

Review Article

Reverse Total Shoulder Arthroplasty for Complex Proximal Humerus Fractures: Mid-Term Results

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Abstract

Background: Comminuted proximal humerus fractures in osteoporotic older adults are difficult to treat with fixation or hemiarthroplasty because of unpredictable tuberosity healing. Reverse total shoulder arthroplasty (RTSA) restores a stable fulcrum independent of cuff function.

Objective: To synthesise mid-term evidence on RTSA for complex fractures versus hemiarthroplasty and fixation.

Methods: Narrative review of comparative cohorts, randomised trials, registry analyses, and reviews on tuberosity fixation, outcomes, and complications.

Findings: RTSA yields superior elevation and functional scores versus hemiarthroplasty; tuberosity healing modulates but does not abolish this advantage. Registry data show durable survivorship comparable to elective RTSA through ten years. Notching, instability, and neurological injury remain the principal complications.

Conclusions: RTSA is effective for complex fractures in selected older patients, though superiority over well-executed fixation in younger patients is less certain.

Keywords: Reverse total shoulder arthroplasty; Proximal humerus fracture; Hemiarthroplasty; Tuberosity healing; Scapular notching

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Introduction

Proximal humerus fractures account for a substantial share of fragility fractures in patients over 65, and three- and four-part comminuted patterns with tuberosity displacement or head-split components are poorly suited to reduction and fixation in osteoporotic bone [1]. Hemiarthroplasty was long the surgical mainstay for these injuries, but functional results proved unpredictable, driven chiefly by variable tuberosity healing and consequent rotator cuff dysfunction [2]. The Grammont-design reverse prosthesis, developed for cuff-deficient glenohumeral arthritis, medialises the centre of rotation and lets the deltoid substitute for an insufficient cuff, so its fulcrum does not depend on

tuberosity union in the way hemiarthroplasty's does [3]. This biomechanical property motivated its extension to acute fracture care in the early 2000s, and it is now a leading option for complex proximal humerus fractures in older adults [1].

This review synthesises the published literature on RTSA for complex proximal humerus fractures: comparative outcomes against hemiarthroplasty and ORIF, tuberosity fixation technique and its influence on function, patient-reported and objective outcome measures, complication rates including instability and scapular notching, and mid-term survivorship from registry data. It is a narrative synthesis of the existing literature rather than a report of original surgical results.

Biomechanical Rationale

The Grammont design's medialised, lower-offset centre of rotation increases the deltoid's effective lever arm and pre-tensions its fibres, allowing the deltoid alone to elevate the arm even when the supraspinatus and infraspinatus are absent or non-functional [3]. In a fracture, this property is decisive: the greater and lesser tuberosities, carrying the cuff insertions, are frequently comminuted, osteoporotic, and prone to malunion or resorption regardless of how carefully they are repaired. Hemiarthroplasty's functional result depends almost entirely on those tuberosities healing in an anatomically reduced position around a correctly retroverted and height-restored humeral component; when they do not, elevation is often limited to well under 90 degrees. RTSA decouples elevation from cuff integrity, converting a technically demanding and outcome-variable tuberosity-dependent reconstruction into a more reproducible procedure, which is the central reason the indication has expanded so rapidly since the first dedicated fracture series [1].

Early Fracture Series and Rationale for RTSA

The first substantial fracture-specific RTSA series, in 43 patients with a mean age of 78 years followed for a mean of 22 months, reported a mean Constant score of 44 points (66% of the age- and sex-matched normal value) and 97 degrees of active elevation, with tuberosity displacement on radiographs in over half of patients yet function that remained acceptable because the prosthesis did not depend on tuberosity healing for elevation [1]. A contemporaneous fracture-specific stem series confirmed feasibility and reasonable pain relief with the Delta III implant in elderly patients with comminuted fractures unsuited to fixation [2]. These series established that RTSA could deliver functional shoulders in a population for whom ORIF often failed and hemiarthroplasty produced inconsistent active elevation.

Comparative Outcomes: RTSA versus Hemiarthroplasty

Direct comparison clarified RTSA's advantage. In a matched cohort of elderly patients, RTSA produced higher American Shoulder and Elbow Surgeons (ASES) scores, greater active forward elevation, and higher patient satisfaction than hemiarthroplasty, findings summarised in Figure 1 [4]. A blinded randomised controlled trial in patients over 70 similarly found better pain relief, function, and a lower revision rate with RTSA, and hemiarthroplasty patients who required conversion to RTSA did not thereafter match the outcomes of primary RTSA [5]. A multicentre randomised trial in patients 65 and older likewise reported superior functional outcomes with RTSA over hemiarthroplasty for displaced three- and four-part fractures [6]. A meta-analysis pooling this comparative literature concluded RTSA is the better option in the elderly on pooled functional and complication endpoints [7], a conclusion echoed by a further systematic review and meta-analysis of the same comparison [8]. Registry-level data corroborate the trial evidence: an Australian joint-registry analysis of 5,946

fracture patients found RTSA associated with a lower revision risk than stemmed hemiarthroplasty [9]. Table 1 summarises the design, size, and principal findings of these comparative studies.

Table 1: Design and principal findings of key studies comparing reverse total shoulder arthroplasty (RTSA) with hemiarthroplasty (HA) for complex proximal humerus fractures [1,4,5,8,7,9,6].				
Study	Design	N	Follow-up	Key finding
Bufquin 2007	Case series, RTSA only	43	22 months (mean)	Constant score 44 (66% of normal); notching 25%
Cuff & Pupello 2013	Retrospective comparative	53	Not stated (mean, short-term)	RTSA: higher ASES, elevation, satisfaction than HA
Sebastia-Fornada 2014	Randomised controlled trial	62	28.5 months (mean)	RTSA: better pain, function, lower revision rate
Gallinet 2018	Systematic review/meta-analysis	Pooled	Variable	RTSA superior functional and complication endpoints
Wang 2016	Meta-analysis	Pooled	Variable	RTSA a better option than HA in the elderly
Critchley 2020	Registry analysis	5946	Registry-based	RTSA: lower revision risk than stemmed HA
Watts 2024 (SHERPA)	Multicentre randomised trial	Not stated	Not stated	RTSA superior functional outcome vs HA, age 65+

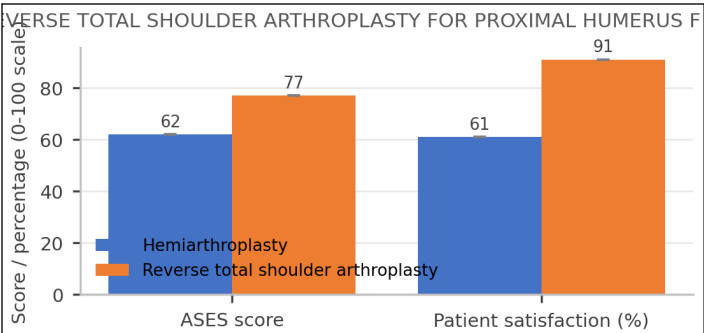


Figure 1: ASES score and patient satisfaction at final follow-up, hemiarthroplasty versus reverse total shoulder arthroplasty, in a matched cohort of elderly patients with proximal humerus fracture: ASES 62 vs 77, satisfaction 61% vs 91% [4].

Comparative Outcomes: RTSA versus Open Reduction-Internal Fixation

Evidence against ORIF is more heterogeneous. An early single-centre comparative series found RTSA and hemiarthroplasty each outperformed ORIF on functional scores in patients whose fractures were not amenable to reliable fixation, while acknowledging that well-fixed ORIF in favourable fracture patterns remained competitive [10]. A subsequent systematic review and meta-analysis of RTSA versus ORIF for three- and four-part fractures found RTSA associated with fewer reoperations and more predictable early function, though ORIF could match RTSA when tuberosity fixation and bone quality were favourable [11]. A network meta-analysis of interventions for displaced proximal humeral fractures situated RTSA among the higher-ranked options for functional recovery relative to ORIF and conservative management, while acknowledging trial heterogeneity [12]. A further meta-analysis specifically interrogating whether arthroplasty outperforms fixation found the comparative advantage of RTSA over ORIF was more consistent in older, lower-demand patients than across all age groups, reinforcing that patient selection—rather than a uniform hierarchy—should guide the choice between reconstruction and replacement [13].

Tuberosity Fixation Technique and Its Influence on Outcome

Even though RTSA tolerates tuberosity nonunion better than hemiarthroplasty, repair technique still matters. A comparative series found reverse arthroplasty outperformed hemiarthroplasty for acute fracture partly because it was more forgiving of tuberosity malunion, but outcomes with hemiarthroplasty deteriorated sharply when tuberosities failed to heal [14]. A systematic review and meta-analysis specifically addressing tuberosity healing after RTSA for fracture found that healed tuberosities were associated with better external rotation and abduction strength than un-united or resorbed tuberosities, even though overall elevation and patient

satisfaction were less affected [15]. A related systematic review examined how humeral component inclination interacts with tuberosity healing and outcome, finding that healing rates and functional benefit varied with prosthesis positioning as well as fixation technique [16]. A five-year retrospective cohort found that 74% of repaired tuberosities consolidated in anatomical position, and that patients with healed tuberosities had better Quick-DASH and Constant scores than those with failed healing, supporting continued attention to tuberosity repair even in a reverse construct [17].

Functional Outcomes and Mid-Term Survivorship

Mid-term follow-up supports durability of the functional gains seen early after RTSA for fracture. The five-year cohort above documented sustained benefit rather than deterioration over time when tuberosity healing was achieved [17]. At the ten-year horizon, a national joint-registry analysis found that RTSA performed for acute proximal humeral fracture had revision-free survivorship comparable to RTSA performed electively for degenerative indications, indicating that the trauma indication itself does not compromise implant longevity [18]. Comparative work examining complication patterns between RTSA and angular-stable locking-plate fixation for proximal humerus fractures in the elderly found each modality carries a distinct risk profile rather than one being uniformly safer, again pointing toward individualised selection [19].

Complications

Complication profiles after fracture RTSA mirror those described for RTSA generally, tempered by the trauma setting. In the original 43-patient fracture series, neurological complications, reflex sympathetic dystrophy, and dislocation were each documented, alongside radiographic scapular notching, summarised in Figure 2 [1]. Systematic reviews of RTSA complications broadly emphasise instability, infection, periprosthetic fracture,

and component loosening as the most consequential problems across indications, with the fracture population additionally susceptible to complications related to tuberosity fixation itself [20,21]. A dedicated series characterising dislocation, pain, and postoperative motion after RTSA found dislocation an uncommon but recognised early complication requiring attention to soft-tissue tensioning and component positioning [22]. A focused review of complications and their evolution over successive implant generations noted that acromial and scapular spine stress fractures, along with notching, have become relatively more prominent as instability and early loosening rates have fallen with improved implant design [23].

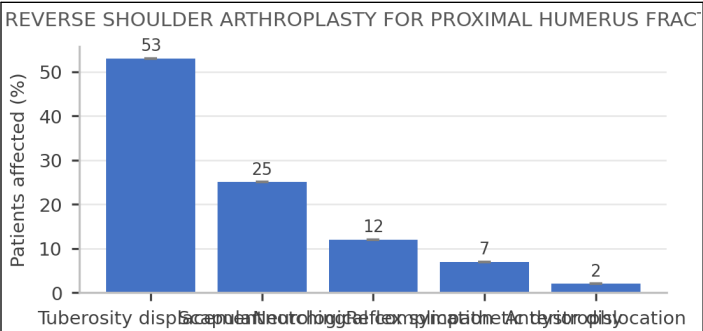


Figure 2: Complication rates after reverse shoulder arthroplasty for three- and four-part proximal humerus fractures in 41 elderly patients at a mean 22-month follow-up [1].

Scapular Notching and Long-Term Complications

Scapular notching, inferior glenoid bone erosion from humeral component impingement, was first graded by the Nerot-Sirveaux classification developed for cuff-arthropathy RTSA and subsequently applied to fracture series [24]. Analysis of notching risk factors identified glenosphere positioning and size as key modifiable determinants [25], and biomechanical work has linked notching risk directly to glenoid baseplate and inclination choices [26]. Long-term follow-up specifically evaluating the clinical consequences of notching found that, while radiographic progression is common, its

correlation with functional decline is inconsistent and appears most relevant when high-grade notching involves the baseplate [27]. Taken together, these findings support inferior glenosphere placement with adequate lateral and inferior overhang as a practical, evidence-based means of limiting notching without requiring routine baseplate augmentation in every fracture case. Table 2 summarises complication-related findings from these sources alongside the fracture-specific series discussed above.

Table 2: Complication-related findings relevant to RTSA for proximal humerus fracture, including scapular notching and instability [20,19,24,25,26,27,22].		
Source	Focus	Key finding
Zumstein 2011	Systematic review, RTSA complications	Instability, infection, periprosthetic fracture, loosening most consequential
Klug 2019	RTSA vs angular-stable plating, fracture	Distinct, not uniformly superior, complication profile per modality
Sirveaux 2004	Notching classification	Nerot-Sirveaux grading of scapular notching, grades 1-4
Levigne 2008	Notching risk factors	Glenosphere positioning and size are key determinants
Roche 2013	Notching biomechanics	Glenoid baseplate/inclination choice affects notching risk
Spiry 2021	Long-term notching outcome	Progression common; functional correlation inconsistent unless baseplate involved
Clark 2012	Dislocation/motion after RTSA	Dislocation uncommon but recognised early complication

Patient Selection

Across this literature, the consistent thread is that RTSA advantages are most pronounced in older, lower-demand patients with comminuted, tuberosity-compromised fractures unsuited to durable fixation [13,11], while ORIF with meticulous tuberosity fixation retains a role in younger patients with reconstructible anatomy and healthier bone [14]. Bone quality, fracture pattern (particularly head-split or fracture-dislocation morphology), pre-existing cuff status, physiological rather than chronological age, and the patient's functional

demands and rehabilitation capacity should all inform the choice between fixation, hemiarthroplasty, and RTSA rather than treating age alone as the deciding variable. Registry data suggest that RTSA implanted for this indication is not a compromise choice: its mid-term survivorship parallels elective RTSA [18], and functional superiority over hemiarthroplasty is now supported by randomised, meta-analytic, and registry-level evidence [5,6,7,9].

Conclusion

Reverse total shoulder arthroplasty has matured from an experimental salvage option into an evidence-supported primary treatment for complex proximal humerus fractures in older adults, delivering more reliable elevation and functional scores than hemiarthroplasty [4,5,6] with mid-term survivorship comparable to elective indications [18]. Tuberosity repair still meaningfully influences rotational strength and outcome even within a reverse construct [15,17], and instability, neurological injury, and scapular notching remain the principal complications to anticipate and mitigate through careful component positioning [20,24,26]. Comparative superiority over well-executed ORIF is less uniform and appears concentrated in older, lower-demand patients [11,13], leaving individualised patient selection, rather than a single universal algorithm, as the guiding principle for treating these fractures.

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