What is the effect of postoperative scapular fracture on outcomes of reverse shoulder arthroplasty?

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\textbf{Background:} Postoperative scapular fracture is a common complication after reverse shoulder arthroplasty (RSA). The purpose of this study was to determine its effect on RSA patient outcomes.

\textbf{Methods:} A retrospective, case-control study of 25 nonoperatively treated postoperative scapular fractures after RSA were analyzed with a minimum 2-year follow-up from surgery and 1-year follow-up from fracture. Eligible patients were matched 1:4 to a control group for age, sex, follow-up time, surgery indication, and primary operation vs revision. Outcome measures, including American Shoulder and Elbow Surgeons (ASES) score and range of motion, were compared between fracture cases and controls. Also analyzed were radiographic features, including fracture location (acromion vs scapular spine) and healing.

\textbf{Results:} Incidence of scapular fracture after RSA in this series was 3.1%. Fractures occurred from 1 to 94 months postoperatively. The revision rate was higher in the fracture group (8% vs 2%) but did not reach statistical significance ($P = .18$). Fracture patients had improved ($\Delta$ASES, 21) but inferior clinical outcomes, with a postoperative ASES score of 58.0 compared with 74.2 ($P \leq .001$). Change in range of motion also diminished in the fracture group, with a mean gain of 26\degree forward elevation compared with 76\degree ($P < .001$). Fracture location ($P = .54$) or healing ($P = .40$) did not affect outcome.

\textbf{Conclusion:} Postoperative scapular fractures may occur at any point postoperatively; increasing incidence is likely as longer follow-up becomes available. This complication leads to inferior clinical results compared with controls. However, patients show improvement compared with their preoperative measurements, even at longer-term follow-up. Patients with postoperative scapular fractures may have increased risk of revision.

\textbf{Level of evidence:} Level III, Case-Control Study, Treatment Study.

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\textbf{Keywords:} Scapular fracture; acromial fracture; reverse shoulder arthroplasty; nonoperative treatment; postoperative complication; outcomes

Reverse shoulder arthroplasty (RSA) is a common procedure for the management of difficult shoulder problems, such as massive and irreparable rotator cuff tears, with and without glenohumeral arthritis, rotator cuff deficiency.
secondary to proximal humeral fractures, and revision shoulder arthroplasty. Approximately 10,000 RSAs were performed in 2007, with estimates that 30,000 were performed in 2012. Although RSA has been shown to be a successful procedure at short-term and midterm follow-up, complications continue to be a concern, especially with increasing numbers of the procedure being performed. Scapular fractures after RSA have been reported in 0.8% to 7.2% in published studies.

A stable fulcrum in RSA is provided by an appropriately tensioned deltoid, which allows active shoulder elevation and a stable prosthesis. Failure to appropriately tension the deltoid may lead to prosthetic instability, neurologic injury, deltoid insufficiency, or scapular fractures. The acromial origin of the deltoid is important in deltoid tensioning and ultimate performance of the implant. Fractures that disrupt the appropriate tension of the deltoid may lead to deleterious consequences for the overall function of the implant.

Previous studies have reviewed the outcomes of scapular fractures after RSA at short-term follow-up. Hamid et al reported 8 fractures, all treated nonoperatively, at mean follow-up of 35 months and found poor elevation and American Shoulder and Elbow Surgeons (ASES) scores, with 6 of the 8 fractures going on to nonunion. Similarly, Hattrup reported 9 postoperative scapular fractures managed nonoperatively and found decreased active elevation and ASES scores compared with other patients undergoing RSA who did not experience a fracture. Walch et al similarly showed poor outcomes in 4 patients with postoperative scapular fractures; however, they also showed that preoperative lesions (os acromiale and acromial fragmentation) did not affect clinical outcomes in 41 patients with preoperative scapular insufficiency. They concluded that preoperative scapular lesions are an entirely different entity from postoperative fractures, which have deleterious consequences on outcomes.

Although these studies showed that postoperative acromial fractures likely lead to inferior outcome scores in the short-term compared with patients who did not experience this complication, none of these studies demonstrated whether these results remained consistent with longer-term follow-up from the fracture. Whether revision rates are affected by postoperative fractures, despite a report that scapular fractures led to subsequent instability, has also not been shown. Although there has been speculation that scapular spine fractures lead to inferior outcomes compared with acromial fractures, whether the fracture location is prognostic of outcome remains unclear. The 49 postoperative scapular fractures documented in previous reports occurred as early as 2 months and as late as 48 months. However, little information exists about the time period at which patients are at risk to develop this complication.

This study used case-control methods to determine whether patients with nonoperatively treated postoperative scapular fractures have inferior outcomes after RSA. We hypothesized that patients with postoperative scapular fractures would continue to have inferior clinical outcomes compared with matched controls without fractures at comparable postoperative follow-up. We also hypothesized that scapular fractures would lead to an increased reoperation rate compared with controls.

Finally, we sought to determine which features of scapular fractures might predict a poor outcome. We hypothesized that fracture healing would lead to improved outcomes compared with patients with nonunion and that scapular spine fractures have inferior outcomes compared with acromial fractures.

Materials and methods

A retrospective analysis of a consecutive, nonselected series of all RSAs performed by the senior surgeon (M.A.F.) from February 1, 2003, through May 31, 2010, was performed to evaluate for the complication of postoperative scapular fracture. During this interval, the senior author performed 1018 RSAs using the Reverse Shoulder Prosthesis (DJO Surgical, Austin, TX, USA). All procedures were performed through a standard deltopectoral approach.

The presence of a scapular fracture was determined by the senior surgeon, with a clinical presentation of pain over the acromion or scapular spine and radiographic confirmation. A total of 32 postoperative scapular fractures in 32 patients were identified. Of these, 27 were diagnosed with clear identification on plain radiographs and 5 with plain radiographs and a confirmatory computed tomography (CT) scan.

Inclusion criteria were all patients undergoing RSA by the senior author who sustained a postoperative scapular fracture and were managed nonoperatively with a minimum of 2 years of follow-up from the time of arthroplasty and 1 year of clinical follow-up since the documented scapular fracture. The analysis excluded patients who died or were lost to follow-up before clinical follow-up a minimum of 1 year from the fracture was obtained.

All postoperative scapular fractures were managed nonoperatively during the study period. Treatment consisted of sling immobilization for 6 weeks and then advancing activities as tolerated.
A total of 25 patients (25 shoulders) met the inclusion criteria. The analysis excluded 7 shoulders in 7 patients: 2 died before minimum 1-year follow-up data were obtained, 1 underwent resection of the implant for deep infection before clinical data were obtained, and 4 patients were lost to follow-up before 1-year follow-up from the fracture was obtained. Demographic data collected for each patient included age, sex, indications for surgery, history of previous surgery on the affected shoulder, and time from surgery to documented scapular fracture. Once the patients with postoperative scapular fracture were identified, a control group of patients undergoing RSA was matched for age, sex, total follow-up time, indication for surgery, and primary vs revision surgery at a ratio of 4:1 (control group:scapular fracture). A total of 100 patients (100 shoulders) were matched as controls. The control group was used to test the hypothesis that postoperative scapular fracture has a deleterious effect on outcomes after RSA.

The primary clinical outcome measure was the change from preoperative to postoperative total ASES score.20 The ASES score has not specifically been evaluated in this patient population but has acceptable psychometric performance for outcomes measurements for patients with rotator cuff disease and glenohumeral arthritis.15 Additional analyses included revision rate, range of motion, and pain scores. Outcomes for patients with postoperative fractures were recorded at the most recent follow-up with greater than 1 year of follow-up after the diagnosis of scapula fracture and a minimum of 2 years from the surgical date. Outcomes for control patients were obtained at the preoperative evaluation and the follow-up visit, with the same length of follow-up as the fracture patient to which they were matched.

Range of motion was determined by evaluation of digital videos of each patient obtained preoperatively and postoperatively, as previously described,6 or by the patient’s self-reported range of motion on a standard questionnaire. Pain scores were recorded from the patient’s self-reported level on a visual analog scale (VAS) at the most recent follow-up.13 Patients who underwent revision surgery were excluded from the analysis comparing clinical outcomes because they were considered failures of nonoperative management.

### Table I (A) Demographic characteristics of patients with postoperative acromial fracture

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (y)</th>
<th>Sex</th>
<th>Pre-op diagnosis</th>
<th>Time to fracture (mo)</th>
<th>Healed</th>
<th>Revised</th>
<th>ASES final$^{14}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>79</td>
<td>M</td>
<td>CTA</td>
<td>10</td>
<td>*</td>
<td>No</td>
<td>48</td>
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<td>28</td>
</tr>
<tr>
<td>5</td>
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<td>CTA</td>
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<td>No</td>
<td>55</td>
</tr>
<tr>
<td>6</td>
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<td>90</td>
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<tr>
<td>7</td>
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<td>35</td>
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<tr>
<td>8</td>
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<td>No</td>
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<tr>
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<tr>
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<td>*</td>
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<td>45</td>
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<tr>
<td>12</td>
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<td>Failed hemiarthroplasty</td>
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<td>13</td>
<td>56</td>
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<td>Failed TSA</td>
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<td>35</td>
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<td>14</td>
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<tr>
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<tr>
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<td>CTA</td>
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<td>17</td>
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<td>1</td>
<td>Yes</td>
<td>No</td>
<td>88</td>
</tr>
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</table>

ASES, American Shoulder and Elbow Surgeons; CTA, cuff tear arthropathy; F, female; M, male; RCR, rotator cuff repair; TSA, total shoulder arthroplasty.

* Did not have radiographic follow-up greater than 1 year from time of fracture.

### Table I (B) Demographic characteristics of patients with postoperative scapular body fracture

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (y)</th>
<th>Sex</th>
<th>Pre-op diagnosis</th>
<th>Time to fracture (mo)</th>
<th>Healed</th>
<th>Revised</th>
<th>ASES final$^{14}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>71</td>
<td>F</td>
<td>CTA</td>
<td>4</td>
<td>*</td>
<td>No</td>
<td>78</td>
</tr>
<tr>
<td>2</td>
<td>74</td>
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<td>CTA</td>
<td>30</td>
<td>No</td>
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<td>85</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
<td>F</td>
<td>Failed TSA</td>
<td>3</td>
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<td>Yes</td>
<td></td>
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<tr>
<td>4</td>
<td>75</td>
<td>F</td>
<td>Failed RCR</td>
<td>25</td>
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<td>No</td>
<td>80</td>
</tr>
<tr>
<td>5</td>
<td>71</td>
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<td>Failed RCR</td>
<td>82</td>
<td>Yes</td>
<td>No</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>76</td>
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<td>CTA</td>
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<td>33</td>
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<tr>
<td>7</td>
<td>72</td>
<td>F</td>
<td>CTA</td>
<td>10</td>
<td>No</td>
<td>No</td>
<td>40</td>
</tr>
<tr>
<td>8</td>
<td>75</td>
<td>M</td>
<td>Failed TSA</td>
<td>11</td>
<td>*</td>
<td>No, but instability</td>
<td>45</td>
</tr>
</tbody>
</table>

ASES, American Shoulder and Elbow Surgeons; CTA, cuff tear arthropathy; F, female; M, male; RCR, rotator cuff repair; TSA, total shoulder arthroplasty.

* Did not have radiographic follow-up greater than 1 year from time of fracture.
A complete set of radiographs, including anteroposterior, true anteroposterior in the plane of the scapula (Grashey), axillary lateral, and scapular Y, for each patient with postoperative scapular fracture were evaluated by 2 fellowship-trained shoulder surgeons not directly involved in the care of the patients (M.J.T. and R.J.O.) for evidence of healing at 1 year postoperatively or until fracture healing occurred (absence of fracture lucency). Fractures were also classified according to the location of the fracture: acromion or scapular spine based on Crosby’s classification. A previous report suggests that plain radiographs are not reliable for the diagnosis of these fractures, with only ∼80% of known fractures correctly diagnosed with plain radiographs alone. Also in this report, Crosby’s classification was only moderately reliable (κ = 0.422), suggesting the need for a more reliable classification scheme. A recent report suggests that a CT scan provides more reliable results at diagnosing these fractures; however, we did not obtain CT scans on all of these patients. The clinical outcome was evaluated with respect to fracture healing and fracture location.

### Table II

<table>
<thead>
<tr>
<th>Variables</th>
<th>Fractures (n = 25)</th>
<th>Controls (n = 100)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (range) mo</td>
<td>72.2 (56-83)</td>
<td>71.9 (48-85)</td>
<td>.84</td>
</tr>
<tr>
<td>Sex, No.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>21</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>4</td>
<td>16</td>
<td></td>
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<tr>
<td>Indication, No.</td>
<td></td>
<td></td>
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<tr>
<td>Primary CTA</td>
<td>17</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Failed RCR</td>
<td>3</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Failed TSA</td>
<td>3</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Failed hemiarthroplasty</td>
<td>2</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Length of follow-up</td>
<td>50 (24-106)</td>
<td>49.8 (24-121)</td>
<td>.97</td>
</tr>
</tbody>
</table>

CTA, cuff tear arthropathy; N/A, not applicable; RCR, rotator cuff repair; TSA, total shoulder arthroplasty.

* No significant differences found between cases and controls for any of the variables matched. Age was tested with the Student t test, sex with the Fisher exact test, and length of follow-up with the Mann-Whitney U test; significance at P < .05.

### Results

The Fisher exact test was used to test the hypothesis that patients with scapular fractures would have a higher revision rate than controls. The Mann-Whitney U test was used to test the hypothesis that patients with scapular fractures would have inferior outcomes than control patients and the hypothesis that patients with postoperative scapular fractures would have diminished satisfaction compared with controls. The Student t test was used to test the hypothesis that patients with scapular fractures have inferior range of motion compared with control patients, that patients with healed fractures have improved outcomes compared with those with nonunions, and that patients with type 3 (scapular spine) fractures have inferior outcomes compared with type 2 (acromial fractures). Statistical significance was set at <.05.

Figure 2. Example of an acromial fracture 3 months postoperatively, with excellent clinical outcome. American Shoulder and Elbow Surgeons score, 90.

Figure 3. Range of motion is shown in a patient with a postoperative acromial fracture, with excellent clinical outcome. Although this outcome is attainable in patients with postoperative acromial fractures, it occurred in a minority of cases.
Indications for surgery included 17 with massive rotator cuff tear, with or without arthritis, 3 failed rotator cuff repairs, 3 failed total shoulder arthroplasties, and 2 failed hemiarthroplasties. The average time to diagnosis of scapular fracture was 16 months (range, 1-94 months). Average follow-up from time of surgery was 50 months (range, 24-106 months; Fig. 1). Average follow-up from the time of the scapular fracture diagnosis was 45 months (range, 12-63 months; Table I, A and B).

The control group consisted of 100 patients (84 women, 16 men) who underwent a RSA and did not sustain a postoperative scapular fracture. Their average age was 71.9 years (range, 48-85 years). Indications for surgery included 65 patients with massive rotator cuff tear, with or without arthritis, 15 failed rotator cuff repairs, 12 failed total shoulder arthroplasties, and 8 failed hemiarthroplasties. Average follow-up from time of surgery was 49.8 months (range, 24-121 months; Table II).

Clinical outcomes

There were 4 revisions in the study group: 2 in the scapular fracture group (8%) and 2 (2%) in the control group ($P = .18$). A statistical power analysis revealed that to demonstrate a significant difference in revision rates, 191 postoperative scapular fractures would be required. One patient with a scapular spine fracture was revised 10 months after the fracture for glenoid loosening. A second patient with an acromial fracture was revised 2 weeks after the fracture for recurrent instability. One patient in the control group was revised at 28 months for humeral loosening. The second patient was revised at 77 months, also for humeral loosening. Of note, a third patient in with a scapular spine fracture noted recurrent instability 26 months after the fracture; however, this patient has not been revised.

The average preoperative total ASES score was 36.8 (range, 3-65) in patients with scapular fractures and 37.2 (range, 2-92) in the control group ($P = .94$). The average postoperative total ASES score was 58.0 (range, 15-90) in fracture patients (Figs. 2 and 3), whereas the average score in the control patients was 74.2 (range, 10-100; $P = .001$).

Average preoperative and postoperative range of motion in flexion, abduction, and external rotation for the fracture and control groups are shown in Figure 4. Flexion improved $26^\circ$ (range, $-65^\circ$ to $120^\circ$) in patients with scapula fractures and $76^\circ$ (range, $-43^\circ$ to $165^\circ$; Fig. 5 and Fig. 6) in the control group ($P \leq .001$). Abduction improved $16^\circ$ (range, $-95^\circ$ to $120^\circ$) in the fracture group and $72^\circ$ (range, $-20^\circ$ to $138^\circ$) in the control group ($P \leq .001$). Patients with fractures lost an average of $3^\circ$ (range, $-70^\circ$ to $30^\circ$) of external rotation, and controls gained $23^\circ$ (range, $-62^\circ$ to $90^\circ$) external rotation ($P < .001$). Patients without scapular fractures had a greater level of satisfaction with the surgery (8.7; range, 1-10) than patients with scapular fractures (6.6; range 1-10; $P = .002$).

Radiographic results

There were 17 acromial fractures and 8 scapular spine fractures. The average final ASES score was 59.9 (range, 28.3-90; Figs. 7 and 8) of acromial fractures and 53.8 for scapular spine fractures (range, 15-85; $P = .54$). The average final VAS pain score was 2.4 (range, 0-10) for acromial fractures and 2.3 (range, 0-6) in scapular spine fractures.
fractures \((P = .96)\). The average increase in forward elevation was 29° (range, −65 to 120°) for acromial fractures and 19° (range, −30° to 66°) for scapular spine fractures \((P = .66)\).

Only 10 of 18 fractures (55%) with greater than 1 year of radiographic follow-up showed osseous union of the fracture, as evaluated by 2 independent blinded reviewers with excellent agreement (Figs. 7 and 8). The union rate was 57% (8 of 14) for acromial fractures and 50% (2 of 4) for scapular spine fractures.

The average ASES score was 56.3 (range, 15-90) in fractures that healed and 65.2 (range, 40-85) in fractures that went on to nonunion \((P = .40)\). The average final VAS pain score was 0.9 (range, 0-4) for healed fractures and 2.7 (range, 0-8) in patients with nonunions \((P = .18)\). The average increase in forward elevation was 26.4° (range, −18° to 95°) for healed fractures and 20.8° (range, −65° to 93°) in patients with nonunions \((P = .79)\).

**Discussion**

Scapular fracture after RSA is a well-defined but poorly understood complication. The incidence of fracture in our series was 3.1%, which is consistent with prior studies that have reported rates from 0.9% to 7.2%. Although this is an infrequent complication, it is undoubtedly under-reported due to difficulty in diagnosis. Otto et al showed that only 79% of these fractures are identified by blinded reviewers with plain radiographs alone. To make this diagnosis, a high index of suspicion must be maintained for patients who present with scapular pain after RSA. The incidence of 3.1% in our series is likely an underestimate of the true incidence of this complication and could possibly be closer...
to 4% when estimating that 20% of these are missed radiographically.

This study demonstrates that patients with postoperative scapular fractures have inferior outcomes compared with controls. Although the long-term outcome of patients with fractures is inferior, these patients still have clinical improvement from their preoperative functional level, noted by a preoperative ASES of 37 to postoperative ASES of 58 (change, 21 points). Similar to the ASES score, objectively decreased range of motion was found in patients with fractures compared with controls; but again, range of motion was improved compared with preoperative values. Therefore, we can conclude that although postoperative scapular fractures have a negative effect on outcomes compared with controls, these patients still have clinical improvement compared with their preoperative state.

Although our data are consistent with previous reports regarding clinical outcomes, no prior study has been able to demonstrate whether patients with scapular fractures are at increased risk for revision surgery. Our study showed that patients with scapular fractures had an 8% revision rate compared with 2% for controls, but this did not reach statistical significance due to the infrequency of revision surgery in both groups ($P = .18$). Previous authors have speculated that scapular spine fractures are at increased risk for instability and poorer outcomes requiring revision surgery. This was not our experience, however: one revision was for glenoid baseplate loosening in a patient with a scapular spine fracture and the other was for instability in a patient with an acromial fracture.

This study is the first with longer-term follow-up to demonstrate that scapular fractures can occur at any point in the postoperative period. Previous reports on scapular fractures after RSA showed they occurred from 2 months to 48 months postoperatively. Our data showed that these fractures can occur at any point in the postoperative period, from as early as 4 weeks to nearly 8 years (94 months). Therefore, the surgeon must maintain a high index of suspicion for this complication whenever a patient presents with scapular pain after RSA. As more RSA procedures are being performed and longer-term follow-up becomes available, the frequency of this complication will undoubtedly increase.

One limitation of this study was the retrospective nature of identification of scapular fracture patients. Given the difficulty of making this diagnosis clinically and radiographically, it is likely that not all patients sustaining this complication were identified in the database, which might have influenced the results.

Second, all patients were managed nonoperatively for their scapular fracture; thus, the conclusions of this study are only applicable to nonoperatively treated fractures. Whether improved outcomes may be obtained with operative intervention remains unknown. This study provides a benchmark for outcomes of nonoperative management of this complication should other authors elect to pursue operative fixation.
The strengths of this study include the strict case-control methodology in a 4:1 manner to assess outcome differences between scapular fracture patients and controls. Another is the large number of fractures available for analysis. Compared with other studies, this is the largest study of postoperative scapular fractures in the literature to date, with the longest-term follow-up from fracture (average, 45 months), and provides conclusions regarding the natural history of this complication.

**Conclusion**

Postoperative scapular fractures after RSA are becoming a greater concern with the increasing use of RSA worldwide. Patients who experience this complication may be at increased risk for revision surgery and experience inferior outcomes compared with patients without fractures. The location of the scapular fracture (acromion or spine) does not affect the results. Treatment focused at prevention of this complication is paramount to optimize outcomes after RSA.

**Disclaimer**

DJO Surgical provided research support to the Foundation for Orthopaedic Research and Education; however, DJO Surgical did not have input into this study because this was an investigator-initiated study.

Randall J. Otto, MD, received consulting fees or honoraria for conducting lecture and cadaver teaching sessions from DJO Surgical, a designer and manufacturer of orthopedic surgical products related to the subject of this work. The research foundation that Benjamin J. Cottrell, BS, is affiliated with received research support from DJO Surgical, a designer and manufacturer of orthopedic surgical products related to the subject of this work. Mark A. Frankle, MD, receives royalties from and is a paid consultant for DJO Surgical, a designer and manufacturer of orthopedic surgical products related to the subject of this work. Matthew J. Teusink, MD, his immediate family, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

**References**


