Prospective Longitudinal Analysis of Postoperative Shoulder Function

A Ten-Year Follow-up Study of Full-Thickness Rotator Cuff Tears

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Background: Rotator cuff repair is associated with good short or mid-term results, but to date there have been no long-term functional outcome studies demonstrating durability of results over time. In most long-term studies, the results have been compared with those of historical controls or with those of other, short-term follow-up studies. The purpose of the present prospective study was to evaluate short and long-term shoulder function after surgical repair in a single population of patients in order to follow changes over time.

Methods: Thirty-three patients underwent surgery, performed by one surgeon, for the treatment of a chronic, symptomatic, full-thickness rotator cuff defect. Data were obtained from questionnaires and physical examinations preoperatively, at two years, and at ten years. Identical standardized pain and function questionnaires were used and clinical evaluation was performed in a consistent fashion at all time-periods. The activity level, Constant score, level of disability, shoulder function score, and patient's subjective rating of the outcome were determined at the time of the final follow-up and compared with the same parameters at the two-year follow-up examination in order to determine if early results change with time.

Results: At the ten-year follow-up examination, there was no change in the raw Constant score determined at the two-year examination. When the Constant score was normalized for expected age-related changes, the percentage of patients who had a satisfactory result at ten years was even greater than the percentage at two years. Activity level decreased significantly over the time-period ($p = 0.005$). At the final follow-up examination, twelve patients worked at the same occupation as they had when the two-year examination was performed, two worked at a less strenuous occupation, and the remaining patients were retired. Only two patients retired because of problems related to the shoulder. The level of disability decreased over the study period, and there was a small improvement in the patients' self-assessment shoulder function score. The patients' subjective assessment of the outcome remained unchanged.

Conclusions: The results of open rotator cuff repair for chronic tears do not deteriorate with time (ten years). The level of disability decreases, presumably because of a concurrent decrease in the activity level and in the demand on the shoulder as the patient ages. It is important to consider age-related changes when assessing the final outcome.

Surprisingly little information is available about the long-term durability of functional outcomes after rotator cuff repair. Although good short and mid-term results after acromioplasty and rotator cuff repair are well documented[1-10], few reports have provided long-term data. It is not known conclusively if short-term results deteriorate with time. This information can have important implications with regard to preoperative indications, postoperative counseling, and follow-up. Additionally, although the short-term relationship between selected preoperative and intraoperative variables and functional outcome is known[11], the implications over the long term are not.

The purpose of this prospective study was to quantitate shoulder function longitudinally ten years after rotator cuff surgery and to compare it with values obtained in the same patient group at the time of a two-year follow-up[11]. Patients were assessed for changes in the score described by Constant and Murley[12], level of disability, outcome rating, and activity level. To our knowledge, this study represents the longest prospective and longitudinal assessment of outcome after rotator cuff repair.

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Materials and Methods

Inclusion and Exclusion Criteria

All consecutive patients in whom a surgical repair of a full-thickness rotator cuff tear was attempted during the period from June 1988 to June 1990 were considered for inclusion in this study. Full-thickness rotator cuff tears were diagnosed preoperatively with either arthrography or magnetic resonance imaging. All patients underwent a course of conservative treatment including rest, anti-inflammatory medication, home-based physical therapy, and at least one corticosteroid injection to the subacromial space. All patients had symptoms for longer than three months before surgery. All had a positive impingement test, which was performed by the senior author (J.P.I.).

Patients were excluded if the tear was operated on within three months after the injury or if they had had previous surgery on the involved shoulder. They were also excluded if they had clinically symptomatic cervical spine disease, acromioclavicular degenerative joint disease, or a frozen shoulder. Of sixty-four patients operated on within the study period, forty-six met the inclusion criteria. Forty patients were available for formal evaluation two years after the operative procedure. They formed the group for longitudinal analysis.

At ten years, three patients had died. Two patients were contacted by telephone, but they could not return for reevaluation and therefore were not included in the study. One of these two patients had reinjured the shoulder and was doing poorly. The other continued to have relief of pain and improved function and was satisfied with the result of the surgery at the time of the final follow-up. Only two patients could not be contacted and were lost to follow-up. The remaining thirty-three patients were formally evaluated ten years after surgery.

The average age of the thirty-three patients at the time of the surgery was fifty-five years. The surgery was performed on the dominant extremity in twenty-six patients and on the nondominant extremity in seven. There were twenty-five men and eight women. Eighteen of the thirty-three patients were receiving Workers' Compensation at the time of the two-year evaluation. Only one patient still had an active Workers' Compensation claim at the time of final follow-up.

Surgical Procedure

All surgical procedures were performed with a standardized operative technique and postoperative protocol[11]. An acromioplasty was performed as described by Neer[13]. Tear size was measured in both the anteroposterior and the mediolateral dimension. A tear was considered to be small if it was <4 cm^2, medium if it was 4 to 9 cm^2, large if it was >9 to 18 cm^2, and massive if it was >18 cm^2.

Five patients had a modification of the standard surgical protocol. One patient had the proximal two-thirds of the subscapularis transferred superiorly to close a defect in the supraspinatus[14]. Four patients had an irreparable massive defect of the rotator cuff, which was debrided[15]. All patients followed a standardized rehabilitation protocol[11].

Outcome Assessment

All patients completed a standardized pain and function questionnaire before the surgery and at two and ten years after it. The form included visual analogue scales for pain at rest, pain with activities of daily living, and pain with strenuous activities such as reaching, lifting, pushing, and pulling. The function portion of the questionnaire addressed several activities of daily living such as personal care and lifting objects overhead. The patients rated their ability to perform each task on a numeric scale. In addition, a routine history was recorded and a physical examination was performed.

Quantitative strength measurements were performed with an isometric dynamometer (Isobex 2.0; Cursor AG, Bern, Switzerland), with elevation of the shoulder in the scapular plane, internal rotation, and external rotation, at all time-points with use of the standardized techniques described by

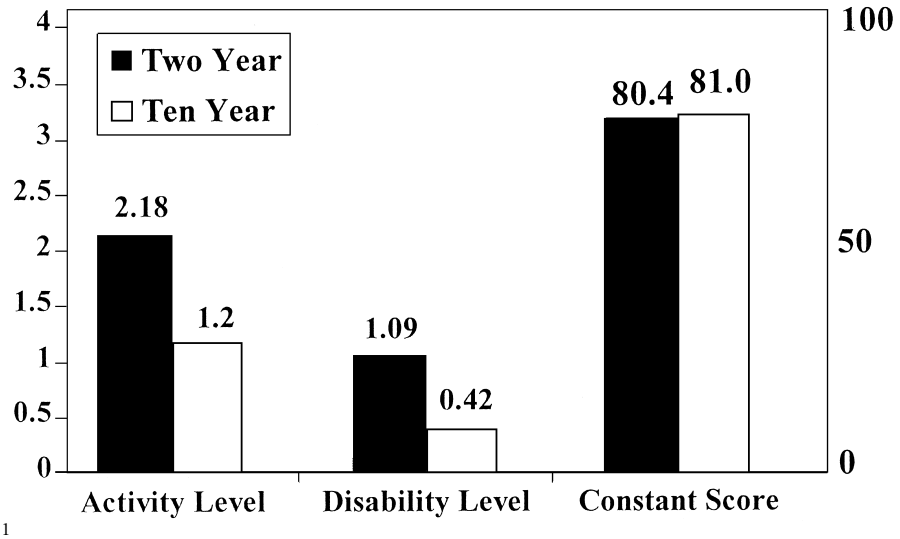

Fig. 1

Activity and disability levels decreased in the patient group, while raw Constant scores remained stable.

Kuhlman et al.[16]. These data were compared with measurements of the contralateral, asymptomatic shoulder. When the contralateral shoulder was symptomatic, the measurements were compared with those of members of an age and gender-matched control group[16]. Isometric strength scores were calculated on a 20-point scale[11]. A score of 20 points was assigned when isometric strength was ≤15% less than that of the contralateral shoulder; 10 points, when it was 16% to 25% less; 5 points, when it was 26% to 36% less; and 3 points, when it was 37% to 50% less. It was demonstrated that the rotator cuff is responsible for approximately 50% of overall shoulder strength in forward elevation and external rotation[17]. Therefore, no points were assigned for strength if the torque output was less than 50% of that of the contralateral shoulder.

A score was calculated according to the system of Constant and Murley[12] for each patient before surgery and at two and ten years after surgery. The scores were then normalized on the basis of accepted values that take into consideration age-related changes[12,18]. The final result was graded, with the normalized 100-point shoulder score, as excellent (90 to 100 points), good (80 to 89 points), fair (70 to 79 points), or poor (less than 70 points). Good and excellent Constant scores were considered satisfactory. Fair and poor Constant scores were considered unsatisfactory.

Subjective Assessment

Patients were asked to rate the postoperative result as "normal" when there was complete resolution of all symptoms, no pain with any activity, and a full return of function and as "nearly normal" when pain had been relieved to a great extent but mild pain that did not limit activity or require any medication was occasionally present. A rating of "improved" indicated that there was substantial relief of pain but the patient occasionally required non-narcotic analgesics. "Improved but with moderate pain" meant that there were limitations in some activities of daily living that often required medication or treatment. "Not improved" signified no improvement from the preoperative level, and "worse" meant that the pain was worse than before the surgery[11].

Activity Level

Overall activity levels were rated as sedentary, light, moderate, or strenuous. The patient was considered to be sedentary when he or she did not participate in sports and general lifting was limited to 15 lb (6.8 kg). Light activity was defined as participation in light recreational sports, such as golf or light gardening, or the ability to lift 25 to 30 lb (11.3 to 13.6 kg). Activity was considered moderate if the patient regularly participated in moderate-stress recreational sports, such as racket sports, gardening, and landscaping, or could lift 50 to 75 lb (22.7 to 34.0 kg) on a regular basis. Strenuous activity meant that the patient regularly participated in contact sports or overhead-throwing sports at a competitive level or could lift >75 to 100 lb (34.0 to 45.4 kg) on a regular basis. Activity level was defined on the basis of the most strenuous work or leisure activities that the patient performed on a regular basis.

Disability Rating

The normalized Constant score alone is not necessarily an accurate indication of disability. Despite having an excellent normalized Constant score, many patients had a disability compared with their counterparts with a lower premorbid activity level and a similar Constant score. Thus the normalized Constant score was used in conjunction with the patient's premorbid activity level to assign a disability rating[11] at two years (see Appendix). A new disability rating was assigned at the ten-year follow-up examination with use of the newly calculated normalized Constant score and the patient's adjusted activity level.

Statistical Analysis

A series of paired t tests were performed to compare two-year follow-up scores with ten-year follow-up scores. This method of analysis assumes that the data are symmetrically distributed around the mean. We checked for significant violations of this assumption. In addition, we performed Wilcoxon signed rank tests, which require no parametric assumption. All analyses were done with version 6.12 of the Statistical Analysis System (Cary, North Carolina).

Results

The two-year results in this patient population were published previously[11]. In summary, twenty-four (60%) of the original forty patients in the two-year study had an excellent normalized Constant score and eleven (28%) received a good score, with an overall rate of satisfactory results of 88%.

Outcome assessment: The raw Constant scores remained virtually unchanged over the time-period (Fig. 1). The average raw Constant score was 80.4 points at two years and 81.2 points at ten years. When the Constant scores were normalized, there was a slight improvement at ten years compared with the scores at two years ($p = 0.026$). At two years, 88% of the patients had a good or excellent normalized Constant score and a satisfactory result. At the time of the final follow-up, 91% (thirty) had a good or excellent normalized Constant score. There was also a small improvement in the shoulder function score for activities of daily living: the average percentage of the maximal score increased from 89% to 92% ($p = 0.04$). This small improvement coincides with the minor improvements seen in the Constant scores and may have been due to compensatory mechanisms developed over time.

Subjective assessment: The patients' subjective assessment of the outcome of the surgery remained unchanged over the study period. Most patients rated the shoulder as nearly normal at two years, and this rating remained the same at the final follow-up examination. There was a very high correlation between the two-year normalized Constant score and the patients' subjective assessment of the result, with 87% of the patients with an excellent normalized Constant score rating the shoulder as normal or nearly normal. Given the stability of the normalized Constant scores over this study period, the subjective assessment would be expected to remain the same. At the ten-year point, 93% of the patients with an excellent normalized Constant score rated the shoulder as normal or nearly normal.

Activity level: The activity level decreased significantly over the time-period ($p = 0.005$) (Fig. 1). At two years, five patients had a strenuous activity level; eight, a moderate level; ten, a light level; and ten, a sedentary level. At ten years, only three patients had a strenuous level, six had a moderate level, six had a light level, and eighteen were sedentary. Twelve patients were working at the same occupation as they had when the two-year follow-up examination was performed. All of these patients maintained the same activity level from the two to the ten-year time-period. Two patients continued to work but were performing a job that required a lower activity level. Seventeen patients were retired primarily because of their age and not because of shoulder-related problems. Two additional patients who were retired stated that they were no longer working because of poor shoulder function.

Disability rating: There was a significant decrease in the assigned disability rating over the study period ($p = 0.0002$) (Fig. 1). Eight patients (24%) had severe or moderate disability at two years, whereas only one patient had moderate disability at the time of the final follow-up. The other patients had no or mild disability. The decrease in the disability rating coincides with the decrease in the activity level and the increase in the age-adjusted Constant score.

At the time of the final follow-up, all patients with a small or medium-sized tear had a normalized Constant score in the excellent range. Of the nine patients with a large tear, seven had an excellent normalized Constant score and two had a good score. Of the eleven patients with a massive tear, seven had an excellent score; one, a good score; and three, a fair score.

Four of the patients had an irreparable rotator cuff tear at the time of surgery and underwent débridement of the cuff and subacromial decompression[15,19,20]. All four were retired at the time of the final follow-up, and only one of them stated that the shoulder was the reason. Three of these four patients had had a preoperative Workers' Compensation claim, which was not active at the time of the final follow-up. The normalized Constant scores of the four patients improved somewhat. At two years there were two good scores, one fair score, and one poor score, and at ten years there was one excellent score, one good score, and two fair scores. The disability rating decreased for three of the patients and remained the same for one. At ten years, one patient subjectively rated the shoulder as nearly normal, two patients thought that the shoulder was improved but with moderate pain, and one thought that the shoulder was not improved.

One patient underwent a subscapularis transfer to close a defect in the supraspinatus[14]. Her occupation and activity level at the time of the final follow-up were the same as those at the time of the two-year follow-up. Her disability rating decreased from mild at two years to none at ten years, primarily because her normalized Constant score increased from 92 to 100 points, giving her an excellent result at ten years.

Discussion

We are aware of only two retrospective, heterogeneous reviews providing information regarding the long-term outcome after rotator cuff repair. Adamson and Tibone[21], in a ten-year retrospective assessment of primary rotator cuff repairs in thirty patients, reported that 80% of the patients had a good result at ten years and 70% gave the result a good or excellent subjective rating. However, the patient population was heterogeneous, including young athletes as well as older patients with degenerative tears, so the outcome data are difficult to apply to specific populations. In another long-term study, Bigliani et al.[1] reported that, of sixty-one patients who had been followed for an average of seven years (range, three to thirteen years) after a repair of a massive rotator cuff tear, 85% had a satisfactory result. However, their study included no quantitative measurements of strength, and again the heterogeneity of the study group in terms of age and comorbidities made it difficult to interpret the findings in terms of specific populations. The lack of a validated, standardized outcome-assessment tool in both studies also made the findings difficult to compare. Additionally, as neither of these studies was longitudinal by design, the long-term durability of the outcome could not be tested. It is possible that the favorable long-term outcome reported in the studies could be explained in part by a decrease in activity levels and patient expectations over time.

In comparison, the prospective and longitudinal nature of our study provided several advantages with regard to outcome assessment: there were strict inclusion and exclusion criteria so a homogeneous population of more elderly patients was studied; a standardized and consistent outcome measure was used for both the short-term (two-year) and the long-term (ten-year) follow-up; functional outcome was tested in an objective fashion with use of an Isobex dynamometer to quantitate rotator cuff strength; a longitudinal analysis was performed by directly comparing the same patients at two-year and ten-year follow-up examinations; and, finally, the effect of patient activity on disability level was calculated.

Our study suggests that rotator cuff repair in an elderly population provides durable results. In this series, 88% of the patients had a good or excellent result at two years and 91% had a good or excellent result at ten years. The normalized Constant score was used to factor out any expected age-related changes. Even without normalization, the two and ten-year raw Constant scores were within 10 points of each other for most patients. The patients' subjective assessments of the outcome also remained unchanged over the study period, with most patients rating the shoulder as normal or nearly normal at both the two and the ten-year follow-up examination.

It should be noted, however, that the activity level of these patients decreased significantly over the extended time-period ($p = 0.005$). The average age of the group was fifty-five years at the time of surgery, so the majority were of retirement age at the completion of the study. Nineteen patients had retired, and this made a major difference in the level of activity in the group as a whole. We emphasize the need to consider the individual's activity level when evaluating outcome and disability.

Three patients had an unsatisfactory result according to the normalized Constant score. All of these patients had a massive rotator cuff tear at the time of surgery. All patients with a small or medium tear had a normalized Constant score in the excellent range at the time of the final follow-up. None of the patients underwent postoperative imaging, so it was not known how many defects healed or how many patients had a persistent or recurrent defect. We were unable to conclude whether outcome correlates with successful healing or whether a tear recurs over time. The purpose of the study, however, was to evaluate functional, not anatomic, outcome.

In summary, this prospective, longitudinal study suggests that the good and excellent results after surgery for repair of the rotator cuff do not deteriorate with time. Shoulder function, as assessed with the Constant score, remained stable, and when the score was normalized for age-related changes there was even a slight improvement in the results. This information has important implications for preoperative indications, postoperative counseling, and long-term follow-up.

Appendix

eA A table showing specific patient data (age; gender; duration of follow-up; and Constant score, normalized Constant score, subjective rating, activity level, and disability rating at two and ten years) is available with the electronic versions of this article, on our web site (www.jbjs.org) and on our CD-ROM (call 781-449-9780, ext. 140, to order). ■

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