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ORIGINAL STUDY

Outcomes of reverse total shoulder arthroplasty with postoperative scapular fracture. A systematic review

Laura Loomans, Philippe Debeer, Carl Dierickx

From the Catholic University of Leuven and University of Hasselt, Belgium

Postoperative scapular fractures are infrequent complications of reverse total shoulder arthroplasty (RTSA). The aim of this study is to discuss the functional outcome, clinical outcome and pain scores of these fractures and to analyze these outcome results based on fracture location.

A systematic review in accordance with the PRISMA guidelines was conducted. Pubmed, EMBASE, Web of Science, Cochrane library and Ovid have been screened.

A total of 78 RTSA in 12 articles were retained for qualitative analysis. The average minimum follow-up was 33.3 ± 14.4 months (range 12-60 months) and the mean age was 74.4 ± 5.6 years (range 63-85 years) with a mean female percentage of 90.9%. Overall, the mean DASH score was 39.8 ± 9.4 points (range 29.5-48.0 points), ASES score 53.4 ± 23.3 points (range 13.3-95.0 points), SST 3.2 ± 2.2 points (range 0.0-5.1 points), the only OSS 28.0 points and Constant-Murley shoulder score 50.5 ± 20.0 points (range 31.5-69.0). The mean anterior elevation was 91.5° ± 30.7° (range 46.0°-160.0°), abduction 87.8° ± 21.8° (range 55.0°-125.0°), external rotation 33.2° ± 22.2° (range 9.0°-85°) and the only internal rotation was 60.0°. The VAS score averaged of 3.8 ± 2.8 points (range 0.8-9.0 points). A subgroup analysis of acromial and scapular spine fractures was performed.

Acromial and scapular spine fractures have an undeniable effect on RTSA outcomes, however patients still improve compared to their preoperative state. We advise to consider acromial and scapular fractures as different problems, as prognosis is worse for more medial fractures.

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Keywords : Reverse total shoulder arthroplasty ; acromial fracture ; scapular spine fracture ; outcome ; systematic review.

INTRODUCTION

Reverse total shoulder arthroplasty (RTSA) is a technique which is increasingly implemented today, as its indications are widening. This surgical procedure is effective for cuff tear arthropathies (CTA) *(1,10,14,22,29,44),* failed RC surgery, *(1,3,22,29)* fracture sequelae *(1,22,44),* revision total shoulder arthroplasty *(22),* and complex proximal humeral fractures *(2,50).* An epidemiological study by Schairer et al. *(42)* reported an incidence of 33% in primary shoulder arthroplasty. Although the good functional and clinical outcome of RTSA, it has a substantial complication rate of 19 to 68% *(22).* Two important problems of this technique

■ Laura Loomans, MSc,
■ Philippe Debeer, MD,
■ Carl Dierickx, MD

Catholic University of Leuven and [2]University of Hasselt, Belgium

Correspondence : Laura Loomans, master student in Medicine, Catholic University of Leuven, Faculty of Medicine, O&N2, Herestraat 49, bus 400, 3000 Leuven, Belgium, +32 494 31 50 70.

E-mail : laura.loomans@student.kuleuven.be

are a high incidence of scapular notching and limited external rotation *(26,29,39)*. Other intra- and postoperative complications are hematoma, periprosthetic infection, humeral stem loosing, failed baseplate, metaglene loosening, glenoid luxation and dislocation *(16,17,29,36,38,41,43)*. Post-operative acromial and scapular spine fractures are less frequent complications with an incidence of 1 to 7% *(16)* and they are the primary focus of this systematic review. These fractures occur spontaneously or after trauma and they result mainly from intra-operative technical factors of the surgeon and bony insufficiency of the patient. The spectrum includes stress fractures to an undisplaced or displaced fracture.

We suspect that the incidence is underestimated, since a study of Otto et al. *(37)* reported that only 78.8% of the fractures were identified on standard shoulder radiographs. Therefore, it is useful to perform a SPECT/CT in patients with a high index of clinical suspicion, especially in the case of undisplaced fractures. We suppose the incidence will grow with extended use of RTSA, awareness of diagnosis by the surgeon and improved imaging interpretation *(32)*. RTSA was originally developed by Paul Grammont in 1985 to handle the challenges from the substitution of a rotator cuff-defective shoulder. Grammont's design compromises important biomechanical principles, including the medialized and distalized centre of rotation, combined with a large glenosphere and a small humeral cup *(4)*. After RTSA, the respective arm is lengthened by approximately 2.5 cm, causing more deltoid fibers are recruited for elevation and abduction. This results in an improved stability of the prosthesis, but is at the same time considered as an increased risk for postoperative fractures as there is an increased stress on the acromion and scapula during shoulder motion *(17, 25)*.

The diagnosis and management of acromial and scapular spine fractures are a challenge for orthopaedic surgeons. Therefore, awareness is required when a postoperative patient presents with acute onset of pain and/or deterioration of shoulder function *(32)*. As these fractures involve the deltoid origin, a reduced function is possible. The literature is sparse about their effect on the outcome of RTSA. The aim of this systematic review is to discuss the functional outcome, clinical outcome and pain scores of reverse replacements with this complication and to analyze the influence on these outcome results based on fracture location.

METHODS

A systematic review of the literature in accordance with the PRISMA guidelines was conducted by using a PRISMA checklist (*Addendum I*) *(34)*. The review protocol was registered in the PROSPERO database, an international register for systematic review protocols (CRD42018108087) *(5)*.

The structure of this study was based on the PICOTS statement (*Addendum II*). Electronic database searches were performed from June 9 to 10, 2018. Five databases were screened : Pubmed, EMBASE, Web of Science, Cochrane library and Ovid. The details of the database search and search terms are described in *Addendum III*. All clinical studies on RTSA which described acromion and/or scapular spine fractures after the surgery, published in English, French or German were included, regardless of sample size or date of publication. Exclusion criteria were biomechanical and cadaveric studies, literature reviews, studies on animals, in vitro studies, posters and technical notes and studies with a mean postoperative follow-up time which was lower than 12 months. After removal of duplicates the abstracts and titles of the 1,734 remaining articles were screened (Figure 1). All articles obtained for full text review were closely evaluated based on inclusion- and exclusion criteria. Moreover, a cross-reference research was performed manually for relevant articles to ensure all possible articles were considered. Articles which described at least one of the outcome assessments for acromial and/or scapular spine fractures after RTSA were taken into account. No randomized controlled trials fulfilled the inclusion criteria. There were no publications with overlapping patient cohorts. To determine the study quality the different study types were assessed for bias with according checklists. Case reports/series were evaluated by using the Quality Appraisal Checklist for Case Series (Institute of Health Economics, Edmonton, Alberta,

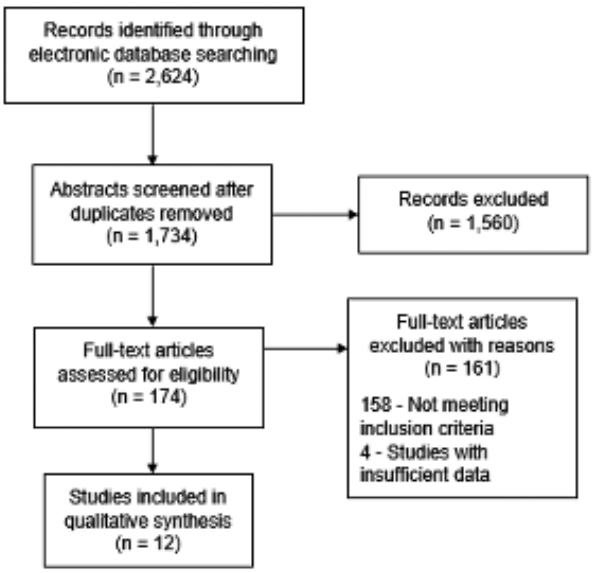

Figure 1. — PRISMA flow diagram.

Canada) (*Addendum IV*), which is a validated checklist, although no cutoff value for excluding studies from further analysis has been established *(15)*. Case-control studies were analyzed by using the Newcastle-Ottawa Scale (NOS, The Ottowa Hospital Research Institute, Wells, Canada) (*Addendum V*) *(51)*. To minimize selection bias strict exclusion and inclusion criteria were defined to provide as much homogeneity as possible. However there was no randomization in any of the articles, the mean ages and female percentages were comparable between the studies included in the final analyses. Data were extracted in an Excel sheet (Microsoft Office 2013, Santa Rosa, California) under the following subheadings : author, year of publication, country, level of evidence, study design, quality score, mean follow-up period, female percentage, mean age, time to fracture, fracture mechanism, indication of RTSA, primary or revision surgery, number of cases, number of patients, incidence, fracture location, left or right shoulder, treatment, DASH-score, ASES-score, SST-score, OSS-score, Constant Murley score, Active ROM, VAS, fracture union and radiographic assessment (*Addendum VI*). Because of the variations in study design, it was not feasible to conduct a traditional study-level meta-analysis.

RESULTS

The search in the different databases yielded 2,624 articles and after the subsequent screening process which is shown in the PRISMA flow diagram (Figure 1) 12 articles with a total number of 78 RTSA were retained for the final qualitative analysis (7,20,48,49,21,27,28,30,40,45-47).

Three of these articles were case reports (level-IV evidence (25.0%)), five case series (2 level IV and 3 level III (41.7%)) and four case-control studies (level III (33.3%)).

Demographic results

The review included 78 RTSA in 76 patients with an average minimum follow-up of 33.3 ± 14.4 months (range 12-60 months). The mean age of the patients was 74.4 ± 5.6 years (range 63-85 years) with a mean female percentage of 90.9%. The mean incidence of postoperative acromion and/or scapular spine fractures was 5.1% (range 0.8-10.2%), of which 9 (11.5%) were caused by a trauma, 5 (6.4%) were defined as a fatigue fracture and for 64 (82.1%) fractures were no data of the mechanism reported. The fractures occurred in a mean time period of 11.1 ± 6.6 months (range 3-26 months) postoperative. 16 RTSA (20.5%) were placed in the right shoulder, 9 (11.5%) in the left shoulder and for 53 RTSA (67.9%) were no data for the operated side mentioned. 59 (75.6%) of the prostheses were implanted as primary surgery and 19 (24.4%) as revision surgery. Indications for RTSA were : 52 (66.7%) cases of CTA, 11 (14.1%) revisions of shoulder arthroplasty, 8 (10.3%) failed RC repairs, 5 (6.4%) of rheumatoid arthritis, 1 (1.3%) fracture sequela and 1 (1.3%) complex humeral fracture.

Outcomes assessment

Clinical outcomes were assessed using the Disability of Arm, Shoulder and Hand score (DASH)*(24)* in 10 (13.2%) patients, the American Shoulder and Elbow Surgeons score (ASES)*(33)* in 62 (81.6%) patients, the Simple Shoulder Test (SST) *(23)* in 26 (34.0%) patients, the Oxford Shoulder Score (OSS)*(12)* in 1 (1.3%) patient and the Con-

stant-Murley shoulder score*(8)* in 10 (13.2%) patients. Functional outcomes were evaluated by measuring the active ROM of the affected shoulder in all patients. The movements reported were : active elevation, abduction, external and internal rotation. The Visual Analog Scale (VAS)*(13)* was considered in 61 (80.3%) patients to assess the pain outcome.

Clinical outcomes

Overall, the mean DASH score was 39.8 ± 9.4 points (range 29.5-48.0 points), the mean ASES score was 53.4 ± 23.3 points (range 13.3-95.0 points), the SST averaged 3.2 ± 2.2 points (range 0.0-5.1 points), the only OSS was 28.0 points and the Constant-Murley shoulder score averaged 50.5 ± 20.0 points (range 31.5-69.0 points).

Functional outcomes

The mean anterior elevation was 91.5° ± 30.7° (range 46.0°-160.0°), the mean abduction 87.8° ± 21.8° (range 55.0°-125.0°), the mean external rotation 33.2° ± 22.2° (range 9.0°-85°) and the only reported internal rotation was 60.0°.

Pain outcome

The VAS score was reported with an average of 3.8 ± 2.8 points (range 0.8-9.0 points).

Radiographic assessment

Acromial and scapular spine fractures were diagnosed by using radiographs and/or CT. RX led to the diagnosis of 59 (75.6%) fractures, both RX and CT of 18 (23.1%) fractures and for 1 (1.3%) fracture only a CT-scan was used.

Treatment and fracture healing

The treatment was conservative for 70 (89.7%) fractures and non-conservative for 8 (10.3%) fractures. Fracture union was attained for 25 fractures (32.1%), non- or mal-union was reported for 34 (43.6%) fractures and for 19 (24.4%) fractures no data of fracture healing were available.

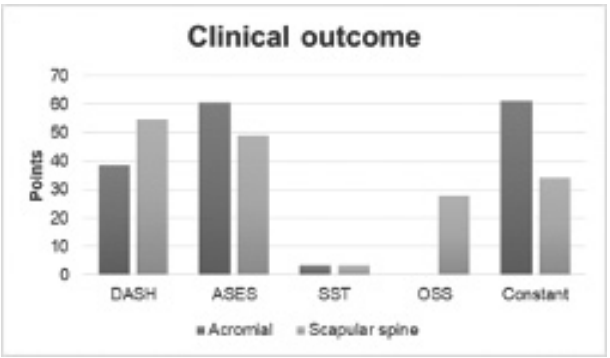

Fig. 2.

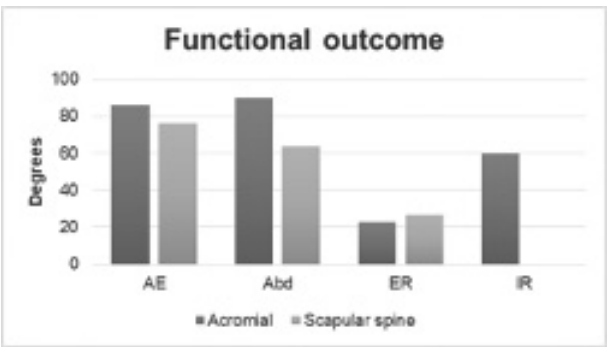

Fig. 3.

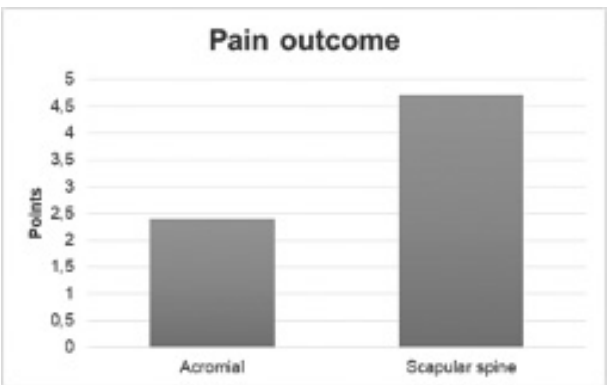

Fig. 4.

Fracture location

Of the reported fractures 39 (50.0%) were acromial fractures and 39 (50.0%) were scapular spine fractures. Outcomes were analyzed separately based on fracture location, with a subgroup analysis of acromion and scapular spine fractures. For acromial fractures the mean DASH score was

38.5 ± 20.2 points (range 20.0-65.0 points), the mean ASES score was 60.7 ± 24.5 points (range 13.3-98.0 points), the mean SST was 3.3 ± 2.2 points (range 0.0-4.5 points) and the Constant-Murley shoulder score averaged 61.2 ± 14.9 points (range 32.0-72.0). There was no OSS reported for any acromial fracture (Figure 2). The functional outcomes averaged an anterior elevation of 86.2° ± 45.7° (range 10.0°-160.0°), an abduction of 90.1° ± 25.0° (range 55.0°-125.0°), an external rotation of 23.1° ± 24.4° (range 0.0°-85.0°) and the only internal rotation reported was 60.0° (Figure 3). For pain outcomes the mean VAS score was 2.4 ± 3.0 points (range 0.0-9.0 points) (Figure 4). There was a fracture union in 16 (41.0%) cases, a non- or mal-union for 13 (33.3%) cases and no data were available for 10 (25.6%) cases. The mean clinical outcomes for scapular spine fractures were a DASH score of 54.6 ± 16.4 points (range 32.0-77.0 points), an ASES score of 49.1 ± 17.7 points (range 15.0-93.0 points), a SST of 3.3 ± 0.1 points (range 3.0-3.3 points), a Constant-Murley shoulder score of 34.2 ± 11.9 points (range 15.0-44.0 points) and the only OSS reported was 28.0 points (Figure 2). The anterior elevation averaged 76.2° ± 19.3° (range 45.0°-110°), the abduction 63.6° ± 10.1° (range 61.0°-100.0°), the mean external rotation was 26.7° ± 3.7° (range 25.5°-40.0°) and for internal rotation no data were available (Figure 3). The VAS score averaged 4.7 ± 0.9 points (range 1.6-4.9 points) (*Figure 4*). A fracture union was reported for 5 (12.8%) RTSA, a non- or mal-union for 9 RTSA (23.1%) and for 25 (64.1%) RTSA were no data about fracture union reported.

DISCUSSION

Popularity of RTSA has increased, despite the sparse reports on results and complications. Postoperative acromial and scapular spine fractures are known complications of RTSA, but they are still poorly understood. These are infrequent complications with an incidence of 5.1% in our analysis, which is comparable with the incidence found in literature (1-7%) *(16)*.

These complications can develop at any point of the follow-up, in our review they occurred in a postoperative period from 3 to 26 months. Probably the frequency will increase, as more RTSA procedures are performed and longer-term follow-up will be available *(32)*.

Acromial and scapular spine fractures are underreported complications, because they are often difficult to detect on initial radiographs. In our review 23.1% of the fractures were detected with an additional CT-scan. For this reason it is important to consider a SPECT/CT-scan, even if initial radiographs are negative, especially when the patient reports sudden deterioration of shoulder function or acute posterior shoulder pain.

The etiopathogenesis of these postoperative fractures remains unclear. It is assumed that both preoperative and intraoperative factors could contribute to the development of these fractures. One preoperative risk factor is acromion weakness caused by acetabulisation and thinning in cases of advanced CTA *(30)*. However, some reports state that preoperative lesions, such as os acromiale and acromial fragmentation have no influence on clinical outcomes *(48,49)*. Furthermore, in our review 90.9% of the patients were female and the mean age was 74.4 ± 5.6 years. This tendency of female dominance and elderly holds true for indicated RTSA in general, a group of the population with a higher incidence of osteopenic bone and potentially osteoporosis, which forms a risk factor for fatigue fractures. Otto et al. *(37)* concluded that osteoporosis was a significant risk factor (P=0.49) from a cohort of 53 postoperative scapular fractures, whereas osteopenic bone, autoimmune disorders, endocrine pathology, ethylism and tabagism were not significant. As intraoperative risk factor certain reports assume that the deltopectoral approach has a greater incidence of postoperative acromial and scapular spine fractures *(35),* while other authors state that there is no difference between the deltopectoral and superolateral approach *(49)*. In addition, the positioning of the metaglene screws plays an important role. Screws placed in the posterior-superior quadrant, directed at the base of the acromion, create a stress which can potentially result in acromion base fractures *(9)*. Finally, quantification of deltoid tensioning is difficult and is mainly guided by experience of the surgeon. At one

end of the spectrum overtensioning of the deltoid forms a risk for postoperative scapular fractures *(20),* but on the other side undertensioning possibly leads to prosthetic instability *(31).*

Although these fractures are a well-defined complication of RTSA, there is paucity of publications describing the implications of these fractures on the outcomes. Frankle et al. *(18)* reported 3 fractures in 60 shoulders. One acromial and one scapular spine fracture, both occurring in one patient. Both fractures were treated conservatively with satisfactory outcomes. The third fracture was an acromial fracture treated successfully with ORIF. Werner et al. *(52)* described 4 acromial or scapular spine fractures out of 58 shoulders. Two were treated conservatively and for two tension band wiring was applied. No specifications were mentioned, but the fractures would not have led to any effect on the outcome. Boileau et al. *(4)* reported 2 incidentally observed acromial fractures out of 45 shoulders, noticed on postoperative radiographs at 3 months without any symptoms. Cuff et al. *(11)* described one fracture in 96 shoulders. It was a traumatic fracture occurring 3 months postoperatively. Treatment was conservatively, with a particularly good outcome. Bufquin et al. *(6)* described one acromial fracture in a series of 41 patients, which healed conservatively without peculiarities.

According to certain publications location of these fractures does not affect functional out-comes *(47),* however we distinct scapular spine fractures from more anterior acromial fractures. In more laterally fractures, the scapulathoracic motion is unaffected, which is more important for the functioning of RTSA than the glenohumeral motion. In contrast to more medial fractures where a greater proportion of the deltoid becomes afunctional, which is a keystone for functioning of RTSA. In general, functional outcomes for scapular spine fractures are inferior to acromial fractures in our analysis. Only external rotation was slightly better for scapular spine fractures, with only a difference of 3.1° and for internal rotation we could not make a comparison because no data for scapular spine fractures were reported. The scores for clinical outcomes are not very conclusive, the mean DASH scores are in favor of acromial fractures, while the ASES and Constant-Murley shoulder scores are more favorable for scapular spine fractures, an equal SST was obtained for both fractures and for the OSS no comparison was possible as no data for acromial fractures were available. Finally, the VAS scores reported for scapular spine fractures were clearly higher. In the end, we can state however that it is impossible to make an objective comparison for different fracture types without a reproducible classification system.

Unfortunately, in this review we could not compare the outcome results with a similar patient group without these postoperative fractures. In other publications is concluded that results of acromial and scapular spine fractures are inferior to those of the group without these fractures, however they still achieve improved functional outcomes compared to their preoperative state, even with a conservative treatment *(20,21).*

There is limited experience regarding the required treatment for postoperative acromial and scapular spine fractures, however some authors recommend a surgical treatment for scapular spine fractures and a conservative treatment for more lateral acromial fractures *(19).* This statement is based on a higher rate of non-union which is explained by the deltoid exerting a greater force on the fracture at the scapular spine. In our analysis there was only for 5 scapular spine fractures fracture-union reported, compared to 16 fracture-unions for acromial fractures.

Limitations of this review are the possibility of selection bias, because only one researcher was responsible for selecting the articles for the final analysis. Secondly, the articles included had different study types and no randomized control trials resulted from the data base search. As mentioned earlier, for outcome results no comparison could be made with a group without fracture complication. Finally, not all outcome measures were reported for each RTSA procedure.

CONCLUSION

Acromial and scapular spine fractures are infrequent complications, but they have a undeniable effect on outcomes of RTSA. However, patients still improve compared to their preoperative state despite

these fracture complications. We advise to consider acromial and scapular spine fractures as different problems, as the prognosis is worse for more medial fractures. A high index of clinical suspicion is needed as initial radiographs can be negative, which legitimates proceeding to other imaging studies such as (SPECT)-CT. The emphasis should be on prevention of these fractures by optimizing for example bone health, selecting correct glenoid base plate screw position and avoiding excessive tensioning the glenoid. In the future, more prospective studies with longer follow-up term are needed to define a reproducible classification for prognosis and treatment based on fracture location and for comparison between studies.

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50. **Wang J, Zhu Y, Zhang F, Chen W, Tian Y, et al**. Meta-analysis suggests that reverse shoulder arthroplasty in proximal humerus fractures is a better option than hemiarthroplasty in the elderly. *Int. Orthop* 2016 ; 40 : 531-539.
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ADDENDUM I

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	
ABSTRACT			
Structure summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	

RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	

ADDENDUM II

Table E-I: PICOTS statement*

Population	Patients treated with RTSA
Intervention	Patients with postoperative acromial and/or scapular spine fracture
Control	Patients without postoperative acromial and scapular spine fracture
Outcome	*Clinical:* DASH-, ASES-, SST-, OSS-, Constant Murley outcome scores *Functional:* active ROM *Pain:* VAS
Time period	Minimum 12 months follow-up after surgery
Study design	Systematic review

* RTSA=Reverse Total Shoulder Arthroplasty, DASH=Disability of Arm, Shoulder and Hand score, ASES=American Shoulder and Elbow Surgeons score, SST=Simple Shoulder Test, OSS=Oxford Shoulder Score, ROM=Range Of Motion, VAS=Visual Analogue Scale

ADDENDUM III

Table E-II: Search strategy

Electronic databases performed: • Pubmed (9 June 2018) • EMBASE (9 June 2018) • Web of Science (9 June 2018) • Cochrane library (10 June 2018) • Ovid (10 June 2018)
Search terms used: "Reverse total shoulder arthroplasty"; "reverse total shoulder prostheses"; "Reverse total shoulder replacement"; "fractures"; "acromial fractures"; "scapula fractures"; "scapular spine fractures"; "acromion base fractures"; "complications"
Results of search: • Pubmed: 714 • EMBASE: 943 • Web of Science: 584 • Cochrane library: 12 • Ovid: 371
Total: 2624 records

ADDENDUM IV

Figure E-2: Institute of Health Economics (IHE). Quality Appraisal of Case Series Studies Checklist. Edmonton (AB): Institute of Health Economics; 2014.*(15)*

Available from: http://www.ihe.ca/research-programs/rmd/cssqac/cssqac-about

IHE INSTITUTE OF HEALTH ECONOMICS ALBERTA CANADA

Quality Appraisal Checklist for Case Series Studies*

Study objective			
1.	Was the hypothesis/aim/objective of the study clearly stated?	Yes	-
		Partial	-
		No	-
Study design			
2.	Was the study conducted prospectively?	Yes	-
		Unclear	-
		No	-
3.	Were the cases collected in more than one centre?	Yes	-
		Unclear	-
		No	-
4.	Were patients recruited consecutively?	Yes	-
		Unclear	-
		No	-
Study population			
5.	Were the characteristics of the patients included in the study described?	Yes	-
		Partial	-
		No	-
6.	Were the eligibility criteria (i.e. inclusion and exclusion criteria) for entry into the study clearly stated?	Yes	-
		Partial	-
		No	-
7.	Did patients enter the study at a similar point in the disease?	Yes	-
		Unclear	-
		No	-
Intervention and co-intervention			
8.	Was the intervention of interest clearly described?	Yes	-
		Partial	-
		No	-
9.	Were additional interventions (co-interventions) clearly described?	Yes	-
		Partial	-
		No	-

Outcome measure			
10.	Were relevant outcome measures established a priori?	Yes	-
		Partial	-
		No	-
11.	Were outcome assessors blinded to the intervention that patients received?	Yes	-
		Unclear	-
		No	-
12.	Were the relevant outcomes measured using appropriate objective/subjective methods?	Yes	-
		Partial	-
		No	-
13.	Were the relevant outcome measures made before and after the intervention?	Yes	-
		Unclear	-
		No	-
Statistical analysis			
14.	Were the statistical tests used to assess the relevant outcomes appropriate?	Yes	-
		Unclear	-
		No	-
Results and conclusions			
15.	Was follow-up long enough for important events and outcomes to occur?	Yes	-
		Unclear	-
		No	--
16.	Were losses to follow-up reported?	Yes	-
		Unclear	-
		No	-
17.	Did the study provided estimates of random variability in the data analysis of relevant outcomes?	Yes	-
		Partial	-
		No	-
18.	Were the adverse events reported?	Yes	-
		Partial	-
		No	-
19.	Were the conclusions of the study supported by results?	Yes	-
		Unclear	-
		No	-
Competing interests and sources of support			
20.	Were both competing interests and sources of support for the study reported?	Yes	-
		Partial	-
		No	-

*Note: Assessor(s) may decide to remove from the checklist the items that are not applicable to their project.

Addendum V

Figure E-3: Ottowa Hospital Research Institute. Newcastle Ottowa Quality Assessment Scale (NOS) of case control studies and cohort studies.*(51*

Available from: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp

NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE
CASE CONTROL STUDIES

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Exposure categories. A maximum of two stars can be given for Comparability.

Selection

1) Is the case definition adequate?
   a) yes, with independent validation *
   b) yes, eg record linkage or based on self reports
   c) no description
2) Representativeness of the cases
   a) consecutive or obviously representative series of cases *
   b) potential for selection biases or not stated
3) Selection of Controls
   a) community controls *
   b) hospital controls
   c) no description
4) Definition of Controls
   a) no history of disease (endpoint) *
   b) no description of source

Comparability

1) Comparability of cases and controls on the basis of the design or analysis
   a) study controls for _____ (Select the most important factor.) *
   b) study controls for any additional factor * (This criteria could be modified to indicate specific control for a second important factor.)

Exposure

1) Ascertainment of exposure
   a) secure record (eg surgical records) *
   b) structured interview where blind to case/control status *
   c) interview not blinded to case/control status
   d) written self report or medical record only
   e) no description
2) Same method of ascertainment for cases and controls
   a) yes *
   b) no
3) Non-Response rate
   a) same rate for both groups *
   b) non respondents described

c) rate different and no designation

ADDENDUM VI

Table E-III: Subtracted data from studies included in final qualitative analysis

Study	Study type	Quality score	No. of cases	No. of patients	Incidence (%)	Female (%)	Mean age (yr)	Mean F/U (mo)	Time to fracture (mo)	Fracture mechanism	Fracture side	Radiographic assessment
Camarda et al. (2015)(7)	Retrospective case series, level IV	9	1	1	NA	100	78	12	9	NR	NR	CT
Hamid et al. (2011)(20)	Retrospective case series, level III	11	8	8	4.9	100	76.3	35	14	NR	NR	RX
Hattrup (2010) (21)	Retrospective case-control study, level III	NOS 7	9	9	7.2	88.9	72.6	30	10.3	5 fall, 4 fatigue	NR	RX
Levy et al. (2013)(27)	Retrospective case series, level III	15	16	15	10.2	81.3	77	25	NR	NR	10 right, 6 left	RX and 5 CT
Levy et al. (2012)(28)	Retrospective case report, level IV	11	1	1	NA	100	85	29	3	Fall	1 right	RX
Lopiz et al. (2015)(30)	Retrospective case-control study, level III	NOS 7	4	4	3.3	75	74.7	39.6	11.9	NR	NR	RX and CT
Rouleau et al. (2013)(40)	Retrospective case report, level IV	11	1	1	NA	100	71	18	5	Blow to shoulder	1 right	RX and CT
Stephens et al. (2015)(45)	Retrospective case series, level III	16	2	2	6.3	NR	NR	51	NR	NR	NR	RX
Stevens et al. (2015)(46)	Retrospective case report, level IV	11	2	1	NA	100	63	60	26.3	1 fatigue, 1 getting up from seated position	1 right, 1 left	RX and CT
Teusink et al. (2014)(47)	Retrospective case-control study, level III	NOS 7	25	25	3.1	84.1	72.2	50	16.1	NR	NR	RX and 5 CT
Wahlquist et al. (2011)(48)	Retrospective case series, level IV	11	5	5	NA	80	74.2	22.4	8.4	NR	3 right, 2 left	4 RX and 1 CT
Walch et al. (2009)(49)	Retrospective case-control study, level III	NOS 6	4	4	0.8	NR	NR	27	7	3 NR, 1 fall	NR	RX

Study	Indication	Primary/ revision	Fracture location	Treatment	Clinical outcome	Functional outcome	Pain outcome	Fracture union
Camarda et al. (2015)(7)	CTA	Primary	Scapular spine	ORIF (mesh plate + TBW + ICBG)	DASH 48, ASES 52, OSS 28	Abd 100°, AE 100°, ER 40°	NR	52 weeks
Hamid et al. (2011)(20)	7 CTA, 1 irreparable rotator cuff tear	Primary	4 base scapular spine, 3 mesoacromion, 1 preacromion	Abduction pillow	DASH 42, ASES 70	AE 71°	NR	6 non-unions, 2 mal-unions
Hattrup (2010)(21)	6 CTA, 2 RA, 1 massive rotator cuff tear with pseudoparesis	Primary	3 acromion, 6 scapular spine	Sling immobilization	ASES 48.5, SST 5.1	Abd 90°, AE 97°, ER 42°	4	1 union, 8 non-unions
Levy et al. (2013)(27)	2 failure of arthroplasty, 11 CTA, 2 RC deficiency with severe RA, 1 non-union of proximal humeral fracture, 1 acute four-part fracture dislocation	2 revision, 14 primary	2 type I, 8 type II, 6 type III	Sling immobilization	ASES 44, SST 4	Abd 64°, AE 77°, ER 25°	5	NR
Levy et al. (2012)(28)	CTA	Primary	Acromial base	Sling immobilization and revision RTSA (after second fall and subsequent instability)	ASES 13.3, SST 0	Abd 55°, AE 70°, ER 30°	9	Mal-union, subsequent revision RTSA
Lopiz et al. (2015)(30)	CTA	Primary	3 acromial process, 1 acromial base	Sling immobilization, ORIF for acromial base fracture because of persistent pain	Constant-Murley 66.5	Abd 91°, ER 9°	NR	Union: 50%
Rouleau et al. (2013)(40)	CTA	Primary	Acromial base	ORIF (90-90 plate)	DASH 29.5, Constant-Murley 69	Abd 125°, AE 160°, ER 85°, IR 60°	NR	NR
Stephens et al. (2015)(45)	Failed shoulder arthroplasty	Revision	1 scapular spine, 1 acromion	Sling immobilization	ASES 95	AE 128°, ER 30°	1.3	NR
Stevens et al. (2015)(46)	1 failed RCR, 1 RA	1 revision, 1 primary	1 acromial base, 1 scapular spine	Sling immobilization	ASES 46, SST 3.5, Constant-Murley 31.5	AE 46°	NR	Bilateral non-union
Teusink et al. (2014)(47)	17 CTA, 3 failed RCR, 3 failed TSA, 2 failed hemiarthroplasty	8 revision, 17 primary	17 acromial, 8 scapular body	Sling immobilization	ASES 58	Abd 80°, AE 93°, ER 25°	2.3	13 union
Wahlquist et al. (2011)(48)	3 failed RCR, 1 failed TSA, 1 RCA	4 revision, 1 primary	Acromial base	2 abduction pillow and bone stimulator, 3 ORIF (2 plate, 1 TBW)	NR	Abd 97°, AE 84°, ER 13°	0.8	Non-operative: 11 and 29 weeks, ORIF: 7.5 to 42 weeks
Walch et al. (2009)(49)	1 failed hemiarthroplasty, 2 CTA, 1 failed coracoid transfer with massive cuff tear	2 revision, 2 primary	Scapular spine	3 abduction pillow, 1 ORIF (TBW) + hardware removal	Constant-Murley 35	AE 81°	4.5	Non-operative: 1 non-union, 2 union (24 months), ORIF: 1 non-union