The natural history of acromial stress fracture after reverse total shoulder arthroplasty

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ABSTRACT
Background:
The purpose of our study was to observe the natural history of acromial stress fracture after reverse total shoulder arthroplasty.

Methods:
In a two-surgeon, single academic institution, seven patients with acromial fractures after reverse total shoulder arthroplasty were identified and evaluated for pain and functional outcome based on a visual analog scale (VAS), Disability of the Arm, Shoulder, and Hand (DASH) score, and range of motion to compare with results after uncomplicated reverse total shoulder arthroplasty. Outcomes of the acromial stress fracture group were broken down by Levy classification.

Results:
There was no significant difference in VAS, DASH score, or range of motion between Levy 1 and 2 and uncomplicated reverse total shoulder arthroplasty. Levy 3 had significantly decreased forward flexion compared with Levy 1 and 2. Multivariate logistic regression did not show any association between fracture and smoking status, hand dominance, gender, or age. Levy 3 acromial fractures fared worse in this series than the other fracture types, eventually requiring open reduction internal fixation.

Conclusions:
The natural history of patients after reverse total shoulder arthroplasty with an acromial fracture is similar to patients without acromial fracture regarding pain and function on a DASH score. Nonoperative treatment should be attempted for Levy 1 and Levy 2 acromial fractures before offering the patient operative treatment after reverse total shoulder arthroplasty. Levy 3 fractures potentially need operative fixation. Multicenter, prospective studies should be carried out to increase the sample size of patients with acromial stress fracture after reverse total shoulder arthroplasty to assess long-term outcome.

Level of Evidence:
Level III, therapeutic study.

Key Words
reverse total shoulder arthroplasty, acromion stress fracture

INTRODUCTION
Reverse total shoulder arthroplasty is a successful operation for patients with rotator cuff arthropathy. As the use of this procedure increases, so will its complications. Acromial stress fracture is a potential complication after reverse total shoulder arthroplasty that is reported in 0.8% to 11% of reverse total shoulder arthroplasties. Previous reports show that acromial fractures result in poor outcomes.

Levy et al. proposed a classification for acromial fractures after reverse total shoulder arthroplasty with function in mind. Higher grade-fractures involve a greater portion of the deltoid origin. Type-I fractures involve only a portion of the middle deltoid origin, type-II fractures involve at least the entire middle deltoid origin and may include a portion of the posterior deltoid origin, type-III involve the entire middle and posterior deltoid origin. The study by Levy et al. was underpowered to determine different outcomes of fracture subtype but found that type III fractures had inferior results.

The purpose of this study was to determine the natural history of acromial fracture after reverse total shoulder arthroplasty while distinguishing among the different Levy subtypes. We hypothesized that patients treated for Levy I or II subtypes of acromial stress fractures after reverse total shoulder arthroplasty will have equivalent Disability of the Arm, Shoulder, and Hand (DASH) scores, visual analog scale (VAS) pain scores, and functional outcomes compared with patients with uncomplicated reverse total shoulder arthroplasty.

MATERIALS AND METHODS
An Institutional Review Board-approved retrospective study was conducted on 102 reverse total shoulder arthroplasties by two orthopaedic surgeons, fellowship trained in sports at a single academic institution between June 2005 and February 2015. Annual volume increased each year. Because of the retrospective nature of the study, informed consent was waived. There were seven documented acromial stress fractures. Inclusion criteria were reverse total shoulder arthroplasty performed for rotator cuff arthropathy, post-traumatic arthritis, or acute three- or four-part proximal humeral fracture between this period of time. Revisions from hemiarthroplasty were included. Exclusion criteria were reverse total shoulder arthroplasty with function in mind. Higher grade-fractures involve a greater portion of the deltoid origin. Type-I fractures involve only a portion of the middle deltoid origin, type-II fractures involve at least the entire middle deltoid origin and may include a portion of the posterior deltoid origin, type-III involve the entire middle and posterior deltoid origin. The study by Levy et al. was underpowered to determine different outcomes of fracture subtype but found that type III fractures had inferior results.

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least one value for the DASH, VAS pain score, forward flexion, external rotation, or abduction that were included with the other values present. Primary outcomes included a DASH and VAS pain score postoperatively.

All patients were treated with the Depuy Reverse Total Shoulder System (Depuy Synthes, Rayham, MA) that was current at the time of surgery using a deltopectoral surgical approach. There were seven patients who presented postoperatively with pain along the acromion or scapular spine. Radiographs and CT scans were evaluated to identify postoperative fractures of the acromion. A Levy classification was determined for all acromial fractures.

Two fractures occurred in men, and five were in women. The average age of the patients was 76 yr (range, 69-83 yr) at the time of surgery. All patients were right-hand dominant, and four sustained acromial fractures in the dominant extremity. Patients began to complain of pain over the acromion or scapular spine at an average of 9 mo (range 1-32 mo) after surgery. Nonoperative treatment included a sling followed by pendulums, active, active-assisted and passive range of motion as comfort allowed. If the patient continued to have a fracture present on imaging and pain that the patient believed was limiting activities of daily living for more than 4 wk they were offered open reduction and internal fixation. The Levy classification was used by a fourth-year orthopaedic surgery resident to classify postoperative acromial fractures. Three fractures were Levy type I, two fractures were Levy type II, and two fractures were Levy type III.

Outcomes were evaluated for each patient, and comparisons were made for each acromial fracture subtype. Clinical outcomes included active shoulder motion (forward flexion, abduction, and external rotation) measured by one of the attending surgeons. Outcome measurements included the VAS for pain (a 10-point scale, with 0 indicating no pain, and 10, the worst pain imaginable) and a DASH score. All outcome measures were obtained at the most recent follow-up and were compared between the fracture groups and the group without complications postoperatively.

Univariate and multivariate regressions were used to correlate smoking status, handedness, gender, age, and current level of pain with outcomes of pain and DASH score among the fracture and no complication groups. A Student t-test was used for continuous variables and a chi-squared test for categorical variables.

RESULTS

Outcomes with regard to different acromial fracture subtypes are detailed. Between 2005 and 2015, the senior two authors performed 102 reverse total shoulder arthroplasties. Of the 102, 38 were ineligible because they were missing either a DASH or VAS score, or did not have objective findings for range of motion. Of the remaining eligible patients, final forward flexion for uncomplicated reverse total shoulders compared with acromial fractures after reverse total shoulder arthroplasty were 75 versus 72 degrees \( P = 0.82 \) (Figure 3). Average VAS score was 3.2 for the nonfracture group and 4.2 for the fracture group \( P = 0.50 \) (Figure 4). Average DASH score was 55.2 for the fracture group and 47.3 for the nonfracture group \( P = 0.44 \) (Figure 5).

There were three Levy I, two Levy II, and three Levy III fractures in our study. When comparing Levy I and II to the Levy III, the Levy type III had significantly worse forward flexion: 124 versus 90 degrees \( P = 0.004 \). The difference in external rotation was 15 versus 0 degrees \( P = 0.36 \), abduction was 82.5 versus 30 degrees \( P = 0.08 \), DASH scores 48.4 versus 48.2 \( P = 0.70 \) and VAS 4.5 versus 3 \( P = 0.66 \). The two Levy type III fractures in our series ultimately needed open reduction internal fixation, which was performed with Acumed scapular plates (Accumed, Hillsboro, Oregon). Other complications included one superficial skin infection, one axillary nerve palsy, and two dislocations, all in the nonfractured group. The superficial skin infection resolved with cephalosporin. The axillary nerve palsy resolved on its own, and the dislocations both needed open reduction and modular component revision.

Univariate, multivariate regression models did not find correlations between smoking status, hand dominance, gender, or age in regards to functional or pain outcomes.
DISCUSSION

The primary purpose of this study was to determine the natural history of atraumatic acromial fractures after reverse total shoulder arthroplasty. The secondary purpose of this study was to determine if outcomes differ between Levy classification subtypes.

In Levy et al.’s study, interobserver reliability was excellent with a correlation coefficient of 0.96. CT scans are often needed to identify fractures initially because atraumatic acromial fractures are difficult to detect. In addition to creating a useful classification for postoperative acromial and scapular fractures, Levy et al. concluded that nonoperative treatment leads to decreased functional outcomes. Outcomes for specific subtypes could not be determined because the study lacked statistical power.

Crosby et al. also classified scapular fractures after reverse total shoulder arthroplasty. Type-I fractures were avulsion fractures of the anterior acromion, type-II fractures were posterior to the acromioclavicular joint, and type-III fractures were of the scapular spine. In their study, type-I fractures were treated nonoperatively with resolution of symptoms, 70% of type II fractures were treated operatively with improvement of clinical symptoms (AC joint resection if stable, open reduction internal fixation if unstable), 100% of type III fractures were treated operatively with open reduction and internal fixation and all healed. They concluded that all type-II fractures treated nonoperatively displace with persistent but tolerable pain. They also recommended not using the superior metaglene screw if possible because it may be a stress riser for type III fractures.

Dubrow et al. retrospectively reviewed clinical outcomes of acromial stress fractures after reverse total shoulder arthroplasty. They found a small reduction in overall motion but no persistent pain or significant decrease in function. They determined that the superior metaglene screw did not increase the risk of fracture but noted that further study of modifiable patient factors may help to reduce the incidence of acromial stress fracture after reverse total shoulder arthroplasty.

Hattrup et al. reviewed the results of reverse total shoulder arthroplasty with acromial and scapular spine fracture compared with those without the complication. They found no significant differences between the fracture and nonfracture groups in regard to age, sex, side of surgery, or diagnosis. Clinical outcomes were decreased in the fracture group but still had better scores compared to prereverse total shoulder arthroplasty. The approximate deficit resulting from the fracture was 50% of the anticipated improvement in pain and active elevation and 60% in outcome scores when compared with the control group.

Hamid et al. retrospectively reviewed eight acromial fractures after reverse total shoulder arthroplasty of which six did not unite. They then surveyed other members of the American Shoulder and Elbow Surgeons (ASES) to determine management. Of the 18% who responded to the survey, 74% recommended nonoperative treatment, 53% thought that acromial fractures after reverse shoulder arthroplasty leads to reduced shoulder function but without persistent pain, and 22% thought that these patients would have decreased function and persistent pain.

Walch et al. examined the incidence of preoperative and postoperative lesions of the acromion and scapular spine and to analyze their influence on the results of surgery. Preoperative acromial pathology, surgical approach, amount of inferior acromial tilt did not diminish postoperative range of motion, Constant score, or subjective results compared to patients without acromial pathology. Four patients with postoperative acromial spine fractures had inferior results with respect to function and subjective results. Walch et al. recommended treatment with an abduction splint for 6 wk but did not comment on results. Os acromiale did not need to be fixed in association with reverse total shoulder arthroplasty to have good results.
In Wahlquist et al.’s7 series of five patients with acromial base fractures, three patients were treated with open reduction and internal fixation (one compression plate, one lag screw and tension band construct, one reconstruction plate with bone graft). Two patients were treated nonoperatively with an abduction pillow sling for 3 mo followed by advancement of passive and active range of motion once pain allowed. They reported that pain improved with fracture union but functional returns were unpredictable regardless of whether treated operatively or nonoperatively. In their series, acromial base fractures did worse than scapular spine fractures.

In our study 6.9% of patients had an acromial stress fractures after reverse total shoulder arthroplasty, which is in the range of 0.8-11% quoted in previous literature.1–7 In addition to the acromial stress fractures, there were four other complications, a total of 17% of cases with complications. DASH and VAS scores were not significantly different for patients with or without acromial fracture after reverse total shoulder arthroplasty. Levy subtypes I and II had satisfactory outcomes treated nonoperatively, but in our series, both with Levy type III went on to require open reduction and internal fixation (Figure 6). Post operatively, the Levy III forward flexion averaged 83 (60-106), ER 15 (0-30), and DASH averaged 42.3 (42-42.5). Perhaps with an increased sample size, there would have been more significant differences in external rotation, abduction, DASH score, and VAS.

As with the Levy et al.3 study, the greatest limitation of our study was sample size. Because of the the retrospective nature of the study, we were not able to gather a DASH, VAS score, or objective range of motion for all of the patients. We also did not obtain preoperative VAS or DASH scores, which would have been interesting to compare with postoperative VAS and DASH scores in the fracture and nonfracture groups. In addition, 38 of 102 patients did not have complete data for range of motion, VAS, or DASH score, which could have greatly affected our final results. Future multicenter studies with more patients would help to conclude if all Levy subtype III fractures should be treated operatively.

In conclusion, the Levy classification is useful to describe postoperative acromial fractures. Types I and II acromial fractures should initially be treated nonoperatively because the natural history suggests that even with slightly more pain, functional scores are not significantly worsened compared with patients who did not have an acromial fracture after reverse total shoulder arthroplasty. Future prospective studies with larger patient numbers are needed to determine the ideal treatment of Levy subtype II acromial fractures after reverse total shoulder arthroplasty.

REFERENCES


FIGURE 6. (A) Preoperative radiograph. (B) Postoperative reverse total shoulder arthroplasty. (C) Acromial fracture. (D) After open reduction and internal fixation of acromial fracture.