The anteromedial approach for shoulder arthroplasty: The importance of the anterior deltoid

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Protection of the anterior aspect of the deltoid muscle is critical to the success of shoulder arthroplasty. Between 1975 and 1980, 75 patients with 81 shoulder arthroplasties had exposure via the anteromedial approach with careful anterior deltoid detachment through fascial tissues, systematic repair, and standardized rehabilitation with early passive range of motion. As with other reports on arthroplasty, pain was significantly reduced and motion was improved. No anterior deltoid detachments occurred; deltoid strength was preserved. Greater postoperative deltoid strength was statistically associated with lesser postoperative pain, greater postoperative active elevation, improved limb function, and an enhanced overall result rating. To understand the contemporary indications for this approach better, those undergoing shoulder arthroplasty between 1990 and 1994 were assessed. The anteromedial approach was used in 14 of these 236 shoulders (5.9%). This approach is currently reserved for patients with frail anterior deltoids that will not tolerate retraction, with severely osteopenic humeral shafts that will not tolerate torsion, with extreme scarring and an inflexible deltoid muscle, with severe bony deformity, or with posterosuperior rotator cuff tearing requiring repair. The importance of the anterior deltoid in shoulder arthroplasty cannot be denied. Use of the extended deltopectoral approach with preservation of the deltoid origin insertion is a very positive step forward. In uncommon instances where added exposure is needed, the anteromedial approach with careful attention to incision and repair of the deltoid with appropriate postoperative rehabilitation can accomplish the goal of maintaining anterior deltoid function and enhancing the success of shoulder arthroplasty. (J Shoulder Elbow Surg 2004;13: 532–537.)

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Thompson[13] in 1918 described transverse section of the anterior deltoid near its origin from the clavicle and acromion as a part of exposure to the shoulder. A similar somewhat modified approach was described by Henry.[5] Cubbins et al[3] and Rowe and Zarins[12] suggested incising not only the anterior deltoid but additional aspects of the deltoid origin for exposure of complex chronic deformities. The anteromedial approach was illustrated in the 1939 edition of *Operative Orthopaedics* by Campbell[1] and usefully distinguished this exposure from the more extensive exposures advocated by Cubbins and others and the more contemporarily used long deltopectoral approach. However, precisely how the deltoid was incised and repaired is unclear.[6]

Earlier, when describing the operative technique for shoulder arthroplasty, Neer[7-8] suggested and illustrated the use of this anteromedial approach. Since the late 1970s, he has favored the extended deltopectoral approach to avoid weakening the anterior part of the deltoid and to facilitate postoperative rehabilitation.[9,10] The longer deltopectoral approach is recognized as the current standard for performance of shoulder arthroplasty.[4,11] However, we occasionally use the anteromedial approach for selected indications.

In this study we describe a technique of anterior deltoid origin incision and reattachment, to identify any unique complications of the anteromedial approach and to evaluate the outcome of shoulder arthroplasty undertaken by use of this exposure—with special attention to the anterior deltoid. In addition, we comment on what seem to be the contemporary indications for this surgical exposure to the shoulder.

MATERIALS AND METHODS

In 1984 we reported on patients undergoing total shoulder arthroplasty with the Neer prosthesis between December 1975 and December 1979.[2] In 1997 we reported on longer-term results of total shoulder arthroplasty with the Neer prosthesis in patients undergoing surgery between December 1975 and December 1980.[14] For the purposes

of this study, we re-reviewed a group of patients undergoing shoulder arthroplasty between 1975 and 1980 whose surgical treatment included the anteromedial approach to the shoulder as a routine part of arthroplasty and who were available for ongoing follow-up. The study proceeded after institutional review board approval. This group of 75 patients with 81 operative shoulders included 43 women and 32 men with a mean age of 56 years. Diagnostic indications for surgery were rheumatoid arthritis in 30 shoulders, posttraumatic arthritis in 21, osteoarthritis in 20, acute comminuted proximal humeral fractures in 4, osteonecrosis in 3, and rotator cuff tear arthropathy in 3. Previous surgery had been performed in 17 shoulders. The patients were followed up at regular intervals as previously described for shoulder arthroplasties at our institution.[2] Both preoperative and postoperative data were collected prospectively on a standard shoulder analysis sheet.[10] The data were then tabulated retrospectively. The preoperative and postoperative physical examinations were performed by the senior author. The most recent physical examination after the operation was done at a mean of 7.9 years (range, 1-20.2 years). The most recent patient contact by interview or questionnaire was done at a mean of 12.7 years after surgery (range, 2.1-20.4 years).

The general results of shoulder arthroplasty continue to be similar to the two previous reports. Postoperatively, the patients reported no pain in 43 shoulders, slight pain in 27, occasional moderate discomfort with unusually vigorous activities in 8, moderate pain in 3, and severe pain in 1. This last patient had a persistent reflex sympathetic dystrophy. Overall, there was a significant improvement in pain ($P < .0001$). The patients assessed their shoulders as much better in 49, better in 28, the same in 2, and worse in 2. Postoperative active elevation increased by a mean of 37° to a mean of 112° (range, 0°-180°). External rotation increased by a mean of 21° to a mean of 46° (range, 0°-100°). Internal rotation postoperatively ranged from the ability of the thumb to touch the abdomen to the ability of the thumb to touch T5. Postoperatively, there were significant increases in active elevation ($P < .0001$), external rotation ($P < .0001$), and internal rotation ($P = .001$).

There were 12 shoulders with complications requiring 7 reoperations. These included axillary nerve laceration in the axilla in 1, reflex sympathetic dystrophy in 2, heterotopic ossification in 1, anterior shoulder instability in 1, postoperative humeral shaft fractures in 2, delayed deep infection in 1, and component loosening in 4.

The clinical results were rated by the method of Neer and Cofield.[2,10,14] When this rating was applied to the 63 shoulders with standard rehabilitation, 26 were rated as excellent, 21 as satisfactory, and 16 as unsatisfactory—usually related to a restriction in active elevation. Of those 18 shoulders with limited rehabilitation goals, 7 were rated as successful and 11 as unsuccessful.

Anterior deltoid muscle strength was assessed on clinical examination by manual muscle testing for flexion. The strength of the anterior deltoid was graded as normal, good, fair, poor, trace, or no activity. Preoperatively, 27 anterior deltoids were graded as normal, 36 as good, and 18 as fair.

The daily function of the limbs with the operative shoulders was assessed by the patients grading their ability to perform 10 tasks (Table I). Each task was graded by patients according to their performance level as normal, difficult, possible with the aid of the opposite extremity, or unable to do. A scoring system was formulated: normal equals 10 points, difficult equals 6 points, with aid equals 3 points, and unable equals 0 points. A maximum score of 100 points could be obtained.

Table I Limb function and postoperative deltoid strength

Function	Deltoid strength*: Mean function score (rounded to nearest function level)			
	Normal (28)	Good (37)	Weak* (16)	*P* value†
Use back pocket	8	7	5	.017
Perineal care	9	9	5	.00002
Wash opposite axilla	9	8	5	.003
Eat with a utensil	10	9	6	.002
Comb hair	8	7	3	.0001
Use hand at shoulder level	7	7	3	.008
Carry 4 kg by side	8	6	5	.043
Dress	9	8	4	.00003
Sleep on affected side	9	8	5	.001
Do usual work	7	6	2	.002
Function score total*†	83	74	43	.0001

*Weak strength combines the grades of fair, poor, and no muscle activity.
†All function scores have a significant association with postoperative deltoid strength.

Statistical analysis was performed with the Wilcoxon rank sum test or the Kruskal-Wallis test for comparison of ordinal or continuous variables. Changes in ordinal or continuous variables were assessed with the Wilcoxon signed rank test. The Spearman rank correlation coefficient was used to test for association between pairs of continuous variables.

Operative technique

The skin incision is 1 cm lateral to the coracoid tip, extending from over the clavicle distally and laterally toward the anterior aspect of the deltoid insertion (Figure 1). The subcutaneous tissues are undermined to identify the anterior acromion, the attachment of the deltoid muscle on the lateral aspect of the clavicle, the anterior deltoid, and the deltopectoral interval. This interval is developed from proximal to distal, retracting the deltoid muscle laterally. The deltoid origin is then carefully incised[6] (Figure 2). The incision begins on the top of the clavicle between the deltoid and trapezius muscles. The deltoid and all attached fascia are then carefully elevated from the J-shaped attachment to the clavicle. The incision continues laterally over the acromioclavicular joint, leaving a portion of the thickness of the joint capsule intact. The incision then continues laterally over the anterior acromion, incising the fascia and elevating the muscle from the bone while preserving the acromial

Figure 1 The skin incision lies 1.5 cm medial to the acromioclavicular joint extending distally, lateral to the coracoid, ending 2 to 3 cm proximal to the anterior aspect of the deltoid insertion.

attachment of the coracoacromial ligament. Three medium-sized Kocher clamps are placed on the edge of the incised deltoid origin. These are then allowed to fall laterally and posteriorly, keeping the anterior deltoid lateral to the operative field. This is further aided after mobilization of the subacromial-subdeltoid bursa by placing a Richardson retractor lateral to the humeral head. Repair of the origin of the deltoid varies depending on the attachment site. No. 2 absorbable or nonabsorbable suture is placed through the bone of the acromion through use of either a trochar needle or burr holes. The suture is passed through approximately two thirds of a centimeter of the detached muscle. Simple sutures are used. Sutures progressing from lateral to medial are then placed through the bone of the anterior aspect of the acromion, through the capsule of the acromioclavicular joint, through the fascia and edge of the trapezius muscle attachment on the clavicle, and through burr holes on the upper and lower cortices of the mid clavicle (Figure 3).

In these 81 shoulders, the rotator cuff was judged to be normal or nearly normal in 42, the rotator cuff was thin in 18, and there was rotator cuff tearing in 21—all but 1 were fully repaired. There were 74 total shoulder arthroplasties and 7 humeral head replacements, all performed by use of Neer II components (3M Company, St Paul, MN). All glenoid components were cemented in place, as were 5 humeral components. Seventy-six humeral components were press-fitted. Postoperatively, the shoulder was managed in an immobilizer at night for 5 weeks and in a sling in the daytime for 4 weeks. For the full rehabilitation program, passive motion in elevation and external rotation was initiated on the first postoperative day within the limits of the rotator cuff or arthrotomy repair determined at surgery. Active assisted motion was started at 4 weeks, with isometric strengthening started at 6 weeks. In the 9 patients with greater tuberosity repair via wire fixation (4 acute fractures and 5 tuberosity osteotomies for malunion), the standard rehabilitation program was followed. For the 18 shoulders with more extensive rotator cuff tearing, a limited-goals rehabilitation program was defined to regain moderate motion but maintain stability.[10] Elevation was limited to 90°, and external rotation was equal to neutral, by use of the passive motion program for the first 6 weeks. Active assisted motion was then started for these patients, with strengthening deferred for another 6 weeks.

RESULTS

On physical examination, there were no detachments of the anterior deltoid. On postoperative strength assessment, the anterior deltoid was graded as normal in 28, good in 37, fair in 14, and poor in 1, and the deltoid had no activity in 1. When preoperative strength assessment was compared with postoperative evaluation, deltoid strength remained the same in 34, increased by one grade in 21, decreased by one grade in 20, increased by two grades in 3, decreased by two grades in 2, and decreased by four grades (from good to no activity) in 1. The patient with poor strength postoperatively had fair strength preoperatively, decreasing by one grade. The patient with no activity had a laceration of the axillary nerve in the axilla. He had an old traumatic deformity with multiple previous surgical procedures. Neurosurgical consultation was obtained at the time before the nerve was repaired, but no recovery occurred. Overall, there was no statistical difference between preoperative and postoperative anterior deltoid strength measurements ($P = .9$).

Anterior deltoid strength was associated with diagnosis, as patients with rheumatoid arthritis were weaker than those with osteoarthritis ($P = .004$) or posttraumatic arthritis ($P = .0003$). Lesser postoperative deltoid strength was associated with greater postoperative pain ($P = .002$). Preoperative and postop-

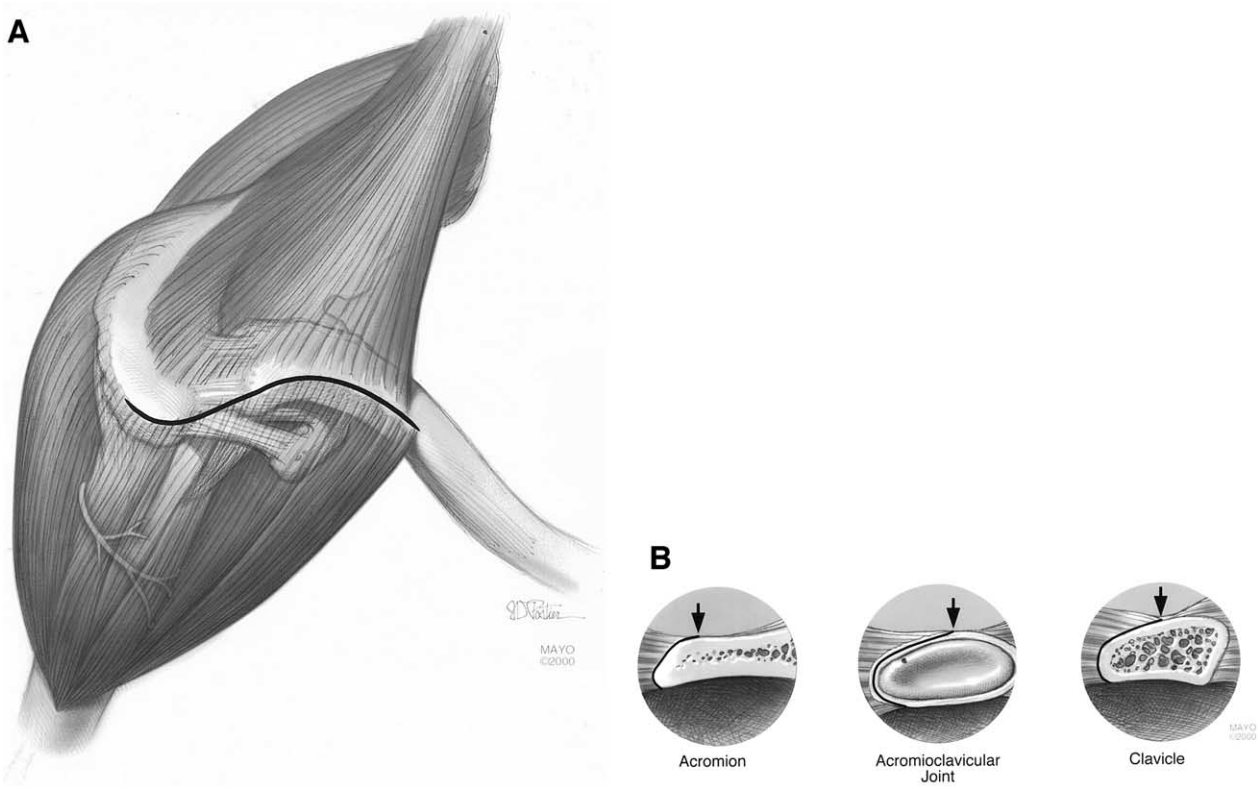

Figure 2 A, The recommended line of deltoid incision from the clavicle, acromioclavicular joint, and anterior acromion. **B**, The clavicle, acromioclavicular joint, and anterior acromion shown in cross section to illustrate the deltoid incision.

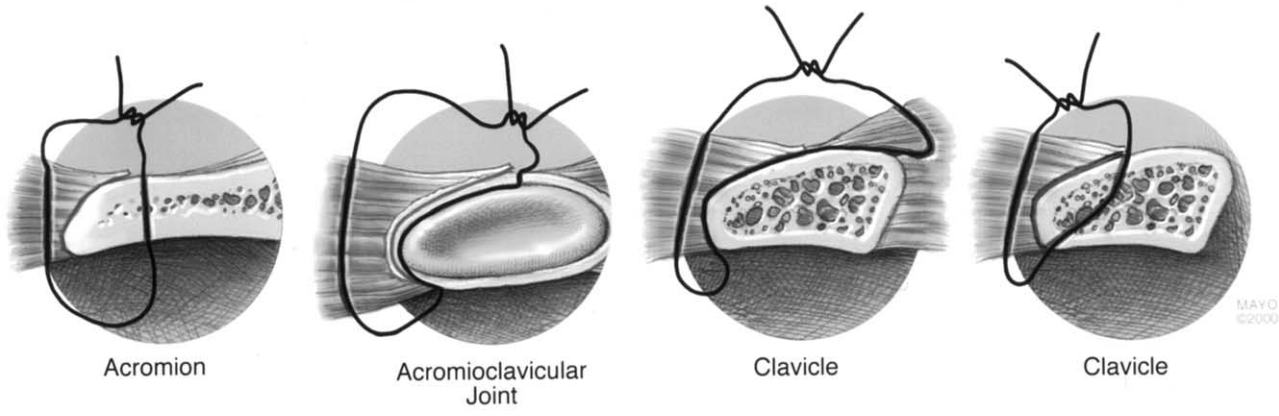

Figure 3 The clavicle, acromioclavicular joint, and anterior acromion shown in cross section to illustrate the repair of the deltoid origin to the bone of the acromion, the acromioclavicular joint capsule, and the fascia and muscle of the trapezius over the lateral aspect of the clavicle and through the clavicle itself (through burr holes) for the most medial 3 to 4 sutures.

erative deltoid strength was significantly associated with postoperative active elevation ($P = .0001$ and $P = .0003$). Postoperative anterior deltoid strength was also significantly associated with postoperative internal rotation ($P = .007$).

The 10 limb function activities are displayed relative to postoperative deltoid strength in Table I. Each function score (as defined earlier) and the total function score had a significant relationship with postoperative anterior deltoid strength. Functional scores

were not significantly associated with age, sex, diagnosis, status of the rotator cuff, or observed radiographic changes.

The overall result rating was highly dependent on both preoperative and postoperative anterior deltoid strength ($P = .002$ and $P = .0004$) and on the preoperative status of the rotator cuff ($P = .05$).

DISCUSSION

This study focuses on the importance of the anterior deltoid and the technical details in managing the anterior deltoid during the anteromedial approach for shoulder arthroplasty. Quite strikingly, in this patient group, a stronger anterior deltoid postoperatively was significantly associated with less postoperative pain, greater postoperative active elevation, greater postoperative internal rotation, increased function of the limb for all 10 activities assessed, and an improved overall result rating. Certainly maintaining, if not increasing, postoperative deltoid strength is associated with favorable outcome parameters for total shoulder arthroplasty.

The timing of this patient series—1975 through 1980—allowed us to develop the technique of performing the anteromedial approach safely by carefully incising the anterior deltoid origin through fascial tissue and not through muscle, by carefully reapproximating it to the acromion, the acromioclavicular joint capsule, the fascia and muscle of the trapezius, and the mid clavicle and by delaying active elevation and muscle strengthening. In performing this approach according to these parameters, there were no apparent anterior deltoid detachments, and on manual muscle testing, the deltoid muscle did not lose strength postoperatively on the basis of statistical assessment.

Currently, the extended deltopectoral approach is used for shoulder arthroplasty and seems to offer a great advantage in protecting the anterior portion of the deltoid muscle. We do, though, continue occasionally to use the anteromedial approach. We surveyed a second more contemporary patient group including those undergoing shoulder arthroplasty between 1990 and 1994. This included 236 shoulders with the diagnoses of osteoarthritis in 133, rheumatoid arthritis in 48, posttraumatic arthritis in 40, osteonecrosis in 8, and rotator cuff tear arthropathy in 7. In this more contemporary group, 14 (5.9%) had the anteromedial surgical approach whereas the remainder underwent the extended deltopectoral exposure. The anterior deltoid origin was released in 4 with rheumatoid arthritis, in 2 to protect a tight yet frail deltoid that would not withstand retraction, in 1 to protect a severely osteopenic humeral shaft, and in 1 to facilitate repair of a posterosuperior rotator cuff tear. The anteromedial exposure was used in 3 shoulders with old trauma. All 3 had had previous open reduction and internal fixation; the subdeltoid scarring was dense, the deltoid was inflexible, and deformity was present. The deformities were associated with a gunshot wound in 1 and greater tuberosity malunion in 2, requiring tuberosity osteotomy and fixation. Three revision shoulder arthroplasties underwent this approach. In 2, the anterior deltoid was tight yet frail and not of the strength to withstand retraction. In 1, there was a chronic posterior dislocation of the implant with a posterosuperior rotator cuff tear requiring repair. This approach was used in 2 patients with cuff tear arthropathy, both with repairable posterosuperior rotator cuff tears—one of which was a re-repair. One patient with osteoarthritis and a large repairable posterosuperior rotator cuff underwent this approach. One patient with osteonecrosis and severe osteopenia of the humerus had this approach.

In summary, there seem to be three major reasons for use of the anteromedial approach for shoulder arthroplasty. The first is for old trauma or revision shoulder arthroplasty in shoulders having had extensive previous surgery and having tight, stiff, and somewhat frail soft tissues associated with underlying bone deformity requiring correction. The second is for protection of a very frail anterior deltoid that will not withstand retraction or for a patient with severe osteopenia of the humeral shaft to protect against iatrogenic fracture; these conditions most commonly occur in patients in rheumatoid arthritis. The third reason is for enhanced access to repairs of posterosuperior rotator cuff tears done in conjunction with shoulder arthroplasty. We believe that these three factors will continue to be reasonable conditions in which to consider the anteromedial approach.

It seems impossible to deny the importance of the anterior deltoid in shoulder arthroplasty. Certainly, the extended deltopectoral approach with preservation of the deltoid origin and the majority of the deltoid insertion is a positive step toward maintaining or enhancing postoperative deltoid function. In those unusual circumstances (approximately 5%-6% of patients) in which added exposure is needed, the anteromedial approach with careful attention to incision of the deltoid, careful repair of the origin, and appropriate postoperative rehabilitation can be used to accomplish the goal of maintaining anterior deltoid function and enhancing the success of shoulder arthroplasty.

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