

SYSTEMATIC REVIEW

Acromial Stress Fractures: A Systematic Review

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Abstract

Background: Acromial stress fracture (ASF) is a unique complication of reverse shoulder arthroplasty (RSA) that can have substantial influence on clinical results. The purpose of this review is to describe demographics, functional outcomes, and union rates for cases of RSA complicated by ASF.

Methods: A systematic review was conducted using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology to identify studies that reported results of RSA complicated by ASF. Searches were performed using PubMed and Scopus up to January 1, 2018. Five articles met inclusion and exclusion criteria.

Results: ASF occurred in 61 (6.9%) of 874 RSA cases identified. 82% of patients who sustained an ASF were female. ASF cases were, on average, 7 years older than cases that were not complicated by ASF. While improved compared to their preoperative state, patients who sustained an ASF demonstrated significantly less improvement in pain, function, and ROM compared to RSA patients without ASF.

Conclusion: Women and older patients appear to be at greater risk for an ASF after RSA. Though nonunion rates are high, fair outcomes can still be achieved in cases of ASF after RSA. Further study is needed to identify modifiable and non-modifiable risk factors associated with the development of ASF.

Level of evidence: IV

Keywords: Acromial, Reverse shoulder arthroplasty, RSA, Stress fracture

Introduction

Reverse shoulder arthroplasty (RSA) is a common surgical treatment for irreparable rotator cuff tears, fractures, rotator cuff arthropathy, and revision shoulder arthroplasty. While complication rates following RSA range between 19%-68%, the rate of acromial stress fractures after RSA is less frequent. Stress fractures result in substantial pain, limited function, and can compromise the final results of surgery (1). Given the low incidence, individual studies are limited in their ability to describe the demographics of patients who sustain stress fractures after RSA and their ultimate clinical results (2).

Because of the low incidence and limitations of

individual studies, the purpose of this systematic review is to synthesize the available data on acromial stress fracture following RSA. The following study questions were investigated: 1. What are the demographics of patients treated for RSA complicated by acromial stress fracture? 2. What are the functional outcomes of patients who sustain acromial stress fracture? 3. What are the union rates of acromial stress fractures?

Materials and Methods

A comprehensive literature review was performed to identify all studies on acromial stress fractures following RSA. Searches for the terms "acromial fracture", "acromion

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fracture”, “scapula fracture”, “scapular fracture” and “reverse arthroplasty”, “reverse replacement” and “reverse ball and socket” were performed using the search engines PubMed and Scopus which were searched through January 2018. Inclusion criteria for our systematic review were all English studies (Level I-IV evidence) that reported on outcomes of acromial stress fractures following RSA. Exclusion criteria were non-English language articles, nonhuman studies, retracted papers, case reports, review papers, studies with less than <5 patients in the sample size, studies with less than 1 year of clinical follow-up, and technique papers without patient data. PRISMA criteria were followed throughout the study. One author performed the initial search, and two authors independently reviewed the references of the qualifying papers and selected the appropriate studies. If one or more of the authors selected a paper at a particular phase of

the review process, it moved on to the next phase. In the final phase of the review (elimination on the basis of a full-text review), there were no disagreements regarding which papers would be ultimately included. References of included papers were reviewed in an attempt to identify further relevant trials missed by the search criteria.

We identified 3779 articles from PubMed and 3229 articles from Scopus. After removal of 3184 duplicate studies, a total of 3824 papers from the combined PubMed and Scopus searches were reviewed. Duplications were confirmed electronically and removed. Five papers met all criteria and were analyzed [Figure 1]. The references of these articles were manually searched for other potential articles of interest, and no additional articles satisfied the inclusion and exclusion criteria.

Demographic statistics were generated from the data in the five individual studies. If the same outcomes

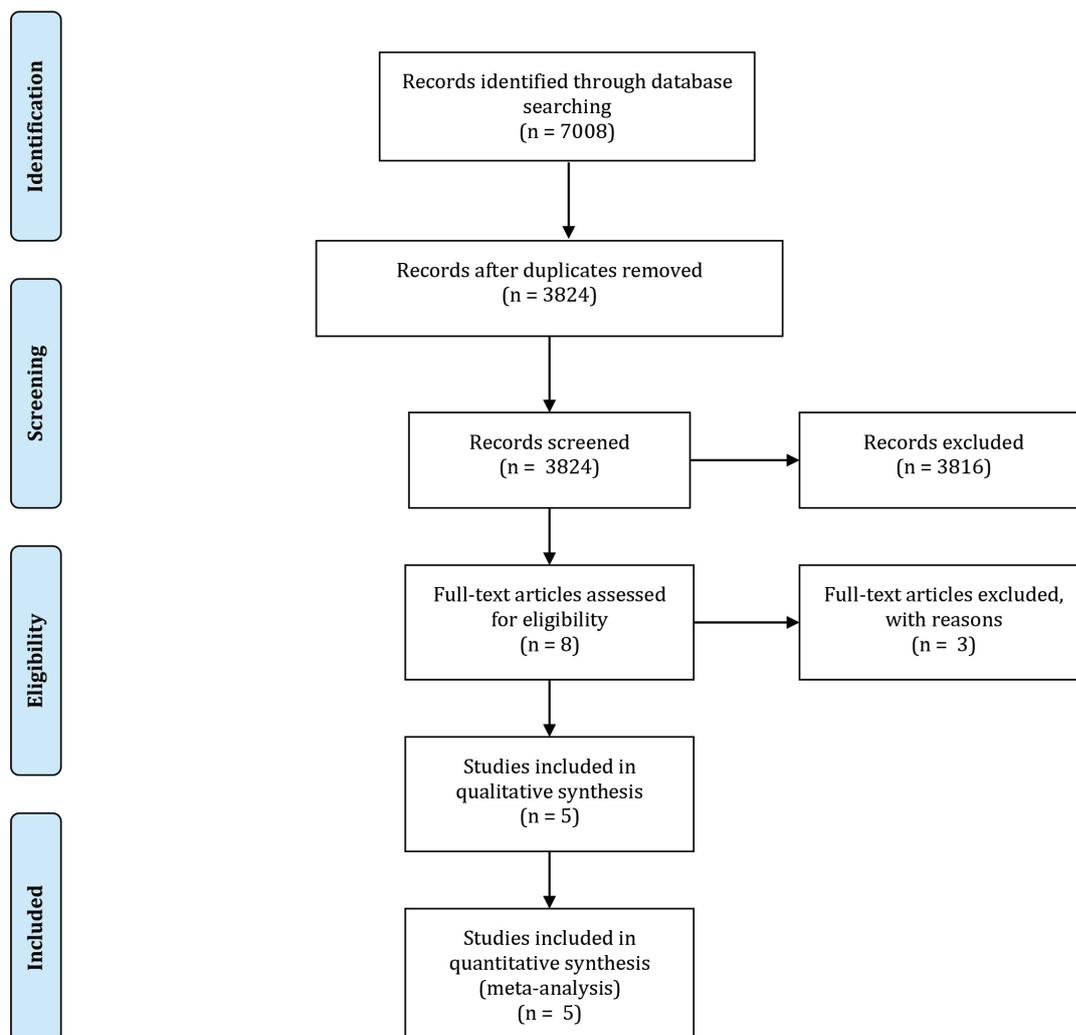


Figure 1. PRISMA flow diagram of the literature search, which includes both included and excluded studies.

instrument was used in multiple studies, the results were pooled to generate an overall percentage or a frequency-weighted (FW) mean value. FW means and grouped standard deviations were used to generate *P* values, using the number of "subjects" as the number of studies. As a result, comparative statistics for each variable were reported as means that 95% of the studies would report. A minimum of two studies that reported the same data parameter were required to generate *P* values.

Results

All 5 studies that met the inclusion and exclusion criteria were retrospective to design (3-7). All were published between 2010 and 2017. Table 1 lists the full study characteristics between groups.

Demographics

Out of a total of 874 patients, 61 (6.9%) acromial stress fractures were identified (3-7). Only two studies reported the average patient age for the non-fracture cases, with an FW mean of 66.9 (N=409, range 48-85) (4, 5). For the fracture cases, the FW mean age was 73.6 (N=61, range, 56-91) (3-7). Gender was not consistently reported for non-fracture cases. There were 11 males (18%) and 50 females (82%) that underwent RSA complicated with acromial stress fracture [Table 1]. Two studies (N=24) reported the number of fracture cases diagnosed with osteoporosis (14/24, 58.3%) (6, 7).

Fractures were classified by the Levy Classification in 2

of the 5 studies (4, 6). Type I indicated involvement of a portion of the anterior and middle deltoid origin; Type II, at least the entire middle deltoid origin with a portion but not all of the posterior deltoid origin; and Type III, the entire middle and posterior deltoid origin (6). In these two studies (n=25), there were 2 Type-I fractures (8.0%), eight Type-II fractures (32.0%), and 15 Type-III fractures (60.0%). In the remaining studies (n=36), fractures were classified as involving either the acromion or scapular spine (3, 5, 7). In this classification, there were 24 (66.7%) acromial fractures and 12 (33.3%) scapular spine fractures.

Functional Outcomes

All 5 studies reported outcomes data [Table 2]. Clinical follow-up was obtained an FW mean of 32.4 months (N=61, range, 12-121). Four studies reported preoperative and postoperative ASES scores for the fracture cases (N=53); FW mean preoperative ASES score was 27.3 and postoperative ASES was 56.2 ($P=0.014$) (3-6). Two studies reported preoperative and postoperative ASES scores for the non-fracture cases (N=216); FW mean preoperative and postoperative ASES scores were 29.0 and 81.5, respectively (3, 5). Two studies reported both preoperative and postoperative VAS pain scores (3, 6). FW mean preoperative VAS pain scores for the fracture cases was (N=20) 8.3 and mean postoperative VAS pain score was 3.3. One study reported pre and postoperative VAS pain scores for the non-fracture group, which was 7.5 and 0.7 respectively (3).

Table 1. Demographic characteristics of the patients of the selected studies

Author	Year	Level of Evidence	Type of Study	Patients					
				Non-Fracture	Fracture	Mean Age, y	Mean Age, y (fx)	Female/Male (fx)	Mean Follow Up (months)
Hamid ³	2011	3	Retrospective	154	8	NR	76.3	8:0	14
Teusink ⁷	2014	3	Retrospective	100	25	71.9	72.2	21:4	50
Levy ⁴	2013	3	Retrospective	134	16	NR	77	13:3	25
Kennon ⁵	2017	3	Retrospective	309	8	65.3	69.3	5:3	3
Hatrup ⁶	2010	3	Case control	116	4	NR	72.6	3:1	30
Total				813	61	66.9	73.6	50:11	31.3

Table 2. Functional outcomes for patients in the fracture and non-fracture cases

Author	PreOp ER fx	PostOP ER fx	PreOp ER control	Post ER control	PreOP Abd. Fx	PostOp Abd. Fx	PreOP abd. Control	PostOp abd. Control	PreOP flexion fx	PostOp flexion fx	PreOp flexion control	PostOp flexion control
Teusink ⁷	25	25	17	38	58	80	61	130	65	91	62	135
Levy ⁴	6	25			42	64						
Kennon ⁵	0	26			43	86			64	123		
Hatrup ⁶	24	42	16	54	54	90	47	151	57	97	58	152
FW mean	15.4	26.4	16.5	46.6	50.6	76.8	53.5	141.3	63.9	98.6	59.9	144.1

Table 3. Preoperative and postoperative range of motions for both fracture and non-fracture patients

Author	Pre ASES (fx)	Post ASES (fx)	Pre ASES (control)	Post ASES (control)	Pre VASpain (fx)	Post VASpain (fx)	Pre VASpain (control)	Post VASpain (control)	Pre SST (Fx)	Post SST (fx)	Pre SST (control)	Post SST (control)
Hamid ³		70										
Teusink ⁷	36.8	58	37.2	74.2		2.3						
Levy ⁴	22	44			8.6	4.7			1	3.6		
Kenyon ⁵	9.4	79							0.125	9.4		
Hatrup ⁶	24.4	48.5	22	87.8	7.2	4	7.5	0.7	2.2	5.1	1.9	10.2
FW mean	27.3	56.2	29.0	81.5	8.3	3.3	7.5	0.7	0.9	5.5	1.9	10.2

Range of Motion

All 5 studies reported range of motion data [Table 3]. Four studies reported preoperative and postoperative external rotation and abduction of fracture cases (3, 6). Two studies also reported these metrics for the non-fracture cases (3, 5). In the non-fracture cases (N=216), external rotation improved +30 degrees, and abduction improved +87 degrees. In the fracture cases (N=53), external rotation improved +11 degrees ($P=0.519$), and abduction improved +26 degrees ($P=0.0892$). Three studies (N=37) reported preoperative and postoperative flexion of the fracture cases with an improvement of +35 degrees ($P=0.266$) (3-5). Two studies reported preoperative and postoperative flexion for the non-fracture cases (N=29), with an improvement of +84 degrees.

Treatment

All stress fracture cases (n = 61) were initially treated non-operatively. Six (9.8%) patients were subsequently treated with open reduction internal fixation for symptomatic nonunion. Of those studies reporting data on healing rates, 11 (36.7%) acromial fractures went on to union, 2 (6.6%) went on to malunion, and 17 (56.7%) went on to nonunion.

Discussion

Acromial stress fracture leads to substantial pain and can slow the recovery after RSA. Female patients and older patients appear to be at greater risk for stress fracture. Despite a low incidence, stress fracture can compromise the results of RSA. Though union rates are low, non-operative management is the most common definitive treatment.

Our systematic review found that older age and female gender are risk factors for acromial stress fracture. Both of these demographic factors can also be associated with the diagnosis of osteoporosis (8). Only two studies in this systematic review specifically evaluated osteoporosis and identified this diagnosis in 58% of those who sustained a stress fracture. Although osteoporosis affects 10 million people in the United States, screening and treatment rates remain low, and so, the true incidence of osteoporosis in

those undergoing RSA and in those sustaining stress fractures remains unknown (9). Patients who are older, female, or who carry a diagnosis of osteoporosis should be counseled regarding the increased risk of acromial stress fracture after RSA. Whether surgical technique, implant selection, or postoperative immobilization or rehabilitation can be modified to decrease the risk in these patient populations requires further investigation.

It is clear that acromial stress fracture after RSA has a substantial impact on outcomes. Though functional scores, pain scores, and range of motion improve compared to preoperative values, results are substantially worse when compared to patients who do not sustain a stress fracture and improvements in motion and ASES score were not statistically significant. While the indications for reverse arthroplasty are expanding to include cases of osteoarthritis without rotator cuff insufficiency reverse shoulder arthroplasty (RSA, the risk of acromial stress fracture in approximately 7% of patients leading to poorer clinical results should be factored into the decision to pursue RSA instead of anatomic arthroplasty in these clinical situations (10, 11). No study specifically evaluated the relationship of fracture classification and displacement to functional results. In our anecdotal experience, fractures that involve the scapular spine and those that lead to greater degrees of acromial tilt result in worse clinical results.

Following acromial stress fracture, successful union rates are low. Our systematic review reports a non-union rate of 56.7%. Several questions remain unanswered. It is unknown whether fracture union results in better clinical results. Additionally, the association between the timing of the diagnosis and union rate is unclear. Theoretically, delayed diagnosis and delayed immobilization can result in greater stress at the fracture site, displacement, nonunion. This systematic review suggests that, given the higher incidence in certain demographic populations and the influence on clinical results, surgeons should have a high index of suspicion when patients present with pain during the first 6 months after RSA.

This systematic review is limited by the small number of studies that report clinical results of patients with

acromial stress fracture following RSA. Like any systematic review, the analysis is also limited by the quality of the data available. Although we followed PRISMA guidelines, none of the reviewed studies reported methods for controlling bias, confounding, and chance. Additionally, each study utilized different outcome measures and did not include raw patient data, limiting our ability to utilize more advanced statistical methods. Finally, since only two studies compared results of stress fractures to a control group, comparative statistics between groups could not be reliably generated.

In this systematic review, we report on the patient demographics, prevalence, healing rates, and clinical results of patients who sustain acromial stress fractures after RSA. Though patients are improved compared to their preoperative state, it is apparent that the occurrence of an acromial stress fracture compromises the ultimate outcome that can be achieved with RSA. Despite low

rates of union, most acromial stress fractures are treated nonoperatively. While this review provides information regarding demographics and outcomes of acromial stress fractures, further study remains necessary to identify modifiable and nonmodifiable risk factors for stress fracture prevention.

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