatic individuals, found a high incidence of partial rotator cuff tears. They were increasingly frequent with advancing age and were compatible with normal, painless, functional activity.

In 1934, Codman[12] described 4 categories of incomplete rupture of the rotator cuff. He suggested that spontaneous healing of partial-thickness rotator cuff tears might occur.

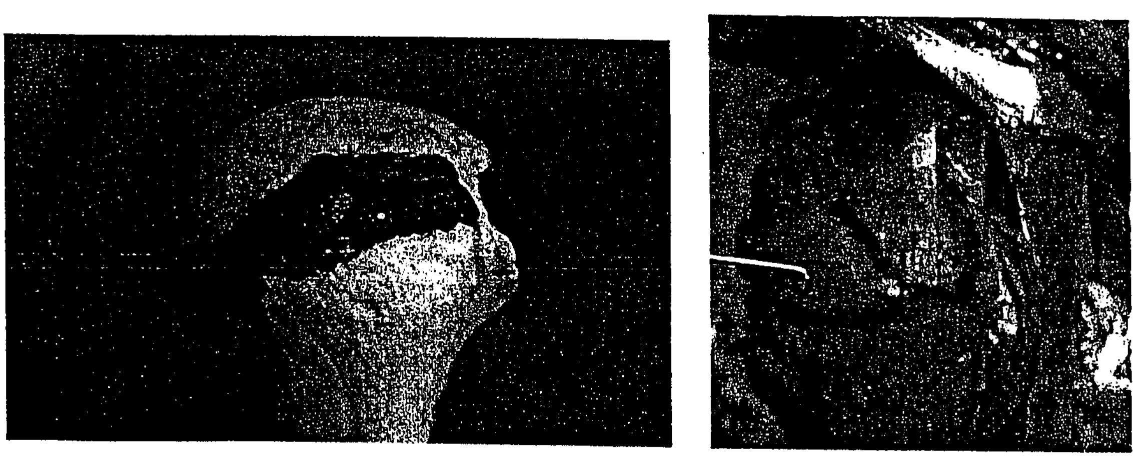

Figure 2 The insertional footprint of the supraspinatus (green) tendon is depicted in this model and cadaver specimen. It inserts approximately from the 11:30 position to 1:00 with an average length of 23 mm (range 18-33 mm) and a width of 17 mm (range 12-24 mm). (Reprinted with permission from the author, Alan Curtis, MD.)

Fukuda and coworkers[20] examined histological sections of partial-thickness rotator cuff tears and found no evidence of active tissue repair. The question of whether or not these partial tears heal or progress is controversial. Yamanaka and coworkers[24] studied 40 patients with symptomatic articular-sided partial rotator cuff tears treated nonoperatively with serial arthrography. At a mean follow-up of 13.5 months, repeat arthrography showed that 4 tears (10%) had disappeared and were presumed to have healed, reduction of the size of the tear occurred in 4 patients (10%), enlargement of tear size occurred in 21(51%), and progression to a full thickness tear occurred in 11 patients (28%). Prognosis of articular sided tears appears to be worse with increasing age, a larger initial tear size, and the absence of a traumatic episode. The patients in whom follow-up arthrography showed a disappearance of the tear often had a history of trauma. Conversely, a history of trauma was seldom noted in those with progressive tear enlargement, resulting in a full-thickness tear.

The role of operative treatment in modifying the natural history of partial-thickness rotator cuff tears is poorly defined.[2] Although Codman[12] believed debridement of partial tears stimulated a healing response, there is no evidence that debridement of a partially torn cuff stimulates a healing response.[15,18] The role of subacromial decompression and its ability to reduce narrowing of the subacromial outlet in those with external impingement has been proposed to delay the progression of cuff pathology.[17,25-27]

The question of whether partial tears progress still needs to be clearly defined. At this point, it appears prudent to follow patients clinically and monitor their symptoms. If their symptoms progress or do not resolve after being treated with proper nonoperative means, the partial tear may be a cause of their symptoms or may be progressing and may need to be addressed surgically.

Clinical Presentation

The prevalence of partial tears of the rotator cuff in asymptomatic individuals was studied by Sher and coworkers in 1995.[23] Magnetic resonance images of the shoulders of 96 asymptomatic individuals found 19 partial-thickness tears (20%). It is evident from this study that partial tears may be asymptomatic and must be evaluated on a case-by-case basis to determine if the pathology is truly causing symptoms.

The symptoms of partial-thickness rotator cuff tears are nonspecific and may overlap with impingement, rotator cuff tendonitis, and small full-thickness rotator cuff tears. Most patients have a painful arc of motion between 60° and 120° of elevation.[9] They may also have loss of motion[20] with posterior capsular tightness and resultant restriction of internal rotation.[8] This may cause anterosuperior translation of the humeral head from a posterior capsular contracture and may potentiate impingement-like symptoms.[2]

The impingement signs described by Neer (pain with forced passive forward elevation) and Hawkins (pain with passive internal rotation of the arm placed in 90° of abduction) are positive in nearly all patients with symptomatic partial-thickness rotator cuff tears.[8] After injection of 10 mL of 1% lidocaine into the subacromial space, the maneuvers may be repeated after 10 minutes. Diminution of pain on repeat testing may be indicative of pure impingement.[2]

Strength is usually preserved on clinical examination. However, pain inhibition may result in an apparent loss of strength and a decrease in active range of motion in these patients with a partially torn rotator cuff.[2] They may also have pain with active resistance to shoulder abduction with the shoulder positioned in 90° of abduction in the scapular plane (Jobe test).

Throwing athletes with partial-thickness rotator cuff tears may also have nonspecific posterior shoulder pain, indicative of "internal impingement."[10,11] They may develop an internal rotation contracture (glenohumeral internal rotation deficity) with an obligate increase in external rotation.[10] Impingement of the deep surface of the supraspinatus tendon may occur as the cuff abrades against the posterosuperior glenoid rim.[10,11] It is a matter of debate as to whether or not rotator cuff injuries observed in individuals with internal impingement develop as a result of pathologic anterior glenohumeral subluxation or repetitive cuff abrasion in an otherwise stable shoulder.[2] Posterosuperior labral lesions (SLAP [superior labrum anterior-posterior] variants) may also be present in throwing athletes and predispose to articular surface partial-thickness rotator cuff tears.[10]

The clinical course of patients with partial-thickness rotator cuff tears is often indistinguishable from that of patients with impingement syndrome, tendonitis, or small full-thickness rotator cuff tears.[25] Symptoms may also be difficult to differentiate from bicipital tendonitis, labral or SLAP lesions, and mild cases of adhesive capsulitis.[2] These associated conditions may also be present in addition to rotator cuff pathology creating a confusing clinical presentation.

Imaging

Imaging techniques to detect partial-thickness rotator cuff tears have improved over the last 10 years. With the advent of magnetic resonance arthrography and newer fat suppression techniques, sensitivity has increased in detecting partial tears.

Radiographic evaluation is the first imaging tool used when evaluating shoulder pathology. Initial x-rays include an anteroposterior view of the glenohumeral joint, an axillary view, and a supraspinatus outlet view. The supraspinatus outlet view is especially important because it not only shows a curved or hooked acromion, but it also ascertains the thickness of the acromion, which is important in preoperative planning. In general, radiographic findings are nonspecific for partial-thickness tears but may be helpful in ruling out other causes of shoulder pain.[2] Arthrography of the glenohumeral joint in detecting partial tears is limited. Although proponents have reported an accuracy of greater than 80%,[9] other authors have been unable to duplicate these results.[8,10]

Bursography may be performed as an adjunct to arthrography to aid in the detection of partial-thickness tears involving the bursal surface. However, subacromial inflammation and adhesive capsulitis may limit the value of this technique.[2] The accuracy of bursography has been reported to range from 25% to 67%.[9,20,21] A negative arthrogram or bursogram cannot reliably rule out the presence of a partial-thickness rotator cuff tear.

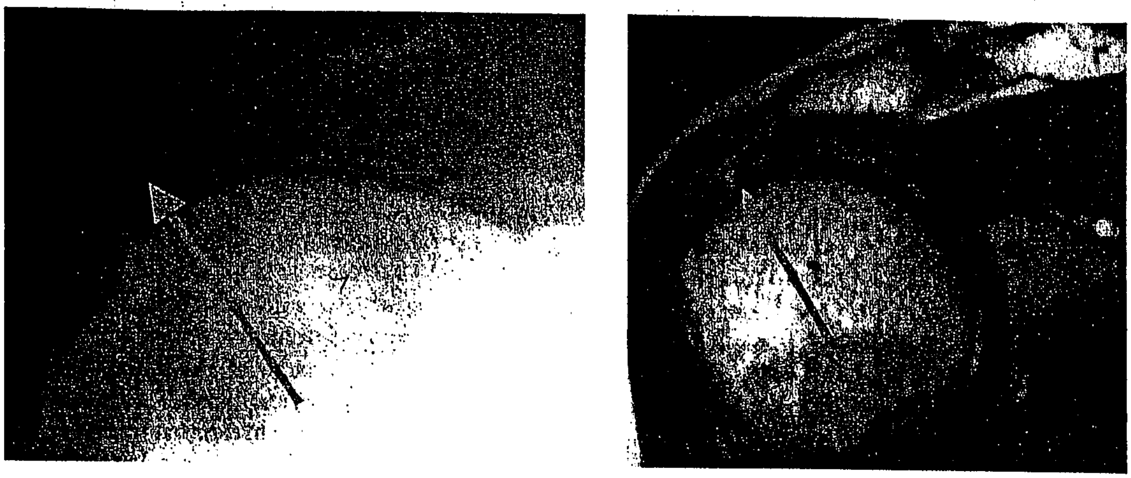

Figure 3 Coronal magnetic resonance view of an intratendinous tear of the supraspinatus tendon.

Ultrasound may be of limited value in detecting partial-thickness tears. Weiner and Seitz[28] reported a sensitivity of 94% and a specificity of 93% in a series of 69 partial-thickness rotator cuff tears. Its clinical use is limited by the availability of personnel experienced in the performance and interpretation of the study.[29]

MRI, although a useful and established technique for detecting full-thickness rotator cuff tears, has been found to be less reliable in detecting partial tears. Newer techniques have been developed to increase sensitivity. By using a T1-weighted image, a diagnosis of a partial tear is suggested by increased signal in the rotator cuff without evidence of tendon discontinuity. Further increase in signal changes on a T2-weighted with a focal defect that is intratendinous or limited to the bursal or articular surface increases the sensitivity of detecting partial tears[29] (Figs. 3-5). Rotator cuff tendonitis may be distinguished from partial-thickness tears by an increased signal on T1 images but a decreased signal on T2 (Fig. 6). However, many cases of tendonitis may actually be partial-thickness rotator cuff tears.

Standard magnetic resonance techniques are relatively insensitive in the detection of partial thickness tears. In 1992, Traughber and Goodwin[30] reported a sensitivity of 56% to 72% and a specificity of 83% to 85% for arthroscopically proven partial-thickness cuff tears. Other studies have reported an 83% rate of false-negative results with arthroscopically proven partial tears.[31] Wright and Cofield found only 6 definite partial tears on preoperative MRI studies in 18 patients with arthroscopically proven partial tears.[11,32]

Fat-suppression techniques accentuate fluid signal contrast on T2-weighted images and have been suggested as a means of increasing detection of partial-thickness tears. Clinical results have varied using this technique (Fig. 7). Quinn and coworkers[33] found a sensitivity of 82% and a specificity of 99% in 11 arthroscopically proven partial tears using fat-suppression techniques. Reimus and coworkers,[34] however, increased the sensitivity only from 15% to 35% using this technique.

Magnetic resonance arthrography improves sensitivity in detecting partial-thickness cuff tears but still has a high false-negative rate. Hodler and coworkers[31] found that intraarticular gadolinium improved sensitivity but that 5 of 13 tears found at the time of arthroscopy were missed by MR arthrogram.

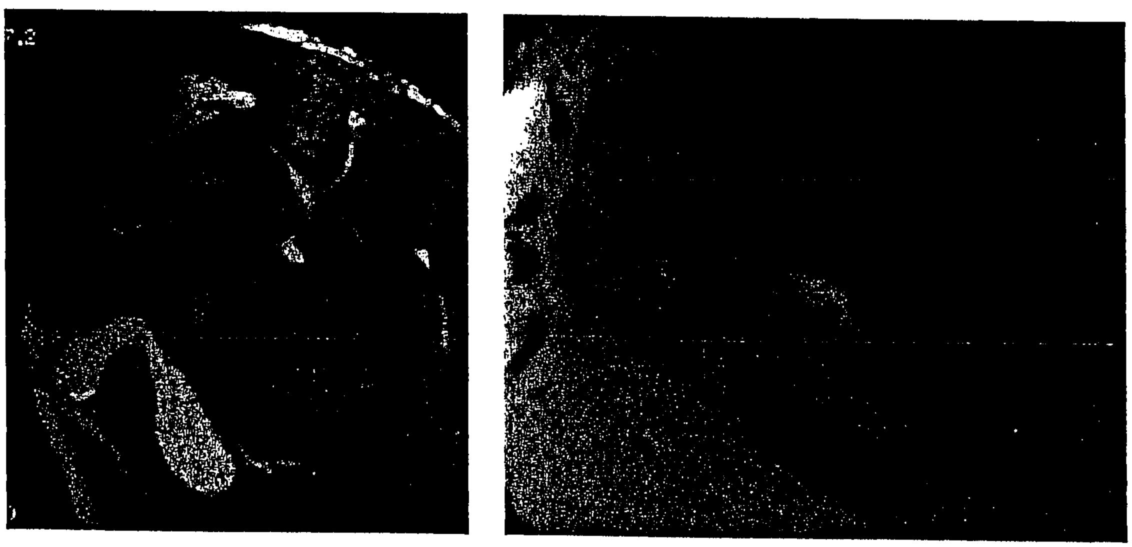

Figure 4 Sagittal and oblique coronal magnetic resonance images showing the signal changes within the supraspinatus indicative of an intratendinous tear.

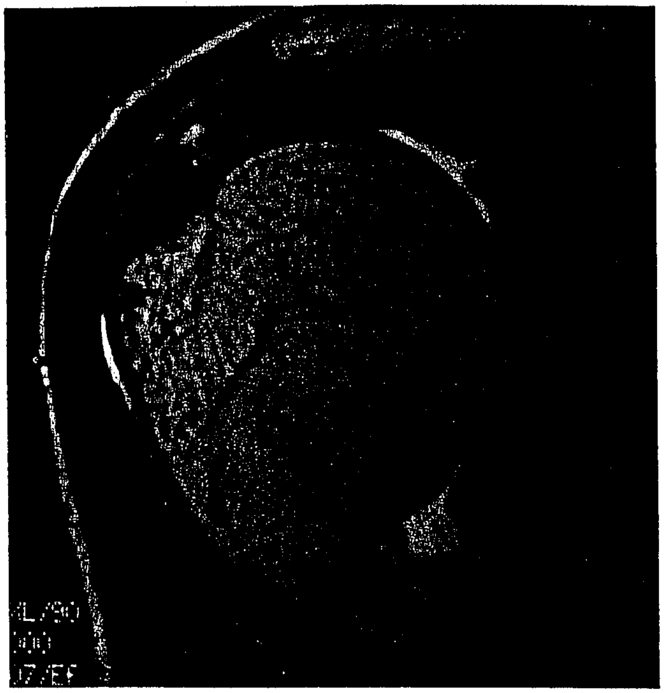

Figure 5 Coronal oblique T1 image of a partial, bursal-sided supraspinatus tendon tear. Note the signal changes within the supraspinatus tendon near its insertion.

Lee and coworkers[35] examined magnetic resonance arthrograms in a retrospective study of 16 patients who underwent shoulder arthroscopy. Standard magnetic resonance arthrogram oblique coronal images detected only 5 partial tears (21%). Using the abduction and external rotation view increased the accuracy to 100% for detecting partial articular sided tears.[35] At this time, it seems prudent to use intraarticular gadolinium if the diagnosis is uncertain or one is suspicious for a partial-thickness rotator cuff tear (Fig. 8).

The occurrence of abnormal MRI signal changes in asymptomatic individuals makes it important to fully evaluate the patient including a thorough history and physical examination before concluding that the MRI findings are the cause of the patient's complaints. In a prospective, randomized study of 96 asymptomatic individuals, magnetic resonance images of the shoulder were evaluated to determine the prevalence of findings consistent with a tear of the rotator cuff. There were 14 full-thickness tears (15%) and 19 partial-thickness tears (20%). The frequency of each type of tear increased with age. In those greater than 60 years of age, 26% had a partial-thickness tear. The results of the study emphasize the potential hazards of the use of magnetic resonance imaging scans alone as a basis for the determination of operative intervention in the absence of associated clinical findings.[23]

Classification

At the present time, there is no widely accepted classification system for partial-thickness rotator cuff tears. This makes it difficult to compare studies because partial tears can vary widely in size and involve the articular, bursal, or both sides of the rotator cuff tendon. Neer[26] first described 3 stages of rotator cuff disease looking at histological specimens of the rotator cuff. Stage I is characterized by hemorrhage and cuff edema, stage II by cuff fibrosis, and stage III by a cuff tear. However, this system has significant limitations clinically and does not address partial-thickness tears.

Ellman[13] recognized the difficulty in using Neer's classification system and proposed a classification for partial-thickness rotator cuff tears. For partial-thickness tears, grade I is less than 3-mm deep, grade II is 3- to 6-mm deep, and grade III tears are greater than 6-mm deep. He also recognized that partial tears could occur on the articular side, bursal side, or be interstitial. He believed that grade III tears involving more than 50% of the tendon should be repaired (assuming average cuff thickness of 9-12 mm in size).[13]

Snyder and coworkers[36] proposed a comprehensive classification system for both partial and complete tears. At the time of a complete 15-point glenohumeral diagnostic shoulder arthroscopy, the articular side of the rotator cuff is fully

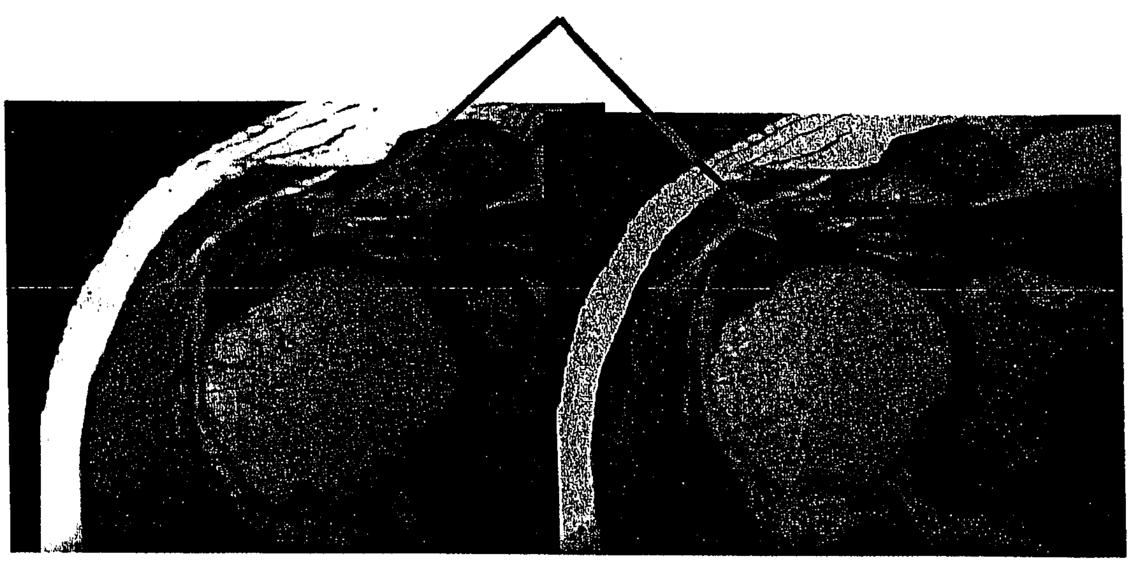

Figure 6 Coronal oblique MR images of signal changes within the supraspinatus tendon characteristic of rotator cuff tendonitis.

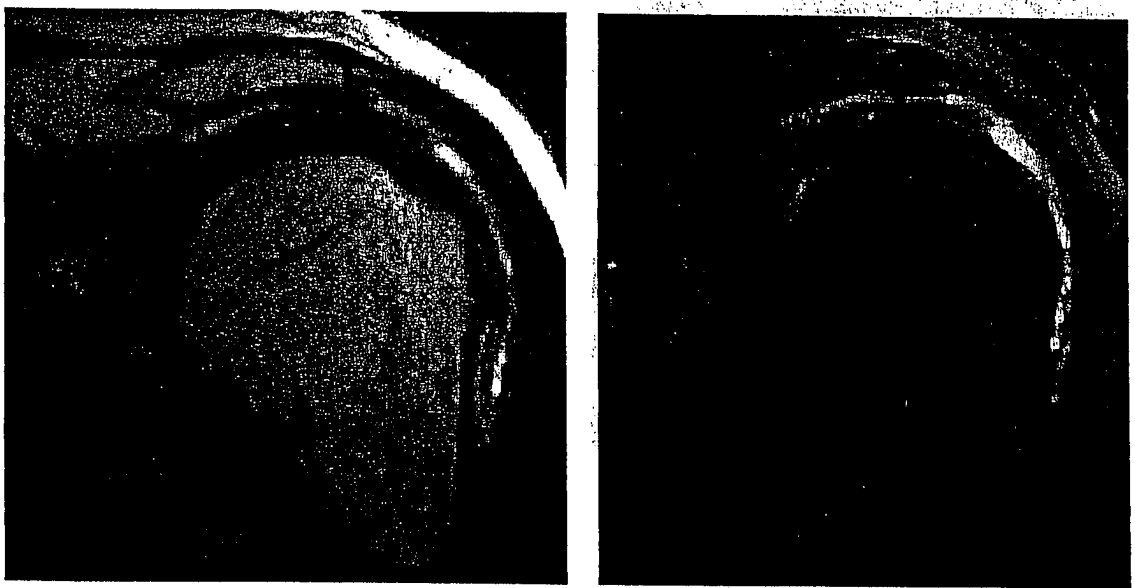

Figure 7 Fat-suppression techniques (right) accentuate fluid signal contrasts on T2-weighted images in partial thickness tears.

evaluated. The degree of tearing is graded from 0 to IV with 0 being normal and IV being a significant partial tear greater than 3 cm in size (Table 1). A designation of IV implies that the partial tear is very severe, having tendon damage over a large area, with fragmentation and often flap formation. For all practical purposes, a grade IV tear is tantamount to a full-thickness lesion even though there are a few remaining fibers (Fig. 9).[37] By using a marker suture technique described by Snyder, the bursal side of the tear can be easily located during the bursal examination. The bursal side of the cuff is then inspected and is graded in a similar fashion. For example, an A-II, B-IV type of partial tear has partial fraying less than 2 cm in size on the articular side and significant tearing on the bursal side of the cuff greater than 3 cm in size (Fig. 10A,B). An A-O, B-IV is normal on the articular side with a significant partial tear on the bursal side.

Many authors have recommended a simple system grading tears based on whether or not the tear depth exceeds 50% of the cuff thickness. If one assumes that the average cuff is approximately 12 mm in size, it is possible to grade the percentage of tearing. By using the supraspinatus footprint as a guide, if more than 6 mm of the footprint is exposed, a greater than 50% tear of the supraspinatus insertion[6,38] has occurred (Fig. 11A,B). To date, clinical studies validating any classification system are lacking. In the meantime, one must be careful when interpreting studies that fail to quantify partial rotator cuff tears and also fail to mention whether or not the tears occur on the articular side, bursal side, or both.

Figure 8 Coronal oblique magnetic resonance arthrogram showing a partial, undersurface tear of the supraspinatus

Table 1 Snyder Classification of Partial Rotator Cuff Tears[37]

Location of tears	
A	Articular surface
B	Bursal surface
Severity of tear	
0	Normal cuff, with smooth coverings of synovium and bursa
I	Minimal, superficial bursal or synovial irritation or slight capsular fraying in a small, localized area; usually <1 cm
II	Actually fraying and failure of some rotator cuff fibers in addition to synovial, bursal, or capsular injury; usually <2 cm
III	More severe rotator cuff injury, including fraying and fragmentation of tendon fibers, often involving the whole surface of a cuff tendon (most often the supraspinatus); usually <3 cm
IV	Very severe partial rotator tear that usually contains, in addition to fraying and fragmentation of tendon tissue, a sizable flap tear and often encompasses more than a single tendon

Nonoperative Treatment

There is no simple treatment algorithm for partial-thickness rotator cuff tears.[2] Treatment of the symptomatic shoulder with a partial tear is directed toward correcting the primary diagnosis such as impingement or treating underlying instability, which is producing the partial tear on a secondary basis. As we know from the work of Sher and coworkers,[23] not all partial tears are symptomatic. Therefore, it is reasonable to direct initial nonoperative treatment toward the primary diagnosis.

Individuals with a suspected partial tear because of extrinsic impingement or intrinsic tendinopathy are treated in a similar fashion as those with impingement syndrome.

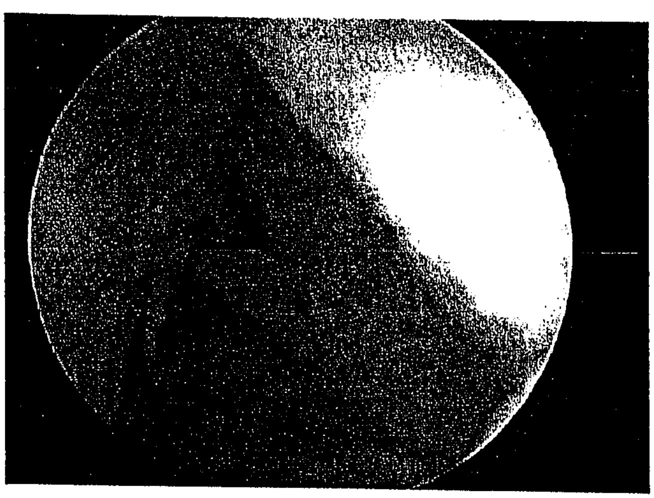

Figure 9 Arthroscopic view of a left shoulder from the posterior portal looking anteriorly of a partial articular sided rotator cuff tear with fraying and a large flap component (Snyder grade A-IV).

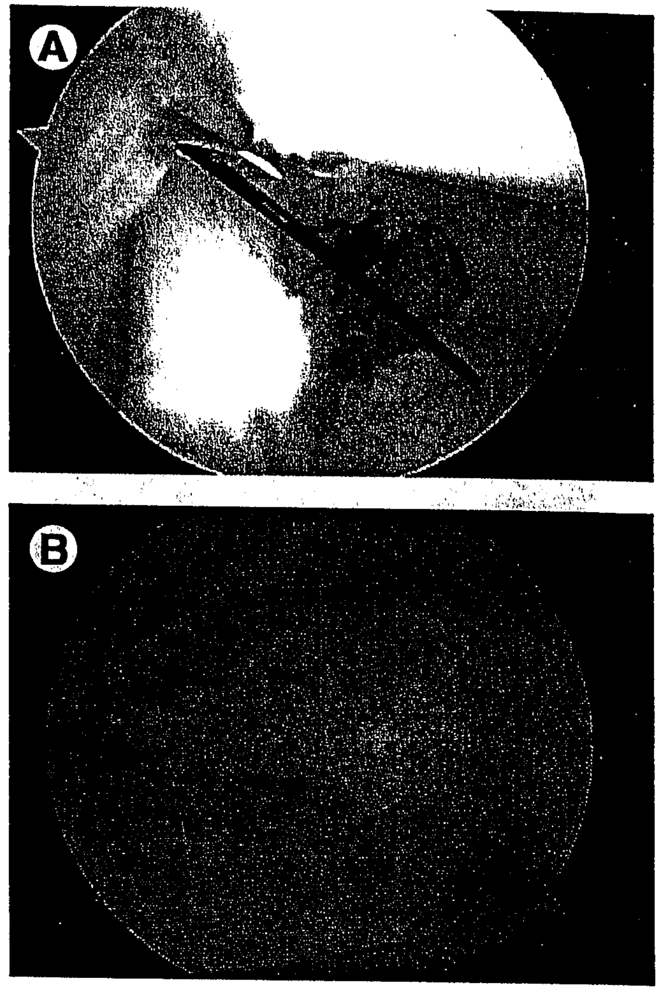

Figure 10 (A) The marker suture being placed through a partial articular-sided rotator cuff tear. This tear was less than 2 cm in size (Snyder grade A-II). (B) The bursal side of the tear is easily located with the aid of the marker suture. This is a large flap tear with fraying and fragmentation measuring four cm in size (Snyder grade B-IV). Therefore, this would be considered an A-II, B-IV type of tear.

Subacromial bursal inflammation is controlled with activity modification, nonsteroidal antiinflammatory medication, and the judicious use of injectable corticosteroids. The role of rehabilitation to restore normal joint mechanics and strengthen the rotator cuff and parascapular musculature has been proposed to reduce the progression of rotator cuff disease in those with both external and internal impingement. The role of the external rotators that act as humeral head depressors may play a role in reducing external impingement, thus reducing further mechanical impingement of the cuff from the coracoacromial arch. Rehabilitation of the parascapular musculature may serve to restore normal scapulothoracic mechanics and minimize impingement secondary to scapulothoracic dyskinesis.[2] In those with "internal impingement" and also in those with underlying instability, restoring normal range of motion and stretching the posterior capsule and reducing internal rotation contractures, may prevent pathologic contact between the supraspinatus and the superior labrum, especially in the overhead athlete.

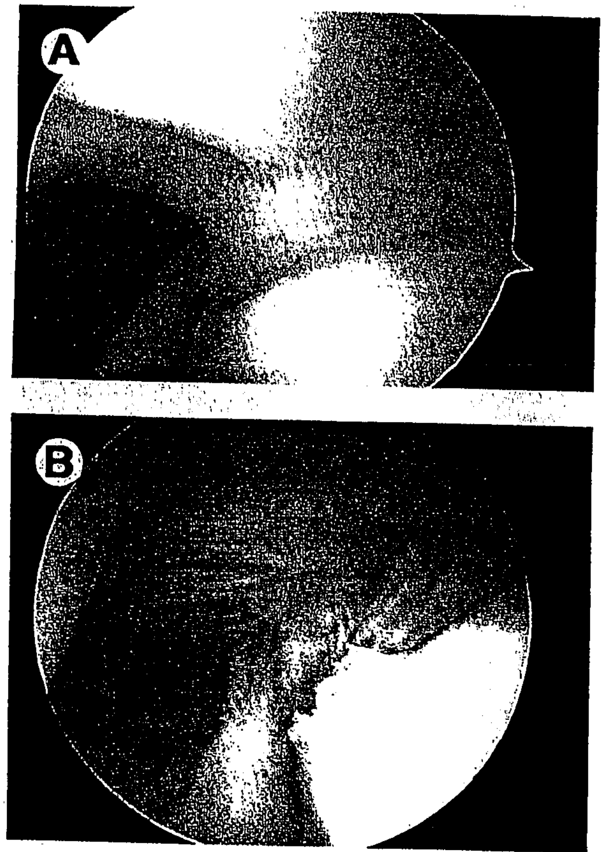

Figure 11 (A) The normal footprint of the supraspinatus tendon. (B) A partial tear of the supraspinatus footprint. The tear can be graded from the distance of the intact supraspinatus fibers to the articular surface. (Reprinted by permission from Alan Curtis, MD.)

Operative Treatment

The timing of surgical intervention when conservative treatment fails is controversial. A minimum of 3 months to as long as 6 months of nonoperative treatment has been recommended before considering surgical intervention. The underlying cause of the tear must be clarified. For example, debridement of a partial articular sided tear in an overhead athlete with instability has been associated with a high failure rate. Jobe and Kvitne[39] recommended treatment of the underlying shoulder instability at the time of surgery, particularly in overhead athletes.

The surgical treatment of partial-thickness rotator cuff tears is also controversial. The lack of uniformity in describing rotator cuff tears and an acceptable classification system has made it difficult to compare study results. Surgical treatment options include tear debridement, acromioplasty with tear debridement, or cuff repair in addition to acromioplasty. Surgery may be performed open, arthroscopically assisted, or entirely as an arthroscopic procedure.[2]

A complete 15-point arthroscopic diagnostic examination of the glenohumeral joint should be done initially to not only evaluate the articular side of the rotator cuff but also to diagnose and to treat labral lesions and other glenohumeral pathology.[37] The diagnosis of partial thickness tears is often not made with certainty until the rotator cuff is examined arthroscopically.[2] Partial tears have been found unexpectedly in as many as 15% to 35% of patients undergoing arthroscopic treatment for impingement syndrome.[21,25] A marker suture (no. 0 absorbable monofilament) may be placed via an 18-G spinal needle laterally off the edge of the acromion into the partial tear. The needle is then removed leaving the suture in place. The subacromial space is then entered into, the marker suture localized, and the extent of any bursal tearing is localized. After debridement of hypertrophic bursal tissue, the area surrounding the marker suture is carefully inspected. Complete visualization of the cuff is done by internally and externally rotating the arm. After debridement with a full radius shaver of any damaged bursal rotator cuff fibers, the extent of the tear can be better assessed (Fig. 10A,B). Arthroscopy affords no substantial advantage in the evaluation and treatment of intratendinous tears because these typically cannot be identified arthroscopically.[2] Tissue appearance and palpation with the tip of the shaver may help to identify these lesions.

Arthroscopic debridement of partial tears has led to mixed results.[10,36,40,41] Andrews and coworkers[40] reported that debridement alone in 34 patients led to 85% satisfactory results at an average of 13 months of follow-up. The average age of the patients was 22 years old, and most were competitive overhead athletes. However, the question of whether these patients actually had underlying instability and whether the partial tear was really the cause of the patient's symptoms is a matter of debate. This study was published in 1985 and our understanding of glenohumeral instability has improved considerably.

Snyder and coworkers[36] proposed arthroscopic debridement of partial rotator cuff tears and reported 84% satisfactory results in a mixed series of articular and bursal sided tears with an average follow-up of 23 months. Over one half of the patients had a subacromial decompression performed at the same time. However, in 9 of 31 cases the bursal side of the cuff was not inspected. This article was one of the first to describe a classification system describing the size of both articular- and bursal-sided tears and found no correlation between the grade of the tear and the result.

However, other authors have reported less satisfactory results with debridement alone. Ogilvie-Harris and Wiley[41] reported on 57 patients treated with arthroscopic debridement without subacromial decompression and had a 50% failure rate. The average follow-up was only 1 year, and no exact description of the tears was given making it hard to compare this study with others. Walch and coworkers[10] also had poor results with arthroscopic debridement of partial tears secondary to "internal impingement," emphasizing the importance of treating the underlying cause of the tear.

Arthroscopic subacromial decompression with arthroscopic debridement of partial tears has also led to mixed results.[25,29,42,43] In 1990, Ellman reported on 20 patients with partial tears involving the articular surface,[12] the bursal surface,[7] or both sides of the tendon.[1] With a short follow-up period that was not documented, he reported a 20% failure rate (5 patients).[13]

Ryu[17] reported on 35 patients treated with an arthroscopic subacromial decompression and debridement with a follow-up of 23 months and had 86% good results. Bursal-sided tears had more favorable results while only 1 of 4 articular-

In 1990, Gartsman[19] reported on 40 patients with partial rotator cuff tears treated with arthroscopic debridement and arthroscopic subacromial decompression. There were 32 tears of the supraspinatus tendon on the articular side, 4 on the bursal side, 4 tears of the infraspinatus, all but one on the articular side. The tears ranged from 0.3 to 3 cm in size averaging 1.1 by 1.6 cm in size. There was no mention of whether any of the tears had both articular- and bursal-side involvement. With an average follow-up of 28.9 months, 33 of 40 patients had marked improvement. Stephens and coworkers[27] reported on 11 patients with partial tears treated with debridement with arthroscopic subacromial decompression. Three patients (27%) required further surgery and 2 of 3 progressed to a full-thickness tear.

Miller and coworkers[44] reported a 26% failure rate in patients treated in a similar fashion with a follow-up of 2.6 years. Noojin and coworkers[1] noted a deterioration of University of California Los Angeles (UCLA) scores over time in a group treated with debridement and subacromial decompression. Cordasco and coworkers[43] found a 29% failure rate (4 of 14 patients) for bursal-sided tears and a 3% (2 of 63 patients) for articular-sided tears also treated in a similar manner.

Debridement of high-grade partial rotator cuff tears with or without subacromial decompression without surgical repair may lead to unacceptable failure rates in long-term studies. Future long-term studies using an acceptable and reproducible classification system is needed before definitive treatment guidelines can be agreed on.

Because of concerns about cuff integrity and tear progression, repair of extensive partial rotator cuff tears has been recommended.[8,13,18] Ellman[13] was one of the first to recommend arthroscopic subacromial decompression along with open repair of significant partial tears of the rotator cuff. He recommended open repair when more than one half of the cuff thickness is involved. Empirically, grading and treating tears in this manner appears reasonable but is often difficult to estimate the thickness of the tear clinically.

Fukuda and coworkers[21] reported on 66 patients with partial tears treated with open acromioplasty and repair. Satisfactory results were obtained in 94% with an average follow-up of 32 months. Location and size of the tears were meticulously recorded and few, if any, other studies have been as thorough and complete. With newer arthroscopic techniques, this study may be the gold standard to which others are compared. Itoi and Tabata[9] had 82% satisfactory results in 38 patients treated in a similar fashion with a follow-up averaging 4.9 years.

Weber has been at the forefront of the controversy surrounding arthroscopic debridement versus miniopen repair versus arthroscopic repair of partial rotator cuff tears. In a retrospective review of 65 patients with partial cuff tears, all were initially treated with arthroscopic subacromial decompression, whereas 32 were treated with additional arthroscopic debridement and 33 with miniopen repair. Treatment was not randomized. The groups were similar in age and types of tear with the majority being articular-sided tears (29/32 in the arthroscopic group and 28/33 in the miniopen group). Statistically significant differences in long-term outcome were noted with a UCLA score of 22.7 in the arthroscopic debridement group versus a 31.6 in the miniopen group. There were 9 poor results in the arthroscopic group versus only one in the miniopen group.

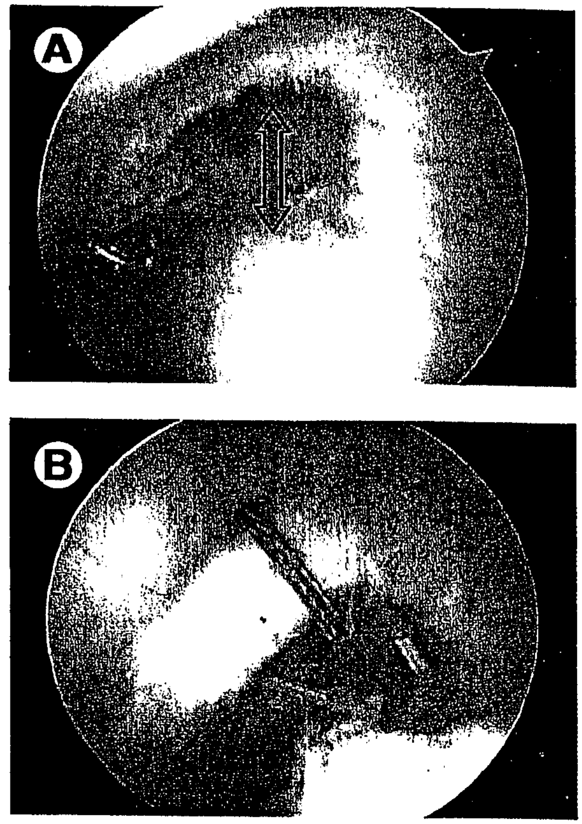

Figure 12 (A) Partial tear of the supraspinatus footprint and the degree of tearing measured from the articular surface. (B) An anchor has been placed into the greater tuberosity with 2 nonabsorbable sutures and woven through the cuff. The sutures are retrieved in the subacromial space and tied. (Reprinted by permission of Alan Curtis, MD.)

In a follow-up study, Weber[45] compared another group of 29 miniopen repair patients to a group of 33 patients with partial articular-sided tears who underwent an arthroscopic repair. By using an arthroscopic technique of completing the tear from the bursal side and then repairing it with suture anchors, outcomes were similar in both groups (UCLA scores 30.67 for the arthroscopic group and 29.84 for the miniopen group). By completing the articular-sided tear, debriding the damaged tissue, and advancing the healthy tendon back to its attachment site, the all-arthroscopic technique led to results equal to those reported with a miniopen approach.

Other arthroscopic repair techniques have been proposed for partial rotator cuff tears. Lyons et al[46] described arthroscopic debridement of articular-sided tears to evaluate tear depth as well as to attempt to promote a healing response. After tear debridement, the arthroscopic shaver is used to lightly abrade the greater tuberosity adjacent to the tear, avoiding the articular surface. An arthroscopic side-to-side suture is placed, placing the debrided tendon end in contact with the abraded humeral surface. This is to inhibit further progression of the tear in patients with Ellman grade I or grade II partial tears and selected grade III tears.

The arthroscopic transtendon technique for treating signif-

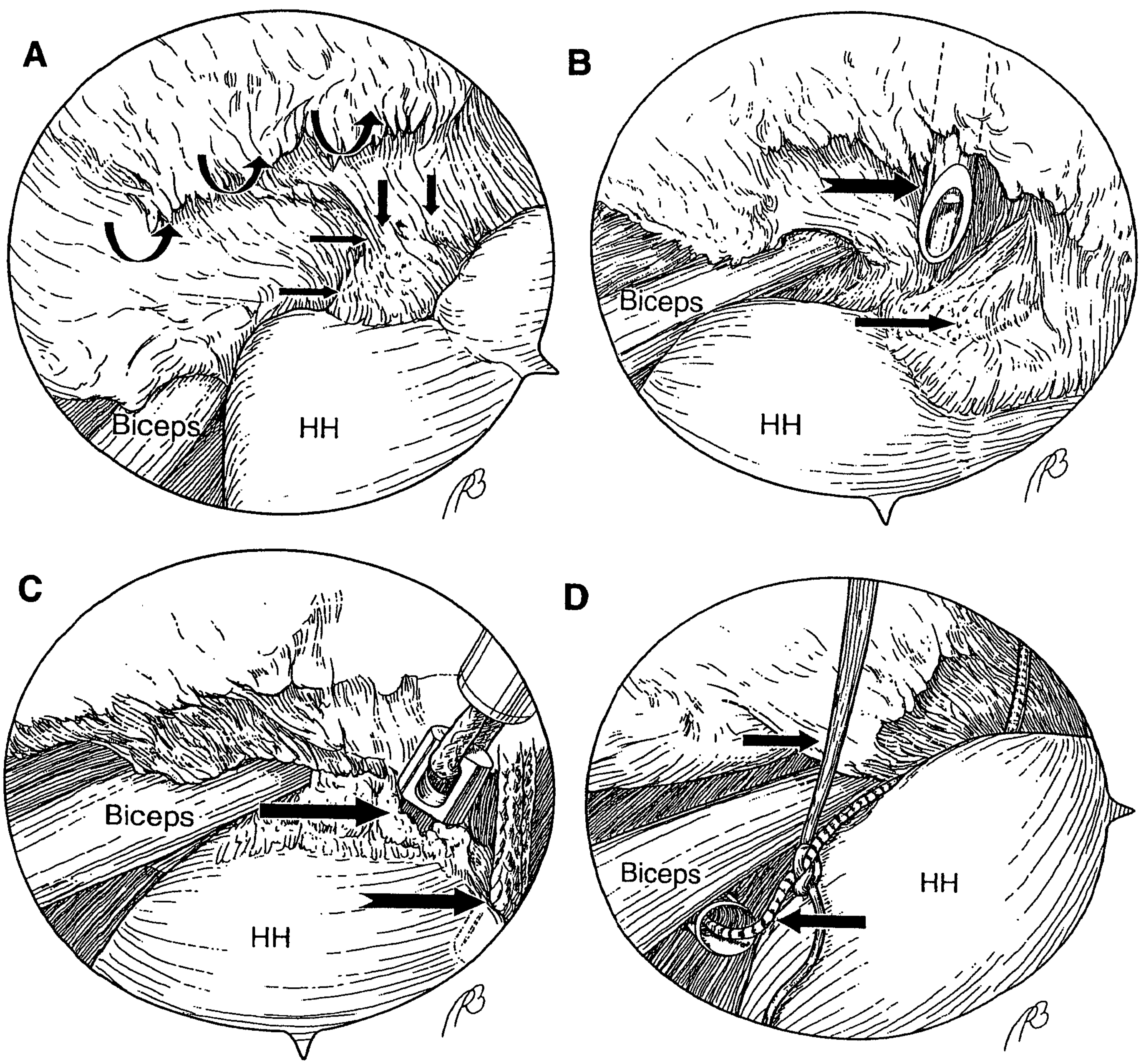

Figure 13 (A) Identify and quantitate the tear using the anatomic "footprint" as the reference point. Prepare the exposed footprint with a motorized shaver using a standard anterior portal. Debride the partial articular sided tear. (B) Pass a percutaneous spinal needle lateral to the edge of the acromion. This needle will traverse through the substance of the remaining attached rotator cuff into the exposed footprint. This will serve as a guide for anchor insertion. (C) A narrow diameter sleeve or instrument-specific cannula is then passed percutaneously through the rotator cuff (transtendon) and the appropriate instrumentation is used to place 1 or 2 anchors, each double-loaded, depending on the size of the tear. (D) For each anchor in sequence, 1 suture limb of the anchor is grasped through the anterior portal. A loaded spinal needle (no. 1 absorbable suture) is then passed through the bursal side of the cuff, aiming for the edge of the partial tear. Some manipulation of the shoulder may be necessary (eg, abduction and/or rotation to pass the loaded needle accurately). The suture is introduced into the joint and grasped through the anterior portal and will serve as a suture shuttle. A simple loop is tied in the absorbable suture and one of the limbs from the anchor, which has been bought through the anterior portal is loaded on the shuttle outside the joint by tightening the loop. The shuttle and accompanying anchor suture is then pulled retrograde, in order, through the cannula, the tear edge, and into the subacromial space. (E) After the shuttle is brought through the cuff (left arrow), the remaining sutures are passed in a similar manner and eventually tied to reproduce the anatomic footprint (right arrow) to the humeral head (HH). (F) The arthroscope is then introduced into the subacromial space. Color-coded sutures facilitate identification of matched sutures. The appropriate suture pairs are separated and then tied through a lateral or anterior cannula. (G) The arthroscope is reintroduced into the glenohumeral space and the edge of the partial tear should be contiguous with the articular margin, completely effacing the previously exposed footprint. The shoulder is then taken through a range of motion to evaluate the quality of the repair, to make sure undue tension is not present, and to make sure a near anatomic repair has been performed. Much like a full-thickness arthroscopic rotator cuff repair, the shoulder is immobilized for 5 to 6 weeks. Early passive range of motion is initiated, and active range of motion allowed at 6 weeks. Internal rotation is avoided for 6 weeks and scapular stabilizing exercises are started immediately. Resistance training is begun

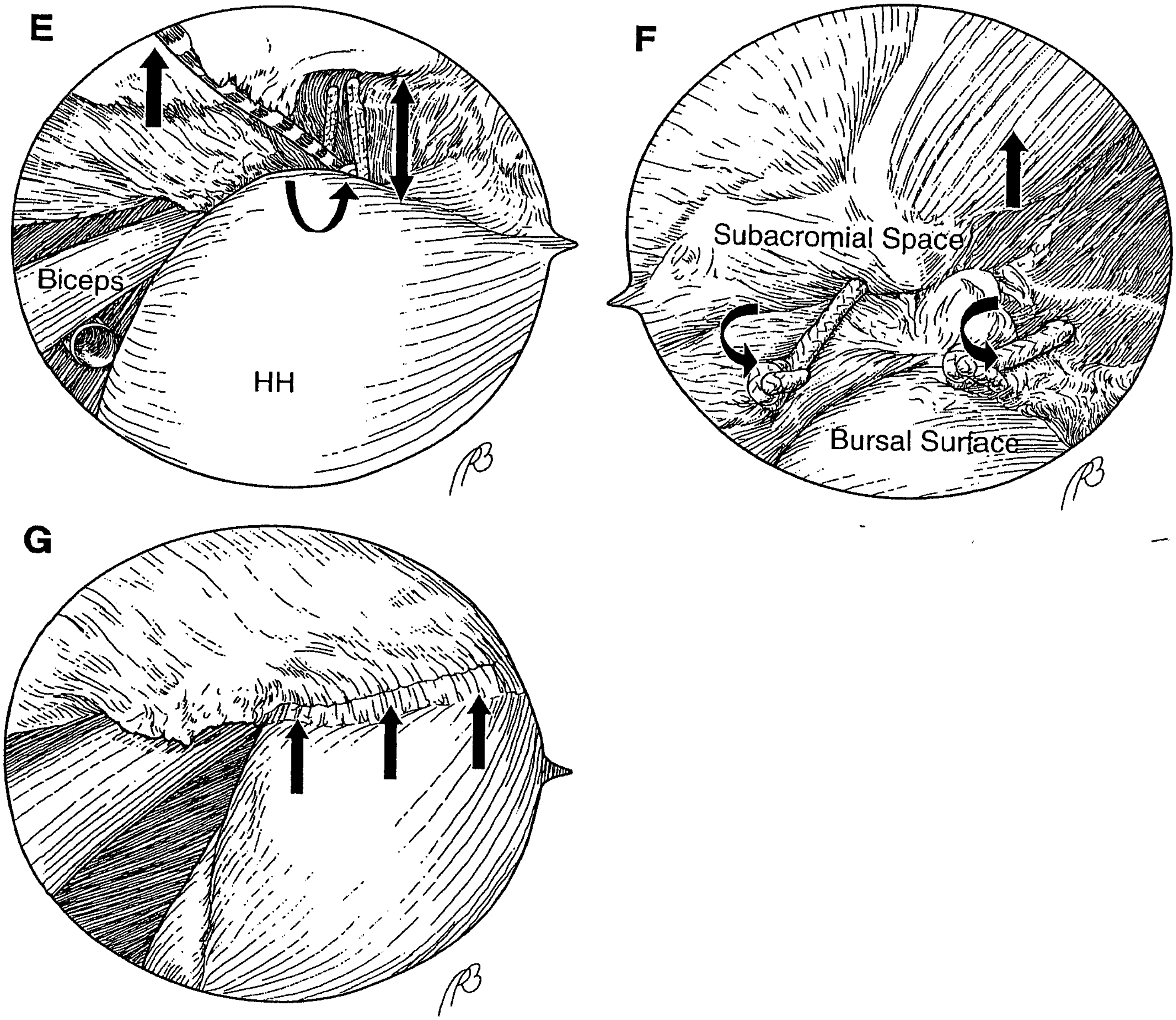

Figure 13 Continued

icant partial articular-sided rotator cuff tears (the so-called partial articular-sided tendon avulsion lesion) has been described by Snyder.[37] This method seeks to replace the torn surface to its native "footprint" area on the tuberosity, preserving the remaining fiber attachment. It is an alternative to arthroscopic debridement and completion of the tear as described by Weber. Further studies are needed using this technique.

When to perform arthroscopic debridement alone versus arthroscopic repair versus miniopen repair is still a matter of controversy. With current arthroscopic techniques, most, if not all partial tears can be treated arthroscopically. This is dependent on the experience and skill level of the surgeon. Weber's study is the best to date showing that an all-arthroscopic technique of completely debriding the damaged tissue, completing the tear, and repairing it arthroscopically with suture anchors can provide excellent outcomes.[45]

Treatment Algorithm

At this time, there is no accepted management algorithm for the treatment of partial rotator cuff tears. Critical decision-making factors include the age of the patient, occupation and/or sport, location of the tear (bursal versus articular versus intratendinous), etiology including acute trauma, repetitive overhead trauma, and possible underlying instability. Clinical symptoms include pain, motion loss, and associated weakness. The simplistic view of repairing those tears with greater than 50% involvement of the tendon versus debriding those with less than 50% involvement is appealing but is sometimes difficult to determine at the time of diagnostic shoulder arthroscopy. Using the footprint as a marker[37] to determine whether or not a tear involves greater or less than 50% of the tendon has been proposed. This is a promising technique, but further clinical studies are needed before this can be recommended.

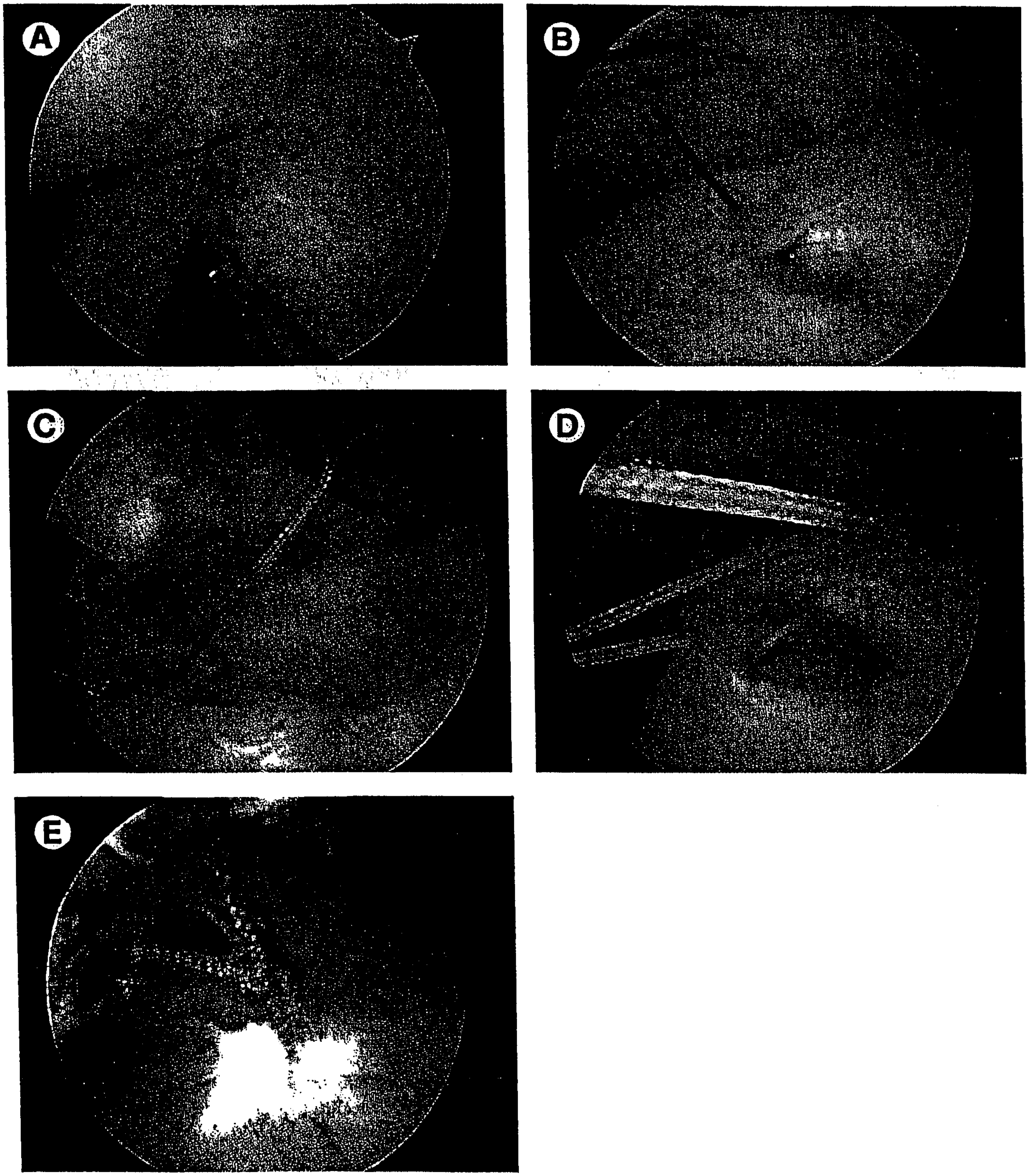

Figure 14 (A) Partial articular-sided tear with a marker suture (Snyder grade A-II). (B) The bursal side of the rotator cuff with marker suture (Snyder grade B-III). This would be considered an A-II, B-III type of tear. (C) After debridement of the damaged tissue and converting it to a complete tear, an anchor is placed at the edge of the articular surface into the greater tuberosity loaded with 2 nonabsorbable sutures. (D) The sutures are woven through the leading edge of the cuff in a mattress type of stitch. (E) The sutures are tied arthroscopically repairing the cuff to its anatomic position.

A reasonable algorithm is complex but can be simplified somewhat if we separate younger, overhead athletes, those with so-called "internal impingement" and those with underlying instability from those older patients with external impingement. Young overhand athletes rarely need decompression but require treatment for their underlying instability.

In those patients in whom instability has been ruled out as an underlying cause of the partial rotator cuff tear, reliably assessing the size and thickness of the tear dictates what treatment is appropriate. In those patients with impingement-like symptoms and good strength on clinical examination and only partial fraying of the articular or bursal side of the cuff (Snyder grade A-I, A-II, or B-I, B-II; Ellman grade I or II), it is reasonable to debride the rotator cuff and perform an arthroscopic subacromial decompression.

In the case of a significant partial articular-sided tear (Snyder grade A-III, B-O; Ellman grade III type of tear) with a normal bursal surface, simple debridement with an arthroscopic subacromial decompression in an older individual may provide significant pain relief. However, in a younger, more active individual this treatment may be inadequate and lead to tear progression and residual pain and weakness. In the higher demand patient category, repairing the high-grade partial tear, the so-called partial articular-sided tendon avulsion lesion, using any of the available techniques would be recommended. These significant partial articular-sided tears may be amenable to the transtendon technique described previously to reproduce the anatomic footprint (Fig. 12A,B). This surgical technique has been outlined in Figure 13A-G.

In those patients with a normal articular surface of the cuff (Snyder grade A-0) but with significant fraying on the bursal surface (Snyder grade B-III or BIV), arthroscopic subacromial decompression is recommended and the surgeon faces the same dilemma of deciding between debridement or repair. Again, those higher demand and younger patients may benefit from an aggressive approach focusing on restoring fiber integrity gained in a repair. Even older patients may benefit from repair. What technique to use for these partial bursal-sided tears is controversial and hopefully further studies will help us determine which technique to use. At this time, it may be prudent to complete the tear and repair it with a side-to-side soft-tissue technique or using a suture anchor.

When both sides of the cuff are involved, the risk of tear progression may be more likely and more aggressive repair measures must be considered. For example, a partial articular-sided tear (Snyder grade A-III) and a partial tear of the bursal side (Snyder grade B-II, B-III, or B-IV) treated with only debridement may lead to residual pain and weakness. A reasonable approach would be to debride the damaged tissue, complete the tear, and repair the healthy tissue with suture anchors (Fig. 14A-E).

The postoperative protocol for these patients is similar to the type of program using a miniopen technique. When a partial tear is debrided and converted to a full-thickness tear and repaired, early passive range of motion is instituted. However, many patients have little pain after an arthroscopic repair and may want to do more actively than a surgeon is comfortable. The general feeling is that time is needed to allow the repair to heal before any active motion is allowed, typically 4 to 6 weeks. It is been the author's experience that many patients do more than they are instructed during this time. We may learn from our experience with anterior cruciate ligament reconstruction rehabilitation that patients may accelerate their rehabilitation.

When a tear is only debrided, an early aggressive range of motion program is instituted with early strengthening. The postoperative regimen for a tear where it is repaired in situ with reattachment to the anatomic footprint is treated similarly as a complete tear repaired arthroscopically. However, many patients feel little pain and may want to do more in the first 4 to 6 weeks actively, which may risk damaging the repair. Further studies are needed to determine if the rehabilitation protocol may be safely accelerated in patients whose tears are repaired using newer arthroscopic techniques.

Conclusion

The treatment of partial rotator cuff tears remains a controversial topic. Some of the controversy stems from our current lack of knowledge regarding the natural history of partial tears as well as from the confusing clinical studies that abound. Suffice it to say that each partial rotator cuff tear must be individually evaluated to determine if indeed the tear is actually the source of clinical symptoms. If a partial tear is deemed in need of treatment, ascertaining associated pathology is critical. If the partial tear is a secondary phenomenon, resulting from labral or ligamentous insufficiency, treatment is directed toward to the primary problem initially. If the partial tear is of limited size and associated with impingement, a simple decompression may solve the problem entirely. The high-grade partial tear continues to be the clinical challenge. However, with our increasing understanding of rotator cuff anatomy and with the ability to grossly measure tear depth arthroscopically, the goal of restoring integrity to the rotator cuff in the younger, higher-demand patient becomes more compelling. Long-term studies evaluating the treatment of partial rotator cuff tears using a standardized classification system and the techniques described are clearly needed before any treatment algorithm can be fully validated.

Acknowledgments

This article is dedicated to the memory of Edward S. Bittar, MD, PhD, a man of enormous intellect, skill, and good humor. We shall miss him.

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