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OPEN ROTATOR CUFF REPAIR WITHOUT ACROMIOPLASTY

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Background: In most clinical reports on rotator cuff repair, acromioplasty was done as part of the procedure. In this prospective study, we evaluated the hypothesis that rotator cuff repair without acromioplasty would result in a substantial improvement in shoulder comfort and function.

Methods: Ninety-six consecutive primary repairs of full-thickness tears of the rotator cuff were performed through a deltoid-muscle-splitting incision that preserved the integrity of the coracoacromial arch and the deltoid insertion. All patients were invited to participate in a prospective study involving periodic self-assessment of shoulder function with the Simple Shoulder Test and general health status with the Short Form-36 (SF-36) questionnaire, both of which are validated instruments. Sixty-one patients provided follow-up information for at least two years postoperatively, and the average duration of follow-up was five years. Thirty-four of the tears involved the supraspinatus tendon alone; sixteen involved the supraspinatus and infraspinatus tendons; and eleven involved the supraspinatus, infraspinatus, and subscapularis tendons.

Results: The percentage of shoulders that could be used to perform each of the twelve functions on the Simple Shoulder Test was significantly increased postoperatively ($p < 0.002$). Men and women had different degrees of function preoperatively ($p < 0.00000001$) and postoperatively ($p < 0.001$), but the improvement in function was essentially identical for the two genders. The mean improvement in the number of shoulder tests that could be performed was best for the patients with one-tendon tears (4.9 tests), next best for those with two-tendon tears (3.6 tests), and worst for those with three-tendon tears (3.3 tests). SF-36 scores for physical role ($p < 0.003$) and comfort ($p < 0.0001$) were significantly improved postoperatively.

Conclusions: Significant improvement in self-assessed shoulder comfort and in each of the twelve shoulder functions was observed after rotator cuff repairs performed without acromioplasty. The technique that we used is very similar to that described by Codman almost seventy years ago.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

In most series of rotator cuff repairs, acromioplasty was performed as part of the technique¹⁻³. Recently, McKee and Yoo¹ reported the results of rotator cuff surgery performed in sixty-seven patients, thirty-one of whom had repair of a rotator cuff tear in association with a standard open acromioplasty and resection of the subacromial bursa. Although their analysis did not distinguish between patients who had had a rotator cuff repair and those who had had an acromioplasty alone, they concluded that the surgery performed in their study reliably and significantly improves the general health status of patients with chronic rotator cuff disease.

In his 1934 book, *The Shoulder: Rupture of the Supraspinatus Tendon and Other Lesions in or about the Subacromial Bursa*, Codman described rotator cuff repair without acromioplasty or incision of the coracoacromial ligament⁴. He stated: “the coraco-acromial ligament has an important duty and

should not be thoughtlessly divided at any operation.” Codman reported excellent results for some patients. For example, one patient worked full time on a farm for twelve years after the rotator cuff repair without acromioplasty.

A number of authors have described the disadvantages associated with acromioplasty and sectioning of the coracoacromial ligament. Specifically, anteroinferior acromioplasty can weaken the deltoid muscle origin when the anterior acromial fibers are detached as part of the procedure, creating a risk of postoperative avulsion^{2,5-7}. Radical acromioplasty results in substantial changes in the deltoid origin and consequently compromises shoulder function^{2,5-7}. When there is an irreparable rotator cuff tear, resection of the acromion and the coracoacromial ligament can lead to anterosuperior instability⁸⁻¹¹. After acromioplasty, a cicatrix can form between the raw cancellous undersurface of the remaining acromion and

the repaired tendon¹². The resulting adhesions that form in the humeroscapular interface between the acromion and the rotator cuff can limit motion and cause discomfort^{5,13}. Budoff et al. demonstrated that débridement of partial-thickness rotator cuff tendinosis or tears without acromioplasty was an effective long-term treatment¹⁴.

In the current prospective study, we evaluated the hypothesis that repair of full-thickness rotator cuff tears without acromioplasty can result in substantial improvement in shoulder comfort and function.

Materials and Methods

From November 17, 1992, to December 19, 2000, the senior author (F.A.M. III) performed ninety-six consecutive open repairs of primary full-thickness tears of the rotator cuff without acromioplasty. All patients were invited to participate in a prospective end-result study by providing periodic self-assessment of shoulder function with use of validated instruments. Sixty-one patients provided follow-up data for at least two years postoperatively. The duration of follow-up ranged from two to ten years, and the average duration (and standard deviation) was 5 ± 2.2 years. The remaining thirty-five patients did not send back questionnaires at least two years after the surgery and were, therefore, not included in the study. We did not determine the reasons for their lack of long-term participation. Patients with an irreparable rotator cuff tear, previous rotator cuff or acromial surgery, or a partial-thickness rotator cuff tear were not included in the study. Patients with a Workers' Compensation claim also were not included because a prior investigation showed that the preoperative characteristics of such patients differ significantly ($p < 0.001$) from those of patients whose shoulder problems are not covered by Workers' Compensation insurance¹⁵. Preoperative shoulder function and general health status were assessed with the Simple Shoulder Test^{16,17} and the Short Form-36 (SF-36)^{18,19}, respectively. Simple Shoulder Test and SF-36 questionnaires were mailed to the patients at six-month intervals after the surgery.

The Simple Shoulder Test is a standardized twelve-question questionnaire for self-assessment of shoulder function^{5,16,17}. It has high test and retest reproducibility, is sensitive to a wide variety of shoulder disorders, and is practical for documenting the efficacy of treatment of shoulder conditions^{5,17,20-22}. It also has high test and retest reliability, can be completed by the patient in a short amount of time, is easy to score, and has satisfactory responsiveness^{23,24}. Patients without rotator cuff disease or another shoulder disorder can perform all twelve functions of the Simple Shoulder Test¹⁶, and the questionnaire has been used to show the substantial variability in the clinical expression of full-thickness rotator cuff tears²⁵.

The SF-36 is a validated, standardized questionnaire for self-assessment of general health status^{18,19,26} that is commonly used in the United States²⁷. It has been applied to the evaluation of shoulder disorders^{5,16,17,20,28,29}.

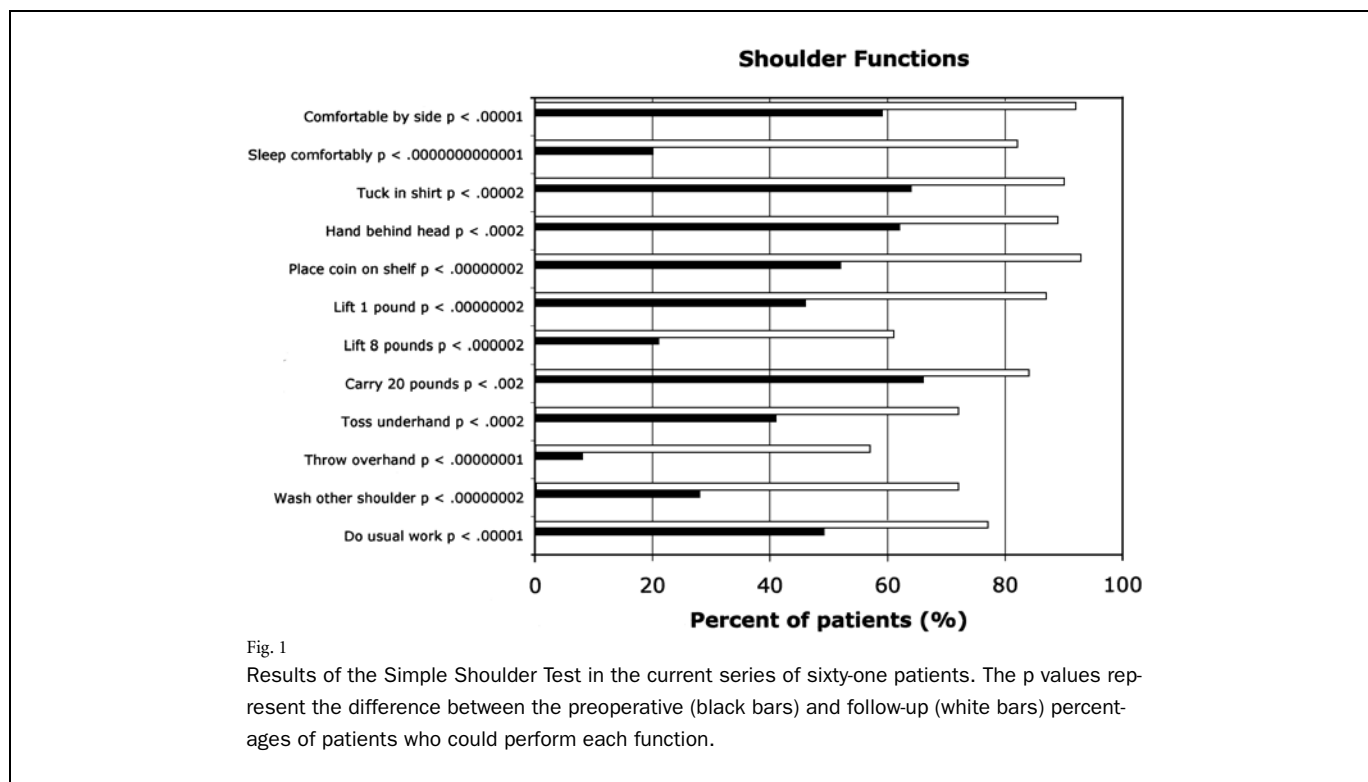
In this series, the surgical goals were based on the principles enunciated by Codman—namely, that the tendon is re-

paired to give power to the arm and a frictionless lower bursal surface is created to relieve inflammation and pain⁴. The surgical technique has been previously described in detail³⁰. The operation begins with an incision along the Langer lines approximately 1 cm distal to the anterolateral border of the acromion. The “deltoid-on approach” avoids any detachment of the deltoid from the acromion or clavicle. It is carried out through a 3-cm split in the most prominent anterolateral raphe of the deltoid muscle near its origin from the acromion. The different aspects of the rotator cuff are exposed through this deltoid split by positioning the arm as needed in flexion and extension and in internal and external rotation as advocated by Codman⁴.

The hypertrophic bursa is resected from the subacromial space and from the surface of the rotator cuff to allow adequate visualization of the torn rotator cuff and to ensure a smooth rotator cuff surface to articulate with the undersurface of the coracoacromial arch. The undersurface of the coracoacromial arch usually is smooth to palpation. If prominent excrescences are palpated, they are smoothed without resection of the coracoacromial arch or the acromion. Although, in some cases, radiographs show calcification in the coracoacromial ligament, this calcification typically does not encroach on the rotator cuff as it moves beneath the arch. Calcification within the ligament is not resected unless it disrupts the smooth contour of the inferior surface of the coracoacromial arch. The extent of the rotator cuff tear is then defined in terms of which tendon or tendons are torn³¹.

The rotator cuff is mobilized as necessary and is repaired under gentle tension into a trough at its anatomic insertion with use of simple number-2 braided polyester sutures passed through transosseous tunnels, as advocated by Codman⁴ and Matsen et al.^{5,30}. The sutures are placed 6 mm apart. The number of sutures used depends on the length of the detachment. The trough is intended to effect a smooth transition from tendon to bone with use of an “inlay” rather than an “onlay” technique to optimize the contact area between the tendon and bone, to prevent joint fluid from entering the repair site, to maintain bone-tendon contact even if unexpected traction is applied to the repair, and to expose the tendon edge to the healing tissue from the subchondral bone^{32,33}. When a side-to-side component of the repair is needed, simple sutures are used, with the knots buried again to allow a smooth upper surface of the repaired cuff. Every effort is made to reestablish the normal smoothness of the convex aspect of the cuff and its insertion as well as to preserve the integrity and smoothness of the undersurface of the coracoacromial arch. Finally, the deltoid is closed in a side-to-side fashion with number-0 polyglycolic acid absorbable sutures.

In this study, the efficacy of the procedure was defined as the difference between the final and the initial Simple Shoulder Test and SF-36 scores. The percent efficacy was defined as the mean efficacy divided by the mean preoperative value for each test. Responsiveness was determined on the basis of the standardized response mean, which is defined as the mean efficacy divided by the standard deviation of the efficacy^{24,34}. Responsive-



ness is defined as large if the value is >0.80 , moderate if it is between 0.50 and 0.80 , and poor if it is <0.50 ²⁴.

Statistical Analysis

The Student t test was used to compare the preoperative and follow-up values of continuous data, such as the SF-36 scores³⁵. The chi-square test was used to compare the preoperative and follow-up values for noncontinuous, categorical data, such as the Simple Shoulder Test functions³⁶.

Results

Patient Characteristics

The average patient age was 61 ± 11 years (range, thirty to eighty-four years). Forty-two of the sixty-one patients were men. The supraspinatus tendon only was ruptured in thirty-four patients (56%); both the supraspinatus and the infraspinatus were ruptured in sixteen patients (26%); and the supraspinatus, infraspinatus, and subscapularis were all ruptured in eleven patients (18%). All sixty-one patients provided follow-up data for at least two years (range, two to ten years; average, 5 ± 2.2 years). The effectiveness of the procedure was correlated with age, gender, and the number of tendons involved.

General Health Status (SF-36)

There was significant postoperative improvement in two of the eight parameters of the SF-36: the average physical role function score improved from 33 points preoperatively to 56 points postoperatively ($p < 0.003$), and the average comfort score improved from 40 to 67 points ($p < 0.0001$). The changes in the

remaining parameters were not significant: physical function improved from 66 to 70 points; social function, from 78 to 79 points; emotional role decreased from 74 to 69 points; mental health improved from 74 to 79 points; vitality, from 61 to 63 points; and general health decreased from 75 to 74 points.

Shoulder Function (Simple Shoulder Test)

The patients were able to perform a mean of five of the twelve functions on the Simple Shoulder Test before the surgery and a mean of nine at the time of the last follow-up ($p < 0.0001$). Thus, the average efficacy was six, and the percent efficacy was 120%. As reflected by the total number of Simple Shoulder Test functions that the patients could perform, these rotator cuff repairs had a large responsiveness, as indicated by a standardized response mean of 1.09. As seen in Figure 1, the percentage of shoulders that could be used to perform each of the twelve Simple Shoulder Test functions was significantly increased after rotator cuff repair without acromioplasty ($p < 0.002$).

Influence of Age, Gender, and Number of Tendons Involved

With the numbers available, patient age did not correlate with improvement after the rotator cuff repair. The mean number of functions that the women could perform improved from 2.3 before the surgery to seven at the time of the last follow-up, whereas the mean number of functions that the men could perform improved from 6.3 to 10.6. Therefore, while men and women had significantly different degrees of function preoperatively ($p < 0.00000001$) and postoperatively ($p < 0.001$), the im-

provement in the number of functions was essentially identical.

The patients with only one torn tendon had the greatest improvement in the number of shoulder functions that they could perform (from 5.2 to 10.1), those with two torn tendons had the next greatest improvement (from 4.8 to 8.4), and those with three torn tendons had the least improvement (from 5.6 to 8.8).

There were no surgical or perioperative complications in this group of patients.

Discussion

Acromioplasty has been advocated as an integral part of rotator cuff repair. Blevins et al.³⁷ reported that fifty-seven (89%) of sixty-four patients were satisfied with the result of a mini-open method of rotator cuff repair that included an arthroscopic acromioplasty and resection of the coracoacromial ligament. Gartsman et al.²⁸ performed arthroscopic acromioplasty with rotator cuff repair, after which the mean University of California Los Angeles score³⁸ improved from 12.4 to 31.1 points, the mean shoulder index of the American Shoulder and Elbow Surgeons³⁹ improved from 30.7 to 87.6 points, and the mean rating with the Constant and Murley system⁴⁰ improved from 41.7 to 83.6 points. Hawkins et al.⁴¹ reported that 86% of their patients had relief of pain after repair combined with acromioplasty. Romeo et al.⁴² reported a mean value of ten on the Simple Shoulder Test after rotator cuff repair with acromioplasty, a result that is comparable with the average outcome of the repairs without acromioplasty in the current series of patients.

Some surgeons have not included acromioplasty as a routine part of rotator cuff surgery. For example, Budoff et al.¹⁴ reported that partial-thickness tears were treated effectively without acromioplasty.

The current study showed that substantial and significant improvement in shoulder comfort and the ability to perform specific shoulder functions can be achieved with repair of full-thickness rotator cuff tears without acromioplasty or section of the coracoacromial ligament.

Although dissimilarities in assessment metrics have made it difficult to compare results among different series, McKee and Yoo¹ used the same assessment tools as were used in the current study when they evaluated the results of rotator cuff surgery with acromioplasty. They followed sixty-seven patients, who had an average age of fifty-six years, for twenty-four months after the surgery. Thirty-one patients had a rotator cuff repair as part of the surgery, although the data in that group were not analyzed separately. The results in the study by McKee and Yoo included an improvement from 21 to 42 points in the average physical role function score of the SF-36 and an improvement from 39 to 66 points in the average comfort score. We followed sixty-one patients, who had an average age of sixty-one years, for an average of sixty months after the surgery. Our results were comparable with those reported by McKee and Yoo, with our patients having an improvement from 33 to 56 points in the average physical role function score and an improvement from 40 to 67 points in the average

comfort score. The patients in the study by McKee and Yoo could perform an average of four functions on the Simple Shoulder Test before the rotator cuff surgery, which improved to an average of nine functions after the surgery ($p < 0.00001$). Our patients could perform an average of five functions before the rotator cuff repair, which improved to an average of nine functions after the surgery ($p < 0.0001$). Although the cohorts in the two studies were not identical, it is of interest that the improvements in the SF-36 and Simple Shoulder Test results were similar.

While it has been theorized that subacromial impingement contributes to the progression of cuff degeneration, it has not been established that acromioplasty effectively prevents progressive failure of the rotator cuff⁴³. It has been suggested that the primary mechanism of rotator cuff failure is tension, which is more likely to occur as a person ages and the cuff tendons undergo normal degenerative changes and weaken^{5,44,45}. Furthermore, while animal studies modeling subacromial impingement showed partial-thickness rotator cuff tears on the bursal side of the cuff⁴⁶, most partial-thickness tears in humans are found on the articular side of the rotator cuff^{5,47-49}. Finally, the gross and histological appearance of tendon adjacent to rotator cuff defects does not suggest either inflammation or abrasive wear⁵⁰. These findings all suggest that acromial abrasion on the cuff may not be the common pathogenic factor in cuff failure.

While the prevalence of complications after acromioplasty has not been rigorously documented, avoidance of acromioplasty eliminates those risks, which include the potential for deltoid detachment⁵⁻⁷ or weakening^{2,5,51,52}, anterosuperior instability^{5,53,54}, and formation of adhesions of the rotator cuff to the bleeding cancellous bone of an osteotomized acromion^{5,12,13,55}.

The current study has several limitations that are similar to the limitations of the study by McKee and Yoo¹. First, imaging tests were not done at the time of follow-up to determine the integrity of the rotator cuff. Second, the average duration of follow-up was only five years. Finally, there was no direct comparison between patients who had rotator cuff repair with acromioplasty and section of the coracoacromial arch and those who had rotator cuff repair without those procedures. However, none of these limitations compromised our conclusion that repair of full-thickness rotator cuff defects without acromioplasty resulted in significant functional improvement. ■

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References

- 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.
- Neer CS 2nd. Anterior acromioplasty for the chronic impingement syndrome in the shoulder: a preliminary report. *J Bone Joint Surg Am.* 1972;54:41-50.
- Packer NP, Calvert PT, Bayley JL, Kessel L. Operative treatment of chronic ruptures of the rotator cuff of the shoulder. *J Bone Joint Surg Br.* 1983;65:171-5.
- Codman EA. The shoulder: rupture of the supraspinatus tendon and other lesions in or about the subacromial bursa. Boston: T. Todd; 1934.
- Matsen FA 3rd, Arntz CT, Lippitt SB. Rotator cuff. In: Rockwood CA Jr, Matsen FA 3rd, editors. *The shoulder.* Volume 2. 2nd ed. Philadelphia: Saunders; 1998. p 755-839.
- Pollock RG, Flatow EL. The rotator cuff. Full-thickness tears. Mini-open repair. *Orthop Clin North Am.* 1997;28:169-77.
- Sher JS, Iannotti JP, Warner JJ, Groff Y, Williams GR. Surgical treatment of post-operative deltoid origin disruption. *Clin Orthop Relat Res.* 1997;343:93-8.
- Matsen FA 3rd, Lippitt SB. Principles of revision surgery. In: Matsen FA 3rd, Lippitt SB, DeBartolo SE, editors. *Shoulder surgery: principles and procedures.* Philadelphia: Saunders; 2004. p 713.
- Rockwood CA Jr, Matsen FA 3rd, Wirth MA, Lippitt SB. Rotator cuff. In: Rockwood CA Jr, Matsen FA 3rd, Wirth MA, Lippitt SB, editors. *The shoulder.* Volume 2. 3rd ed. Philadelphia: Saunders; 2004. p 847.
- Lee TQ, Black AD, Tibone JE, McMahon PJ. Release of the coracoacromial ligament can lead to glenohumeral laxity: a biomechanical study. *J Shoulder Elbow Surg.* 2001;10:68-72.
- Scheibel M, Lichtenberg S, Habermeyer P. Reversed arthroscopic subacromial decompression for massive rotator cuff tears. *J Shoulder Elbow Surg.* 2004;13:272-8.
- Liu SH, Panossian V, al-Shaikh R, Tomin E, Shepherd E, Finerman GA, Lane JM. Morphology and matrix composition during early tendon to bone healing. *Clin Orthop Relat Res.* 1997;339:253-60.
- Romeo AA, Loutzenheiser T, Rhee YG, Sidles JA, Harryman DT 2nd, Matsen FA 3rd. The humeroscapular motion interface. *Clin Orthop Relat Res.* 1998;350:120-7.
- Budoff JE, Nirschl RP, Guidi EJ. Debridement of partial-thickness tears of the rotator cuff without acromioplasty. Long-term follow-up and review of the literature. *J Bone Joint Surg Am.* 1998;80:733-48.
- Viola RW, Boatright KC, Smith KL, Sidles JA, Matsen FA 3rd. Do shoulder patients insured by workers' compensation present with worse self-assessed function and health status? *J Shoulder Elbow Surg.* 2000;9:368-72.
- Lippitt SB, Harryman DT 2nd, Matsen FA 3rd. A practical tool for evaluating function. The simple shoulder test. In: Matsen FA 3rd, Fu FH, Hawkins RJ, editors. *The shoulder: a balance of mobility and stability.* Rosemont, IL: American Academy of Orthopaedic Surgeons; 1993. p 501-18.
- Matsen FA 3rd, Ziegler DW, DeBartolo SE. Patient self-assessment of health status and function in glenohumeral degenerative joint disease. *J Shoulder Elbow Surg.* 1995;4:345-51.
- Ware JE Jr, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med Care.* 1992;30:473-83.
- Ware JE Jr, Snow KK, Kosinski M, Gandek B. SF-36 health survey: manual and interpretation guide. Boston: The Health Institute, New England Medical Center; 1993.
- O'Kane JW, Jackins S, Sidles JA, Smith KL, Matsen FA 3rd. Simple home program for frozen shoulder to improve patients' assessment of shoulder function and health status. *J Am Board Fam Pract.* 1999;12:270-7.
- Rozencaig R, van Noort A, Moskal MJ, Smith KL, Sidles JA, Matsen FA 3rd. The correlation of comorbidity with function of the shoulder and health status of patients who have glenohumeral degenerative joint disease. *J Bone Joint Surg Am.* 1998;80:1146-53.
- Soldatis JJ, Moseley JB, Etninan M. Shoulder symptoms in healthy athletes: a comparison of outcome scoring systems. *J Shoulder Elbow Surg.* 1997;6:265-71.
- Beaton DE, Richards RR. Measuring function of the shoulder. A cross-sectional comparison of five questionnaires. *J Bone Joint Surg Am.* 1996;78:882-90.
- Beaton D, Richards RR. Assessing the reliability and responsiveness of 5 shoulder questionnaires. *J Shoulder Elbow Surg.* 1998;7:565-72.
- Duckworth DG, Smith KL, Campbell B, Matsen FA 3rd. Self-assessment questionnaires document substantial variability in the clinical expression of rotator cuff tears. *J Shoulder Elbow Surg.* 1999;8:330-3.
- Radosevich DM, Wetzler H, Wilson SM. Health Status Questionnaire (HSQ) 2.0: scoring comparisons and reference data. Bloomington, MN: Health Outcomes Institute; 1994.
- Martin DP, Engelberg R, Agel J, Swiontkowski MF. Comparison of the Musculoskeletal Function Assessment questionnaire with the Short Form-36, the Western Ontario and McMaster Universities Osteoarthritis Index, and the Sickness Impact Profile health-status measures. *J Bone Joint Surg Am.* 1997;79:1323-35.
- Gartsman GM, Khan M, Hammerman SM. Arthroscopic repair of full-thickness tears of the rotator cuff. *J Bone Joint Surg Am.* 1998;80:832-40.
- Gartsman GM, Brinker MR, Khan M, Karahan M. Self-assessment of general health status in patients with five common shoulder conditions. *J Shoulder Elbow Surg.* 1998;7:228-37.
- Matsen FA 3rd, Lippitt SB. Procedure: rotator cuff repair. In: Matsen FA 3rd, Lippitt SB, DeBartolo SE, editors. *Shoulder surgery: principles and procedures.* Philadelphia: Saunders; 2004. p 347-77.
- Harryman DT 2nd, Mack LA, Wang KY, Jackins SE, Richardson ML, Matsen FA 3rd. Repairs of the rotator cuff. Correlation of functional results with integrity of the cuff. *J Bone Joint Surg Am.* 1991;73:982-9.
- Uthoff HK, Sano H, Trudel G, Ishii H. Early reactions after reimplantation of the tendon of supraspinatus into bone. A study in rabbits. *J Bone Joint Surg Br.* 2000;82:1072-6.
- Uthoff HK, Trudel G, Himori K. Relevance of pathology and basic research to the surgeon treating rotator cuff disease. *J Orthop Sci.* 2003;8:449-56.
- Liang MH, Fossel AH, Larson MG. Comparisons of five health status instruments for orthopedic evaluation. *Med Care.* 1990;28:632-42.
- Weinberg G, Schumaker JA, Oltman D. Statistics: an intuitive approach. Monterey, CA: Brooks/Cole; 1981. The t distribution and t tests. p 252-77.
- Weinberg G, Schumaker JA, Oltman D. Statistics: an intuitive approach. Monterey, CA: Brooks/Cole; 1981. Chi square tests for independence and goodness-of-fit. p 387-408.
- Blevins FT, Warren RF, Cavo C, Altchek DW, Dines D, Palletta G, Wickiewicz TL. Arthroscopic assisted rotator cuff repair: results using a mini-open deltoid splitting approach. *Arthroscopy.* 1996;12:50-9.
- Kay SP, Amstutz HC. Shoulder hemiarthroplasty at UCLA. *Clin Orthop Relat Res.* 1988;228:42-8.
- Richards RR, An KN, Bigliani LU, Friedman RJ, Gartsman GM, Gristina AG, Iannotti JP, Mow VC, Sidles JA, Zuckerman JD. A standardized method for the assessment of shoulder function. *J Shoulder Elbow Surg.* 1994;3:347-52.
- Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. *Clin Orthop Relat Res.* 1987;214:160-4.
- Hawkins RJ, Misamore GW, Hobeika PE. Surgery for full-thickness rotator cuff tears. *J Bone Joint Surg Am.* 1985;67:1349-55.
- Romeo AA, Hang DW, Bach BR Jr, Shott S. Repair of full thickness rotator cuff tears. Gender, age, and other factors affecting outcome. *Clin Orthop Relat Res.* 1999;367:243-55.
- Hyonen P, Lohi S, Jalavaara P. Open acromioplasty does not prevent the progression of an impingement syndrome to a tear. Nine-year follow-up of 96 cases. *J Bone Joint Surg Br.* 1998;80:813-6.

- 44.** Codman EA. Rupture of the supraspinatus—1834-1934. *J Bone Joint Surg.* 1937;19:643-52.
- 45.** Milgrom C, Schaffler M, Gilbert S, van Holsbeeck M. Rotator-cuff changes in asymptomatic adults. The effect of age, hand dominance and gender. *J Bone Joint Surg Br.* 1995;77:296-8.
- 46.** Schneeberger AG, Nyffeler RW, Gerber C. Structural changes of the rotator cuff caused by experimental subacromial impingement in the rat. *J Shoulder Elbow Surg.* 1998;7:375-80.
- 47.** Lohr JF, Uthoff HK. The microvascular pattern of the supraspinatus tendon. *Clin Orthop Relat Res.* 1990;254:35-8.
- 48.** Ozaki J, Fujimoto S, Nakagawa Y, Masuhara K, Tamai S. Tears of the rotator cuff of the shoulder associated with pathological changes in the acromion. A study in cadavera. *J Bone Joint Surg Am.* 1988;70:1224-30.
- 49.** Uthoff HK, Hammond DI, Sarkar K, Hooper GJ, Papoff WJ. The role of the coracoacromial ligament in the impingement syndrome. A clinical, radiological and histological study. *Int Orthop.* 1988;12:97-104.
- 50.** Nirschl RP. Rotator cuff tendinitis: basic concepts of pathoetiology. *Instr Course Lect.* 1989;38:439-45.
- 51.** Kumar VP, Satku K, Liu J, Shen Y. The anatomy of the anterior origin of the deltoid. *J Bone Joint Surg Br.* 1997;79:680-3.
- 52.** Torpey BM, Ikeda K, Weng M, van der Heeden D, Chao EY, McFarland EG. The deltoid muscle origin. Histologic characteristics and effects of subacromial decompression. *Am J Sports Med.* 1998;26:379-83. Erratum in: *Am J Sports Med.* 1998;26:743.
- 53.** Watson M. Major ruptures of the rotator cuff. The results of surgical repair in 89 patients. *J Bone Joint Surg Br.* 1985;67:618-24.
- 54.** Wiley AM. Superior humeral dislocation. A complication following decompression and debridement for rotator cuff tears. *Clin Orthop Relat Res.* 1991; 263:135-41.
- 55.** Harryman DT 2nd, Lazarus MD, Rozencwaig R. The stiff shoulder. In: Rockwood CA Jr, Matsen FA 3rd, editors. *The shoulder.* Volume 2. 2nd ed. Philadelphia: Saunders; 1998. p 1064-106.