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Systematic Review of Arthroscopic Rotator Cuff Repair and Mini-Open Rotator Cuff Repair

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Introduction

Rotator cuff repair is one of the most common surgical procedures performed in the shoulder, and the benefit of repair is well known[1-5]. Over the past decade, the treatment of rotator cuff tears has evolved from an open procedure to an arthroscopic-assisted (mini-open) technique to an all-arthroscopic technique. Traditional open rotator cuff repairs produce satisfactory results when used for the treatment of nonmassive tears (<5 cm). However, this procedure has been associated with morbidity such as severe early postoperative pain, deltoid detachment and/or weakness, and arthrofibrosis[6-8]. Mini-open repairs were developed because they had the potential advantage of less deltoid morbidity, and they have demonstrated results that have been similar to those of open repairs (Figs. 1-A through 1-D)[9-14]. With recent advances in arthroscopic techniques, many surgeons are now performing complete arthroscopic repairs. The potential advantages of this procedure include less pain, more rapid rehabilitation, the ability to treat intra-articular lesions, smaller skin incisions, less soft-tissue dissection, and an extremely low risk of deltoid detachment (Figs. 2-A through 2-E). In the short and long term, the arthroscopic approach has shown promising results[3,7,15-27]. Despite these advantages, the use of the complete arthroscopic repair is technically demanding and requires a large-volume practice in order for a surgeon to obtain proficiency in this procedure[28]. Because of the technical demands of this procedure, many orthopaedic surgeons still consider the mini-open repair to be the gold standard for rotator cuff repair[29]. We hypothesized that arthroscopic rotator cuff repair produces clinical results comparable with those of mini-open rotator cuff repair, with fewer complications.

In order to compare the mini-open and all-arthroscopic techniques, we performed a qualitative systematic review with use of a defined methodology to collect the most relevant information to answer a specific clinical question. This analysis included published literature on mini-open and all-arthroscopic techniques in patients with full-thickness rotator cuff tears with a mean duration of twenty-four months of follow-up. The purpose of the present study was to compare the clinical outcomes of mini-open and all-arthroscopic techniques of rotator cuff repair with use of a systematic review of the published literature.

Materials and Methods

Prior to conducting a literature search, we established the study design and specific objectives. The objectives were (1) to compare the clinical results of arthroscopic and mini-open rotator cuff repairs with use of shoulder outcome scales, (2) to compare the postoperative ranges of motion, and (3) to compare the complication rates for each procedure. The inclusion criteria were the performance of rotator cuff repair with use of arthroscopic and mini-open techniques involving tendon-to-bone fixation (i.e., transosseous tunnels or suture anchors) with a mean duration of follow-up of twenty-four months. Studies of rotator cuff repair involving direct tendon repair, margin convergence, or interposed allograft did not meet the inclusion criteria. Studies were excluded if they involved partial repairs or revision repairs or if >50% of the rotator cuff tears were massive (>5 cm) or involved multiple tendons. Studies that did not provide information on the size or tendon involvement were also excluded. Studies that compared two techniques were only included if technique-specific data could be extracted for the analysis. Demographic information, rotator cuff tear characteristics, operative technical details, objective and subjective outcome measurements, and complications were gleaned from the studies.

Literature Search

We searched Medline, CINAHL, and the Cochrane Central Register of Controlled Trials for all literature published from January 1966 to November 2005 using the keywords *shoulder, rotator cuff, rotator cuff tear, rotator cuff repair, arthroscopic, arthroscopic-assisted, mini-open, treatment outcome,* and *outcome.* General search terms were chosen to prevent the possibil-

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Fig. 1-A

Figs. 1-A through 1-D Mini-open rotator cuff repair. **Fig. 1-A** The skin incision and arthroscopic portals are marked. Arthroscopic glenohumeral joint inspection, débridement of torn tendon edges, greater tuberosity preparation, and subacromial decompression are performed.

Fig. 1-B

Subcutaneous tissue is divided in line with the skin incision to the level of the deltoid fascia, and the deltoid muscle is split in line with its fibers.

ity of missing studies. Studies that were only presented as abstracts were not included in the final analysis[30]. To ensure that all possible articles were considered, the references of all relevant articles and review articles were manually cross-referenced.

Data Abstraction

The data were abstracted from each of the studies that met the inclusion criteria by two independent reviewers (S.J.N. and M.K.S.). The demographic data that were collected included

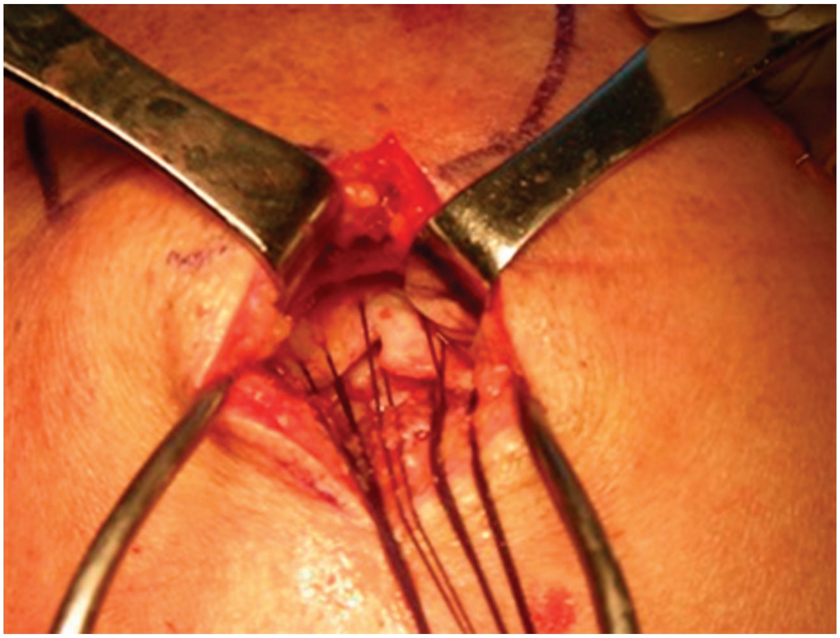

Fig. 1-C
The rotator cuff tear is exposed under direct visualization by rotation of the humeral head. The tear is fixed with either suture anchors or sutures placed through transosseous tunnels.

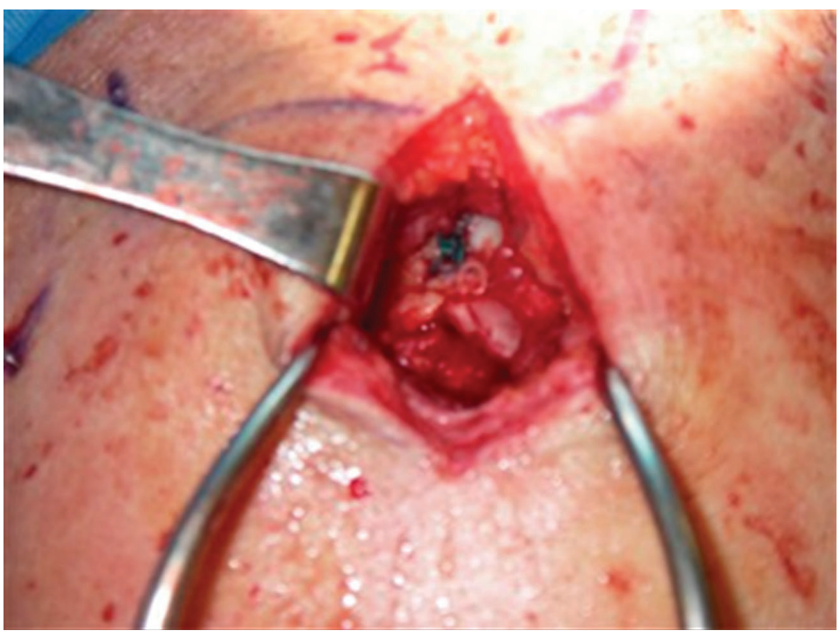

Fig. 1-D
After repair of the tear in the supraspinatus tendon, the deltoid and the subcutaneous layers are reapproximated.

the type of study; the level of evidence; the number of patients enrolled; the number of patients at the time of the latest follow-up; the age, gender, and dominant extremity of the patients; the duration of follow-up; and the duration of symptoms. The characteristics of the rotator cuff tear, including size, width, length, and area, were also collected. Studies that did not describe rotator cuff tears according to size were only included if they provided the number of tendons involved.

Fig. 2-A
Figs. 2-A through 2-E Arthroscopic rotator cuff repair. **Fig. 2-A** With the patient in the beach-chair or lateral decubitus position, the skin is marked for arthroscopic portal placement.

Intraoperative data were recorded, including the surgical technique, tendon-to-bone fixation, the number of points of fixation, and concomitant procedures. The percentage of satisfied or very satisfied patients for each group was collected. Preoperative and postoperative data included range of motion, strength, clinical outcome scales (Constant-Murley[16], Neer Shoulder Assessment Scale[31], University of California at Los Angeles [UCLA][32], American Shoulder and Elbow Surgeons [ASES][33], Simple Shoulder Test [SST][23], Japanese Orthopaedic Association [JOA][34], Short Form-36 [SF-36][35], and Visual Analog Scale [VAS][36]), and complications were extracted. The complications were subcategorized according to orthopaedic complications (revision, arthrofibrosis, ruptured biceps tendon, infection, hematoma, deltoid avulsion, postoperative impingement syndrome, heterotopic ossification, nerve injury, painful suture, and hypertrophic scar) and medical complications (pneumonia, myocardial infarction, and deep venous thrombosis). Additional relevant information, such as information obtained from postoperative radiographic images, was also included from each study when appropriate. The data are presented in tabular format (see Appendix), and no statistical comparisons were performed as part of the systematic review.

Results

Literature Search

Of the 3445 articles that were identified, 2576 were written in the English language and involved human subjects. The abstracts of these 2576 studies were reviewed to determine the appropriateness to the present study as determined by the inclusion and exclusion parameters. Forty-five articles were appropriate for the analysis. Ten articles were rejected because they had a majority of rotator cuff tears that were massive (>5 cm in size)[6,8,15,19,37-42]. Eleven studies were excluded because the mean duration of follow-up was less than twenty-four months[10,43-52]. Four studies were excluded because they combined more than one method of treatment but the treat-

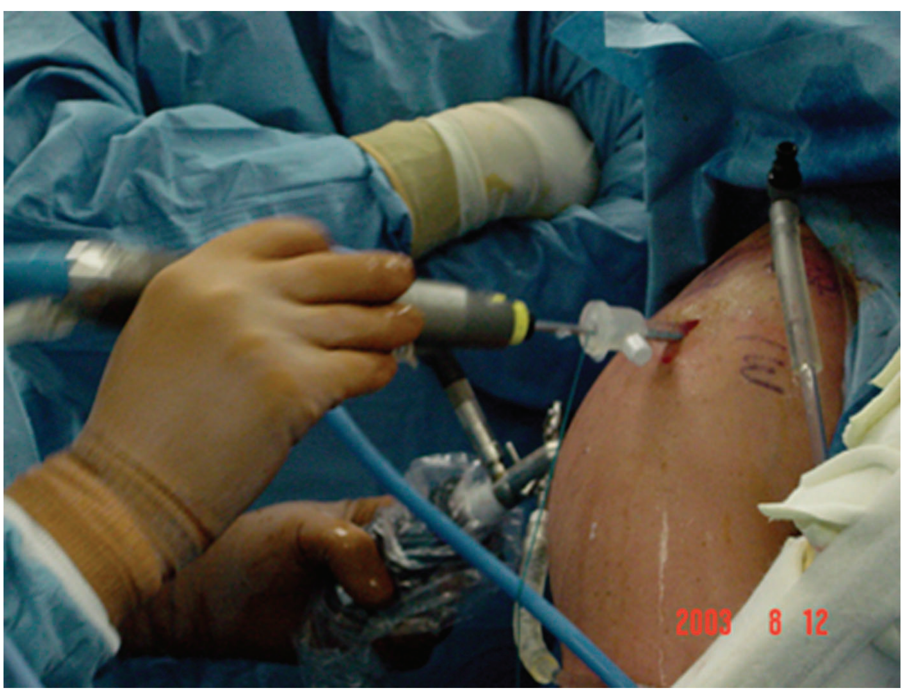

Fig. 2-B
The glenohumeral joint is inspected arthroscopically for associated abnormalities, such as a superior labrum anterior posterior (SLAP) lesion, capsulolabral tear, or biceps tear.

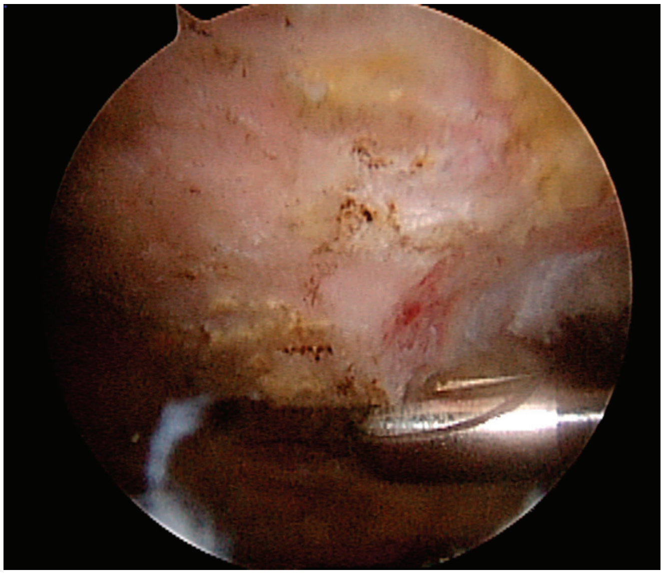

Fig. 2-C
An acromioplasty, bursectomy, and cuff mobilization are performed as indicated.

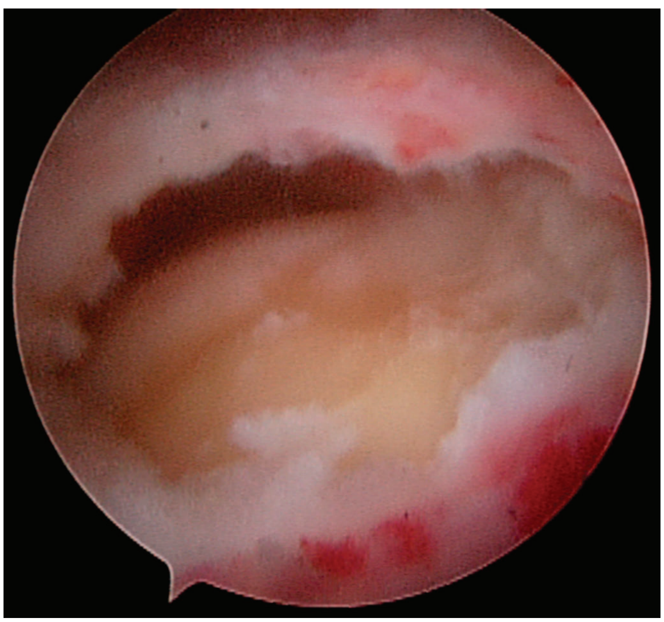

Fig. 2-D
The rotator cuff tear and the osseous insertional footprint are visualized.

ment groups were not extractable[44,53-55]. Two studies were excluded because the size of the tears were not reported[26,56]. The study by Gartsman et al.[21] included the same cohort as another published study[23], and the more recent study[23] was included in the final analysis. Wilson et al.[27] compared arthroscopic rotator cuff repair with staple fixation and suture anchor fixation, but the staple group required arthroscopic removal of the staples; thus, only the suture anchor group was included in the arthroscopic group. Another study compared arthroscopic rotator cuff repair of full-thickness and partial-thickness tears, and only the full-thickness rotator cuff repairs were included in the arthroscopic group[57]. In five studies that compared arthroscopic and mini-open rotator cuff repairs, each treatment group was extractable and therefore each was included in the arthroscopic group or the mini-open group, respectively[34,58-61]. Among the seventeen studies, there was a total of twenty-two cohorts in the final analysis: eleven in the arthroscopic group and eleven in the mini-open group.

Demographic Data

The study design, level of evidence, total number of patients, number of patients at the time of follow-up, and percentage of effective follow-up were included in the analysis (see Appendix). Demographic data, including the percentage of involvement of the dominant extremity, the mean age, the mean duration of follow-up, the percentage of male patients, and the duration of symptoms (in months) was recorded. According to the DeOrio and Cofield[24] classification system for rotator cuff tear size, the treatment groups were defined in terms of the percentage of small tears (<1 cm), medium tears (1 to 3 cm), large tears (>3 to 5 cm), and massive tears (>5 cm). Studies that provided information in terms of tendon involvement were separated into the percentages of single-tendon and multiple-tendon tears.

There were no randomized controlled trials (Level I) or prospective cohort studies (Level II) in either group. Five of the eleven reports in the arthroscopic group were retrospective cohort studies (Level III), and five of the eleven reports in the mini-open group were retrospective cohort studies (Level III). The effective follow-up ranged from 64.9% to 100% in the arthroscopic group and from 60% to 100% in the mini-open group.

The age, percentage of male patients, and percentage of

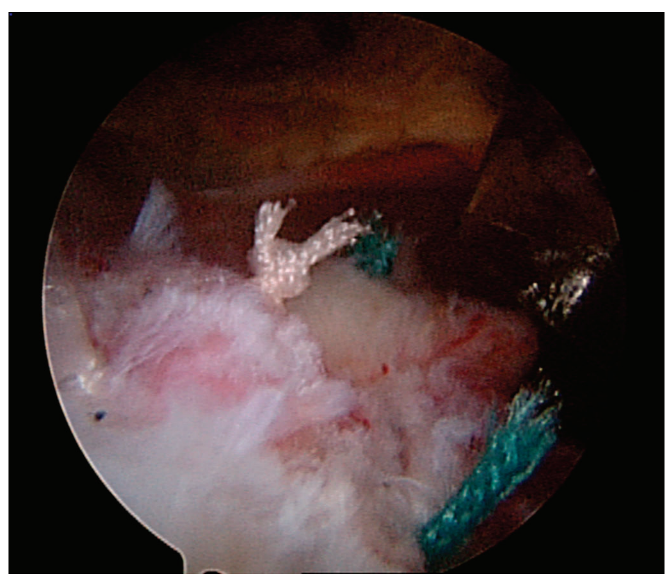

Fig. 2-E
Arthroscopic fixation of a full-thickness supraspinatus tear with suture anchors.

dominant extremity involvement were similar between the two groups. All studies had a mean duration of follow-up of at least twenty-four months. In only one of the eleven arthroscopic studies and five of the eleven mini-open studies was the mean duration of follow-up greater than or equal to forty-eight months. Although studies were excluded if the majority of tears were massive (>5 cm) or if multiple tendons were torn, the percentage of massive tears or multiple-tendon tears differed only slightly between the two groups.

Surgical Technique

All patients in all studies in the arthroscopic group underwent an all-arthroscopic rotator cuff repair with suture anchor fixation (see Appendix). Four of the eleven studies in the mini-open group evaluated repair involving the use of suture anchor fixation, and the others evaluated repair involving the use of sutures placed in transosseous tunnels. Paulos and Kody[12] used suture anchors to augment the transosseous tunnels or used transosseous tunnels alone. In the retrospective cohort study by Kim et al.[58], the surgeon attempted arthroscopic rotator cuff repair for all patients, but, when arthroscopic repair could not be performed, the operation was converted to the mini-open technique. The patients in each group had similar clinical scores.

Subacromial decompression was performed in all patients in nine of the eleven arthroscopic studies and in all eleven mini-open studies. In the remaining two arthroscopic studies, subacromial decompression was performed in 79%[7] and 94%[62] of the cases. Distal clavicle excision was performed in 81%[63] and 89%[27] of the cases in two of the arthroscopic studies, and biceps tenodesis was an adjunctive procedure in 82% of the cases in one study[62].

Rehabilitation Protocol

For the five retrospective cohort studies in each group, the postoperative rehabilitation was the same for the arthroscopic and mini-open groups (see Appendix), and therefore, performance bias is limited for these studies. In the remaining six arthroscopic studies, patients began active shoulder range-of-motion exercises as early as three weeks and as late as nine weeks after surgery, and strengthening was initiated by six weeks after surgery. In the other six mini-open studies, active shoulder range-of-motion exercises were begun at four to six weeks and strengthening was initiated between six and eight weeks or after the sling was removed[12].

Range of Motion (Forward Elevation and External Rotation)

Only four of the eleven arthroscopic studies and five of eleven mini-open studies recorded range of motion as a separate outcome (see Appendix). The mean postoperative forward elevation ranged from 149.0° to 169.6° for the arthroscopic group and from 155.0° to 173.0° for the mini-open group. In the study by Warner et al.[60], the arthroscopic and mini-open cohorts were compared retrospectively and there was no difference between the two groups. The mean postoperative external rotation ranged from 50.0° to 85.7° for the arthroscopic group and from 50.0° to 66.0° for the mini-open group.

Postoperative Shoulder Scores (UCLA, ASES, and Satisfaction)

The UCLA score was the one most commonly used for both the arthroscopic group (eight studies) and the mini-open group (ten studies) (see Appendix). The UCLA shoulder score was also expressed as excellent (34 or 35 points), good (29 to 33 points), fair (25 to 28 points), and poor (≤24 points) in seven arthroscopic studies and eight mini-open studies. Only one of the seven arthroscopic studies had <90% good or excellent results, compared with five of the eight mini-open studies. All studies had a mean postoperative UCLA score of >30.

Seven of the eleven arthroscopic studies and four of the eleven mini-open studies included ASES scores; the mean postoperative scores ranged from 83.0 to 95.0 and 81.0 to 95.0, respectively. Four retrospective cohort studies[34,58,59,61] compared UCLA scores, two retrospective cohort studies[59,61] compared ASES scores, and none of them were able to demonstrate a significant difference between the two groups. The percentage of patients who were either satisfied or very satisfied after rotator cuff repair appeared to be similar, with a range of 90% to 100% in the arthroscopic group and 86% to 100% in the mini-open group.

Complications

There were fourteen complications after 473 procedures (prevalence, 3.0%) in the arthroscopic group and twenty-seven complications after 411 procedures (prevalence, 6.6%) in the mini-open group (see Appendix). Revision rotator cuff repair was reported in three cases in three studies in the arthroscopic group and in six cases in four studies in the mini-open group. Arthrofibrosis was reported in five cases in the arthroscopic group, compared with nine cases in the mini-open group. Postoperative symptoms consistent with impingement occurred in one case in the arthroscopic group and in six cases in the mini-open group. No medical complications were reported in any of the studies.

Discussion

The treatment of rotator cuff pathology has evolved with an improved understanding of rotator cuff anatomy, more sophisticated instrumentation, and advances in surgical technique. The most effective method of surgical repair is controversial given that both arthroscopic and mini-open rotator cuff repairs have been shown to produce satisfactory clinical results. There has been growing interest in arthroscopic rotator cuff repair, and it is believed to be at least as effective as mini-open rotator cuff repair with the added advantages of reduced surgical morbidity, reduced postoperative stiffness, and, potentially, a more rapid return to baseline shoulder function once rotator cuff healing has occurred[29]. The present study is a qualitative description of the clinical results of published articles on arthroscopic and mini-open rotator cuff repairs. On the basis of the observations in the present study, there are no apparent differences between arthroscopic repair and mini-open repair in terms of range of motion or clinical scores after a mean of twenty-four months of follow-up, but there may be a trend toward increased complications associated with mini-open repair.

There appeared to be a higher percentage of complications in the mini-open group, including revision, arthrofibrosis, and postoperative impingement; however, the mini-open studies also tended to have longer follow-up, which might allow for a greater number of complications. In the retrospective cohort studies, there were approximately two times the number of revisions and cases of arthrofibrosis in the mini-open group. Specifically, there were four revisions and six cases of arthrofibrosis in the mini-open group, compared with two revisions and three cases of arthrofibrosis in the arthroscopic group.

Arthroscopic repairs are thought to be better able to reproduce rotator cuff anatomy because the three-dimensional evaluation allows for the recognition of tear configuration, thereby allowing the surgeon to formulate a strategy that is most appropriate for that particular pattern[61,64,65]. In contrast, the visualization during a mini-open procedure is limited by the size of the lateral split, which may not allow adequate access to the rotator cuff and can compromise one's ability to perform necessary surgical releases, perhaps resulting in less-optimal repairs[61,66]. Severud et al.[59] described four patients who underwent a mini-open repair who had development of fibrous ankylosis (defined as <120° of forward flexion by twelve weeks postoperatively). Splitting of the deltoid and surgical retraction can result in postoperative pain and may account for the increased prevalence of postoperative arthrofibrosis[67]. There were six cases of postoperative impingement in the mini-open group, compared with only one in the arthroscopic group. Four patients required repeat subacromial decompression. The other two patients were found to have acromioclavicular joint degeneration, one at seven to twelve months[68] and the other at two to five years[68] after the initial operation, requiring débridement and acromioclavicular joint resection, respectively. It is impossible to determine if these patients had unrecognized acromioclavicular joint pathology at the time of the rotator cuff repair or if the degeneration developed after surgery.

One of the difficulties in comparing arthroscopic and mini-open repairs is identifying which primary outcome[5] (clinical score, range of motion and strength, pain, patient satisfaction, rate of complications, or postoperative evidence of rotator cuff healing) defines success. Eight of the eleven arthroscopic studies and ten of the eleven mini-open studies involved the use of the UCLA shoulder score to assess clinical outcome. While many studies included range of motion (assessed on a 5-point scale) as part of the UCLA score, only four arthroscopic studies and five mini-open studies included separate range-of-motion data. Three studies included visual analog scores outside of the UCLA score. All but one study from each group assessed complications. Five arthroscopic and six mini-open studies assessed patient satisfaction. Only one study from each group included a postoperative imaging study to evaluate the healing of repaired rotator cuff tendons as an outcome. Aside from the UCLA score, the outcome measures varied considerably, making comparisons difficult within and between groups. At the time of the literature search, radiographic analysis after rotator cuff repair was not routinely performed, but more recently published studies have incorporated postoperative imaging as an objective outcome measurement[19,62,69,70].

Selection Bias

Because the majority of the studies were case series of either arthroscopic or mini-open repairs, we set strict inclusion and exclusion criteria to provide homogeneity between the two groups to limit the potential for selection bias. As previously mentioned, no randomization was performed in any of the studies, but the studies that were included in the final analysis had similar patient ages, percentages of male patients, and percentages of involvement of the dominant extremity. Numerous studies in the literature on open, mini-open, and arthroscopic procedures have shown that tear size is an important determinant of outcome and healing[3,58,62,70-73]. We excluded any clinical study on massive rotator cuff tears and any study in which >50% of the patients had large and massive rotator cuff tears. Studies that did not provide information on tear size characteristics were also excluded. Studies that provided information on the number of tendons torn were included if >50% of the patients had an isolated supraspinatus tendon tear[6,60,63,71].

Although the clinical results of the repair of massive rotator cuff tears may be satisfactory, postoperative imaging studies have demonstrated rates of recurrent defects to be as high as 68% in mini-open studies[72] and as high as 94% in arthroscopic studies[19]. There is a growing body of evidence suggesting that although patients with failed repairs demonstrate good pain relief and the ability to perform activities of daily living in the short term, their outcomes may deteriorate over time[19]. In comparison with patients with healed tendons, patients with failed rotator cuff repairs have decreased range of motion and strength, which has been a consistent finding following both open and arthroscopic procedures[19,62,69,70,72].

Performance Bias

Performance bias may occur in studies in which a disproportionate number of concomitant procedures are performed. Subacromial decompression was performed in all patients in eight of the eleven arthroscopic studies and in all eleven mini-open studies. We do not believe that this represents a substantive difference leading to performance bias. In the arthroscopic group, there were two studies with an unusually high percentage of patients who had concomitant procedures for the treatment of acromioclavicular joint pathology[27,63]. One other study had a large proportion of combined arthroscopic rotator cuff tears and treatment of biceps tendon pathology[62]. On the basis of the clinical outcomes, these three studies performed similarly to the rest of the arthroscopic studies and therefore remained in the final analysis. Variation in the rehabilitation protocol is another potential variable that may influence performance bias. The retrospective cohort studies eliminated performance bias by implementing the same rehabilitation for each group. There were only minimal differences in the rehabilitation for the case series. Thus, performance bias was minimized.

Exclusion Bias

Of the studies in the final analysis, seven of the eleven arthroscopic studies and seven of the eleven mini-open studies had >80% follow-up and all studies had a mean duration of follow-up of twenty-four months. There is a potential for exclusion bias for any study in which patients were lost to follow-up, but especially for those four studies in each group that had <80% follow-up.

Detection Bias

Eight of the eleven arthroscopic studies and ten of the eleven mini-open studies involved the use of the UCLA Shoulder Score as the primary outcome measure. Among the retrospective cohort studies, no significant differences were noted between the arthroscopic and mini-open groups in terms of the UCLA score[34,58,59,61] and the ASES score[58,59,61]. Among the case series, there was no appreciable difference between arthroscopic and mini-open studies in terms of range of motion, the UCLA score, the ASES score, and satisfaction.

The present study had many strengths related to a design that resulted in homogeneity between the two study groups. With use of strict inclusion and exclusion criteria, there were eleven arthroscopic and eleven mini-open groups that had similar patient ages, percentages of male patients, percentages of involvement of the dominant extremity, percentages of effective follow-up, durations of follow-up (mean, twenty-four months), and distributions of rotator cuff tears. We attempted to exclude any study with a potential confounding factor such as less than twenty-four months of follow-up, a majority of massive tears, a failure to define tear sizes, partial tears, revision cases, mixed cohorts, and fixation other than tendon-to-bone. The final analysis included 473 patients in the arthroscopic group and 411 patients in the mini-open group, and most studies had the same primary outcome.

Whether qualitative or quantitative, systematic reviews are limited by the quality of the published studies. After reviewing the literature, there were no published randomized controlled trials (Level I) or prospective cohort studies (Level II) that met the study criteria at the time of the literature search. Because of a lack of randomized clinical trials, a quantitative systematic review, or meta-analysis, could not be performed, indicating the need for an improvement in the quality of published studies on the treatment of rotator cuff repairs, with a focus on prospective, randomized clinical trials with validated outcome scores and postoperative imaging studies. There were studies in the final analysis with <80% effective follow-up, which may subject the present report to exclusion bias.

In terms of the surgical technique, all of the arthroscopic studies involved the use of suture anchor fixation whereas the majority of the mini-open studies involved the use of transosseous tunnels for tendon-to-bone fixation. The majority of studies evaluating rotator cuff repair investigated either tendon-to-bone healing with use of transosseous tunnels[18,74-78] or ex vivo biomechanical analyses of suture anchors[17,72,79-81]. To date, we are aware of no studies that have compared the effect of these two techniques on tendon-to-bone healing.

Finally, there was also heterogeneity in the proportion of concomitant procedures performed, but with no apparent effect on clinical outcomes. By including these studies, we were able to maximize the overall number of patients.

The rehabilitation protocol was the same for the retrospective cohort studies, but although there were no clinical differences, there was a slight difference in the rate of complications. We believe that the difference in arthrofibrosis rates, for instance, is likely related to the technical aspects of surgery. For the case series, there was minor variation in the rehabilitation, which potentially could have affected the outcomes, but it did not seem to affect the analysis.

Aside from the UCLA Shoulder Score, the outcomes varied greatly from study to study, thus limiting the number of variables in the analysis. Range-of-motion data were incomplete and therefore could not be used reliably to compare the two groups. Many studies involved the use of other shoulder-scoring systems that could not be readily compared. Overall, there was a lack of objective outcome measures at the time of the analysis, but the rate of healing may be an interesting outcome to compare between the two techniques.

In conclusion, this systematic review demonstrates that both arthroscopic and mini-open rotator cuff repair can result in significant improvement from baseline in terms of shoulder function and clinical outcome, with relatively low complication rates. Although we could not identify a difference between the two techniques in terms of range of motion or function, there may be a slightly increased rate of complications associated with the mini-open repair. We do not recommend one technique over the other; instead, we believe that both techniques are effective and that the surgeon should use the technique that produces the most reliable result with the least complications in his or her hands.

Appendix

eA Extensive tables presenting data from all of the included studies are available with the electronic versions of this article, on our web site at jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM). ■

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