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REVIEW ARTICLES

# Acute versus delayed reverse total shoulder arthroplasty for the treatment of proximal humeral fractures in the elderly population: a systematic review and meta-analysis

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**Background:** Recent literature has shown that acute reverse total shoulder arthroplasty (RTSA) yields good outcomes in the treatment of displaced proximal humeral fractures, and there have also been recent studies showing that delayed RTSA can be successfully used for sequelae of proximal humeral fractures such as nonunion and malunion. The use of meta-analysis affords the opportunity to formally compare the outcomes of acute RTSA for fracture and delayed RTSA for fracture sequelae.
**Methods:** We searched the MEDLINE, Embase, and Cochrane Library databases. We included all studies reporting on RTSA for the treatment of proximal humeral fracture sequelae with a comparison group of acute RTSA or with no comparison group in adults with a mean age older than 65 years and at least 2 years of follow-up. We calculated weighted mean differences for range of motion, standardized mean differences for clinical outcome scores, and relative risks for dichotomous outcomes.
**Results:** Sixteen studies met the inclusion criteria, which comprised 322 patients undergoing RTSA for fracture sequelae. Of these studies, 4 were comparative (46 patients) whereas 12 were case series (276 patients). Among studies directly comparing acute versus delayed RTSA, no differences in forward flexion ($P = .72$), clinical outcome scores ($P = .78$), or all-cause reoperation ($P = .92$) were found between the 2 groups. Patients undergoing delayed RTSA achieved 6° more external rotation than those undergoing acute RTSA; this difference was significant ($P = .01$).
**Conclusions:** Given the risks associated with surgery in the elderly population, consideration may be given to an initial trial of nonoperative treatment in these patients, saving RTSA for those in whom nonoperative treatment fails without compromising the ultimate outcome.
**Level of evidence:** Level IV; Systematic Review and Meta-analysis


**Keywords:** Proximal humeral fracture; elderly; reverse total shoulder arthroplasty; fracture sequelae; operative treatment; systematic review; meta-analysis

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Proximal humeral fractures are the third-most common nonvertebral fracture in patients older than 65 years,[3,10,38] and their incidence is projected to rise in the coming decades.[26,30] The morbidity and costs of geriatric proximal humeral

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fracture are substantial.[7,15,35] Despite their prevalence, treatment of geriatric proximal humeral fractures remains highly variable.[4]

Recent studies have shown improved outcomes using reverse total shoulder arthroplasty (RTSA) compared with hemiarthroplasty for acute displaced proximal humeral fractures in geriatric patients.[9,25,40,45] Other studies have shown that RTSA can also result in good outcomes when used for sequelae of nonoperatively treated proximal humeral fractures such as malunion or nonunion.[12,37,39] It is unclear, however, whether there are any differences in function or patient-reported outcome scores between RTSA performed in the acute fracture setting and RTSA performed in patients in whom symptomatic sequelae such as malunion and nonunion develop after initial nonoperative management. This is an important question because if sequelae that cannot be as effectively treated with delayed RTSA develop in patients initially treated nonoperatively, then perhaps surgeons should be treating acute proximal humeral fractures more aggressively with acute RTSA. On the other hand, if outcomes of delayed RTSA performed for fracture sequelae such as nonunion and malunion are as good as or better than those of RTSA performed acutely, then there is little reason to proceed immediately to acute RTSA for most fracture patterns.

We therefore sought to perform a systematic review and meta-analysis to compare range of motion, clinical outcomes, and complications of RTSA performed for proximal humeral fractures in the acute setting versus delayed RTSA performed for the sequelae of proximal humeral fractures in geriatric patients. Our hypothesis was that, when compared directly, the outcomes of RTSA performed acutely for proximal humeral fractures are not different from those of RTSA performed later for fracture sequelae such as nonunion or malunion. The technique of meta-analysis is ideally suited to answering this question because the use of RTSA for fracture sequelae is relatively rare, resulting in a small size and low power of existing studies, and meta-analysis allows use of a statistical approach to combine the results of these smaller studies to increase power and potentially answer this clinically relevant question.

## Methods

### Review protocol

We outlined our planned approach in an a priori protocol. We followed the outlined procedure in the *Cochrane Handbook*[14] and the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement[22] to create our protocol.

### Study eligibility criteria and outcome measures

Our inclusion criteria were comparative study designs including randomized controlled trials or cohort studies comparing acute RTSA with delayed RTSA for proximal humeral fractures or any cohort study that included a group of delayed RTSA patients. We also included case series of patients treated with RTSA for delayed proximal fracture sequelae. On the basis of the criteria of several studies included in our meta-analysis, an RTSA was considered delayed if it was completed 4 or more weeks from the time of injury and/or was described as being completed specifically for fracture sequelae, nonunion, or malunion. Additional inclusion criteria included patients with a mean age greater than 65 years, at least 2 years' follow-up for clinical outcomes and complications, and reporting of at least 1 of our prespecified outcomes.

The outcome measures were as follows: range of motion including forward flexion, abduction, and external rotation in degrees; clinical scores including the Constant score,[11] American Shoulder and Elbow Surgeons (ASES) score,[27] Penn shoulder score,[20] University of California–Los Angeles shoulder score,[2] Simple Shoulder Test (SST) score,[13] visual analog scale score,[31] and Single Assessment Numeric Evaluation score[46]; and postoperative complications including the all-cause reoperation rate, all-cause revision rate, aseptic revision rate, and deep infection rate.

### Search methods: databases, search terms, and limits

We searched the following electronic databases in January 2018: MEDLINE (1946-2018), Embase (1947-2018), and the Cochrane Library (1898-2018), as well as ClinicalTrials.gov (National Institutes of Health). Our themes for searching the databases were "shoulder arthroplasty" and "proximal humerus fracture." We did not restrict studies based on language. We manually reviewed references of relevant articles including all systematic reviews.

### Study selection

After removal of duplicates (N.C. and L.J.), 2 reviewers (D.C.A. and M.T.T.) screened studies by title and abstract. Articles that initially met the criteria were then further evaluated by a full-text review.

### Data collection

Two reviewers used a standardized data collection form to extract relevant data from included studies. Discrepancies were resolved by consensus or a third party if consensus could not be reached.

### Assessment of methodologic quality

We used a modified Newcastle-Ottawa Scale[43] that has been previously used to determine the methodologic quality of included randomized controlled trials and cohort studies.[25] Studies were ranked according to a high risk, low risk, or unclear scale. Two independent reviewers assessed the methodologic quality of each study. Discrepancies were resolved by consensus.

### Analysis

#### Measure of treatment effect

We analyzed range of motion and the individual clinical outcome scores using mean differences. To combine disparate outcome measures, we calculated the standardized mean difference between the groups. A predetermined hierarchy, designed to minimize the number of different clinical outcome scores, was developed a priori as follows:

ASES score, Constant score, and SST score. This hierarchy was used whenever studies reported more than 1 clinical outcome score. We used risk ratios to analyze dichotomous variables. We used the incidence rate to further analyze postoperative complications. All-cause reoperation was defined as any return to the operating room to address the original implant. We calculated 95% confidence intervals (CIs) for all comparisons, and the level of statistical significance was set at $P < .05$.

### Dealing with missing data

When data were missing, statistical methods outlined in the *Cochrane Handbook* were used when possible.[17] The methodology found in section 7.7.3 of the *Cochrane Handbook* includes calculating a standard deviation from the *P* value of a *t* test, an interquartile range, or a standard error.[17] When other methods were not possible for determining a missing standard deviation, we used an average standard deviation from the other included studies as outlined in section 16.1.3.1 of the *Cochrane Handbook*.[17] When data remained incomplete, we contacted the study authors to request relevant information and received an appropriate reply.[37]

### Data synthesis

We used RevMan, version 5.3,[36] to analyze and summarize the findings of studies using the random-effects model. Given the methodologic differences of the studies examined, we elected to use the random-effects model because of its more conservative nature. If more than 1 shoulder score was reported by a study, we used the previously described hierarchy to determine which score to include in the summary estimate.

### Subgroup analysis

Our search criteria included any study that reported on the surgical treatment of the sequelae of geriatric proximal humeral fractures. There was variation in how the term "sequelae" was used in various studies; some studies reported only the sequelae of nonoperatively treated fractures, whereas others grouped the sequelae of fractures treated surgically and those treated nonoperatively. Given that the differences in definitions created different groups of patients, we performed a subgroup analysis of only patients who underwent RTSA after nonoperative treatment of their proximal humeral fracture.

## Results

### Description of studies

#### Search results

We identified 2148 unique references by means of our search strategy. After screening of titles and abstracts, we retrieved 39 articles for full-text review. After full-text review, 16 studies met our inclusion criteria,[1,6,12,16,21,23,24,29,32-34,37,39,44,47,48] as outlined in Figure 1.

#### Included studies

Of the 16 studies that met our inclusion criteria, 4 were comparative studies of patients undergoing acute and delayed RTSA whereas 12 were case series—or individual cohorts treated as case series—of patients undergoing delayed RTSA (Supplementary Table S1). If studies reported on the type of

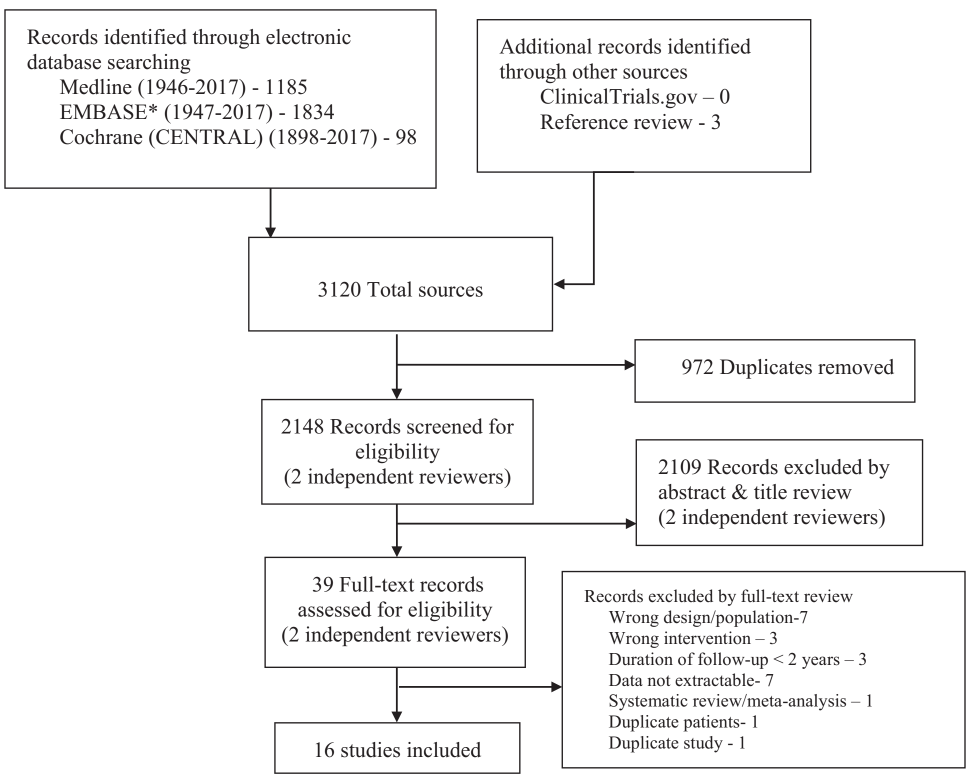


**Figure 1** Study selection flow diagram.

fracture sequelae according to the classification of Boileau et al[5] or Checchia et al,[8] these results were reported in Supplementary Table S1. In total, we aggregated results for 322 patients undergoing delayed RTSA for fracture sequelae. In the meta-analysis of range of motion, we included 4 studies representing 46 patients undergoing delayed RTSA and 51 patients undergoing acute RTSA after a fracture. The weighted average age in the delayed RTSA group was 71.8 years, and 74.4% of patients in the group were women. The average follow-up duration was 45.0 months after delayed RTSA.

## Methodologic quality of included studies

The 4 comparative studies available generally had a low or unclear risk of bias. The 12 available case series generally had a low risk of bias. Variable rates of follow-up were noted among studies, which introduced bias, and many studies did not report the follow-up period. An additional source of bias was differences among studies in whether they included patients who received surgery before delayed RTSA. Five studies exclusively reported on patients who were treated nonoperatively before delayed RTSA, whereas the remaining 11 studies contained heterogeneous groups of patients treated both operatively and nonoperatively before delayed RTSA. To account for these differences, we completed subgroup analyses limited to patients treated nonoperatively. The full analysis of methodologic quality for all studies is available in Appendix 1.

## Effects of interventions

### Range of motion

Among the 4 comparative studies that reported forward flexion, no difference in forward flexion was found between acute and delayed RTSA (mean difference, 3°; 95% CI, –12° to 18°; $P = .72$; Fig. 2, *a*). The overall weighted average forward flexion for delayed RTSA from the 13 studies reporting this value was 110° (Table I). The subgroup analysis of studies reporting exclusively on patients treated nonoperatively before delayed RTSA showed a greater weighted average forward flexion of 123° (Table II). Average range-of-motion measurements for each included study can be found in Appendix 2.

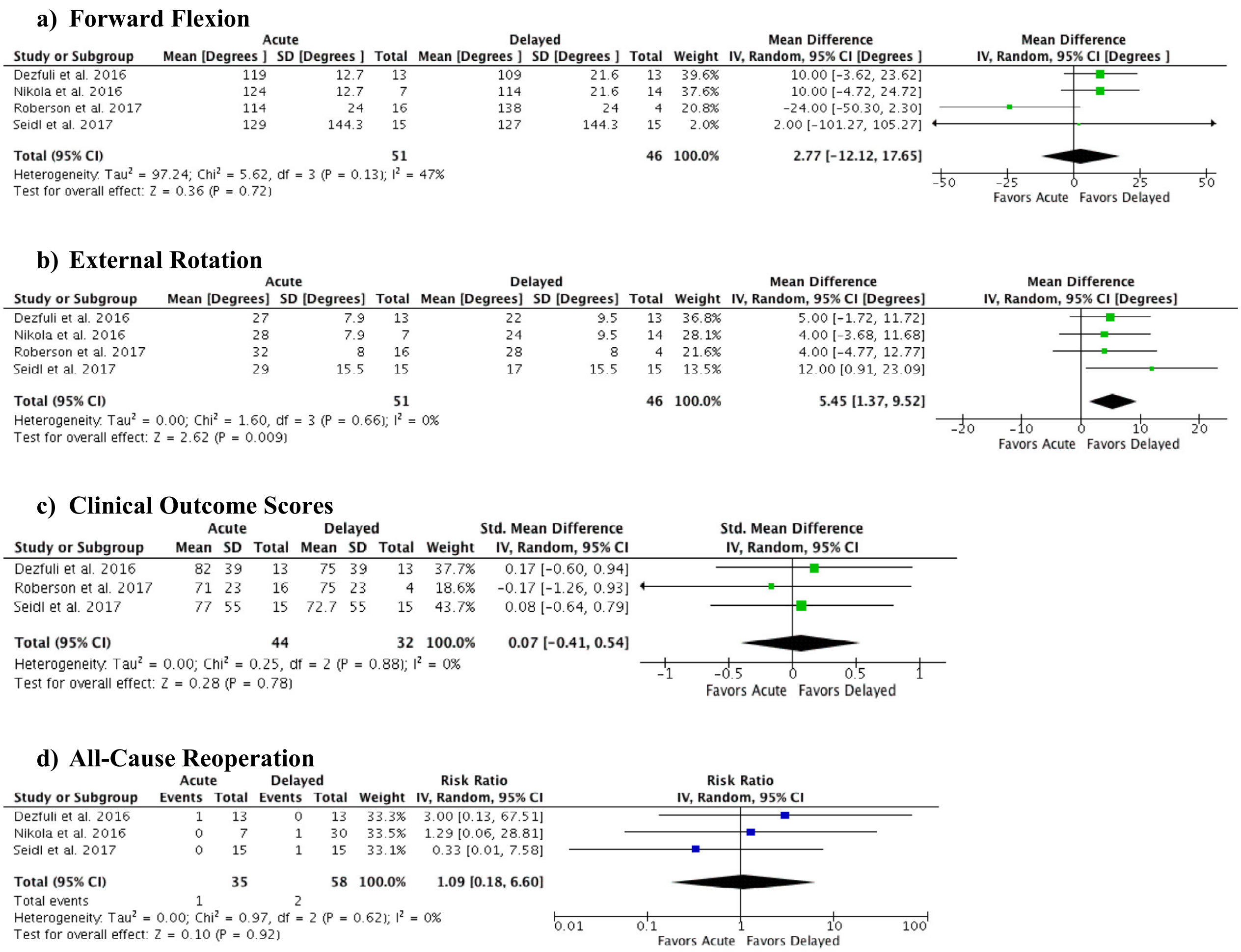


**Figure 2** **(a-d)** Forest plots of selected clinical outcomes. *SD*, standard deviation; *CI*, confidence interval; *Std*, standard; *IV*, inverse variance.

**Table I** Summary of all examined outcomes

| | Included studies | Acute weighted mean (range) | Delayed weighted mean (range) | Mean difference (acute – delayed) |
|---|---|---|---|---|
| Clinical outcome score | | | | |
| Constant score | 10 | 70† | 55.0 (46.6-65.5) | 15.0 |
| ASES score | 4 | 76.3 (71-82) | 71.3 (63-75) | 5.0 |
| SST score | 4 | 8.1 (7.3-9.1) | 7.0 (4-8.5) | 1.1 |
| VAS score | 3 | 2† | 2.9 (1.3-3) | −0.9 |
| SANE score | 2 | 78.9 (77-80.9) | 73.1 (72.3-76) | 5.8 |
| UCLA shoulder score | 1 | 30† | 28† | 2 |
| Penn shoulder score | 1 | 69† | 70† | −1 |
| Range of motion | | | | |
| Forward flexion | 13 | 121° (114°-129°) | 110° (89°-140°) | 11° |
| External rotation | 13 | 29° (27°-32°) | 20° (9°-35°) | 10° |
| Abduction | 6 | 103°† | 93° (79°-105°) | 10° |
| Complication rate* | | | | |
| All-cause reoperation | 10 | 1.01 (0-2.7) | 3.74 (0-9.5) | −2.73 |
| All-cause revision | 10 | 1.01 (0-2.7) | 3.64 (0-9.5) | −2.63 |
| Aseptic failure | 8 | 0.00 (0.0-0.0) | 2.44 (0-6.0) | −2.44 |
| Deep infection | 8 | 0.00† | 1.30 (0-4.8) | −0.93 |

*ASES*, American Shoulder and Elbow Surgeons; *SST*, Simple Shoulder Test; *VAS*, visual analog scale; *SANE*, Single Assessment Numeric Evaluation; *UCLA*, University of California, Los Angeles.
* Acute or delayed events per 100 patient-years.
† Only reported measure.

Among the 4 comparative studies reporting external rotation, delayed RTSA patients had significantly more external rotation than acute RTSA patients (mean difference, 5°; 95% CI, 1°-10°; $P = .01$; Fig. 2, *b*). The overall weighted average external rotation from 13 eligible studies was 20° for delayed RTSA (Table I). The value in the subgroup analysis of 4 studies reporting on nonoperatively treated delayed RTSA patients was similar, at 22° (Table II).

### Functional outcome scores

No difference in functional outcome scores was found between the acute and delayed RTSA groups in the 3 studies that

**Table II** Range-of-motion measurements in delayed RTSA patients initially treated conservatively

| Outcome measure | Acute, mean, ° | Delayed, mean, ° | Mean difference (acute – delayed), ° | *P* value |
|---|---|---|---|---|
| Forward flexion | | | | |
| Comparative studies | | | | |
| Dezfuli et al,[12] 2016 | 119 | 109 | 10 | NR |
| Nikola et al,[29] 2015 | 124 | 114 | 10 | >.05 |
| Roberson et al,[37] 2017 | 114 | 138 | −24 | .09 |
| Seidl et al,[39] 2017 | 129 | 127 | 2 | .97 |
| Weighted average | 121 | 119 | 0.5 | |
| Case series | | | | |
| Hattrup et al,[16] 2016 | No data | 140 | No data | No data |
| Overall weighted average | | 123 | | |
| External rotation | | | | |
| Dezfuli et al,[12] 2016 | 27 | 22 | 5 | NR |
| Nikola et al,[29] 2015 | 28 | 24 | 4 | >.05 |
| Roberson et al,[37] 2017 | 32 | 28 | 4 | .38 |
| Seidl et al,[39] 2017 | 29 | 17 | 12 | <.05 |
| Weighted average | 29 | 22 | 6 | |

*RTSA*, acute reverse total shoulder arthroplasty; *NR*, not reported.

**Table III** Clinical outcome scores in delayed RTSA patients initially treated conservatively

| Outcome measure | Acute, mean | Delayed, mean | Mean difference (acute – delayed) | *P* value |
|---|---|---|---|---|
| Constant score | | | | |
| Dezfuli et al,[12] 2016 | 70 | 64 | 6 | NR |
| ASES score | | | | |
| Dezfuli et al,[12] 2016 | 82 | 75 | 7 | NR |
| Roberson et al,[37] 2017 | 71 | 75 | 4 | .76 |
| Seidl et al,[39] 2017 | 77 | 72.7 | 4.3 | .813 |
| Weighted average | 76.3 | 73.9 | 5.6 | |
| SST score | | | | |
| Comparative studies | | | | |
| Dezfuli et al,[12] 2016 | 9.1 | 7.9 | 1.2 | NR |
| Seidl et al,[39] 2017 | 7.3 | 7.1 | 0.2 | .996 |
| Weighted average | 8.1 | 7.5 | 0.7 | |
| Case series | | | | |
| Hattrup et al,[16] 2016 | No data | 8.5 | No data | No data |
| Overall weighted average | | 7.7 | | |
| SANE score | | | | |
| Roberson et al,[37] 2017 | 77 | 76 | 1 | .94 |
| Seidl et al,[39] 2017 | 80.9 | 72.3 | 8.6 | .568 |
| Weighted average | 78.9 | 73.1 | 5.6 | |
| UCLA shoulder score | | | | |
| Dezfuli et al,[12] 2016 | 30 | 28 | 2 | NR |
| Penn shoulder score | | | | |
| Roberson et al,[37] 2017 | 69 | 70 | 1 | .96 |

*RTSA*, acute reverse total shoulder arthroplasty; *NR*, not reported; *ASES*, American Shoulder and Elbow Surgeons; *SST*, Simple Shoulder Test; *SANE*, Single Assessment Numeric Evaluation; *UCLA*, University of California, Los Angeles.

reported an applicable clinical outcome score (standardized mean difference, 0.07; 95% CI, –0.41 to 0.54; *P* = .78; Fig. 2, *c*). The weighted average Constant score for delayed RTSA was 55.0 based on 10 studies (Table I). The overall weighted average ASES score was 71.3 and the overall weighted average SST score was 7.0 in delayed RTSA patients (Table I). In the subgroup analysis of studies reporting exclusively on nonoperatively treated patients before delayed RTSA, the weighted average ASES score was 73.9 and the weighted average SST score was 7.7 (Table III). The mean clinical outcome scores reported for each included study can be found in Appendix 3.

### Postoperative complications

Ten studies reported on all-cause reoperation and all-cause revision. Eight studies reported on aseptic failure and deep infection. In the meta-analysis, no difference in all-cause reoperation was found between acute and delayed RTSA (relative risk, 1.09; 95% CI, 0.18-6.60; *P* = .92; Fig. 2, *d*). In delayed RTSA patients, the overall rate of all-cause reoperation per 100 patient-years was 3.74 and the overall rate of all-cause revision was 3.64 per 100 patient-years (Appendix 4). In delayed RTSA patients, the aseptic failure rate was 2.44 per 100 patient-years and the deep infection rate was 1.30 per 100 patient-years (Appendix 4).

## Discussion

### Summary of main results

We found no differences regarding forward flexion, clinical outcome scores, and risk of reoperation between RTSA performed acutely and RTSA performed in a delayed fashion among geriatric patients who sustained proximal humeral fractures. Moreover, patients undergoing delayed RTSA for proximal humeral fractures had significantly increased external rotation compared with those undergoing acute RTSA, although the degree of that difference (6°) may not be clinically significant.[41] Although our results are limited by the short follow-up and relatively small sample size found in the existing literature, the aggregate of our findings suggests that RTSA performed in a delayed fashion for the treatment of proximal humeral fracture sequelae does not result in inferior outcomes or more complications, making initial conservative treatment, with the possibility of delayed RTSA if symptomatic sequelae develop, a reasonable treatment strategy. Our data suggest that some geriatric patients who might currently undergo an acute RTSA for a proximal humeral fracture may instead undergo a trial period of nonoperative management without important outcomes being sacrificed. Because many patients treated conservatively for proximal humeral fractures are satisfied with their results and do not seek surgery for fracture sequelae, the net effect of this more conservative initial treatment strategy might mean that many fewer patients ultimately require RTSA at all.

## Agreements and disagreements with other studies or reviews

Recent systematic reviews comparing RTSA with hemiarthroplasty for acute proximal humeral fractures have provided comprehensive data describing the outcomes that can be expected after RTSA for acute fracture[25,28] and afford an important comparison for the results we observed in delayed RTSA. A systematic review by Namdari et al[28] reported a weighted average ASES score of 76.0 after RTSA for acute fracture, whereas Mata-Fink et al[25] observed a weighted average ASES score of 74.9 after RTSA for acute fracture. These values are similar to the weighted average ASES score of 71.3 that we observed, as the small difference between our value and the values in the previous studies is well within the ASES score's minimal clinically important difference for total shoulder arthroplasty patients of 13.6.[42] This equivalence is also seen when comparing the weighted average Constant score of 55.0 that we observed in delayed RTSA with the weighted averages of 50.3[28] and 54.4[25] reported in the previous reviews of patients undergoing RTSA for acute fractures. The average Constant score of 64 reported by Dezfuli et al[12] in a series of patients who did not undergo any surgical intervention before delayed RTSA suggests that conservatively treated patients undergoing delayed RTSA may even outperform acute RTSA patients, although future studies are needed to explore this possibility.

The previous systematic reviews have reported weighted average forward flexion of 114°[28] and 113°,[25] similar to the 110° weighted average observed in our review. The subgroup analysis of patients who did not receive any surgical intervention before delayed RTSA showed weighted average forward flexion of 123°, again suggesting that they may even outperform patients undergoing acute RTSA. The weighted average external rotation of 20° in our study of delayed treatment was remarkably similar to the previously reported weighted average of 20° for acute treatment.[25,28] Overall, the weighted averages for clinical outcome scores and range of motion after delayed RTSA for fracture sequelae compare very favorably with previously reported values after RTSA for acute fractures.

## Overall completeness and applicability of evidence

To our knowledge, this is the first meta-analysis examining acute versus delayed RTSA in the treatment of geriatric proximal humeral fractures. Although a previous systematic review on RTSA for the sequelae of proximal humeral fractures has been published, it did not compare results with acute RTSA and did not discriminate between operative and nonoperative sequelae of proximal humeral fractures.[19] Our study used a comprehensive search that was created in collaboration with professional reference librarians, initially identifying 2148 unique references. We used an international database (Embase) in our search and did not limit results by language. Our final inclusion of 16 studies is more than double that of the previously published systematic review,[19] and our review includes studies from 6 different countries, thus increasing its generalizability. The results of our study are clinically applicable and actionable. No differences were found between the acute and delayed patients among 3 of the 4 major outcomes our study examined (forward flexion, clinical outcome scores, and risk of reoperation). This consistency among the outcomes and among prior studies of each treatment group individually lends further weight to the conclusion that no major differences exist between the 2 approaches for treating geriatric proximal humeral fractures with RTSA; in turn, this permits more robust, data-driven conversations with this patient population to help guide the best clinical decisions.

## Quality of evidence

Our analysis was limited to the existing literature on the topic. No randomized controlled trials were included in our work because none exist currently. All included studies were observational in nature, and only 4 of the 16 studies were prospective.[1,6,44,48] Among the comparative studies, none used regression techniques or other methods to adjust for differences between the 2 groups. Despite these limitations, when we systematically examined the included studies for risk of bias using a previously published technique,[25,43] we found only 4 instances in which a particular aspect of a study was deemed to be at high risk of bias (Appendix 1). Consistent with this, funnel-plot analysis of our 4 forest plots did not indicate any significant degree of publication bias (Appendix 5). Moreover, three-quarters of our heterogeneity scores ($I^2$ values) in the forest plots were in the low to moderate range according to published standards.[18] When heterogeneity is present, it does not necessarily preclude analysis of the data; rather, it is necessary to consider the overall consistency of the results when interpreting the findings.[18] Among the comparative studies, our results showed remarkable consistency both between individual studies and between 3 of the major outcomes we examined (range of motion, clinical outcome scores, and risk of reoperation), which suggests that heterogeneity did not impact the overall thrust of our conclusions.

## Strengths and limitations

Our study had several strengths. First, we developed an a priori search strategy and analysis plan. Second, the search strategy was not limited by language, and we used an international database (Embase). Third, we adhered to PRISMA guidelines when reporting our results. Fourth, we used accepted methods for dealing with missing data and analysis according to the *Cochrane Handbook*. In addition, we discriminated between studies that only reported on the sequelae of nonoperative treatment of proximal humeral fractures and studies that included the sequelae of both nonoperative and surgical treatment of these fractures. This is an important distinction that has not been consistently made in the existing literature and has important implications for interpreting results. Finally, we systematically ranked our studies based on their risk of bias according to a previously published method[25] based on the Newcastle-Ottawa Scale.[43] Related to this, we saw little evidence of publication bias in our funnel plots.

We acknowledge several limitations. First, our included studies did not report on a uniform set of outcomes. Even within a class of outcomes such as clinical outcome scores, there was variability in the specific outcome score used. This limited the total number of studies we could include in our forest-plot analysis and thus limited our interpretation of the data. Second, several studies had missing statistical values that needed to be indirectly calculated. Although these methods are well accepted in the literature, they do potentially introduce bias into our results. Third, our analysis is likely underpowered to detect differences in reoperations between the 2 groups because it is a rare outcome. Furthermore, our analysis is limited to short-term follow-up; differences in outcomes between the 2 groups may become more apparent with increasing follow-up. In addition, we were unable to perform subgroup analyses according to fracture classification or time from injury to RTSA because these data were not available in the included studies. Finally, our analysis is limited to RTSA and does not include comparison with nonoperative management, open reduction–internal fixation, hemiarthroplasty, or any other means of treating these fractures.

### Implications for practice and research

Our results are clinically actionable in the short term. We found no significant differences among geriatric patients with proximal humeral fractures treated acutely compared with delayed RTSA in range of motion, clinical outcome scores, or risk of reoperation. This finding implies that geriatric patients with proximal humeral fractures may be offered a trial of nonoperative treatment without fear of compromising their ultimate outcome if conservative treatment fails and they elect to undergo delayed RTSA. This more conservative initial treatment strategy could mean that, in aggregate, many fewer patients require surgical intervention for their fractures.

## Conclusions

No differences in range of motion, clinical outcome scores, or risk of reoperation were found between geriatric patients who underwent RTSA for proximal humeral fractures in the acute setting and those treated in a delayed fashion. Given the risks associated with surgery in the elderly population, consideration may be given to an initial trial of nonoperative treatment in this patient population.


## Disclaimer

The authors, their immediate families, 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.


## Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jse.2018.10.004.

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