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Long-term survivorship and outcomes after surgical repair of full-thickness rotator cuff tears

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Introduction: Rotator cuff injuries are commonly diagnosed orthopaedic conditions. The purpose of this study was to determine survivorship of primary open cuff repairs, with survivorship defined as a shoulder not requiring additional surgery.

Materials and methods: Between 1993 and 2004, open cuff repairs were performed in 254 patients (263 shoulders). All had a complete tear of the supraspinatus. In addition, 86 patients had tears of the infraspinatus and 50 had subscapularis tears. Survivors did not require further surgery. Survivorship was analyzed by use of the Kaplan-Meier method, and the log-rank test was used to compare survivorship between variables.

Results: After surgery, 233 of 263 patients (89%) were contacted for survivorship data. Overall, 11% of patients (26 of 233) in this cohort had another surgery, with a survivorship of 94% at 5 years and 83% at 10 years. Increased survivorship was associated with single-tendon repairs ($P = .02$). For survivors, the mean follow-up was 6.3 years (range, 1 to 16 years), and there was a statistically significant improvement in mean American Shoulder and Elbow Surgeons (ASES) score from 56 preoperatively to 88 postoperatively. Chronic tears and tears that involved the subscapularis had lower ASES scores, and satisfaction with surgical outcome was 8 on a 10-point scale.

Conclusion: Overall survivorship was 94% at 5 years after open rotator cuff surgery and 83% at 10 years. Among those patients who survived at 6.3 years, there was a mean 32-point increase in the ASES score and a rating for patient satisfaction with surgical outcomes of 8 of 10. As a consequence, most failures occurred in the first 2 years and if the cuff repairs survived the initial years, they were highly likely to survive over the 10-year period.

Level of evidence: Level IV, Case Series, Treatment Study.

Keywords: Open rotator cuff repair; Kaplan-Meier survivorship; outcomes; ASES score; patient satisfaction

Rotator cuff injuries are among the most commonly diagnosed upper extremity orthopaedic conditions.[2] Advances in shoulder surgery over the last few decades have provided pain relief and improved shoulder function in patients with rotator cuff tears.[1,3,6,8-10,28,30,34] Surgical techniques have also advanced in the last decade from an open approach, which allows full visualization of the

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rotator cuff, to a mini-open approach, which was less invasive.[1,2,5,31,33,36,37]

The first open rotator cuff repairs detached the deltoid and repaired the torn cuff tendon with sutures through transosseous tunnels.[18] A significant advancement in surgical technique spared the deltoid with a mini-open approach that used arthroscopy for the acromioplasty and a less invasive split in the deltoid to gain access to the tear.[4,37] The rotator cuff tendons were then repaired with transosseous sutures through bone tunnels, which then evolved to suture anchors that reapproximated tissue back to bone.[4,18] Historically, failure rates after rotator cuff repair have ranged from 6% to 32%.[5,15,16,35] In 2004, Williams et al[34] reported good to excellent clinical results 10 years after rotator cuff repair despite having a cuff rerupture rate of 20% to 65%. Zheng et al[38] reported that most cuff tendon repairs fail because of tendon failure at the suture-tendon junction, suture breakage, knot slippage, or anchor pullout. As surgical techniques evolved, the failure rates have improved.[22,36]

There are few studies that document long-term survivorship after open cuff repairs. Despite this, patients frequently ask about the risk of retear and the need for additional surgery. The purpose of this study was to determine the survivorship after primary open rotator cuff repair and examine factors that influence long-term survivorship, patient satisfaction, and functional outcomes.

Methods and materials

Patient population

Between 1993 and 2004, primary open rotator cuff repair was performed on 279 shoulders in 269 patients by a single surgeon. All patients included in this study had complete tears of the supraspinatus. In addition, patients with tears of the infraspinatus and/or subscapularis were included. All tears were surgically repaired by a standard open or mini-open approach. Patients were excluded if they had confounding co-pathology or treatments, such as advanced glenohumeral osteoarthritis, tendon transfers for cuff augmentation, total shoulder arthroplasty, or prior surgery. In this cohort of 269 patients, we were unable to perform postoperative subjective follow-up on 7 patients who refused to participate and another 8 who had died, leaving a study population of 254 patients (263 shoulders).

The mean subjective follow-up was 6.3 years (range, 1 to 16 years). At a minimum of 1 year after surgery (range, 1 to 16 years), 233 of 263 patients (89%) were contacted regarding survivorship data. There were 174 men and 59 women in this study group. The mean age at the time of index surgery was 58 years (range, 25 to 80 years) (Fig. 1). Surgery was performed on 72 left and 161 right shoulders. In addition to the supraspinatus, 86 shoulders also had infraspinatus tears and 50 shoulders had subscapularis tears. Of the patients, 124 had single-tendon tears repaired, 83 had 2-tendon tears repaired, and 26 had 3-tendon tears repaired. There were 203 shoulders with transosseous repairs or anchor repairs to the tuberosity and 30 with side-to-side repairs.

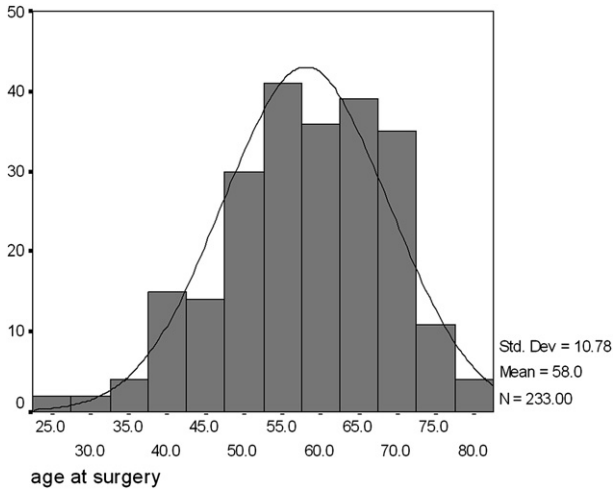

Figure 1 Age distribution for cohort.

The quality of tendon repair was rated intraoperatively, with an excellent rating in 51.5% of patients, good in 27%, fair in 6%, and poor in less than 1%. Of the patients, 15% were missing this objective assessment of the quality of repair by the surgeon. At the time of rotator cuff repair, 23 patients (10%) had a distal clavicle excision. Of the shoulders, 109 had an open acromioplasty, 97 had an arthroscopic acromioplasty, and 26 received a subacromial decompression without acromioplasty. Concomitant treatment of the long head of the biceps (LHB) tendon was performed in 69 shoulders, with 30 undergoing a biceps tenodesis and 39 undergoing simple biceps tenotomy.

At the time of repair, the number of tendons involved, type of repair, quality of repair, biceps treatment, and demographic data were documented. A subjective self-administered questionnaire was used to assess pain and function preoperatively. The questionnaire included the American Shoulder and Elbow Surgeons (ASES) score, which is a condition-specific instrument that was developed in 1994 for patients to report shoulder limitations.[27] The ASES score has been validated for rotator cuff pathology and consists of 2 equally weighted domains totaling 100 points.[17,19] Pain was measured on a scale from 0 to 10, with 0 indicating no pain and 10 indicating very bad pain. Patient satisfaction with surgical outcomes was measured on a scale from 1 to 10, with 10 being very satisfied and 1 being very unsatisfied. Patients were asked to complete the same pain and functional questions preoperatively and postoperatively. All data were collected prospectively, maintained in a clinical database, and analyzed retrospectively. Patients who did not return the questionnaire were contacted by phone and asked about further surgery to calculate survivorship. They were also encouraged to return the follow-up questionnaire for functional assessment. To reduce bias, no follow-up questionnaire data were documented by phone.

Surgical technique

After an interscalene block and general anesthetic, the patient was positioned in the beach-chair position and the affected arm was prepared and draped. Diagnostic arthroscopy was performed first, and intraoperative pathology was documented. When deemed necessary, an acromioplasty (n = 206) and distal clavicle excision

(n = 23) were performed along with LHB tenotomy (n = 69) before proceeding to the rotator cuff repair. The rotator cuff was repaired by similar techniques regardless of whether repair was done by a mini-open or open approach. The majority of cuff tears were secured in a transosseous manner or by suture anchor fixation methods (n = 168), but some tear patterns were fixed via side-to-side margin-convergence techniques (n = 30). Drill holes or suture anchors were placed in the juxta-articular cortex of the humerus for tendon fixation.[18] Tendons were then repaired with modified Mason-Allen sutures to secure the tendons to the tuberosity. After the rotator cuff repair, tenodesis of the biceps was performed in 30 patients. Thirty-nine were left with LHB tenotomy.

Rehabilitation

Patients in this series were started on gentle pendulum exercises and a passive elevation program on postoperative day 1. At first, the repaired shoulder was protected until the healing tissue was strong enough to begin active range of motion. The basic rehabilitation protocol included 3 phases.[20] When the tissue quality was good and the repair construct was strong, early passive range of motion was initiated with minimal loads across the repair for weeks 1 to 6 in phase 1 of rehabilitation. For weeks 6 to 12, phase 2 was initiated, which included active range-of-motion exercises that progressively applied loads to the repair construct and began to transfer loads back to the healing tissues. Phase 3 of rehabilitation consisted of strengthening exercises that focused on restoring power and endurance to the healed rotator cuff muscles. This began from week 8 to week 12 depending on the size of the tear and the security of the repair and was continued until 4 to 6 months postoperatively. Therefore, the basic postoperative rehabilitation goals were to mobilize the joint early, load the repaired cuff tendons safely, and strengthen the cuff muscles progressively.

Statistical analysis

Survivorship was defined as shoulders not requiring further surgery and was measured over the duration of the study. Nonsurvivors were defined as shoulders that required further surgery. The nonsurvivors (failures) were further categorized as having either surgically related complications, such as infection, stiffness, or retear, or another surgery for all other reasons. Survivorship was analyzed by use of the Kaplan-Meier method, and the log-rank test was used to compare survivorship between variables. The Kaplan-Meier method analyzed time to an endpoint, which in this study was a second surgery. Survivorship was calculated by taking a beginning point (index surgery) and a discrete time interval and counting the failures occurring in that time (1, 5, and 10 years). The Kaplan-Meier estimates the probability of the proportion of patients with subsequent surgery at a particular time and can account for patients who are lost to follow-up or have not reached future time points at the time of the analysis (censored data).

The ASES score (Kolmogorov-Smirnov $Z = 3.94$, $P < .001$) and patient satisfaction (Kolmogorov-Smirnov $Z = 2.44$, $P < .001$) were also statistically analyzed and showed significant departure from normal distribution. Nonparametric univariate analysis was performed with the Mann-Whitney U test for 2-group comparisons and Kruskal-Wallis analysis of variance for multiple-group comparisons. The Spearman ρ was used to assess associations between continuous variables. Statistical analysis was done with SPSS software, version 11.0 (SPSS, Chicago, IL). All reported P values are 2 tailed, with a α level of .05 indicating statistical significance.

Results

Survivorship

Follow-up was obtained in 89% of patients (233 of 263). Overall, 26 of the 233 patients (11%) reported having a subsequent surgery on their affected shoulder, with a mean time from index cuff repair to subsequent surgical intervention of 4.2 years (range, 15 days to 12.9 years). Of these patients, 7 (3%) had early surgical complications that required surgery at a mean of 268 days (range, 215 days to 2.9 years) and 19 (8%) had surgery for other reasons at a mean of 4.7 years (range, 15 days to 12.7 years). Four patients had surgery for infections at a mean of 385 days (range, 15 days to 2.9 years), with one of these patients also having had a deep vein thrombosis. Three patients underwent surgery for adhesive capsulitis at a mean of 127 days (range, 110 to 161 days) from the index operation. Nine patients had recurrent tears and underwent revision rotator cuff repair at a mean of 4.3 years (range, 215 days to 8.9 years), two patients had progressive arthritis and underwent shoulder arthroplasty, and four patients had various other surgeries (suprascapular nerve release, acromioclavicular reconstruction, biceps release, and biceps reattachment). Four patients reported another surgery on the affected shoulder but were unable to describe the type of surgery that was performed. Most failures occurred early, in the first 2 years. If patients' cuff surgery survived the first 2 years, it was likely to survive over the 10-year period.

The rate of revision rotator cuff repair, at a mean of 4.3 years (range, 215 days to 9 years), was 4%. Subsequent surgeries that did not involve the rotator cuff (arthroplasty, acromioclavicular reconstruction, biceps release, and biceps reattachment) were done at a mean of 5 years (range, 1 to 10 years). In the 2 subjects who had progressive glenohumeral arthrosis, one of the arthroplasties was performed 3 years after the rotator cuff repair and the other was done 8 years after repair. Overall, survivorship was 94% at 5 years after open rotator cuff surgery and 83% at 10 years (Fig. 2). Survivorship was not associated with age, gender, quality of repair, or biceps treatment. Increased survivorship was associated with single-tendon repairs as compared with multiple-tendon repairs (Fig. 3).

Outcomes

For the 217 shoulders that ''survived'' and did not undergo a subsequent surgery, the mean subjective follow-up was 6.3 years (range, 1 to 16 years). The mean postoperative ASES

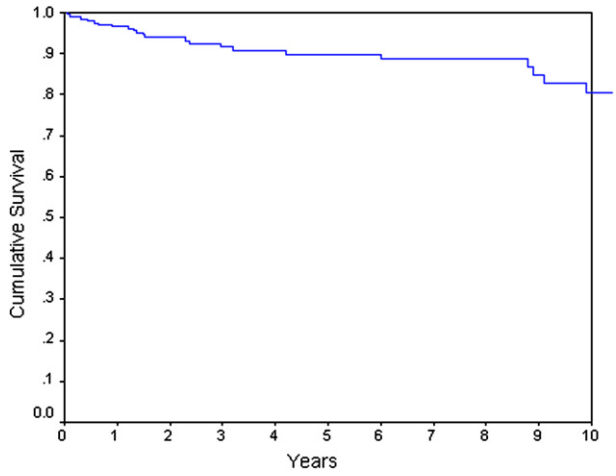

Figure 2 Overall survivorship was 94% at 5 years after open rotator cuff surgery and 83% at 10 years.

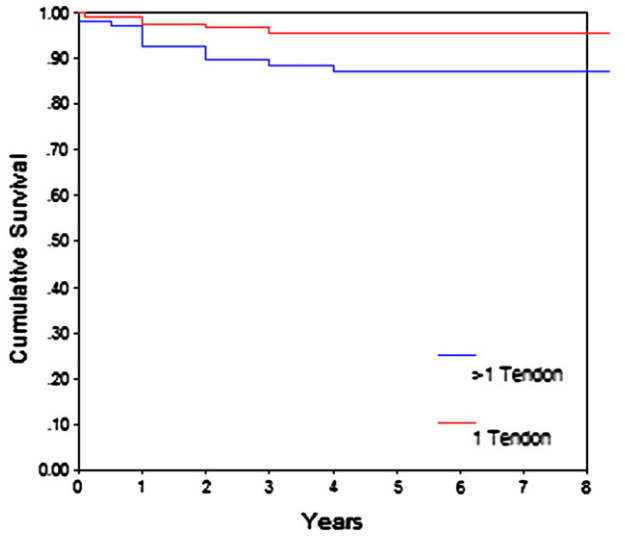

Figure 3 Increased survivorship was associated with 1 tendon having been repaired (*red line*) versus more than 1 tendon (*blue line*).

score was 88 (range, 28 to 100). This improved by a mean of 33 points (range, −24 to +72) from the preoperative score. The mean patient satisfaction with outcomes was 8 on a 10-point scale. Women had a statistically significantly greater improvement in ASES score, with a mean 44-point improvement (range, 8 to 72), where as men, who only had a mean 30-point improvement (range, −24 to 69) ($P = .005$). There was no significant difference in the final postoperative ASES score between women and men. In 2 patients, the surgeons rated the repaired tendon quality as poor; however, these patients did not progress to another surgery and had good outcome scores. One patient with poor tendon quality had 16 years' follow-up with an ASES score of 88 and was very satisfied with the outcome, and the other patient had an ASES score of 98 just over 2 years postoperatively.

There was a statistically significant difference in satisfaction with surgical outcomes in patients who had tendon quality rated as fair (mean satisfaction score, 4; range, 1 to 10) versus those with an excellent repair (mean, 8; range, 1 to 10) and those with a good-quality repair (mean, 7; range, 1 to 10) ($P = .007$). Adjusting for multiple comparisons with Bonferroni correction shows that the significant difference was between the group rated as having fair-quality tendon repair and the group rated as excellent ($P = .011$). The number of tendons involved also had a statistically significantly effect on patient satisfaction scores ($P = .02$). The mean patient satisfaction score for patients with single-tendon repair was 8 (range, 1 to 10). Patients with 3-tendon tears were significantly more satisfied, with a mean score of 9 (range, 1 to 10), than patients with 2-tendon tears, who had the lowest mean satisfaction score, at 7 (range, 1 to 10) ($P = .011$). There was no significant difference in the postoperative ASES score and the number of tendons repaired.

There was no significant difference in ASES score ($P = .34$) or patient satisfaction with surgical outcomes ($P = .71$) among acromioplasty treatment groups, indicating patients who received a subacromial decompress at the time of rotator cuff repair did not report higher patient satisfaction or a higher ASES score with outcomes. There was no significant difference in ASES score ($P = .21$) or satisfaction with surgical outcomes ($P = .64$) between types of tendon repair (side to side or trough/anchor).

There was a significant association between age and patient satisfaction with outcomes ($\rho = 0.18$, $P = .017$). When we compared outcome measures between patients aged 65 years or older (n = 79) and patients aged under 64 years and younger (n = 154) at follow-up, there was a significant difference in current pain levels ($P = .003$) and satisfaction with surgical outcomes ($P = .003$), with older patients doing better; however, postoperative ASES scores ($P = .12$) showed no differences. If patients' initial subjective complaint included loss of shoulder motion, they had a significantly lower preoperatively ASES score (mean, 49; range, 5 to 92) than those who did not complain of shoulder motion loss (mean, 61; range, 20 to 83). There was a significant negative association between months from injury to surgical intervention and postoperative ASES score ($\rho = -0.261$, $P = .009$). When we compared outcome measures between patients with and without complete tears of the subscapularis, the postoperative ASES score ($P = .67$) and satisfaction with outcomes ($P = .09$) showed no differences. Patients who reported a reinjury with no surgical intervention were significantly less satisfied (mean, 5; range, 1 to 10) than patients who had not had a reinjury (mean, 8; range, 1 to 10).

Discussion

This study showed that there is a high survivorship after rotator cuff repair, with an overall survivorship of 94% at 5

years and 83% at 10 years. Most failures occurred in the first 2 years. If the cuff repairs survived the first 2 years, then they were highly likely to survive over the 10-year period. This information is particularly useful for surgeons when counseling their patients about the overall success of this procedure. The study also showed that survivorship of open rotator cuff repairs was not associated with age, gender, type of repair, quality of repair, or biceps treatment but was associated with the number of tendons repaired. Patients with 3-tendon tears had lower survivorship yet had the highest satisfaction with their surgical outcomes. Overall, patients in this surgical cohort reported significant improvement in ASES score and had high patient satisfaction. The only factor that was associated with lower postoperative ASES scores was longer duration between injury and surgery. Factors associated with lower patient satisfaction were increased age at surgery, good to fair quality of tendon repair, and a 2-tendon tear, as well as whether the patient had had a reinjury.

The open rotator cuff repair technique is an established, successful surgical operation.[3,7,9,12] Patients needing surgery for a complication after primary open rotator cuff repair are rare.[23] In 2002, Herrera et al[13] reported a 1.9% incidence of infection after mini-open rotator cuff repair in 360 patients over a period of 9 years. Similar results were found in our study, with 4 of the 233 patients (1.7%) requiring surgical and medical treatment for infection. In 1 of these 4 patients, a deep vein thrombosis developed that resolved with medical treatment. However, 2 of these 4 patients had to have their rotator cuff repairs revised because of the infections. Postoperative infections are difficult to identify, because they often present in a delayed and subtle manner,[15] which may explain why the times between the index surgeries and debridements were so varied.

Another potential complication to the open technique is stiffness, with a 2% to 20% incidence reported in the literature.[11,32,34,35] Williams et al[34] and Yamaguchi et al[36] reported that the incidence of stiffness after open rotator cuff repair ranged between 11% and 20%. Mormino et al[21] reported on 13 patients who had subdeltoid adhesions after open cuff repair. Of the 13 patients in their study, 11 had undergone a prior open rotator cuff repair, which indicated a 4.8% captured or stiff shoulder complication rate. All patients were successfully treated with an arthroscopic release of the adhesions. In our cohort of 233 patients, 3 (1.3%) required capsular releases for stiffness. This lower rate of stiffness may be because of the early mobilization and aggressive physical therapy that were typically used during the early postoperative period.[18,20] Patients in this series were started on gentle pendulum exercises and a passive elevation program beginning on day 1 postoperatively.

In our study population, 19 patients required subsequent surgery for reasons not directly attributable to surgical complications. Two patients had total shoulder arthroplasties because of progressive osteoarthritis. One patient underwent biceps tenodesis, and another patient who had a biceps tenotomy at the time of the index procedure underwent reattachment with a biceps tenodesis. One patient required a nerve release after the rotator cuff repair but was unable to provide further details, and one worker's compensation patient underwent an acromioclavicular reconstruction and a SLAP (superior labrum anterior-posterior) repair. Four patients reported having additional surgeries at outside institutions after their index repairs, but they were unable to describe the surgeries performed.

Nine patients underwent revision repairs of the rotator cuff, for a revision rate of 3.9%. Published reports of rotator cuff repair failures are either reported as cuff retear rates or as patients who elected to proceed with revision surgery.[3,8,14,16,26] Posada et al found that 5 of 60 patients had a retear, for a rate of 8.0%, but the study did not indicate whether these 5 patients elected to have revision surgery.[25] Fuchs et al[8] reported a retear rate of 13%. Most of the patients in our study did not have subsequent imaging, so we cannot comment on the structural integrity or retear rates for this cohort. Our study did, however, show similar results to those of Cofield et al,[3] where 5 of 105 patients (4.7%) in their follow-up cohort had revision rotator cuff surgery, with a mean of 13.4 years' follow-up.

There are published reports documenting patient satisfaction and long-term outcomes after open rotator cuff repair.[3,9,29,37,39] Published studies consistently show improvements in pain and function from preoperative levels despite the presence of retears.[14,16,39] Patient satisfaction after rotator cuff repair is highly correlated with pain and function at follow-up.[24] We found the same correlations in this study between the subjective pain and function questions and satisfaction with surgical outcomes. Over 56% of the patients (131 of 233) indicated they were highly satisfied with their surgical outcomes. Unfortunately, 10% of the patients (23 of 233) indicated they were highly unsatisfied with their surgical outcomes.

This study had several limitations, which include the retrospective review of prospectively collected data. Patients with 3-tendon tears had the lowest survivorship yet had the highest satisfaction with their surgical outcomes when compared with patients with 1- and 2-tendon repairs, which is the exact opposite of what we expected. This might indicate that patient education and expectations after surgery may play a role in satisfaction levels. Selection bias from a sports medicine referral center could also have affected survivorship rates and outcome data, but with over 85% follow-up, we hope to have minimized any of these effects.[23] Another limitation was the choice of a subsequent surgery as an endpoint. Certainly, there may have been patients who were considered ''survivors'' because they did not undergo further surgery even though, clinically, they may not have been doing well. There are others who could have been doing well clinically but may have had structural failure of the repair. Postoperative imaging studies such as

magnetic resonance imaging were not included in the analyses to look at the integrity of the repairs. Jost et al[14] and Zumstein et al[39] showed that in patients with massive cuff repairs, good and excellent clinical results could be achieved despite having a retear rate of 37%. They found that patients with a retear had improvement from preoperative levels but those patients with a structurally intact repair had substantially better results. Although this study lacks follow-up rotator cuff structural data, the choice of subsequent surgery as an endpoint is a clinically important one that is easily documented and very meaningful not only to patients but also to the treating surgeon.

Conclusion

In this series of patients treated with traditional open surgical techniques, rotator cuff repairs had an overall survivorship of 94% at 5 years and 83% at 10 years. If the repair did not require surgical intervention within the first 2 years, then it was highly likely to survive over a period of 10 years. This study showed that survivorship after open surgical rotator cuff repair was not associated with age, gender, type of repair, quality of repair, or biceps treatment. There was an increased cuff repair survivorship in patients who had fewer tendons repaired. At final follow-up, patients who did not have subscapularis tears reported that they had significantly greater painless ranges of motion of their index arm than patients who had subscapularis tears. In those patients who did not undergo a subsequent surgery, the mean ASES score was 88 (range, 28 to 100) at a mean of 6.3 years postoperatively.

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