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Acromial spine fracture after reverse total shoulder arthroplasty: a systematic review

Diana C. Patterson, MD*, Debbie Chi, BS, Bradford O. Parsons, MD, Paul J. Cagle Jr, MD

Department of Orthopaedic Surgery, Mount Sinai Health System, New York, NY, USA

Background: Reverse total shoulder arthroplasty (RSA) accounts for nearly one-third of shoulder arthroplasty utilization nationally. The complication rate has increased concurrently. Consensus is lacking regarding the incidence, etiology, and treatment of acromial or scapular spine fractures after RSA. The purpose of our study was to perform a systematic review of the literature to analyze the occurrence and outcomes of this complication.

Methods: The MEDLINE, Embase, Google Scholar, and Cochrane databases were queried in late 2017 for combinations of the words "acromial," "fracture," "reverse," "shoulder," and "arthroplasty." We included all studies that contained a clearly defined performance of RSA, acromial fracture(s) noted, and treatment (if any) and outcomes of treatment. The initial search yielded 50 studies; 32 met the inclusion criteria.

Results: Among 3838 RSAs, 159 acromial fractures were reported, for an overall incidence of 4.14%; the mean time to diagnosis from surgery was 9 months (range, 1.3-24 months). Treatments included nonoperative treatment in a sling or abduction brace in 139 cases and open reduction–internal fixation in 20. Regardless of treatment, patients reported inferior function after fracture compared with initially after RSA. Forward flexion was 95° (range, 30°-110°), abduction was 76° (range, 30°-180°), the Constant score was 63 (range, 59-67.5), and the American Shoulder and Elbow Surgeons score was 57 (range, 7-83); all values were reduced compared with patients without fractures.

Conclusion: This study suggests the occurrence of acromial fractures after RSA is a common event, with a rate of over 4%. These fractures correlate with worse postoperative outcomes regardless of treatment method; open reduction–internal fixation was not shown to be clinically superior despite a limited complication rate. Additional high-quality studies addressing acromial spine fracture after RSA are needed.

Level of evidence: Level IV; Systematic Review

Keywords: Acromial fractures; acromial spine fracture; reverse shoulder arthroplasty; complications; poor outcomes; fatigue fractures

Total shoulder arthroplasty is a widely performed, cost-effective treatment for glenohumeral arthritis and similar conditions.[7,15,23,31,39,41] However, there is a large and growing subset of patients who are not candidates for anatomic total shoulder arthroplasty for several reasons but in particular because of large or massive irreparable rotator cuff tears.[5,16,32,43,55] The advent of the reverse total shoulder arthroplasty (RSA), which relies on the deltoid muscle to achieve motion, has allowed pain

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*Reprint requests: Diana C. Patterson, MD, Department of Orthopaedics, Mount Sinai Hospital, One Gustave L. Levy Place, Box 1188, 5 E 98th St, Room 908, New York, NY 10029, USA.

E-mail address: diana.c.patterson@gmail.com (D.C. Patterson).

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relief, greater shoulder function, and an improved quality of life in these patients. It currently accounts for one-third of shoulder arthroplasty utilization nationally, and its use is growing.[10,46,60] The indications for use now range from proximal humeral fracture to pseudoparalysis, and as the long-term outcomes become more clear and consistent, RSA is being performed in increasingly younger patients.[1,54]

RSA is not without complications. Studies have identified dislocation and instability, neurologic injury, hematoma, acromial or scapular spine fracture, and scapular notching as common complications after RSA.[2,9,14,17,18,21,33,57] Although the current literature on how to prevent and treat most of these complications is robust, acromial and scapular spine fractures have been largely ignored or only mentioned in passing in a list or table of complications. With increasing rates of RSA, the burden of common complications after RSA will increase as well.[1,9,10,17] The development of policies that incentivize high-value care by tying total shoulder arthroplasty and RSA payments to quality measures and resource utilization in the postoperative period[48,52,54] make it of critical importance that surgeons understand in which patients RSA can, and should, be done, as well as its common complications. With a growing emphasis on value, understanding how to treat common complications of RSA has important implications for practicing orthopedic surgeons, health care administrators, and policymakers.

A cohesive discussion of acromial fractures after RSA is complicated by the existence of 2 separate classifications, those by Crosby et al[11] and Levy et al.[27] Both are descriptive and based on the anatomic location of the fracture, but they conflict. Crosby et al defined type I fractures as small fractures of the anterior acromion near or including the footprint of the coracoacromial ligament, possibly resulting from acromial wear from prior acromioplasty; type II fractures are those through the anterior acromion just posterior to the acromioclavicular joint; and type III fractures are those of the posterior acromion or scapular spine, likely propagating from the tip of the most superiorly placed metaglene screw. In contrast, Levy et al defined type I fractures as those through the midpart of the acromion, including a portion of the origin of the anterior and middle deltoids; type II fractures involve the whole origin of the middle deltoid and a portion of the posterior deltoid; and type III fractures involve the anterior middle and posterior deltoid origin.

There is no consensus on the expected incidence or optimal treatment of acromial or scapular spine fractures after RSA. The purpose of our study was to perform a systematic review of the literature to analyze the incidence, treatments, and functional outcomes of acromial spine fractures (ASFs) after RSA.

Methods

Literature search

We queried the MEDLINE, Embase, Google Scholar, and Cochrane Central Register of Controlled Trials databases to identify potentially relevant publications. The search strategy contained combinations of the following keywords applied to each database: "acromial," "fracture," "reverse," "shoulder," and "arthroplasty." The full list of articles from all 4 searches was compiled, and duplicates were removed. Each publication in the remaining list was screened against the following criteria, and we included all study reports that met these criteria: (1) English translation of study required to be available, (2) clearly defined surgical technique of RSA, (3) acromial fracture(s) noted, (4) time to follow-up and/or discovery of fracture noted, and (5) treatment (if any) of acromial fracture and outcomes of treatment noted. The criteria for automatic exclusion included case reports; letters to the editor; technique articles without discussion of results; and biomechanical, cadaveric, or animal studies. For studies in which a subpopulation met the inclusion criteria, we included the study and presented only the results of the subpopulation.

Study selection

Two reviewers assessed each potential study against the inclusion and exclusion criteria. The initial screen was based on review of the title, abstract, and full text when required. In cases of disagreement, a third reviewer screened the study in question and a consensus method was used. This happened for less than 5% of the initial inclusion set (Fig. 1).

Data extraction, outcome measures, and quality assessment

Two reviewers independently extracted the following data from each study that met the inclusion criteria: author, study design (randomized controlled trial, case-control study, or observational cohort study), total number of RSAs, total number of fractures, fracture location, type of implant used, mean age, sex, mean time to diagnosis, treatment, results of treatment, and overall RSA outcomes. The primary outcomes of interest were incidence of fracture, time to fracture, treatment modalities, and outcomes after fracture in comparison with patients who did not have acromial fractures.

Results

Study selection

The search initially identified the abstracts of 50 articles, of which 28 were removed because they did not meet our criteria. The references and text of these 22 articles were screened against the same criteria, yielding 10 additional studies for inclusion. Ultimately, 32 full-text articles were included in the systematic analysis (Fig. 1).

Study populations

Across the 32 studies, there were a total of 3838 RSAs and 159 fractures involving the acromial and scapular spine (4.14%, Table I), and patients were on average 72.2 years old, with male patients comprising 33.6%. The average time to diagnosis from surgery was 9 months (range, 1.3-24 months),

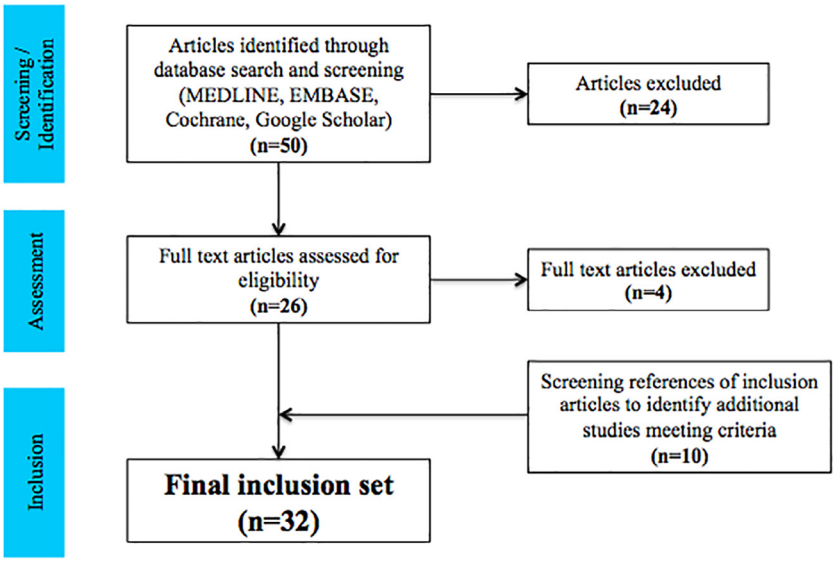

Figure 1 Flow for study selection through different phases of review, in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) strategy. Full-text articles were excluded if they did not meet the following criteria: (1) English translation available, (2) clearly defined surgical technique of reverse total shoulder arthroplasty, (3) acromial fracture(s) noted, (4) duration to documented follow-up and discovery of fracture noted, and (5) treatment (if any) of acromial fracture and outcomes of treatment noted.

with the diagnosis made after trauma or complaints of new-onset shoulder pain not present at the time of surgery. The most common etiologies of fractures included falls, stress, fatigue, and spontaneous occurrence (Table I). Among those studies that classified the observed fractures (9 studies), 3 used the Levy classification and the remainder used descriptive classifications either by location (acromion vs scapular spine) or by etiology (traumatic vs fatigue). Thirty studies discussed treatment modalities, with 3 that were proposed: nonoperative treatment in a sling or abduction brace, delayed open reduction–internal fixation (ORIF), or acute ORIF with a surgical technique of plating or tension band wiring.

Outcomes after acromial or scapular spine fracture

In all studies regardless of treatment, patients reported inferior function after fracture compared with what they initially achieved after RSA. Of the studies, 12 performed quantitative assessments of shoulder function including range of motion (forward flexion [FF], external rotation [ER], and abduction [AB])[4,13,18-20,26,27,30,51,53,56,62] (Table II), 7 assessed the American Shoulder and Elbow Surgeons (ASES) score,[13,18-20,27,51,53] and 6 used a visual analog scale (VAS) pain score[13,19,20,51,53,56] or patient satisfaction[8,18,27,37,53,62] (Table III). Other commonly used outcome scores that were identified but only evaluated in fewer than 5 studies included the Constant shoulder score,[4,26,30] Simple Shoulder Test (SST) score,[19,20,27] Single Assessment Numeric Evaluation (SANE) score,[13,27] EuroQol VAS score,[30] VAS function score,[27] and Neer functional outcomes.[56] Twenty studies contained qualitative commentary exclusively. FF was 95° (range, 30°-110°) and AB was 76° (range, 30°-180°), and these were the most severely affected (Table II). The Constant score was 63 (range, 59-67.5), and the ASES score was 57 (range, 7-83); all values were reduced compared with patients who did not have ASFs (Table III).

For 55 fractures, most occurring as a result of falls, across 5 case-control studies, measurements were available comparing RSA patients who had ASFs versus controls, that is, RSA patients with no complications or other minor complications.[13,19,20,30,53] Across these studies, all clinical measurements and satisfaction ratings were worse in ASF patients than in patients who did not have a fracture, especially FF, AB, and ASES scores. ASF patients and control patients had similar preoperative measurements in all studies with the exception of those of Hattrup et al,[19,20] in which the control patients had worse preoperative measurements. ASF patients did show improvements compared with their preoperative measurements, although studies that measured ER and VAS pain scores showed that these values actually became worse. Lópiz et al[30] measured decreases in FF and AB. Dubrow et al[13] actually found no significant differences in measurements except for FF between ASF and control patients. Teusink et al[53] and Hattrup[19] showed a smaller magnitude of improvement from preoperatively in all measures in ASF patients compared with controls. In addition, those ASF patients whose fractures healed had incrementally improved measurements compared with those whose fractures continued to show nonunion. All of the fractures in these 5 studies were treated with conservative management in a sling. The union rate of ASFs reported across 2 studies was 50% to 60%,[30,53] although Hattrup[19] reported a union rate of 11%.

Table I Pooled patient demographic characteristics, including age at surgery, number of reverse shoulder arthroplasties performed in each included study, number of reported fractures, any mention of fracture etiology, and time from index procedure to diagnosis of fracture

Authors	Age at surgery, yr	No. of RSAs	No. of fractures	Etiology of fracture	Time from surgery to fracture diagnosis
Kurowicki et al[25] (2016)	77	72	9		
Lópiz et al[30] (2015)	78	126	4		11.9 mo
Dubrow et al[13] (2014)		125	14	Stress	5.1 mo
Teusink et al[53] (2014)	72	1018	25 (17 acromial, 8 scapular spine)	ND	16 mo
Groh and Groh[17] (2014)	64	114	1	ND	10 mo
Levy et al[27] (2013)	75.3	157	16	ND	3 mo
Hamid et al[18] (2011)	69.4	162	8	Fall in 1, MVA in 1, atraumatic in 6	
Young et al[62] (2011)	74.3	18	2		
Wahlquist et al[56] (2011)	72	97	5		8.2 mo
Crosby et al[11] (2011)	70.4	400	22	Some with history of minor slipping and grabbing onto something to prevent fall	10.3-10.8 mo (depending on type)
Hattrup[19] (2010)	71.7	125	9 (3 acromial, 6 scapular spine)	Fall in 5, fatigue in 4	10.9 mo
Bufquin et al[6] (2007)	73	43	1		12 mo
Frankle et al[16] (2005)	71	60	3 (1 scapular, 2 acromial)	During therapy in 1, fall in 1, incidental in 1	9.3 mo
Klein et al[24] (2010)	74.2	143	2		
Mulieri et al[37] (2010)	70	72	2	Pathologic in 1, lifting in 1	
Wiater et al[61] (2014)	70.1	101	1	"Stress"	
Shafritz and Flieger[49] (2012)	73	41	3		4 mo, 2 yr
Nolan et al[38] (2011)	72	71	2 (1 acromial, 1 scapular spine insufficiency)		16.6 mo
Melis et al[34] (2011)		68	1		24 yr
Sebastia-Forcada et al[47] (2017)	77	60	1	"Spontaneous"	12 mo
Lopiz et al[29] (2017)	66	20	1	ND	
Mellano et al[35] (2017)	71	100	5		
Hattrup et al[20] (2012)	68	19	3	Fall in 2 (scapular spine) (8 and 15 mo), acromial stress in 1 (8 mo)	10.3 mo
Bateman and Donald[3] (2012)	71.8	5	1	Heavy lifting	
Lädermann et al[26] (2009)	74.2	47	2	Fall in 1, incidental in 1	3 mo
Boileau et al[4] (2006)	76	45	2	Incidental	3 mo
Werner et al[59] (2005)	70.4	58	4	Fatigue	
Cuff et al[12] (2008)	70	96	1	Fall	3 mo
Stephens et al[51] (2015)	74.7	32	2		
Chacon et al[8] (2009)	72.6	25	1		3 mo
Mollon et al[36] (2016)	71.7	297	5	Stress	
Shi et al[50] (2015)	72.2	21	1	Trauma	

RSA, reverse total shoulder arthroplasty; *MVA*, motor vehicle accident.

Fifty-five fractures across 20 case-cohort studies with no controls were treated by nonoperative measures. Six studies reported on 32 fractures with measurements, whereas the other 14 studies reported on 23 fractures only qualitatively. In general, the ASFs healed uneventfully with decent patient satisfaction (>75% rated as mild pain to no pain and satisfactory). In those studies that reported unsatisfied patients or patients with postoperative FF of less than 100°, the ASF patients who fared most poorly were those who had nonunions, most likely due to osteoporosis (6 of 8 in the study of Hamid et al[18]), or those who had Levy type I or III fractures (4 of 8 unsatisfactory vs 1 of 8 unsatisfactory for type II fractures). Only type II fractures showed statistically significant improvements from preoperatively until fracture healing postoperatively

Table II Included studies that detailed range-of-motion outcomes (forward flexion, 12 studies; abduction, 5 studies; external rotation, 6 studies)

Authors	Forward flexion, °	Abduction, °	External rotation, °
Boileau et al[4] (2006)	135 (no detrimental effect)		
Lädermann et al[26] (2009)	120		
Stephens et al[51] (2015)	127.5		30
Young et al[62] (2011)	140 in 1, "poor motion" in other		
Hamid et al[18] (2011)	71		
Levy et al[27] (2013)	77 (range, 15-135)	64 (range, 30-110)	25 (range, 0-60)
Wahlquist et al[56] (2011)	43 after fracture, increasing to 84 after fracture union		
Hattrup et al[20] (2012)	Fractured: 113; not fractured: 143	Fractured: 108; not fractured: 139	Fractured: 25; not fractured: 57
Lópiz et al[30] (2015)	Decreased by 39 from preoperatively	Decreased by 34 from preoperatively	
Hattrup[19] (2010)	Fractured: 87; not fractured: 152	Fractured: 79; not fractured: 149	Fractured: 36; not fractured: 53
Dubrow et al[13] (2014)	Fractured: 116.6; not fractured: 143.5		Fractured: 22.4-41.7; not fractured: 20.3-51.3
Teusink et al[53] (2014)	Fractured: improved by 26 from preoperatively; not fractured: improved by 76 from preoperatively (increase of 29 in acromial fractures and 19 in scapular spine fractures; increase of 26.4 in healed fractures vs 20.8 in nonunions)	Fractured: improved by 16; not fractured: improved by 72	Fractured: lost 3; not fractured: gained 23

in range of motion (FF, ER, and AB) and outcome measures (ASES, VAS pain, and VAS function scores). Patients with type I fractures showed no improvements, and those with type III fractures only showed improvement postoperatively in ER.

Outcomes of nonoperative treatment compared with operative treatment

Seven studies reported on operative treatment, with 6 of 7 reporting both nonoperative and operative treatment.[11,16,25,35,50,56,59] In these studies, there were 49 fractures, 29 treated nonoperatively and 20 treated operatively, but only 1 study reported quantitative measures.[56] In the study of Wahlquist et al,[56] 2 patients were treated nonoperatively and 3 patients were treated with ORIF. In all patients, preoperative and postoperative pain and FF were similar. In ORIF patients, however, the magnitude of improvement in pain and FF from postoperatively before ASF treatment until union was greater, whereas the time to union and Neer functional outcomes were similar to those in patients who were treated nonoperatively.[16,35,50,59] In 4 studies, 13 ASFs occurred after RSA for rotator cuff deficiency, RSA for pseudoparesis, and RSA with muscle transfer. Five patients were treated with ORIF with follow-up outcomes unreported. Kurowicki et al[25] did not report fracture-specific outcomes either but suggested that locked anterior shoulder patients who undergo RSA may be more likely to have ASFs in general and are more likely to have Levy type II or III ASFs. Crosby et al[11] looked at ASFs through a slightly different but similar classification to that of Kurowicki et al. Type I fractures were treated nonoperatively, whereas most type II and III fractures were treated with ORIF. The 8 type I fracture patients fared well, as did the 11 ORIF type II and III fracture patients. Of the 3 type II patients who underwent conservative management, 2 had persistent pain and decreased function. This finding suggests that the type of acromial fracture plays a role in determining the type of management.

In 18 fractures treated nonoperatively across 2 studies, pain and dysfunction were improved in those fractures that achieved

Table III Most frequent outcome scores and metrics mentioned across all included studies, with comparison between patients with fractures and those without fractures detailed when mentioned

Authors	ASES score	Constant score	VAS pain score	SST score	Patient satisfaction
Bufquin et al[6] (2007)					Satisfactory
Chacon et al[8] (2009)					Satisfactory
Boileau et al[4] (2006)		59 (no detrimental effect)			Good
Lädermann et al[26] (2009)		67.5			Good
Stephens et al[51] (2015)	95		1.3 (1 and 1.6)		Good
Young et al[62] (2011)					50 of 50 (satisfactory in 1, pain for 1 yr in other)
Hamid et al[18] (2011)	70				4 patients with no pain, 2 with mild pain, 1 with moderate pain, 1 with severe pain
Levy et al[27] (2013)	44		5	4	75; excellent in 4, good in 3, satisfactory in 4, unsatisfactory in 5
Wahlquist et al[56] (2011)			6.8 after fracture, decreasing to 0.8 after union		
Hattrup et al[20] (2012)	Fractured: 50; not fractured: 80		Fractured: [1.3] 3.7 (10, 0, 1); not fractured: [6.5] 0.7	Fractured: 5.3; not fractured: 8.5	
Lópiz et al[30] (2015)		Fractured: 34.7 (preoperatively) to 66.5; control: 37.3 (preoperatively) to 81.2			
Hattrup[19] (2010)	Fractured: 44.8; not fractured: 87.8		Fractured: 4; not fractured: 0.7	Fractured: 5; not fractured: 10.4	
Dubrow et al[13] (2014)	Fractured: 66.9; not fractured: 67		Fractured: 2.1; not fractured: 2.1		
Teusink et al[53] (2014)	Fractured: 58.0; not fractured: 74.2 (59.9 in acromial fractures, 53.8 in scapular spine fractures, 56.3 in fractures that healed vs 65.2 in fractures with nonunion)		2.4 in acromial fractures, 2.3 in scapular spine fractures (0.9 in healed fractures vs 2.7 in patients with nonunions)		Fractured: 6.6; not fractured: 8.7

ASES, American Shoulder and Elbow Surgeons; *VAS*, visual analog scale; *SST*, Simple Shoulder Test.

union.[27,56] Complications associated with nonoperative treatment included painful nonunion and need for revision. Regarding the studies that reported surgical treatments, outcome scores were not presented in any study, but subjective outcomes were reported to be superior to those of nonoperative treatment. In the study of Wahlquist et al,[56] 2 of 3 patients underwent delayed ORIF after nonoperative treatment, and function improved with surgery compared with the patient who underwent immediate ORIF (FF of 137.5°, AB of 115°, and Neer score of 76.5 vs FF of 40°, AB of 60°, and Neer score of 42). No complications after ORIF or tension band treatment were reported in any of the studies.

Discussion

As technology improves and indications expand, the prevalence of RSA continues to increase rapidly. Schairer et al[46] reported an incidence of 33% in a recent population study and attributed a proportion of this rise in popularity to the increased use of RSA in nearly one-quarter of proximal humeral fractures. However, as the incidence of arthroplasties performed increases, so will the incidence of complications. The most commonly described complications after RSA are scapular notching, glenosphere loosening or failure, infection, and instability, and rates ranging from 19% to 68% have been reported in the literature.[5,14,32,43,45,58] Fractures of the acromion, due to either stress or minor trauma, are less common, occurring in 3.1% to 10% of cases,[11,18,19,28,30,33,44,53,56,57] but are frequently described anecdotally and recognized as an etiology of poor postoperative outcomes. This systematic review of the literature shows that fractures of the acromion occur with greater frequency than previously reported and commonly result in lower postoperative outcome scores, loss of range of motion, persistent pain, and dissatisfaction.

A cohesive discussion of acromial fractures after RSA is complicated by the existence of 2 separate classifications, those by Crosby et al[11] and Levy et al.[27] However, these schemas are limited by small sample sizes, a lack of validation, and an inability to provide guidance for the management of the fracture types.[22] The similar nomenclature but conflicting definitions can lead to difficulty assessing treatments and outcomes. For example, these classifications describe distinct different locations of type I and type II fractures, with the fractures being smaller and more anterior according to the Crosby classification. The type II fractures in the Crosby system also occur in a much smaller area than those in the Levy system, whereas the type III fractures in the Crosby classification appear to overlap with a majority of the area defined by Levy et al for type II fractures. Such overlap may lead to confusion when evaluating treatment options and outcomes, as 10 of 22 type II fractures in the group described by Crosby et al required delayed surgical treatment and all 4 type III fractures were treated with immediate surgery, whereas all fracture types in the series of Levy et al were treated nonoperatively. In addition, for the majority of fractures identified in the literature, neither classification was used and the fractures were identified descriptively, and in many older studies, a fracture was only mentioned in a list of postoperative complications.[3,5,6,17,24,30,35] For more accurate reporting and evaluation of acromial fractures in future studies, consideration should be given to validation and adoption of a single classification system, improved identification of the classification being referenced in a given study, or the disuse of any single classification and a return to simple descriptive grading. In addition, future studies would be improved by specifying the style of implant used so that the center of rotation and offset can be compared with outcomes.

In a review of cemented versus uncemented RSA, Phadnis et al[42] found the incidence of postoperative stress fractures of the acromion to be significantly higher with lateralized implants than with Grammont-style implants. Lateralized implants provide improved stability by creating greater deltoid tension but have been implicated by Cheung et al[9] to be a factor associated with stress fractures of the acromion and scapular spine. This is consistent with our findings. However, this analysis is limited by the number of studies (17 studies) that specifically mentioned the implant type or design.[4,6,8,11-13,17-20,24-27,29,34-37,46,48,49,52,55,58,60,61] In addition, in the studies using both cemented and uncemented implants, all fractures of the Grammont-style prosthesis were seen in the cemented group. This is consistent with the findings in the study of Phadnis et al, in which fractures of the acromion were more frequent in cemented prostheses. Future studies are needed to define whether it is purely implant design or also the cemented technique that contributes more to the increased rate of acromial fractures.

Outcomes after acromial fractures were inferior to those in patients without fractures. Measured outcome scores (ASES, Constant, VAS pain, EuroQol VAS, SANE, and SST) were decreased in patients with fractures versus patients without fractures,[13,19,20,28,30,47,56] as well as before and after the development of the fracture within the same patients.[53] Patients with acromial fractures also showed loss of AB, FF, and ER. The changes in these outcome scores or functional assessments rarely reached statistical significance in the majority of studies, which may be because of small sample sizes, but the loss of function was highly correlated with patient satisfaction.

One area illustrated by several articles in this study that is an area for future research is the association of underlying osteoporosis and occurrence of acromial stress fractures. Mayne et al[33] discussed that 2 key principles of the design of the reverse shoulder arthroplasty that places increased stress on the acromion during motion: the distalized and medialized fixed center of rotation and the deltoid lever arm. Of the 8 patients with fractures discussed by Hamid et al,[18] 6 had previously been diagnosed with osteoporosis. Otto et al,[40] in a study group of 53 patients with acromial fractures versus a control group of 212 without fractures after RSA, found that osteoporosis was the only clinical risk factor to significantly increase the risk of postoperative scapular fracture (odds ratio, 1.97; 95% confidence interval, 1.00 to 3.91). Osteoporosis was present in 30.8% of fracture patients compared with 18.4% of control patients ($P < .05$). Osteopenia, endocrine disease, autoimmune disease, excessive alcohol intake, smoking, and corticosteroids have not been identified as significant risk factors for acromial pathology.[33] With the majority of RSA procedures in this review having been performed in women and given the prevalence of osteoporosis in this population, further delineating this correlation is an area for future study.

Several studies also examined the presence of acromial pathology preoperatively,[16,49,57,62] such as fragmentation, os acromiale, or prior fracture. Walch et al[57] found fatigue or stress

fractures preoperatively in 18 of 457 patients and found no difference between RSAs with and without preoperative acromial pathology with respect to the Constant score, active elevation, and subjective satisfaction. In fact, patients with postoperative fractures of the scapular spine had significantly worse results than patients with preoperative acromial pathology.[57] Among 18 shoulders with rheumatoid arthritis, Young et al[62] identified an acromial fracture or fragmentation in 3 and acromial spine pseudarthrosis in 1. Postoperative clinical outcomes did not appear to be adversely influenced.

This study has several limitations. It is a systematic review of mostly level IV evidence, which illustrates the need for more robust studies on this subject. Many older studies of RSA outcomes only mentioned the incidence of a postoperative acromial fracture in passing, as one of a list of postoperative complications. This limits the contribution of these fractures to an overall assessment of the functional impact of acromial fractures. Second, despite careful data extraction, few studies reported any fracture-specific outcomes (eg, complete resolution of fracture, further complications, or readmission). In addition, in those few studies in which outcome scores were reported, there was no consistency in which scores were collected. For example, only 3 studies used the Constant score, 7 used the ASES score, 3 used the SANE score, and 3 used the SST score. These outcomes do show inferior outcomes, but the data remain largely anecdotal. Future studies can improve on the available data with greater attention paid to the fracture-specific outcomes and more widespread outcome score collection.

Conclusion

This study suggests the occurrence of acromial fractures after RSA is a common event, with a rate of over 4% in 3838 patients. These fractures correlate with worse postoperative outcomes regardless of the method of treatment. On the basis of this comparison, ORIF was not shown to be clinically superior despite a limited complication rate. Nonoperative management showed a higher rate of nonunion.

Disclaimer

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