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Indications for Rotator Cuff Repair

A Systematic Review

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Despite the popularity of surgical repair of rotator cuff tears, literature regarding the indications for and timing of surgery are sparse. We performed a systematic review of the literature to investigate factors influencing the decision to surgically repair symptomatic, full-thickness rotator cuff tears. Specifically, how do demographic variables, duration of symptoms, timing of surgery, physical examination findings, and size of tear affect treatment outcome and indications for surgery? We reviewed the best available evidence, which offers some guidelines for surgical decision making. Variables suggest earlier surgical intervention may be needed in the setting of weakness and substantial functional disability. With regard to demographic variables, the evidence is unclear regarding their association with treatment outcome. However, older chronological age does not seem to portend a worse outcome. Pending worker's compensation claims does seem to negatively affect treatment results. Further research is required to define the indications for surgery for full thickness rotator cuff tears. However, the design and conduct of an ethical study to obtain Level I evidence on this issue will be a major challenge.

Level of Evidence: Level IV, systematic review. See Guidelines for Authors for a complete description of levels of evidence.

Rotator cuff tears are one of the most common causes of shoulder pain and disability in the upper extremity.[7] With the growing elderly population, treatment of full-thickness rotator cuff tears has become a common dilemma facing orthopaedic surgeons. More than 4.5 million physician visits and approximately 40,000 inpatient surgeries were performed for rotator cuff problems at a cost of approximately $14,000 per surgery in 2002.[43,96] During the past two decades, there has been a surge of publications discussing rotator cuff injury and treatment strategies. There has been a substantial increase in the volume of operative intervention for symptomatic rotator cuff tears, and surgical repair of these tears is now common.[4,9,16,17,19,21,22,25,34,38,65] Despite the popularity of surgical repair of rotator cuff tears, literature regarding the indications for and timing of surgery are sparse.

In the general population, the prevalence of rotator cuff disease seems to correlate with the aging process. Magnetic resonance imaging (MRI) and ultrasound studies on asymptomatic individuals have found a high prevalence of partial and full thickness tears, with percentages correlating closely with subject age.[90,92] Magnetic demonstrated partial or complete tears of the rotator cuff in 4% of patients < 40 years of age, and 54% in those > 60 years of age.[90] Ultrasound detected a prevalence of rotator cuff tears in 40% of subjects > 50 years of age.[92] Tears were seen in 13% of volunteers in the fifth decade, 20% in the sixth decade, and 31% in the seventh decade of life.

Guidelines for treatment, whether operative or nonoperative, are ambiguous at best. Several of the oft-followed indications for surgery were outlined 35 years ago and included: (1) patients physiologically younger than 60 years; (2) patients with clinically or arthrographically demonstrable full-thickness cuff tear; (3) patients who failed to improve with nonoperative treatment; (4) patients who need to use the involved shoulder in overhead elevation in their vocation or avocation; (5) patients with full passive shoulder range of motion (ROM); 6) patients willing to exchange decreased pain and increased external rotator strength for some loss of active abduction; and (7) patients able and willing to cooperate with the postoperative care.[89] However, many of these guidelines were arbitrarily chosen

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based on limited evidence. Since 1975 many factors have been found to correlate with outcome after treatment, including demographic factors, physical examination findings, imaging results and intra-operative details.[1,2,4,5,8,9,11,12,15–23,25–34,36,38–42,45–53,56–62,64–69,71,73,74,78–83,85–95,97,98,101–104,106–112]

It is also unknown what constitutes appropriate nonoperative treatment. Nonoperative treatment of rotator cuff disease has included NSAIDs, physical therapy, subacromial corticosteroid injections, and various modalities including ultrasound, heat, ice, electrical stimulation, or a combination thereof. The rate of successful nonoperative treatment varies from less than 50% to greater than 90%.[1,5,8,28,40,47,89,104] Studies on nonoperative treatment for symptomatic full-thickness tears have used various therapeutic regimens and widely differing evaluation tools.[1,5,40,47,104] There is no consensus on the indications for nonoperative treatment or on the optimal duration of a nonoperative treatment trial.[1,5,8,28,31,33,36,40,44,47,62,89,95,104,105,110] Expert opinion on the optimal duration of nonoperative therapy varies, and there is no consensus on what constitutes failure of nonoperative therapy.[1,5,8,28,31,33,36,40,44,47,62,89,95,104,105,110] Trials of nonoperative management are common despite evidence demonstrating potentially irreversible changes that occur within the rotator cuff muscles after a tear. These changes are two-fold and include fatty infiltration or degeneration of the muscles and muscle atrophy.[18,25,29,93] In basic science sheep models, fatty infiltration and atrophy progress steadily over the first 16 weeks following tendon detachment.[10,26] Animal studies and human followup studies suggest some of these changes are irreversible.[25,29,60,97]

We performed a systematic review of the best available evidence to explore the multitude of factors that influence the indication for surgical repair of symptomatic, full-thickness rotator cuff tears.[1,3,12,14,16,33,62,74,78] The specific questions addressed in this systematic review are: (1) How do demographic variables influence the outcome of rotator cuff tears, operative and non-operative; and should any demographic criteria be used when indicating patients for surgery? (2) How does acuity (or chronicity) of rotator cuff tear or timing of surgery affect treatment outcome? (3) How do physical examination findings affect treatment outcome, and subsequently indications for surgery? (4) How do radiographic and intraoperative findings affect treatment outcome and indications for surgery? Our ultimate goal is to identify any prognostic factors that may predict outcome and could subsequently be helpful in making future treatment decisions. For example, who should initially undergo nonoperative treatment, and who should be offered surgery early in their presentation? When should these patients undergoing nonoperative treatment be converted to surgical management?

MATERIALS AND METHODS

The literature search strategy consisted of retrieving articles as listed in Medline, EMBASE, CINAHL, and Cochrane Central Register of Controlled Trials from inception to August 2005 using various combinations of subject headings and keywords. Subject headings used in the literature search included rotator cuff and treatment outcome. Keywords used in the search strategy were the following: rotator cuff, rotator cuff tear, full-thickness rotator cuff tear, rotator cuff repair, surgical indication, operative indication, indication for surgery, outcome, and treatment outcome.

When using the keyword "rotator cuff repair," Medline yielded 289 articles, EMBASE 295, CINAHL 66, and Cochrane Controlled Trials Register 18. The keyword "full-thickness rotator cuff tear" resulted in 54 articles in Medline, 42 in EMBASE, 10 in CINAHL, 2 in Cochrane Register. When "rotator cuff" was used as both a subject heading and keyword, and combined with the keywords "surgical indication," "operative indication," or "indication surgery," Medline resulted in 6 articles, EMBASE 1, CINAHL 0, and Cochrane 0. Medline yielded 627 articles, EMBASE 552, CINAHL 82, and Cochrane 46 when using the subject heading "rotator cuff" or keyword "rotator cuff" in combination with the subject heading "treatment outcome" or keywords "outcome." Using keywords "full-thickness rotator cuff tear" in combination with the subject heading "treatment outcome" or keyword "outcome," Medline resulted in 14 articles, EMBASE 15, CINAHL 4, and Cochrane 1. As expected, there were many articles which had multiple listings.

In addition to the search strategy outlined above, references of retrieved articles and of relevant overview articles were reviewed to identify additional studies. Study selection for inclusion in the systematic review was determined by examining the title, keywords, and abstract of all articles obtained from the literature search. Studies were included if they met the following inclusion criteria: (1) study limited to full-thickness rotator cuff tears; (2) discussed indications for surgery; (3) contained clinical outcome data following either nonoperative treatment or operative intervention; and (4) outcome data limited to humans. Articles were excluded if the study was limited to the discussion of radiographic criteria for or diagnosis of rotator cuff tear, comparison of surgical techniques or implants, animal studies, or histologic analysis without clinical outcome data. Also excluded were studies limited to either partial thickness or massive rotator cuff tears, and subacromial impingement without rotator cuff tear. Articles written in a language other than English were not necessarily excluded.

One individual performed the literature search (LSO), and three of the authors independently reviewed the results and selected the appropriate studies (LSO, BRW, MPH). Initial screening based on the title, abstract, and keywords yielded 136 references eligible for inclusion in the systematic review (LSO, MPH). The full papers of these eligible publications were then

thoroughly evaluated (LSO, BRW, MPH). Applying the selection criteria resulted in a total of 50 studies, which were selected for this review.

RESULTS

Three demographic variables that may influence outcome after either nonoperative or operative treatment of rotator cuff tears were selected for this systematic review: (1) age; (2) gender; and (3) pending worker's compensation claims.

Age

Older chronological age should not be considered a contraindication for operative repair, since these patients demonstrate improved postoperative pain relief and function.[39,78] Although older patients may have slightly worse tendon quality and outcomes, surgical outcomes are not necessarily poor.[7,27,39,78,86,92,109] Some reports suggest older age leads to less functional and emotional disability in patients indicated for surgical intervention for cuff related pathology, despite an increase in the prevalence of major rotator cuff pathology.[84]

Although larger tears and poor results were more frequent in the older population, one study reported excellent to good results (UCLA score) were nevertheless achieved in 78% of patients older than 70 years.[78] For patients in this age group, a rather gratifying subjective outcome may be achieved in addition to a small improvement in pain and ROM.[78]

Another study that investigated patient age as a demographic variable affecting outcome after operative repair evaluated 35 patients less than age 65 and 53 patients age 65 or older.[39] Outcome was graded as excellent in patients with no or mild discomfort, active abduction of at least 145 degrees and active external rotation of at least 55 degrees. A satisfactory result consisted of occasional discomfort, active abduction of at least 100° and external rotation of at least 30°. All other patients were considered to have an unsatisfactory result. In the younger patient group, excellent results were found in 89%, satisfactory in 9% and unsatisfactory in 3% of patients. In contrast, excellent results were seen in 77%, satisfactory in 13% and unsatisfactory in 9% of patients in the older patient group.

No strict chronological age cutoff seems appropriate given the diverse population and varied activity levels among the patients as they get older. Each patient should be evaluated independently to assess activity level, vocational use of the shoulder, and independent performance of activities of daily living.[6] It must be recognized there often is a distinct difference between chronological age and physiological age. Unfortunately, a measure of physiologic age does not currently exist for guidance.

Gender

Two studies suggest female gender is a negative prognostic factor (Table 1).[9,86] In a retrospective review of 72 patients with full thickness rotator cuff tears who were treated with an open repair and had subsequent followup of at least 2 years, various subjective and objective factors that could influence the final result were evaluated.[86] Three shoulder evaluation tools were used to assess the results: UCLA scoring scale, Simple Shoulder Test and Constant Score.[55] Similar to other published studies, patient satisfaction was high and pain relief was substantial.[4,9,16,17,19,22,25,34,38,65,86] An average of 54 months after open rotator cuff repair and acromioplasty, 94% of patients were satisfied with the outcome of their surgery. In addition, 96% of patients reported improvement in pain: 74% reported complete pain relief, and 22% reported slight pain without restriction of activities. Women had a negative relationship between age (> 65 years in this series) and shoulder scoring scales, meaning women tended to have worse outcomes after age 65 years.[86] For men, age at the time of surgery was not related to any outcome variables. A limitation of this study is that this retrospective review represents Level IV evidence.

One study[39] reported no differences in outcomes between men and women. Female gender was a negative predictor for postoperative pain relief, active motion and subjective result rating in a series of 105 rotator cuff re-

TABLE 1. Studies Evaluating Differences in Clinical Outcome Between Men and Women

Authors	Sample Size	Followup	Findings	Level of Evidence
Romeo et al[86]	72	Average 54 months	Women had a negative, statistically significant relationship between age and shoulder scoring scales, but age at the time of surgery was not related to any outcome variables for men. An associated biceps tear in female patients is a poor prognostic factor	IV
Cofield et al[9]	105	Average 13.4 years	Men had less postoperative pain and greater postoperative abduction than women	IV

pairs consisting of 72 men and 33 women.[25] Men and women were found to have the same results following rotator cuff repair in a series of 88 cuff repairs.[39]

Workers' Compensation

Patients who have pending workers' compensation claims tend to have a lower patient satisfaction rating with regard to nonoperative treatment for rotator cuff pathology.[40] The best available evidence is a retrospective cohort study that evaluated 33 patients with full-thickness rotator cuff tears categorized into two groups after a supervised nonoperative program of rotator cuff strengthening exercises: Group I, patients who were satisfied with their nonoperative care; and Group II, those who were not satisfied.[40] Average patient followup was 3.8 years (range, 2.6–4.6 years). With regard to insurance claims, a higher proportion (5 of 14) of individuals in Group II were receiving disability benefits compared to Group I (2 of 19).[40]

In a study that evaluated patients with workers' compensation claims who had surgery, neither preoperative activity level nor the presence of a worker's compensation claim adversely affected the postoperative Constant score.[46] Moreover, all patients who were gainfully employed before surgery returned to the workforce after surgery, although at a lower activity level for some patients.[46]

Nonoperative Treatment

The current literature is limited with regard to delineating indications for nonoperative treatment and comparing outcomes against those patients who had surgery. A retrospective review examined 62 shoulders in 54 patients to identify findings on clinical examination that may correlate with the final result.[47] The study group was selected from 114 patients (124 shoulders) with a full-thickness tear of the rotator cuff. The patients enrolled in the study did not meet criteria for surgery because of age, work demands, or successful initial nonoperative treatment. Thus, investigators did not evaluate all patients with cuff tears, only those who were not candidates for surgery. The authors reported the best results achieved with nonoperative treatment were seen in patients who initially had preserved ROM and strength despite initial pain severity. Given the patient selection method, this finding is not surprising. This study shows the difficulty of performing a prospective, randomized clinical trial to compare nonoperative treatment with surgery without denying proper treatment for certain patients.[47]

Another study evaluated pain, ROM, strength, and function after nonoperative treatment of 53 patients with full-thickness tears of the rotator cuff.[5] Nonoperative treatment included NSAIDs, stretching, strengthening, and occasional steroid injections. There was a substantial improvement in pain relief after a mean followup of 7.6 years. At initial presentation, 51 of 53 patients reported pain while 39 of 53 patients reported little or no continuing discomfort at followup. Patients subjectively reported improved activities of daily living after nonoperative treatment, but no validated outcome measures were used. Thirty four of the 53 patients were available for a followup physical examination. Interestingly, higher subjective patient assessment of activities of daily living correlated with better objective ROM and strength.[5] Another limitation is 40 of the 53 study patients reported a history of shoulder trauma. As such, the findings in this study may not be applicable to those patients with atraumatic rotator cuff tears.

A cohort study of 136 patients with rotator cuff impingement or tears found three factors predictive of nonoperative treatment failure.[1] Tears greater than 1 cm^2, a history of symptoms greater than 1 year, and severe weakness or functional impairment on initial presentation were poor prognostic factors for nonoperative treatment.[1] They reported 13% of patients with severe weakness on initial examination showed a satisfactory end result. Patients who have these poor prognostic factors for nonoperative treatment could be offered early surgical intervention.[1] Limitations of this study include it was not a prospective study, nonoperative treatment modalities and regimen were not randomized, and the quality and efficacy of physical therapy were difficult to control.

One study[4] analyzed the benefit of subacromial injection, a common procedure tried with nonoperative management. This study[4] reported patients who had more than three local steroid injections preoperatively had a higher failure rate after surgery. Among patients with a failed end result, 63% had more than three preoperative local steroid injections. The remaining 37% had fewer than two steroid injections. The authors proposed the frequent local steroid injections may cause additional damage to the degenerated cuff and contribute to the development of arthropathy.[4] However, it is possible in addition to causing damage to the cuff, it may reflect the longer duration of preoperative symptoms in those individuals who received more than three local steroid injections.

Duration of Symptoms

There is disagreement regarding the duration of symptoms and ultimate clinical outcome (Table 2). One large retrospective study reported duration of symptoms greater than 1 year is one of three negative prognostic factors for nonoperative treatment.[1] Therefore, early operative intervention was recommended. Other studies arrived at the same conclusion.[5,23,59] In contrast, another study reported among patients who experienced symptoms for less than 3

TABLE 2. Studies Evaluating the Relationship Between Duration of Symptoms and Clinical Outcome

Authors	Sample Size	Followup	Findings	Level of Evidence
Bartolozzi et al[1]	136	Average 20 months	Symptoms > 1 yr in duration increase the likelihood of an unfavorable outcome with nonoperative treatment.	IV
Boker et al[5]	53	Average 7.6 years	Patients with symptoms < 3 months have a greater outcome with nonoperative treatment	IV
Bjorkenheim et al[4]	78	5–10 years	Duration of preoperative symptoms did not correlate with final clinical outcome	IV

months in duration a substantial percentage reported lasting improvement with nonoperative intervention.[5]

Several studies found no correlation between duration of symptoms and outcome. In a retrospective study of 78 patients who had symptomatic chronic rotator cuff tears in Finland from 1978 to 1983, preoperative symptoms had little predictive value in the final outcome after open repair.[4] However, all patients in this study had a chronic rotator cuff condition and had been previously treated with physical therapy, local steroid injections, manipulation, or a combination of these methods. Hence, there were likely few patients with a short duration of preoperative symptoms in this series.

Given the disparity in the literature regarding the correlation between duration of symptoms and outcome, it is possible any detected correlation may have been attributable to a factor associated with duration of symptoms, such as progressing size of a tear or increased difficulty of repair of tendons that have retracted or become infiltrated with fat over time. Many of the variables evaluated in these studies, such as duration of pain, preoperative strength, ROM, and acromiohumeral distance, were more useful in predicting the degree of difficulty of repair rather than outcome.[1,18,23,59] Clinical outcomes after repair may not necessarily have been related to these preoperative variables *per se*, but rather to whether or not a secure repair could be accomplished.[18]

Further complicating this issue is duration of symptoms does not necessarily reflect the duration a patient has had a rotator cuff tear. As noted in the introduction, not all rotator cuff tears are symptomatic. It is not understood why full-thickness tears become symptomatic in some individuals and not others. Progression of rotator cuff tear size and development of symptoms was studied in 58 patients with unilateral symptoms who also had rotator cuff tears detected by ultrasound on the contralateral asymptomatic shoulder.[110] For followup, 45 of these 58 eligible patients were successfully contacted. Twenty-three of the 45 had a repeat sonogram and returned for a followup examination. Of these 23 patients, nine had progression of tear size, which was defined in this study as an increase greater than 5 mm. Of the 45 patients included in the study, 51% reported new onset of pain at followup. In addition to the onset of symptoms, these patients also had a loss of active elevation. Although useful information can be gleaned from this study, careful evaluation reveals the results were derived from a specific subset of patients and may not be applicable to the general population since the subjects all had a symptomatic contralateral shoulder. Therefore, the patients may have had an intrinsic weakness of the rotator cuff that caused bilateral rotator cuff tears, which may have predisposed these patients to progression of the tear and development of symptoms.[110]

Timing of Surgery

Determining the acuity of a rotator cuff tear is difficult. Patients occasionally have an acute traumatic full thickness tear, immediate pain and weakness, with no prior history of shoulder symptoms. These injuries account for less than 10% of all rotator cuff tears and are usually sustained after a fall or shoulder dislocation.[2] Prompt surgical treatment in this setting is recommended.[2] A retrospective review of rotator cuff repairs performed within 12 weeks of acute injury was done.[2] This included only 43 patients out of 510 who underwent rotator cuff surgery during this time, reflecting both the relatively uncommon scenario of acute injury and the bias toward initial nonoperative management. Of the 43 patients, 37 were evaluated as the study group 1.25 to 21 years after surgery, age range of 19 to 74. All of these patients had moderate or pronounced weakness after injury and prior to surgery. Twelve shoulders were repaired within 3 weeks, six between 3 and 6 weeks after injury and 19 between 6 and 12 weeks. The majority of tears were large (> 5 cm in diameter) for each of the three groups. Those repaired within 3 weeks of injury had substantially better improvement in active abduction motion and total active abduction than those repaired 3 to 6 or 6 to 12 weeks after injury.[2] Better external rotation and abduction strength were seen in cuff tears repaired within 6 weeks compared to those repaired after six weeks, although statistical significance was not achieved. Additionally, a trend toward improved strength was seen for the small and medium size tears as compared to large tears.[2]

In contrast, a retrospective Level IV study evaluated 74 patients who underwent rotator cuff repair.[108] Possible factors affecting outcome, including the timing of surgery, were compared. Results showed 70% of patients who had repair within 100 days of exacerbating injury had good to excellent results, compared with 68% of patients who had repair after 100 days.[108] These results suggest timing of repair may not be important if a secure repair is performed. However, this retrospective study was performed more than 30 years ago and possibly did not accurately classify acute traumatic full-thickness tears.

Many patients may not see an orthopaedic surgeon for months after onset of pain.[78] A retrospective study was completed with prospectively collected data on 58 complete rotator cuff tears in 54 patients treated using an open technique by one surgeon in patients with an average age older than 60 with chronic, symptomatic, full-thickness rotator cuff tears.[78] All patients were evaluated at 3, 6, and 12 weeks, 6 months, and 1 year after surgery. The study evaluated several preoperative and intraoperative factors that influenced postoperative outcome. One of the prognostic factors evaluated was time to surgery. Of note, each patient received a minimum of 3 months of isolated or combined nonoperative treatment modalities including physical therapy, NSAIDs, steroid injection, and avoidance of pain-inducing activities. Using a 3-month period as a timetable, the authors considered nonoperative treatment to have failed in this patient population.[78] No patient had surgery within the first 3 months, and more than 50% of patients in this study had surgery more than 6 months after initial symptoms. The authors found no correlation between time to surgery and final outcome. It seems satisfactory results can be obtained with delayed repair (Table 3).[78] Although the standardized assessment criteria and followup are noted, a limitation of this study was the lack of a control group.

The timing of surgery seems to be based largely on practice preferences of experienced surgeons in the field because sound evidence-based data for guiding treatment are limited.[16] The early reports on the management of rotator cuff disease were unclear regarding the recommended timing of surgery. Post and Cohen recommended surgery after nonoperative treatment failed "over an extended period of time."[81] Neviaser and Neviaser proposed surgery is indicated "after several months."[72] Kessel and Watson recommended operative intervention if symptoms persisted "after two or three [corticosteroid] injections."[49] Hawkins and Abrams considered surgery if symptoms persisted for 1 year despite nonoperative treatment.[41] Neer believed rotator cuff tears should be repaired only if symptoms persist for 18 months with nonoperative treatment.[67] Some authors recommend surgery if there is no improvement in symptoms in 6 weeks, whereas others recommend waiting 18 months before considering surgical repair.[23,36] On the other hand, Itoi and Tabata[47] as well as Bokor et al[5] concluded symptoms lasting longer than 12 months and 6 months, respectively, were poor prognostic indicators, suggesting perhaps surgery should be considered earlier.

For most symptomatic full-thickness rotator cuff tears, it is recommended all patients, regardless of age, should begin a trial of nonoperative therapy before considering surgical repair.[5,23,36,41,49,67,72,78,81] Should there be exemptions to this recommendation? Should younger patients with severe weakness have immediate surgical repair? Should older, less active patients with acute traumatic full-thickness tears who were asymptomatic prior to the injury be treated nonoperatively? Unfortunately, no comparative evidence is available to help answer these questions.

Range of Motion

Decreased active ROM preoperatively also has been associated with poor outcome after operative treatment of rotator cuff tear (Table 4).[9,18,19,78] In a patient with a symptomatic rotator cuff tear who presents with decreased shoulder ROM, it is important to evaluate the patient for adhesive capsulitis. For patients with adhesive capsulitis and concomitant rotator cuff pathology, repair of the torn rotator cuff will not improve the loss of shoulder motion; therefore, adhesive capsulitis should be addressed first.[37,99,100]

Preoperative shoulder ROM has been associated with postoperative shoulder motion and ultimate outcome.[18,19,78] In a retrospective cohort study, active forward flexion, abduction, internal rotation, and external ro-

TABLE 3. Studies Evaluating the Relationship Between Timing of Surgery and Clinical Outcome

Authors	Sample Size	Followup	Findings	Level of Evidence
Wolfgang[108]	74	6 months	Good to excellent results in 70% with repair within 100 days of injury vs. 68% with repair after 100 days.	IV
Bassett and Cofield[2]	43	Average 7 years	Repair within 3 weeks of acute injury had greater abduction ROM compared to those repaired after 3 weeks	IV
Pai and Lawson[78]	58	Average 34 months	No correlation of timing of surgery to clinical outcome	IV

TABLE 4. Studies Evaluating the Relationship Between Preoperative Shoulder Range of Motion and Clinical Outcome

Authors	Sample Size	Followup	Findings	Level of Evidence
Ellman et al[18]	50	Average 3.5 years	Preoperative active abduction < 100 deg has 9 times greater risk of worse clinical outcome	IV
Cofield et al[9]	105	Average 13.4 years	Less preoperative ROM is correlated with greater tear size and less postoperative ROM	IV
Pai and Lawson[78]	58	Average 34 months	Preoperative active abduction < 90 associated with worse clinical outcome	IV
Feng et al[19]	1067	Average 7.9 years	Preoperative active abduction > 90 with positive statistical correlation with postoperative outcome	IV

tation were measured.[18] Patients with poor preoperative active abduction were more likely to have an unsatisfactory result after operative treatment of rotator cuff tear. Specifically, patients whose preoperative abduction was less than 100° had a 9 times greater risk of having an unsatisfactory result compared with patients whose preoperative abduction was greater than 100°.[18]

Similar findings were also reported in an analysis of prospectively collected data with a difference in outcome between patients whose preoperative abduction was less than 90° compared with those who had greater than 90° of abduction preoperatively.[78]

Strength

Just as preoperative shoulder ROM is associated with postoperative shoulder motion, preoperative shoulder strength is also predictive of strength and clinical outcome after operative treatment of rotator cuff tear (Table 5).[1,9,18] Weakness with forward flexion and external rotation has been well documented as a predictor of poor outcome.[1,19] In a retrospective cohort study, 68 of 92 patients (74%) who demonstrated no preoperative weakness obtained an excellent or good result after surgery.[1] Among patients with mild weakness, 17 of 24 patients (73%) obtained excellent or good results. Substantially fewer patients with moderate or severe weakness had excellent or good results (four of 12 patients [33%] with moderate and one of eight patients [13%] with severe weakness).

A retrospective cohort study concluded the preoperative strength of abduction and external rotation is a valuable prognostic factor.[18] Specifically, patients with manual muscle strength rating of 3 or less ultimately had the worst results after surgical repair because of the association with tears that were difficult to repair. Loss of strength is not only associated with tears that are difficult to repair, but is also associated with a larger tear size, both of which are associated with worse outcomes after surgery.[1,9,18] One study concluded tear size is the most critical factor in determining the outcome of operative repair; therefore, if preoperative weakness provides insight into tear size then it is also useful in predicting clinical outcome.[9]

Functional outcomes after rotator cuff surgery have been shown to remain stable up to ten years after surgery.[22] Improved Constant scores persisted in a cohort of 33 patients evaluated at 2 years and then at 10 years after surgery. Activity level had diminished for this group, however, the level of disability also decreased with time after surgery.[22]

Size of Tear

We found general agreement tear size predicts long-term results (Table 6). Good outcomes were seen in 95% of

TABLE 5. Studies Evaluating the Relationship Between Preoperative Shoulder Strength and Clinical Outcome

Authors	Sample Size	Followup	Findings	Level of Evidence
Bartolozzi et al[1]	136	Average 20 months	33% (4/12) of patients with moderate preoperative weakness and 13% (1/8) of patients with severe preoperative weakness had excellent or good outcomes	IV
Ellman et al[18]	50	Average 3.5 years	Strength grading less than 3 had poorest clinical results	IV
Cofield et al[9]	105	Average 13.4 years	Less preoperative strength is associated with greater tear size and less postoperative strength	IV
Galatz et al[22]	33	10 years	The subjective results of open rotator cuff repair is the same or better at 10 years compared to 2 years postoperatively	IV

small, 94% of medium, 88% of large, and 84% of massive tears in one study.[80] An additional study reported similar outcomes in their comparison of small and large tears.[82] It is widely reported massive tears have worse outcomes after surgical repair.[13,15,21,24,25,32,35,48,63,70,71,75–77,85] One study suggested these tears have worse outcomes because they have a higher rate of rerupture.[38]

Another study collected data prospectively from 1975 to 1983 on patients who underwent surgical repair of chronic rotator cuff tears performed by one surgeon.[9] A combination of patient questionnaires and followup clinical examination were used to determine clinical results at a mean of 13.4 years (range, 2–22 years). In this series, tear size was the most important determinant of outcome in terms of postoperative active ROM, strength, patient satisfaction, clinician rating of the result, and need for reoperation.[9] Other variables found to portend a worse outcome, such as older age, less preoperative active motion, preoperative weakness, distal clavicular excision, and biceps transposition, were associated with a larger tear size.[9] In this study, 94% and 85% of patients in the small (< 1 cm) and medium (1–3 cm) tear groups, respectively, rated the status of their shoulder after surgery as either excellent or satisfactory. In contrast, results were excellent or satisfactory in 74% of patients in the large (3–5 cm) tear group, and in 27% of patients in the massive (> 5 cm) tear group.

Two additional retrospective case series also concluded the size of the tear was predictive of functional outcome.[4,47] In addition, pathologic changes of the long head of the biceps tendon were correlated with the size of the rotator cuff tear. A large series of tears treated nonoperatively correlated larger tear size with worse outcome.[47]

Relatively few studies have analyzed healing rates of the rotator cuff after surgery. However, existing data reveals rotator cuff repairs either fail or incompletely heal in a notable percentage of patients.[21,53,111] Re-tear, or failure to heal, for rotator cuff repairs as determined by MRI is 20% to 39%.[53,91,111] For tears > 2 cm, the re-tear rate at 2 years is even higher (41–94%).[21,25,93] Outcomes showed major initial improvement at 12 months despite these results, although there appears to be some deterioration thereafter.[21,22,25,53,91]

Larger tears were found more frequently in patients 65 years of age or older.[27,39,54,90,92,109] In older patients, the quality of the rotator cuff tendon may be poor and healing is likely inferior.[39,56] They are also more likely to have larger tears, greater degrees of retraction and fatty replacement.[27,29,30,90,92] This supports the predominating practice of earlier repair in younger individuals before tear progression, tendon retraction, and fatty replacement occur.[29,30,39]

In summary, there is Level III and IV evidence that larger size of tear is associated with worse results after nonoperative management and after surgical repair.[9,15,21,32,39,47,48,71,80,82,85,86]

DISCUSSION

Better evidence is needed to help guide rotator cuff tear treatment given the prevalence of the problem. Clinical decision-making for the treatment of rotator cuff tears is not straightforward or consistent across the orthopaedic surgery community.[16] No Level I or II studies have been performed regarding treatment recommendations. Lack of any prospective, randomized clinical trials offering Level I evidence contributes to difficulty in making clinical recommendations. Almost all evidence guiding current treatment is Level III at best. However, orthopaedic surgeons in the United States regularly prescribe physical therapy and nonsteroidal anti-inflammatory drugs (NSAIDs), administer subacromial corticosteroid injections, and perform surgical repair of rotator cuff tears.[16] Unfortunately, the treatment decision for symptomatic full-thickness cuff tears seems largely based on the physicians' personal

TABLE 6. Studies Evaluating the Relationship Between Size of Tear and Clinical Outcome

Authors	Sample Size	Followup	Findings	Level of Evidence
Postacchini et al[82]	73	Average 2.3 years	Satisfactory results decreased from Grade I and II tears (88% and 89% respectively) to Grade III tears (56%)	IV
Harryman et al[38]	105	Average 5 years	More than 50% of repairs involving more than the supraspinatous tendon had a recurrent defect	IV
Cofield et al[9]	105	Average 13.4 years	Tear size is the most important determinant of outcome for ROM, strength, patient satisfaction, clinician rating, and need for reoperation	IV
Bjorkenheim et al[4]	78	5–10 years	Size of tear is predictable of functional outcome	IV
Itoi and Tabata[47]	62	Average 3.4 years	Larger tear size correlated with worse outcomes of nonoperative treatment	IV
Romeo et al[86]	72	24–102 months	53% had unsatisfactory outcome tear size greater than 5 cm^2.	IV
Hattrup[39]	88	Average 1.6 years	Excellent results decreased from 89.2% in small or medium tears to 80.4% in large or massive tears.	IV

experience and Level III and IV evidence, as high quality data for guiding treatment is limited.[16]

Further complicating matters is the multitude of variables potentially influencing treatment decisions and ultimate outcome. The relative dearth of Level I evidence in the orthopaedic surgery literature on treatment of rotator cuff tears reflects this complexity and variability associated with different clinical presentations, available treatment options and surgical techniques. For many of the variables reviewed above, a randomized controlled trial may not be feasible or ethical. Hence, a systematic review of the evidence is helpful.[3] In addition, this systematic review limited its discussion only to full thickness tears. The treatment options for the remainder of rotator cuff disease, including partial tears and subacromial bursitis/impingement is equally complex. A further limitation in the literature we reviewed is a lack of real understanding of the natural history of rotator cuff disease. It has been suggested one of the reasons explaining the lack of data on the natural history of untreated rotator cuff tears may be the increasing tendency to surgically repair the cuff after it becomes symptomatic.[110] An article by Yamaguchi et al[110] prospectively evaluated progression of rotator cuff tear size and development of symptoms in patients with initially asymptomatic rotator cuff tears. This article is commonly cited as the best study currently available describing the natural history of rotator cuff tears. It is, in fact, the first longitudinal investigation on the development of symptoms in patients with asymptomatic rotator cuff tears.[110] However, it does not offer definitive Level I evidence. Despite these limitations, useful information may still be gleaned from these studies.

An additional limitation of this review involves the growing number of radiographic variables potentially influencing the treatment of rotator cuff disease.[18,20,25,27,29,30,53,90,93,109,111,112] This includes acromiohumeral distance and acromial morphology analyzed on plain radiographs.[18,23,25,27,29,93,109] Advanced imaging such as MRI and CT arthrogram can further delineate rotator cuff atrophy, fatty infiltration and tear retraction.[18,25,29,30,53,90,93,111,112] These factors often give insight to chronicity of the pathology and have been found to be predictive of repair success.[18,25,29,93]

Based on studies investigating the results of nonoperative treatment, it seems safe and reasonable to start nearly every patient with symptomatic, full-thickness rotator cuff tears on a nonoperative treatment consisting of physical therapy and antiinflammatory medication for at least 6 weeks to 3 months, assuming adhesive capsulitis has been ruled out as a concomitant condition.[1,4,5,12,17,28,31,33,40,44,47,62,104,105] The exception to this would be a patient with a previously asymptomatic shoulder who sustains trauma with resultant weakness (after the pain from the injury subsides) for whom imaging studies indicate an acute full-thickness tear. The optimal duration for a nonoperative treatment trial has not been clearly delineated. However, our review suggests nonoperative treatment is often successful in patients with symptom duration less than 3 months, and who subsequently improve with nonoperative means. Our review also suggests nonoperative management often fails when duration of symptoms extends beyond one year.[1,4,5,47] It is unclear what constitutes appropriate nonoperative treatment. Evidence is limited in relation to medication and physical therapy usage. Level IV evidence would suggest possible detrimental effects of multiple subacromial steroid injections in the setting of a symptomatic full thickness tear.

Operative intervention seems appropriate if a patient fails nonoperative therapy. Several studies have evaluated poor prognostic factors for nonoperative treatment.[1,40] Variables associated with poor prognosis following nonoperative treatment include larger full thickness tear size, symptom duration greater than one year, and patient functional weakness or disability.[1,40]

The evidence is unclear regarding the influence of demographic variables on rotator cuff tear treatment. Previous studies are mixed regarding the importance of age and gender on outcome. Given the available literature, age and gender should not heavily impact treatment decision-making. A better evaluation of chronologic versus physiologic age is needed. A history of workers' compensation has been reviewed in relatively few series but does seem to negatively impact treatment results.

Limited evidence is available for treatment of acute rotator cuff tears. Delineating an acute tear versus an acute or chronic exacerbation is possible with advanced imaging assessment of fatty infiltration, edema associated with acute injury, and rotator cuff atrophy. Our review suggests early surgical management in the setting of a traumatic acute tear may improve outcome.

Our review of physical examination findings suggests weakness portends a worse outcome with nonoperative management in symptomatic tears. This suggests earlier surgical intervention may be needed in the setting of weakness and substantial functional disability.

Treatment for rotator cuff tears is currently guided by limited evidence. Future studies could improve guidelines for treatment. Better studies are needed to determine optimal nonoperative measures for treatment. This includes prospective evaluation of the use of a standardized physical therapy program. Additionally, NSAIDS are commonly prescribed for this problem. Studies are needed to assess the efficacy of these medications on rotator cuff tears. The use of corticosteroid injections in rotator cuff tears is common but unproven. A randomized trial on the usage of injection is needed. In addition to a patient's age,

his or her activity level should be another major consideration before proceeding to operative repair. Very active individuals are more likely to require surgery to achieve their previous strength and motion. Recently, a rating scale to evaluate patient activity level has been developed.[6] For future studies, it would be helpful to evaluate a patient's activity level as a demographic variable that may alter treatment outcome in addition to age or vocation.[6] Lastly, more prospective multiple surgeon studies are needed to more closely evaluate the impact of the variables reviewed above. Only with large numbers of patients can factors that truly impact outcome be elucidated.

Clinical decision making in the treatment of symptomatic, full-thickness rotator cuff tears is complex. Level I and II evidence is lacking regarding surgical indications for operative repair. However, a review of the existing Level III and IV evidence in the available literature offers some guidelines for surgical decision making. Further research is required to define the indications for surgery for full thickness rotator cuff tears. However, the design and conduct of an ethical study to obtain Level I evidence on this issue will be a major challenge.

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