

Acromial Stress Fractures: Correlation With Acromioclavicular Osteoarthritis and Acromiohumeral Distance

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abstract

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Fractures around the acromion are a known complication of reverse total shoulder arthroplasty. The literature provides limited data on the risk factors associated with this complication as well as the ultimate outcomes after nonoperative treatment. The goal of this study was to report clinical outcomes in patients with acromial fractures after nonoperatively treated reverse total shoulder arthroplasty. The authors performed a retrospective review of 125 patients undergoing reverse total shoulder arthroplasty that included several acromial stress fractures in the postoperative period. They prospectively compared radiographic data, including acromiohumeral distance, the presence of acromioclavicular joint arthritis, clinical measures of motion, visual analog scale (VAS) pain score, American Shoulder and Elbow Surgeons (ASES) score, and Single Assessment Numeric Evaluation (SANE) score, in 2 groups based on the presence or absence of fracture in the postoperative period. Fourteen patients (11.2%) had an acromial fracture after reverse total shoulder arthroplasty at an average of 5.1 months postoperatively. Patients who had fractures had worse postoperative forward elevation before fracture (116.6 vs 143.5; $P=.02$) and greater pain relief after reverse shoulder replacement, before fracture ($P=.04$). No significant difference was found between groups when the degree of arm lengthening was compared (27.6 vs 26.2 mm), and no difference was found in the prevalence of degenerative acromioclavicular joint changes identified preoperatively (66.4% vs 77.3%). After conservative management, most patients who had an acromial fracture returned to a functional level that was comparable to that achieved before fracture. [Orthopedics. 2014; 37(12):e1074-e1079.]



Figure: Acromiohumeral distances were measured with conventional radiography. Measurements were performed from the dense cortical bone of the undersurface of the acromion to the greater tuberosity of the humeral head preoperatively.

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Reverse total shoulder arthroplasty is an effective treatment for disorders of the shoulder associated with a deficient rotator cuff; however, complication rates of 10% to 65% have been reported.¹⁻³ Acromial stress fracture is an uncommon but potentially debilitating complication of reverse total shoulder arthroplasty that occurs in 0.8% to 7.4% of patients.⁴⁻⁸ These fractures are believed to result from overtensioning of the deltoid with excessive distalization of the scapulohumeral articulation, which is believed to provide better shoulder elevation if performed correctly.⁹ Limited data are available on risk factors and overall clinical outcomes after acromial stress fracture, making prevention and treatment difficult.

This study reviewed the outcomes of conservative management after acromial stress fracture in a large cohort of patients after reverse total shoulder arthroplasty and compared outcomes against those of patients who did not have a fracture. Based on their clinical experience, the authors hypothesized that patients who sustained a fracture and completed a course of nonoperative management would achieve outcomes equivalent to those of patients who did not sustain a fracture.

MATERIALS AND METHODS

The authors conducted a retrospective review of 125 reverse total shoulder arthroplasty procedures performed by a single fellowship-trained shoulder surgeon at 1 institution between 2006 and 2011. These procedures were performed for painful and debilitating shoulder arthritis or a massive rotator cuff tear that was unresponsive to conservative management. Patients undergoing reverse total shoulder arthroplasty for revision of standard total shoulder arthroplasty or treatment of an acute proximal humerus fracture were excluded from the review. All acromial stress fractures that were recognized and treated during that period were included in the analysis. However, several cases of reverse total shoulder arthroplasty with-

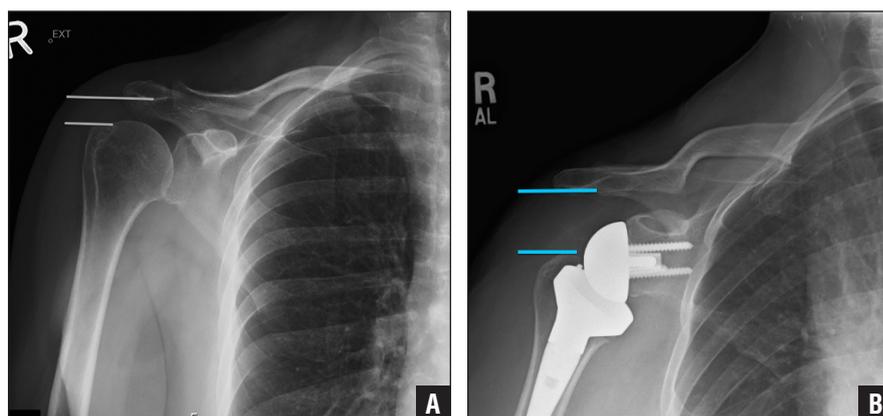


Figure: Acromiohumeral distances were measured with conventional radiography. Measurements were performed from the dense cortical bone of the undersurface of the acromion to the greater tuberosity of the humeral head preoperatively (A) and postoperatively (B) after reverse shoulder replacement.

out postoperative complications were not included in the review because long-term clinical data were not available for many patients. Therefore, this study represents a nonconsecutive series of reverse total shoulder arthroplasty in the authors' practice, collected to provide a representative comparison group for patients with acromial stress fractures.

A Grammont-style^{10,11} design reverse total shoulder arthroplasty (Tornier, Inc, Edina, Minnesota), characterized by a medialized and distalized center of rotation, was implanted in all patients with a standard deltopectoral approach in the beach chair position. The baseplate for the glenosphere (metaglene) was fixed to the glenoid with 4 screws. A superiorly directed screw, directed toward the base of the coracoid, was used in all patients. The postoperative rehabilitation protocol consisted of sling immobilization for 2 weeks, followed by progressive passive, active assisted, and active range of motion exercises over the next 6 weeks. Plain radiographic images consisting of a Grashey anteroposterior view, an axillary view, and a scapular Y view were obtained, according to the authors' normal routine, in the preoperative evaluation period and 1 week, 6 weeks, 3 months, 6 months, and 1 year postoperatively, and then annually.

Patients were diagnosed with postop-

erative acromial stress fracture when radiographs showed acromial displacement compared with previous radiographs. The authors obtained new imaging if the patient presented with new-onset shoulder pain or a history of trauma involving the operative extremity. The authors measured the acromiohumeral distance for all patients to determine the amount of arm lengthening imparted by the procedure and, for patients who sustained a fracture, to determine the change in this interval as a result of injury. The acromiohumeral distance was measured from the dense cortical bone of the undersurface of the acromion to the greater tuberosity with conventional radiography (**Figure**). Measurements were obtained by 2 fellowship-trained orthopedic surgeons specializing in shoulder surgery. Degenerative acromioclavicular joint changes were also evaluated preoperatively and documented for each patient because acromioclavicular joint stiffness could potentially increase the risk of acromial stress fracture. All fractures were treated nonoperatively with sling immobilization and a bone stimulator for 4 weeks. Alternating current electric stimulation, through the use of a bone stimulator, has previously shown to accelerate callus maturation and facilitates new bone bridging across fracture sites.¹² Passive range of motion under

Table 1

Clinical Outcomes				
Clinical Measure	Preoperative	Postoperative	Difference	P
Visual analog scale pain score, mean (SD)				
Overall	7.3 (2.1)	2.1 (2.5)	5.2	<.05
Group 1	7.2 (2.2)	2.1 (2.6)	5.1	<.05
Group 2	7.6 (1.6)	2.1 (1.7)	5.5	<.05
Active forward elevation, mean (SD), mm				
Overall	72.8 (38.8)	138.5 (38.5)	65.8	<.05
Group 1	72.7 (37.7)	143.5 (32.9)	70.8	<.05
Group 2	73.4 (44.7)	116.6 (52.6)	43.2	<.05
Active external rotation, mean (SD), mm				
Overall	20.7 (11.1)	49.6 (32.4)	28.9	<.05
Group 1	20.3 (11.2)	51.3 (31.4)	40.0	<.05
Group 2	22.4 (10.3)	41.7 (36.5)	19.3	<.05
Active internal rotation				
Overall	L5	Sacrum	N/A	.22
Group 1	L5	L5	N/A	.6
Group 2	L5	Sacrum	N/A	.09

Abbreviation: SD, standard deviation.

the guidance of a physical therapist was begun after the patient no longer reported pain in the shoulder.

Full clinical data were available for the 125 patients in this study and included active range of motion in forward elevation, external rotation, and internal rotation as well as a visual analog scale (VAS) pain score and functional measures recorded in the American Shoulder and Elbow Surgeons (ASES) score or Single Assessment Numeric Evaluation (SANE) score.¹³⁻¹⁵ Internal rotation was measured relative to the spinal level that patients could reach with the thumb. Each level was assigned a number (buttock=0, T9 and above=10) for analysis. All data sets were recorded at each scheduled follow-up visit at 1 week, 6 weeks, 3 months, 6 months, and yearly after surgery. Patients with incomplete data were excluded from analysis.

Statistical Analysis

Patients were divided into 2 groups. Group 1 included patients who did not

have an acromial fracture postoperatively. Group 2 included patients who had an acromial fracture at some point after reverse total shoulder arthroplasty. Count data were compared with Fisher’s exact test, and quantitative data were analyzed with Student’s *t* test. Statistical significance was set at *P*<.05.

RESULTS

The authors studied the outcomes of 125 patients (35 men and 90 women) who underwent reverse total shoulder arthroplasty at a mean age of 71.7 years (range, 46-93). The average length of follow-up was 19.7 months (range, 1-68). Acromial stress fractures were diagnosed in 14 patients at a mean of 5.1 months after surgery (range, 1-16). This group accounted for 11.2% of the patients studied. Because a nonconsecutive group was studied, this number does not represent the true incidence of acromial stress fracture encountered in the authors’ practice. Two fractures occurred in men, and 12 occurred in women.

The mean age of patients in group 1 (no fracture) was 71.6 years, and the mean age of patients in group 2 (fracture) was 72.1 years (*P*=.85). The proportion of men and women was not different between groups (*P*=.61). No significant differences were found in preoperative clinical measures (active forward elevation, active external rotation, VAS pain score) between groups (Table 1).

For the group as a whole, mean active forward elevation improved from 72.8° (standard deviation [SD], 38.8°) to 138.5° (SD, 38.5°) (*P*<.001) postoperatively. Group 1 showed significantly more improvement than group 2 before fracture, with active forward elevation reaching 143.5° (SD, 32.9°) compared with 116.6° (SD, 52.6°) (*P*=.02). No significant difference was found in postoperative forward elevation for group 2 when the visit before fracture was compared with the visit at which the fracture was diagnosed (114.5° vs 113.3°, *P*=.91). The final forward elevation achieved by patients after treatment of postoperative acromial stress fracture was 116.6°, which was significantly different (*P*=.02) from the final forward elevation achieved by patients who did not sustain a fracture (143.5°).

Mean active external rotation also improved for the cohort as a whole, from 20.7° (SD, 11.1°) to 49.6° (SD, 32.4°) postoperatively (*P*<.001). There was a trend toward a difference between the degree of external rotation measured in group 2 patients at the visit before fracture (27.5°±7.3°) compared with what was noted at the visit when fracture was recognized (43.3°±36.6°) (*P*=.08). No significant difference in improvement in external rotation was seen between group 1 and group 2 at final follow-up after the fracture group had been treated (*P*=.18).

Active internal rotation showed no significant improvement from preoperative to postoperative measurements (L5 preoperatively, sacrum postoperatively) (*P*=.22). No difference was detected between groups based on the presence or

absence of fracture (L5 in group 1 and L5 in group 2, $P=.15$). A trend toward a difference was noted in group 2 before and after fracture (L5 vs sacrum, $P=.09$).

Pain relief was significantly improved for the entire cohort at the time of final evaluation, with mean VAS pain score decreasing from 7.3 (SD, 2.1) preoperatively to 2.1 (SD, 2.5) postoperatively ($P<.001$). Group 1 showed a decrease in VAS pain score from 7.2 (SD, 2.2) to 2.1 (SD, 2.6) postoperatively. Group 2 also showed a decrease in VAS pain score from 7.6 (SD, 1.6) to 2.1 (SD, 1.7) at final evaluation, which was not different between groups ($P=.89$). However, at the clinic visit before the detection of acromial stress fracture, group 2 had a mean postoperative VAS pain score of 0.3 (SD, 0.67), which showed greater pain relief compared with group 1 ($P=.04$). The mean VAS pain score at the visit when acromial stress fracture was recognized was 3.5 (SD, 2.4). All patients showed clinical evidence of union by demonstrating improved motion and reduced pain at final follow-up. Radiographically, there was no evidence of further displacement at the fracture site, with bone callus formation visualized on radiograph.

The mean ASES score improved from 31.5 to 67.1 ($P<.001$) after reverse total shoulder arthroplasty. The mean ASES score for patients in group 2 at the visit before fracture was 67.5, which was not different from that group's final ASES score of 66.9 ($P=.70$). No difference was found between group 1 (67.0) and group 2 before ($P=.62$) and after fracture ($P=.48$). The mean SANE score improved from 20.3 to 78.5 ($P<.001$), and no difference was found between group 1 (79.2) and group 2 (77.8, $P=.58$) at final follow-up. The mean SANE score for patients in group 2 at the visit before fracture was 76.2, which was not different from the group's final SANE score (77.8, $P=.16$).

The prevalence of acromioclavicular joint arthritis was 66.4% (83 of 125), and

Table 2

Acromiohumeral Distance					
Group	Preoperative AHD	Postoperative AHD	Difference	Postfracture AHD	AHD Displacement
1 (no fracture), mean (SD), mm	12.4 (4.3)	40.1 (7.8)	27.6	N/A	N/A
2 (fracture), mean (SD), mm	11.6 (4.6)	38.0 (5.4)	26.4	28.8	9.2

Abbreviations: AHD, acromiohumeral distance; SD, standard deviation.

this prevalence was not different between group 1 (64.1%) and group 2 (77.3%) ($P=.23$). Acromiohumeral distance increased from a preoperative mean of 13.3 mm (SD, 4.3) to 41.9 mm (SD, 7.4) at the first postoperative visit ($P<.001$), and the degree of lengthening between group 1 (27.6 mm) and group 2 (26.2 mm) was not significantly different ($P=.09$). After fracture, mean acromiohumeral distance decreased from 38.0 mm to 28.8 mm ($P<.001$) (Table 2). Acromiohumeral distance did not show a significant change at final follow-up for patients who sustained an acromial stress fracture (29.2 mm) compared with the acromiohumeral distance noted at the time of fracture ($P=.36$).

DISCUSSION

The authors retrospectively reviewed 14 acromial stress fractures after reverse total shoulder arthroplasty performed by a single surgeon in a nonconsecutive series of patients to determine whether patients experience long-term sequelae when this injury is recognized and treated nonoperatively. Fractures occurred at a mean of 5.1 months after surgery, and patients who ultimately sustained a fracture showed reduced forward elevation after fracture compared with those who did not sustain a fracture. Interestingly, pain relief before fracture had been excellent. Conservative management of acromial stress fractures resulted in a small loss of motion compared

with what had been achieved before fracture, but clinical outcome scores (ASES, SANE, VAS) were not different at final follow-up compared with those achieved by patients who did not sustain a fracture. The degree of arm lengthening after reverse total shoulder arthroplasty and the presence of acromioclavicular joint arthritis before surgery were not predictive of fracture.

Acromial stress fracture is an infrequent complication of reverse total shoulder arthroplasty, but its effect on the treatment and ultimate outcome of patients has not been evaluated, causing patients and surgeons unease. The authors currently counsel their patients on the occurrence of acromial stress fracture as a potential complication, based on its incidence in the literature. Frankle et al⁵ reported an incidence of 3.3% (2 of 60), Hamid et al¹⁶ reported an incidence of 4.9% (8 of 162), Crosby et al¹⁷ reported an incidence of 5.5% (22 of 400), and Gerber et al¹⁰ reported an incidence of 6.9% (4 of 58). It has not been the authors' practice to evaluate patients postoperatively with computed tomography for fracture, and based on the results of the evaluation of clinical outcomes that showed no difference at final follow-up, such advanced imaging may not be necessary.

The clinical outcomes of patients who were managed conservatively for acromial stress fracture after reverse total shoulder arthroplasty are encouraging. In a recent study that included a survey of

ASES members, 53% of respondents believed that acromial fracture after reverse total shoulder arthroplasty led to reduced long-term function without persistent pain.¹⁶ The results of this study agree with this finding, although the reduction in function appeared to have occurred before fracture in many patients. Conservative management of these fractures, with immobilization, a bone stimulator, and gradual return to activity, produced functional outcomes and motion that were similar to what had been achieved before fracture. The limitation of motion that the authors observed without a significant increase in pain makes detection of patients who are at risk for fracture difficult. Reduced motion is often treated by more aggressive attempts at improvement with physical therapy, whereas painful motion is often an indicator that the patient should slow the pace of rehabilitation. The authors have not modified their postoperative protocol for patients after reverse total shoulder arthroplasty.

Unfortunately, no radiographic findings appear to be predictive of acromial stress fracture after reverse total shoulder arthroplasty. The degree of arm lengthening imparted by surgery was not predictive of fracture in the current study. Typically, reverse total shoulder arthroplasty using a Grammont-style prosthesis results in arm lengthening of approximately 2.5 cm, increasing the tension of the deltoid and improving motion while subsequently increasing the load on the acromion.⁹ Overall lengthening, as measured by acromiohumeral distance, was actually greater in the nonfracture group (27.6 mm) compared with the fracture group (26.2 mm). However, this difference was not significant. Crosby et al¹⁷ postulated that stiff, arthritic acromioclavicular joints concentrate stress on the acromion, increasing the risk of stress fracture after reverse total shoulder arthroplasty. However, based on the current results, the authors cannot determine whether this belief is accurate. Acromioclavicular joint OA was present

in most of the patients in both the fracture and nonfracture groups, although there was a greater prevalence in the fracture group (77.3%) vs the nonfracture group (64.1%) that was not statistically significant. Placement of the most superior screw in the metaglene baseplate is not recommended because it may lead to a stress riser that can contribute to fractures of the scapular spine.¹⁷ Superior metaglene screws were placed in all patients in this study, as is the authors' practice, and most patients did not sustain a fracture. Without radiographic parameters to guide treatment, modifiable patient factors may contribute to the risk of acromial stress fracture. In this patient population, it is likely that bone mineral density is low, and better attention to osteopenia and osteoporosis in patients undergoing reverse total shoulder arthroplasty could reduce the incidence of fracture. Although they attempt to optimize nutrition in all patients, the authors do not routinely obtain dual-energy x-ray absorptiometry scans or other testing for osteoporosis before surgery.

Limitations of this study include those associated with a retrospective case series. A nonconsecutive group of patients was examined. Therefore, the results should not be interpreted as representative of the true incidence of acromial stress fracture in their practice. Finally, no patients underwent operative intervention, so conclusions cannot be drawn about the relative value of nonoperative vs operative treatment.

CONCLUSION

Acromial stress fractures after reverse total shoulder arthroplasty can lead to a small reduction in motion but minimal change in pain or function after conservative treatment. Patients who sustained an acromial stress fracture had already shown reduced forward elevation before detection of the fracture, but had not reported pain. The degree of arm lengthening does not appear to be related

to the occurrence of fracture, nor does the presence of acromioclavicular joint arthritis. Because the authors could not identify clinical or radiographic signs of impending fracture risk, further study of modifiable patient factors ultimately may help to reduce the incidence of this frightening, but ultimately conquerable, complication of reverse total shoulder arthroplasty.

Acromial fractures are a relatively common complication of reverse total shoulder arthroplasty, but it is difficult to identify patients who are at risk. Fortunately, most patients appear to be able to return to the previous level of postoperative function after conservative treatment.

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