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# Functional outcome and structural integrity following mini-open repair of large and massive rotator cuff tears: A 3-5 year follow-up study

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**Background:** Mini-open approach has been considered for years the gold standard for rotator cuff repairs. Nevertheless, the rate of tendon-to-bone healing, and that of cuff re-tear, still remains unclear.
**Methods:** Between 2001 and 2004, 37 shoulders (32 patients) with a mean age of 54.8 years (range, 34-72) and a large or massive cuff tear were repaired with a mini-open procedure. At a minimum of 3 years post-operatively (range, 36-60 months), 27 shoulders (23 patients) underwent functional evaluation and US investigation of cuff integrity.
**Results:** The rotator cuff was completely healed and watertight in 13 cases (48.1%), while recurrent defects were detected in the remaining 14 shoulders (51.9%). In 12 cases (92.5%), the recurrent tears were smaller and in 2 (7.5%) larger than the initial tear. Despite the high re-tear rate, the overall Constant and UCLA scores improved from of 38.4 to 72.1 and 11.2 to 29.4, respectively. However, only ''large'' re-tears were correlated with a worse functional outcome ($P < .005$). The preoperative tear size was negatively associated with tendon healing. Patients with an intact rotator cuff repair were, on average, 15 years younger (49.9) than those who sustained a tear recurrence (64.14) ($P < .005$).
**Discussion:** Our results suggest that large and massive rotator cuff tears treated with mini-open technique using a tendon-grasping suture have a very satisfactory clinical outcome, despite a significant re-tear rate. Patient age, the size of the initial tear, as well as the size of a potential re-tear are factors affecting the final clinical outcome.
**Level of evidence:** Level IV, Case Series, Treatment Study.


**Keywords:** Rotator cuff tear; mini-open repair; structural integrity; ultrasound

Rotator cuff injuries are common, especially for those above the age of 60, and have an effect not only on shoulder function but also on the overall health status and quality of life of patients.[26] Since Codman and Ackerson's[9] first rotator

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cuff pathology description, rotator cuff repair has been one of the most common surgical procedures performed in the shoulder.[1,3,15,19,32]

Despite the exact technique used (open, mini-open or arthroscopic),[11,37] the short- and long-term clinical results are very promising.[14,16,25,29] Although the clinical benefits of rotator cuff repair are well established, there are still questions on the factors affecting the integrity of the repair over time as well as on the impact of a recurrent defect on the clinical outcome.[4,7,14,18,21,25]

The purpose of this study is to evaluate the clinical and structural results following mini-open repair of large and massive rotator cuff tears, using clinical evaluation and ultrasound imaging at a minimum of 3 years following the index procedure. Additionally, we aimed to explore the various factors that may have an effect in tear recurrence as well as in the mid-term clinical outcome.

## Materials and methods

Between January 2001 and October 2004, an arthroscopic subacromial decompression followed by a mini-open rotator cuff repair was performed in 57 patients (62 shoulders). Thirty-five patients were male and 22 female with a mean age of 54.8 years at operation (range, 34-72). In 32 patients (37 shoulders), the tear was large (18 cases with maximum tear diameter 3-5 cm) or massive (19 cases with maximum tear diameter >5 cm).[10] Twenty-four patients were male and 8 female with a mean age of 52.62 (range, 35-71). The dominant arm was affected in 23 cases (62.16%) and all tears were chronic.

Detailed medical history, clinical examination, and plain radiographic evaluation were performed in all patients before surgery. A magnetic resonance imaging (MRI) scan documenting the tear was obtained preoperatively in all cases, while the exact size of the tear was verified intraoperatively.

All procedures were performed by a consultant orthopaedic surgeon specializing in shoulder surgery (JC, PP, or DK) under general anaesthesia and with the patient in beach chair position. A diagnostic arthroscopy of the glenohumeral joint and subacromial space was followed by a combination of arthroscopic acromioplasty and bursa debridement.

Although in all cases the coracoacromial ligament was released, neither distal clavicle resection nor biceps tenotomy was performed. The greater tuberosity was debrided and gently decorticated without exposure of the subcortical bone. Subsequently, the arthroscope was withdrawn and a 3-5-cm incision was made starting from the anterolateral corner of the acromion and extending distally. The incision was followed by a deltoid splitting approach to the already debrided subacromial space. The tear was mobilized and reattached to the bone with 2-4 (mean 2.5) 5-mm metal bone anchors-G4 Superanchors (DePuy Mitek, Raynham, MA) with double-loaded No. 2 Ethibond sutures (Ethicon, Somerville, New Jersey). A single-row tendon repair with modified Mason-Allen suture technique was performed in all patients.

Postoperatively, all shoulders were protected in a broad arm sling for 6 weeks, while light pendulum exercises were commenced as soon as pain allowed. Passive range of motion exercises including forward flexion and external rotation were initiated under the guidance of a physical therapist 2 weeks later. Active-assisted shoulder motion was permitted after the 6th postoperative week and hydrotherapy was encouraged at the same time. Return to high-demand daily activities was allowed 6 months postoperatively.

Out of the 32 patients with a large or massive tear, 23 patients (27 shoulders)—16 with large tear and 11 with massive—were available for clinical and US evaluation at a minimum of 3 years postoperatively and constitute our study population. Functional assessment was performed at 6, 12, and 24 months postoperatively and on final follow-up, using the Constant-Murley and UCLA scores for objective evaluation. Patient satisfaction was also recorded.

In all patients, a musculoskeletal US was performed at least 3 years postoperatively by the same experienced examiner (AF), using a high-resolution linear-array transducer with variable high frequency (8-13 MHz) (Siemens Antares, Erlangen, Germany). The sonographic evaluation of the rotator cuff was performed according to a standard protocol.[13] Rotator cuff tendons, including subscapularis, supraspinatus, and infraspinatus, as well as the long head of biceps, were examined in transverse and longitudinal planes with additional coronal views of the supraspinatus when necessary. Dynamic scan was employed in all cases.

The ultrasound criteria for the diagnosis of full-thickness rotator cuff tears were: 1) nonvisualization of the supraspinatus tendon due to retraction under the acromioclavicular joint; 2) detachment of the supraspinatus from the greater tuberosity with medial dislocation, or loss of normal supraspinatus substance with widening of the gap between the supraspinatus and biceps tendon and exposure of a bare area of bone and cartilage; 3) a hypoechoic or anechoic cleft extending through the entire substance of the cuff; and 4) coexistence of fluid in the subacromial-subdeltoid bursa and/or the presence of fluid in the sheath of the long head of biceps tendon.[2,20] The size of the tear was measured in millimeters directly on freeze-frame images with the use the cursor software function.

Statistical analysis was performed using the SPSS 14.0 (SPSS Inc, Chicago, IL). The Student $t$ test was used to compare preoperative, postoperative tear size, age, and UCLA and Constant functional shoulder scores. Significance level was set at $P < .05$.

## Results

At final follow-up 40.2 months postoperatively (range, 36-60), there was a significant improvement in the overall UCLA score from 11.2 to 29.4. According to the UCLA score, the result was rated as excellent in 71% (19 shoulders), good in 22% (6 shoulders), and fair in 7% (2 shoulders). According to the Constant scoring system, results were rated as excellent in 67% (18 shoulders), good in 26% (7 shoulders), and fair in 7% (2 shoulders). The overall Constant score improved from 38.4 to 72.1. In 24/27 cases, the patients stated that they were very satisfied with the outcome and they would undergo the procedure again. Two patients (3 shoulders) stated they were moderately satisfied. One patient developed a superficial wound infection that was successfully treated with surgical debridement and antibiotics.

Rotator cuff repair integrity was assessed in all 27 cases at an average of 40.2 months postoperatively (range, 36-60) with ultrasonographic evaluation. Thirteen repairs were intact and watertight (Figure 1), while recurrent defects were detected in

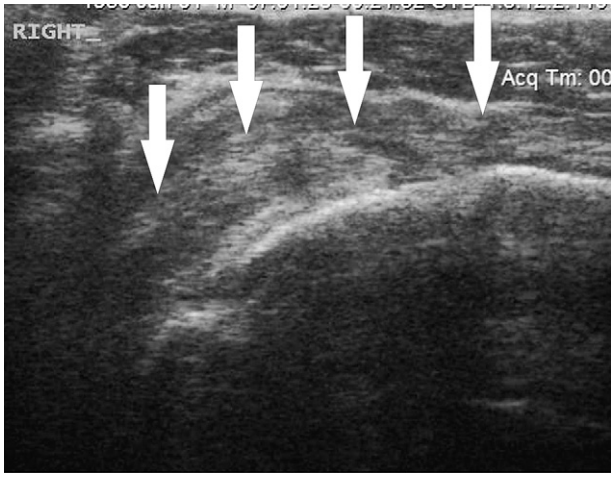


**Figure 1** Longitudinal scan of the supraspinatus tendon of the right shoulder. Normal, intact ultrasonographic appearance of the repaired supraspinatus tendon.

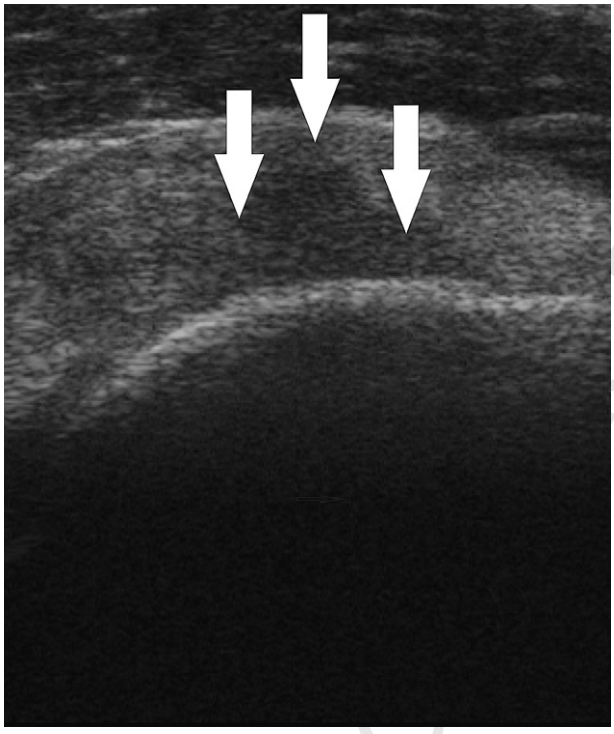

**Figure 2** Longitudinal scan of the supraspinatus tendon of the left shoulder. Ultrasonographic appearance of a small recurrent defect of the supraspinatus tendon on the articular side.

the remaining 14 cases (51.9%). Recurrent tears were categorized as ''small'' if the defect was at least 1-2 mm smaller than the preoperative dimension (Figure 2) and ''large'' if it was >2 mm larger than the initial one[14] (Figure 3). In 12 shoulders (92.5%), the recurrent tear was ''small'' [10 cases <3 cm and 2 cases >3 cm and <5 cm] and only in 2 cases (7.5%) the defect was ''large'' [>5 cm].

Using Student *t* test, the size of the preoperative tear was found to be related to a poorer outcome on final follow-up at least 2 years post surgery; but the difference was not

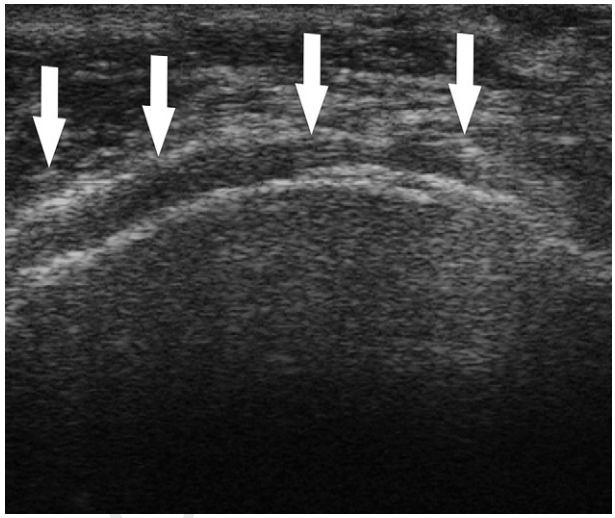

**Figure 3** Transverse scan of the supraspinatus tendon of the left shoulder. Ultrasonographic appearance of a large recurrent defect of the supraspinatus.

statistically significant ($P = .329$ for UCLA, $P = .08$ for Constant score). In addition, recurrence of a ''small'' tear did not clearly affect the clinical outcome, and this is emphasized by the fact that both clinical scores in this patient subgroup were directly comparable to the scores of patients with an intact cuff ($P = .889$ and $P = .877$ for UCLA and Constant scores, respectively) (Table). On the other hand, a ''large'' postoperative re-tear was recorded in 2 cases and found to be related to the preoperative tear size (massive in both cases). Moreover, it led to a fair functional outcome that was significantly worse than that of the subgroup of patients with an intact cuff ($P < .005$ for both UCLA and Constant scores) (Table).

Additionally, our results show a correlation between older patients and ''bad'' postoperative UCLA and Constant scores (Figures 4 and 5) ($P < .005$), establishing age as a negative predicting factor. Finally, our results indicate a strong correlation between age and tendon healing capacity. Patients with an intact rotator cuff were, on average, 15 years younger (mean age 49.9 years) than those who sustained a tear recurrence (mean age 64.14 years); the difference was highly significant (*t* test: $P < .005$). Comparing the preoperative tear size and the patients' age, it was revealed that patients with a large preoperative tear had a mean age of 52 years, while patients with a massive one had a mean age of 65 years; and the difference was statistically significant ($P = .009$) (Figure 6). Moreover, ''older'' patients with larger preoperative tear are prone to failure repair ($P < .001$) (Figure 7).

Despite the high re-tear rate, objective functional evaluation with UCLA and Constant scoring systems presents very satisfactory long-term clinical results of RC repair with mini-open rotator cuff repair. Our results reveal that the presence of a re-tear does not necessarily mean surgical failure or poor outcome. Even if a ''large'' [4] re-tear occurs, the postoperative

**Table** Number of patients with intact rotator cuff, small or large post-operative defects. Mean age, UCLA and Constant score of these patients. *P* values are showing the significance of the UCLA and Constast score differences between patients with intact rotator cuff and patients with small re-tears, and the differences between patients with intact cuff and large re-tears, respectively

| Post-op cuff integrity | No patients | Mean age | UCLA score | Constant score | *P* value |
|---|---|---|---|---|---|
| Intact | 13 | 49.92 | 32.23 | 85 | |
| Small | 12 | 63 | 29.8 | 77.1 | $P = .889$ and $P = .877$ |
| Large | 2 | 70.5 | 25.5 | 67.5 | $P < .005$ and $P < .005$ |

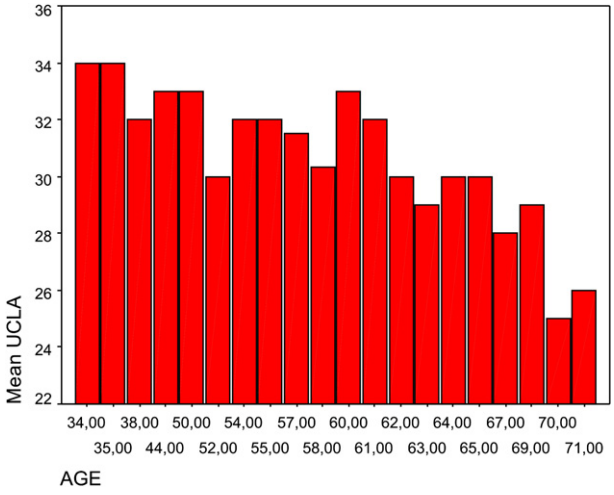


**Figure 4** Postoperative functional UCLA score according to age. Worse clinical results in older patients ($P < .005$).

functional condition of the shoulder remained improved. However, a structurally intact cuff or even a ''small'' re-tear were related with a superior clinical outcome.

## Discussion

Favorable mid- and long-term clinical outcomes have been reported by a number of authors, using a combination of arthroscopic acromioplasty and mini-open rotator cuff repair.[27,29,30] Excellent or good clinical results, significant improvement of the quality of life, and patient satisfaction rates as high as 94% have established the above technique as the ''gold standard'' for the management of rotator cuff tears for a number of years. However, our knowledge on the structural condition of the rotator cuff over time following mini-open repair and its potential correlation with the clinical outcome is far less detailed.

Our anatomical failure rate of 51.9% gives a clear negative answer to the question of whether the tendon retains its structural integrity over time. Despite the fact that only large and massive tears were included in this study, our results compare favorably with re-tear rates of 20-60% reported in the literature for open or mini-open rotator cuff repairs.[7,17,18,21,22,25] Similar results of cuff integrity have been reported following arthroscopic procedures.[4,11,14,37,38]

In order to confirm the structural status of the rotator cuff tendons, we preferred US evaluation, because it has lately been shown to offer greater specificity and increased accuracy compared to other imaging modalities.[31,36] This may explain, in part, the higher failure rates of the structural-anatomical status of the repaired tendons reported in some studies.[14] In the past, many authors used arthrography or MRI in order to assess the integrity of the repair. These techniques, though, provide little information about the tear configuration and size, while some also think that it may underestimate the failure incidence.[4,11,25] For example, Boileau et al[4] found healed and watertight supraspinatus tendons in 71% of their patients using a CT arthrogram, while Cole et al[11] with MRI evaluation report 22% recurrence rate.

Despite the high re-tear rates, clinical improvement and patient satisfaction was obvious in our study. In a similar population, Galatz et al[14] reported excellent pain relief and improvement in the ability to perform activities of daily living, at a minimum follow-up of two years, despite a very high recurrence rate of 94%, after a fully arthroscopic procedure. They also observed that large or massive preoperative tears correlated with a higher re-tear rate and worse functional results, an observation that is in accordance with our findings.

Our study corroborates the findings of Castagna et al,[8] Jost et al,[21] and, more recently, of Hanusch et al,[17] and confirms that a re-tear does not necessarily mean surgical failure, since the postoperative clinical scores recorded were significantly improved, even if a tear re-occurred, provided the re-tear was smaller in size than the initial one.

Our results also support the findings of a number of published studies in that age is a negative predicting factor for rotator cuff healing, predisposing to more structural defects and a worse clinical outcome in older patients.[4,6,12] Rotator cuff delamination and poor tissue quality appear to be more common in people over 65 years old.[4,18] It is highly likely that degenerated cuff tissue has a decreased healing potential, resulting in significantly higher re-tear rates, even if a satisfactory repair was initially achieved. This may also be the reason behind the correlation between supraspinatus fatty infiltration and a worse clinical outcome.[21,33]

Double-row suture techniques may lead to higher rates of tendon healing, according to Lafosse et al[24] and Sugaya et al.[34,35] However, the overall functional scores did not significantly differ from those obtained with mini-open or single-row arthroscopic techniques.[35] In addition, Ozbaydar et al,[28] in an experimental study, found that double-row repair leads to an increase in surface area for tendon-to-bone

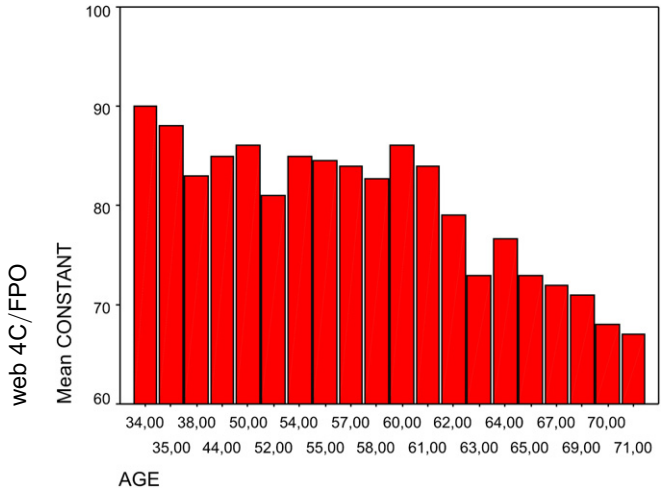


**Figure 5** Postoperative functional Constant score according to age. Again, the age is a negative predictive factor for good clinical results ($P < .005$).

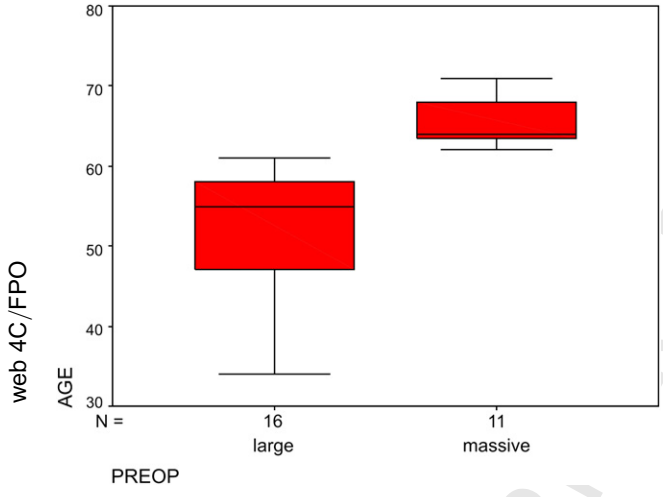


**Figure 6** Younger patients are prone to have smaller cuff tears compared with older patients ($P < .009$).

healing, but not to better quality tissue formation. One should also bear in mind that rotator cuff healing occurs by reactive scar tissue formation rather than regeneration of a histologically normal insertion site, despite the exact fixation technique used.[23]

The fact that all procedures were carried out by the same shoulder surgeons, in the same clinical setting, in a homogenous study population, with a uniform surgical technique and a common postoperative protocol, together with prospective data collection constitute the strengths of this study. Additionally, all postoperative US investigations were carried out by the same experienced operator. However, we appreciate that the present case study is faced with a number of limitations including the relatively small study population and the different pre- and postoperative imaging modalities. Therefore, conclusions should be reviewed in light of the aforementioned limitations.

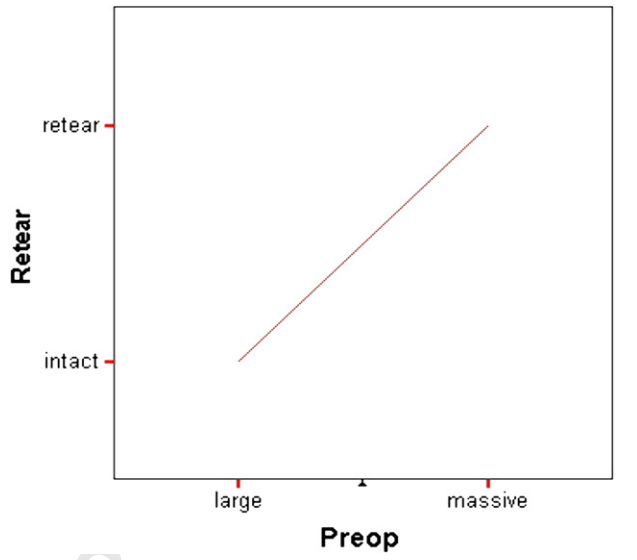


**Figure 7** Patients with bigger preoperative size tears are more possible to have new cuff defects during the final follow-up ($P < .001$).

For a number of years our efforts have been focused on the strength of the repair construct by improving anchor design and suture material and refining technical aspects in an effort to achieve a watertight repair. Recent evidence, though, has suggested that the potential for healing is decreased especially in older patients with sizeable, chronic tears, thus shifting our interest from mechanics more towards biology. Although every effort should be made to achieve a solid repair, a watertight construct at any cost is not our goal anymore, as there is mounting evidence that ''watertight'' repairs of chronic tears are rather likely to fail structurally over time.

One should note, though, that, especially in large or massive degenerative tears, the strength of initial fixation might not be as important as the biologic capacity for healing.[39] Despite the predisposing healing factors or the technique preferred, probably the most crucial point is to transform a ''nonfunctional tear'' to a ''functional'' one and restore the suspension bridge model proposed by Burkhart[5] in order to achieve a satisfactory clinical outcome.

## Conclusion

In summary, this retrospective study suggests that the size of the initial tear, as well as the age of the patient are factors negatively affecting the incidence and size of a recurrent cuff tear at the final clinical outcome. Nevertheless, large and massive tears treated with a mini-open technique using a tendon-grasping suture have a very satisfactory clinical outcome, despite a significant re-tear rate.

## Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated did not receive any financial payments or other benefits from any commercial entity related to the subject of this article.

## References

1. Bennett WF. Arthroscopic repair of full-thickness supraspinatus tears (small-to-medium): a prospective study with 2- to 4-year follow-up. Arthroscopy 2003;19:249-56. doi:10.1053/jars.2003.50083
2. Bianchi S, Martinoli C, Abdelwahab IF. Ultrasound of tendon tears. Part 1: general considerations and upper extremity. Skeletal Radiol 2005;34:500-12. doi:10.1007/s00256-005-0956-1
3. Bigliani LU, Cordasco FA, McIlveen SJ, Musso ES. Operative repairs of massive rotator cuff tears: long-term results. J Shoulder Elbow Surg 1992;1:120-30. doi:10.1016/1058-2746(92)90089-L
4. Boileau P, Brassart N, Watkinson DJ, Carles M, Hatzidakis AM, Krishnan SG. Arthroscopic repair of full-thickness tears of the supraspinatus: does the tendon really heal? J Bone Joint Surg (Am) 2005;87:1229-40. doi:10.2106/JBJS.D.02035
5. Burkhart SS. Fluoroscopic comparison of kinematic patterns in massive rotator cuff tears: A suspension bridge model. Clin Orthop Relat Res 1992;284:144-52.
6. Burns JP, Snyder SJ. Arthroscopic rotator cuff repair in patients younger than fifty years of age. J Shoulder Elbow Surg 2008;17:90-6. doi:10.1016/j.jse.2007.05.006
7. Calvert PT, Packer NP, Stoker DJ, Bayley JI, Kessel L. Arthrography of the shoulder after operative repair of the torn rotator cuff. J Bone Joint Surg (Br) 1986;68:147-50.
8. Castagna A, Conti M, Markopoulos N, Borroni M, De Flaviis L, Giardella A, et al. Arthroscopic repair of rotator cuff tear with a modified Mason-Allen stitch: mid-term clinical and ultrasound outcomes. Knee Surg Sports Traumatol Arthrosc 2008;16:497-503. doi:10.1007/s00167-007-0461-2
9. Codman EA, Ackerson IB. The pathology associated with rupture of the supraspinatus tendon. Ann Surg 1931;93:348-59. doi:10.1097/00000658-193101000-00043
10. Cofield RH. Subscapular muscle transposition for repair of chronic rotator cuff tears. Surg Gynecol Obstet 1982;154:667-72.
11. Cole BJ, McCarty LP III, Kang RW, Alford W, Lewis PB, Hayden JK. Arthroscopic rotator cuff repair: prospective functional outcome and repair integrity at minimum 2-year follow-up. J Shoulder Elbow Surg 2007;16:579-85. doi:10.1016/j.jse.2006.12.011
12. DeFranco MJ, Bershadsky B, Ciccone J, Yum JK, Iannotti JP. Functional outcome of arthroscopic rotator cuff repairs: a correlation of anatomic and clinical results. J Shoulder Elbow Surg 2007;16:759-65. doi:10.1016/j.jse.2007.03.020
13. Fotiadou AN, Vlychou M, Papadopoulos P, Karataglis DS, Palladas P, Fezoulidis IV. Ultrasonography of symptomatic rotator cuff tears compared with MR imaging and surgery. Eur J Radiol 2008;68:174-9. doi:10.1016/j.ejrad.2007.11.002
14. Galatz LM, Ball CM, Teefey SA, Middleton WD, Yamaguchi K. The outcome and repair integrity of completely arthroscopically repaired large and massive rotator cuff tears. J Bone Joint Surg (Am) 2004;86-A:219-24.
15. Galatz LM, Griggs S, Cameron BD, Iannotti JP. Prospective longitudinal analysis of postoperative shoulder function: a ten-year follow-up study of full-thickness rotator cuff tears. J Bone Joint Surg (Am) 2001;83:1052-6.
16. Gartsman GM, Brinker MR, Khan M. Early effectiveness of arthroscopic repair for full-thickness tears of the rotator cuff: an outcome analysis. J Bone Joint Surg (Am) 1998;80:33-40.
17. Hanusch BC, Goodchild L, Finn P, Rangan A. Large and massive tears of the rotator cuff: functional outcome and integrity of the repair after a mini-open procedure. J Bone Joint Surg Br 2009;91:201-5. doi:10.1302/0301-620X.91B2.21286
18. Harryman DT II, Mack LA, Wang KY, Jackins SE, Richardson ML, Matsen FA III. Repairs of the rotator cuff. Correlation of functional results with integrity of the cuff. J Bone Joint Surg (Am) 1991;73:982-9.
19. Iannotti JP. Full-thickness rotator cuff tears: factors affecting surgical outcome. J Am Acad Orthop Surg 1994;2:87-95.
20. Iannotti JP, Ciccone J, Buss DD, Visotsky JL, Mascha E, Cotman K, et al. Accuracy of office-based ultrasonography of the shoulder for the diagnosis of rotator cuff tears. J Bone Joint Surg (Am) 2005;87:1305-11. doi:10.2106/JBJS.D.02100
21. Jost B, Pfirrmann CW, Gerber C, Switzerland Z. Clinical outcome after structural failure of rotator cuff repairs. J Bone Joint Surg (Am) 2000;82:304-14.
22. Knudsen HB, Gelineck J, Sojbjerg JO, Olsen BS, Johannsen HV, Sneppen O. Functional and magnetic resonance imaging evaluation after single-tendon rotator cuff reconstruction. J Shoulder Elbow Surg 1999;8:242-6. doi:10.1016/S1058-2746(99)90136-2
23. Kovacevic D, Rodeo SA. Biological augmentation of rotator cuff tendon repair. Clin Orthop Relat Res 2008;466:622-33. doi:10.1007/s11999-007-0112-4
24. Lafosse L, Brozska R, Toussaint B, Gobezie R. The outcome and structural integrity of arthroscopic rotator cuff repair with use of the double-row suture anchor technique. J Bone Joint Surg (Am) 2007;89:1533-41. doi:10.2106/JBJS.F.00305
25. Liu SH, Baker CL. Arthroscopically assisted rotator cuff repair: correlation of functional results with integrity of the cuff. Arthroscopy 1994;10:54-60. doi:10.1016/S0749-8063(05)80293-2
26. McKee MD, Yoo DJ. The effect of surgery for rotator cuff disease on general health status. Results of a prospective trial. J Bone Joint Surg (Am) 2000;82:970-9.
27. Mohtadi NG, Hollinshead RM, Sasyniuk TM, Fletcher JA, Chan DS, Li FX. A randomized clinical trial comparing open to arthroscopic acromioplasty with mini-open rotator cuff repair for full-thickness rotator cuff tears: disease-specific quality of life outcome at an average 2-year follow-up. Am J Sports Med 2008;36:1043-51. doi:10.1177/0363546508314409
28. Ozbaydar M, Elhassan B, Esenyel C, Atalar A, Bozdag E, Sunbuloglu E, et al. A comparison of single-versus double-row suture anchor techniques in a simulated repair of the rotator cuff: an experimental study in rabbits. J Bone Joint Surg (Br) 2008;90:1386-91. doi:10.1302/0301-620X.90B10.20862
29. Paulos LE, Kody MH. Arthroscopically enhanced mini approach to rotator cuff repair. Am J Sports Med 1994;22:19-25. doi:10.1177/036354659402200104
30. Pollock RG, Flatow EL. The rotator cuff. Full-thickness tears: mini-open repair. Orthop Clin North Am 1997;28:169-77. doi:10.1016/S0030-5898(05)70277-7
31. Prickett WD, Galatz LM, Calfee R, Teefey S, Middleton WD, Yamaguchi K. The accuracy of ultrasound for imaging the rotator cuff in the postoperative shoulder. Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons; San Francisco, CA: Feb 28-Mar 4, 2001.
32. Romeo AA, Mazzocca A, Hang DW, Shott S, Bach BR. Shoulder scoring scales for the evaluation of rotator cuff repair. Clin Orthop Relat Res 2004;427:107-14. doi:10.1097/01.blo.0000142624.05526.dd
33. Shen PH, Lien SB, Shen HC, Lee CH, Wu SS, Lin LC. Long-term functional outcomes after repair of rotator cuff tears correlated with atrophy of the supraspinatus muscles on magnetic resonance images. J Shoulder Elbow Surg 2008;17(1 Suppl):1S-7. doi:10.1016/j.jse.2007.04.014
34. Sugaya H, Maeda K, Matsuki K, Moriishi J. Repair integrity and functional outcome after arthroscopic double-row rotator cuff repair.

A prospective outcome study. J Bone Joint Surg Am 2007;89:953-60. doi:10.2106/JBJS.F.00512

35. Sugaya H, Maeda K, Matsuki K, Moriishi J. Functional and structural outcome after arthroscopic full-thickness rotator cuff repair: single-row versus dual-row fixation. Arthroscopy 2005;21:1307-16. doi:10.1016/j.arthro.2005.08.011
36. Teefey SA, Hasan SA, Middleton WD, Patel M, Wright RW, Yamaguchi K. Ultrasonography of the rotator cuff. A comparison of ultrasonographic and arthroscopic findings in one hundred consecutive cases. J Bone Joint Surg Am 2000;82:498-504.
37. Wilson F, Hinov V, Adams G. Arthroscopic repair of full-thickness tears of the rotator cuff: 2- to 14-year follow-up. Arthroscopy 2002; 18:136-44. doi:10.1053/jars.2002.30443
38. Wolf EM, Bayliss RW. Arthroscopic rotator cuff repair clinical and arthroscopic second-look assessment. In: Gazielly DF, Gleyze P, Thomas T, editors. The cuff. Paris: Elsevier; 1996. p. 319.
39. Yamaguchi K, Levine WN, Marra G, Galatz LM, Klepps S, Flatow EL. Transitioning to arthroscopic rotator cuff repair: the pros and cons. Instr Course Lect 2003;52:81-92.

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