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Research Article

Tuberosity Healing Impact in the Short-Term Clinical Outcome of Complex Proximal Humeral Fractures Treated with Reverse Shoulder Arthroplasty: A Scoping Review

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Abstract

Background: Tuberosity healing in proximal humerus fractures (PHFs) has been associated with better outcomes for hemiarthroplasty, however, there is still debate concerning its effects in reverse shoulder arthroplasty (RSA). This study aims to assess the current state of the knowledge regarding the impact of tuberosity healing in PHFs treated with RSA, evaluate the functional results of patients with complex PHFs submitted to RSA with and without tuberosity healing and to evaluate the tuberosity healing rate after RSA.

Methods: A scoping review was conducted with a multi-database search and data from the published literature meeting inclusion criteria were reviewed and evaluated.

Results: Fifteen studies (including 1085 patients) were included. Weighted mean age was 75,1 years old, and weighted female percentage was 79,9%. The weighted healing rate was 59,3%. Patients in the tuberosity healed group demonstrated a statistically significant superior Constant-Murley Score (CMS) in 6 of the total 15 studies included.

Conclusion: Tuberosity healing appears to provide better CMS and accordingly, superior overall shoulder function, following RSA for PHFs. The tuberosity healing also seems to impact RSA biomechanics primarily during external rotation. Further randomized controlled trials are needed to confirm the benefits of tuberosity healing.

Keywords: *Shoulder Arthroplasty; Reverse Total Shoulder Arthroplasty; Tuberosity fixation; Tuberosity Healing*

Introduction

Proximal humeral fractures (PHFs) account for about 6% of all the fractures in adult population [1].

Although most PHFs are treated conservatively with a satisfactory clinical outcome, complex fractures (Neer classification 3 and 4) require surgical treatment [2].

When osteosynthesis is not recommended, hemiarthroplasty (HA) and reverse shoulder prosthesis (RSA) have been used for management of complex PHFs, with the later becoming increasingly popular, owing to better clinical outcome scores and lower complication rates [3,4].

The management of complex PHFs remains an area of ongoing controversy with variable surgical approaches [5,6].

Although, with RSA, functional outcomes are less dependent on tuberosity healing and cuff integrity (comparing to HA), theoretically, tuberosity fixation would still contribute to higher healing rates and consequently better clinical outcomes, nonetheless, studies have reported variable results [7-9].

Healing of greater tuberosity in RSA has been a matter of recent studies, investigating functional outcomes and range of motion (ROM) of shoulder after RSA based on tuberosity healing [10-12].

The potential impact of greater tuberosity healing on clinical outcomes of RSA patients led to the development of new prosthesis designs, allowing better and more reliable fixation of tuberosities and bony ingrowth [13].

Aim of the Study

The aim of this review is to provide a comprehensive assessment of the current state of the knowledge regarding the impact of tuberosity healing in PHFs treated with RSA and to analyze the functional results of patients with complex PHFs submitted to RSA with and without tuberosity healing. The secondary goal is to evaluate the tuberosity healing rate after RSA.

Methods

A systematic search was performed in four computer databases (EMBASE, MEDLINE, Web of Science, Scopus) to identify articles related to the impact of tuberosity healing in PHFs treated with RSA. Databases were initially searched on March 6, 2023, and an updated search was performed on July 17, 2023. All English-language articles published from inception until July 17, 2023, were included for screening. Reference lists of extracted articles were also manually searched to identify additional relevant studies. Key search terms included “proximal humeral fractures”, “reverse shoulder prosthesis” and “tuberosity healing”. Boolean operator “or” followed by “and” was used to consolidate the search results. All articles of any study design, reporting on the outcome based on tuberosity healing in PHFs treated with RSA, published since 2018, were then, considered for inclusion.

For studies that were included after full-text screening, background data (authors, publication year, study design), participant characteristics (sample size, mean age, percentage female), and outcome-related information (Constant-Murley Score, ROM, and healing rate) were extracted into a standardized Excel spreadsheet.

Quality of studies included in this review was evaluated using the Joanna Briggs Institute (JBI) checklist for case series [14,15].

Duplicate studies, non-peer reviewed studies, unpublished manuscripts, conference abstracts, non-English language studies, and studies not directly studying the impact of tuberosity healing in PHFs treated with RSA were excluded.

The study screening and selection process is summarized in the PRISMA-ScR flow diagram for the scoping review process (Figure 1) [16].

Results

A total of 1395 studies were identified through the database search.

Three additional studies were found through forward and backward citation searching.

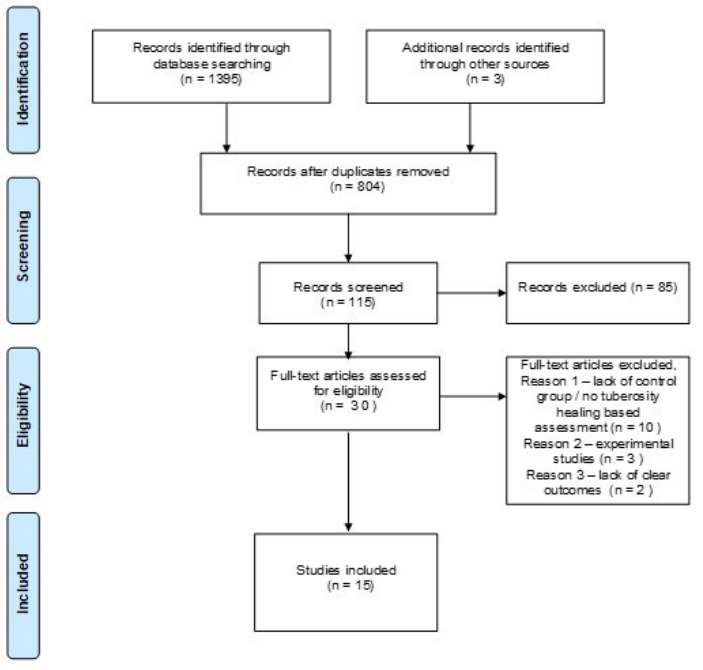

Figure 1: *PRISMA-ScR flow diagram for the scoping review process. Modified: The Joanna Briggs Institute reviewers' manual 2015. Methodology for JBI scoping reviews. Published by the Joanna Briggs Institute, 2015.*

After removing duplicates, 804 studies remained and underwent title and abstract screening. At this stage, 689 studies were deemed irrelevant and the full texts of 115 studies were collected and further examined. 30 studies met the inclusion criteria and were incorporated into the qualitative synthesis. 15 of these 30 studies were excluded from the review due to lack of sufficient information required to quantitatively pool the results (10 studies regarding lack of control group/no tuberosity healing based assessment, 3 were experimental studies and 2 studies were excluded due to lack of clear outcomes). In the end, 15 studies (including 1085 patients) were included in the scoping review.

Study characteristics are displayed in table 1.

The weighted mean age was 75,1 years old, and the weighted female percentage was 79,9%.

Ohl., *et al*. [17] was the largest study including a total of 420 patients while Takayama., *et al*. [18] had the smallest cohort with 18 patients.

The weighted healing rate was 59,3%. Except for two studies [17,19], the healing rate was higher than 60%, being 75% or more in 6 studies and reported to be 100% in one study [18].

The Constant-Murley Score (CMS) was higher on the tuberosity healed group in almost every included study, exceptions were two studies [20,21]. Patients in the tuberosity healed group demonstrated a statistically significant superior CMS in 6 studies [11,17,22-25] of the total 15 included. None of the studies with higher CMS on the non-healed tuberosity group reported statistically significance in this factor.

Most studies reported better ROM parameters in tuberosity healed patients.

Study	Study location	Study design	Condition	Sample size	Patients' characteristics	Range of motion (mean, healed vs not healed)	Constant-Murley Score (mean, healed vs not healed)	Healing rate (%)
Barros., *et al.* (2020) [11]	Portugal	Cohort study	Neer 3-4	28	Mean age: 70,1 Female: 78,6%	a) 105º vs 75º b) 135º vs 90º* c) 60º vs 30º* d) 60º vs 30º*	79 vs 55*	76,3
Boileau., *et al.* (2019) [26]	France	Retrospective Cohort study	Neer 3-4	38	Mean age: 80 Female: 92%	a) N/A b) 141º vs 115º c) 27º vs 11º d) N/A	64 vs 51	84
Fortane., *et al.* (2020) [27]	France	Retrospective Cohort study	Neer 3-4	34	Mean age: 70,5 Female: 85%	a) N/A b) 116º vs 119º c) 19º vs 14º d) N/A	59 vs 57	79,4
Gunst., *et al.* (2021) [22]	France	Retrospective Cohort study	Neer 4	28	Mean age: 77 Female: 85%	a) N/A b) 112º vs 87º c) 22º vs 11º* d) 60º vs 30º*	59,8 vs 51,5*	78,5
Holschen., *et al.* (2021) [20]	Germany	Retrospective Cohort study	Neer 3-4	58	Mean age: 78,5 Female: 89%	a) 106º vs 111º b) 124º vs 126º c) N/A d) N/A	61 vs 63	65,5
Marin., *et al.* (2021) [28]	Italy and Switzerland	Retrospective Cohort study (multicenter)	Neer 3-4	90	Mean age: 74 Female: 78%	a) 122º vs 121º b) 133º vs 128º c) 15º vs 13º d) 3º vs 4º	67,9 vs 58,1	72,6

Mohapatra., *et al*. (2022) [23]	India	Retrospective Cohort study	Neer 3-4	41	Mean age: 70,4 Female: 34,1%	a) 159º vs 138º* b) 165º vs 141º* c) 30º vs 35º* d) 38º vs 33º*	70,7 vs 55,5*	68,3
Ohl., *et al*. (2018) [17]	France	Retrospective Cohort study (multicenter)	Neer 3-4	420	Mean age: 78 Female: 83%	a) N/A b) 127º vs 114º* c) N/Aº d) 5º vs 4º	61 vs 54,5*	40,2
Reuther., *et al*. (2018) [21]	Germany	Case series (multicenter)	Neer 4	81	Mean age: 78,5 Female: 86,7%	a) 119º vs 127º b) 128º vs 135º c) 20º vs 11º d) 72º vs 76º	60,3 vs 62,3	86,4
Simovitch., *et al*. (2018) [30]	United States	Prospective study (multicenter)	Neer 3-4	55	Mean age: 78,5 Female: 69%	a) 114º vs 111º b) 132º vs 127º c) 40º vs 29º* d) 4º vs 3º	64,6 vs 63,2	61,2
Schmalzl., *et al*. (2020) [24]	Germany	Retrospective Cohort study (multicenter)	Neer 3-4	64	Mean age: 76 Female: 86%	a) N/A b) 128º vs 92º* c) 33º vs 17º* d) N/A	64 vs 44*	77
Torrens., *et al*. (2018) [29]	Spain	Retrospective Cohort study	Neer 3-4	41	Mean age: 77,9 Female: 86%	a) N/A b) >90º c) N/A d) N/A	61 vs 61	68
Fischer., *et al*. (2023) [19]	Switzerland	Prospective study	Neer 2-4	56	Mean age: 81 Female: 96%	a) 150º vs 138º b) 150º vs 140º c) N/A d) 8º vs 6º	72 vs 68	55

Takayama., *et al*. (2021) [18]	Japan	Retrospective Cohort study	Neer 3-4	18	Mean age: 80,4 Female: 89%	a) 116º b) 119º c) 27º d) 6º	77 (ASES score)	100
Troiano., *et al*. (2023) [25]	Italy	Retrospective Cohort study	Neer 3-4	33	Mean age: 77,1 Female: 81,8%	a) 120º vs 113º b) 132º vs 110º* c) 38º vs 33º d) 6º vs 4º	68,2 vs 55,3*	87,9

Table 1: *Included studies data. a) Abduction; b) Anterior elevation; c) External rotation; d) Internal rotation; *Statistically significant test result (P ≤ 0.05); N/A data not available.*

Discussion

Various studies have investigated the impact of tuberosity healing in PHFs treated with RSA. Theoretically, by healing, the volume of the greater tuberosity influences the restoration of the lateral offset, improving deltoid wrapping over the RSA, and supporting the function of the subscapularis. Nevertheless, a gold standard technique is yet to be determined [25].

Jain., *et al*. [31] performed a systematic review, published in 2019 with the inclusion of 7 studies, reporting 381 patients, regarding clinical and functional outcomes of RSA in PHFs with and without tuberosity healing. The marked and continuous increase in publications since then, validates the pertinence of this subject, materialized on this review with far more patients included.

The weighted healing rate of the included studies in this review was 59,3%. However, this result is significantly impacted by the fact that the lowest healing rate (40,2%) is found on the study with the larger sample (420), by Ohl., *et al* [17]. In 13 of the 16 included studies, the healing rate was higher than the weighted rate.

The CMS is a widely used instrument to evaluate overall shoulder function, especially for subacromial pathology [32,33]. However, it has not been validated with cross-cultural adaptation in every language and population [34]. It encompasses an individual extent as 35 out of 100 points are related to subjective components based on pain and daily living activities. The remaining 65 points are objective in nature, linked to range of motion (ROM) and strength.

In 6 of the 15 included studies in this review, the tuberosity healed group demonstrated a statistically significant superior CMS.

While ROM parameters are included in the CMS, evaluating ROM parameters alone is important as it removes the subjective element from the analysis.

Although most studies included in this review, reported better ROM parameters in tuberosity healed patients, this trend was not statistically significant in many of the studies and only one study [23] reported statistically significant superiority in every ROM parameter evaluated. However, one must consider that this study, by Mohapatra and colleagues, presents as an outlier in demographic parameters as it is the only study with male predominance and the youngest mean age cohort.

Onggo., *et al*. [35] compared the outcomes between the use of fracture vs. nonfracture stems in PHFs. They reported superior clinical outcomes with fracture stems and a greater chance of tuberosity healing. However, it is not possible to conclude if the superiority arises from the stem itself or the tuberosity healing effect.

Hess., *et al*. [36] conducted a multicenter prospective study evaluating a reattachment technique that led to tuberosity healing rate of 90% and mean CMS of 73 points. Barbosa., *et al.* [37] retrospectively reviewed 33 patients that were treated with RSA for complex PHFs, they reported a tuberosity healing rate of 85,7% with a mean CMS of 64,4 points and mentioned the lack of timely initiation and duration of physiotherapy as a motive for suboptimal results.

These studies were not included in this review because the lack of data regarding non-healed groups but encompass the importance that the surgical technique and post-operative care may play in clinical results.

In an experimental study using computer-aided design models for PHFs, Sabesan., *et al*. [38] reported that great tuberosity healing effect would be predominantly important for the external rotation functional results. This conclusion was consistent with the findings from this review, as external rotation ROM was significantly higher in healed tuberosity, among the included studies, except for the study of Mohapatra and coworkers [23].

Limitation of the Study

This study design had limitations. First, most of the comprised studies were retrospective with a relatively small sample size. Furthermore, methodological rigor in this study was assessed by only a single author, at each stage of this review. Quality assessment identified methodological differences among the included studies, namely the use of diverse prosthesis, different surgical techniques (use of bone cement and tuberosity fixation technique) and inconsistent healing criteria (conventional radiology rather than CT scans) of the greater tuberosity among the included studies. Furthermore, healing status of the lesser tuberosity was not mentioned in many studies.

Conclusion

There is still a debate if tuberosity healing is beneficial on tuberosity healing in PHFs treated with RSA.

The primary finding of this study is that tuberosity healing following RSA appears to provide better CMS and consequently, superior overall shoulder function. The tuberosity healing also seems to impact RSA biomechanics predominantly during external rotation.

However, due to limited quantity of high-quality evidence, further rigorous randomized controlled trials are needed to confirm the benefits of tuberosity healing.

Bibliography

1. Court-Brown CM and Caesar B. "Epidemiology of adult fractures: A review". *Injury* 37.8 (2006): 691-697.
2. Murray IR., *et al*. "Proximal humeral fractures: current concepts in classification, treatment and outcomes". *Journal of Bone and Joint Surgery. British Volume* 93.1 (2011): 1-11.
3. Mata-Fink A., *et al*. "Reverse shoulder arthroplasty for treatment of proximal humeral fractures in older adults: a systematic review". *Journal of Shoulder and Elbow Surgery* 22.12 (2013): 1737-1748.
4. Shukla DR., *et al*. "Hemiarthroplasty versus reverse shoulder arthroplasty for treatment of proximal humeral fractures: a meta-analysis". *Journal of Shoulder and Elbow Surgery* 25.2 (2016): 330-340.
5. Handoll HH., *et al*. "Five-year follow-up results of the PROFHER trial comparing operative and non-operative treatment of adults with a displaced fracture of the proximal humerus". *Bone and Joint Journal* 99-B.3 (2017): 383-392.
6. Du S., *et al*. "Interventions for treating 3- or 4-part proximal humeral fractures in elderly patient: A network meta-analysis of randomized controlled trials". *International Journal of Surgery* 48 (2017): 240-246.

7. Uzer G., *et al*. "Does grafting of the tuberosities improve the functional outcomes of proximal humeral fractures treated with reverse shoulder arthroplasty?" *Journal of Shoulder and Elbow Surgery* 26.1 (2017): 36-41.

8. Austin DC., *et al*. "Decreased reoperations and improved outcomes with reverse total shoulder arthroplasty in comparison to hemiarthroplasty for geriatric proximal humerus fractures: a systematic review and meta-analysis". *Journal of Orthopaedic Trauma* 33.1 (2019): 49-57.

9. Jonsson E., *et al*. "Reverse total shoulder arthroplasty provides better shoulder function than hemiarthroplasty for displaced 3- and 4-part proximal humeral fractures in patients aged 70 years or older: a multicenter randomized controlled trial". *Journal of Shoulder and Elbow Surgery* 30.5 (2021): 994-1006.

10. Chun YM., *et al*. "Reverse shoulder arthroplasty for four-part proximal humerus fracture in elderly patients: can a healed tuberosity improve the functional outcomes?" *Journal of Shoulder and Elbow Surgery* 26.7 (2017): 1216-1221.

11. Barros LH., *et al*. "Tuberosity healing after reverse shoulder arthroplasty for proximal humerus fractures: is there clinical improvement?" *Revista Brasileira de Ortopedia (Sao Paulo)* 55.6 (2020): 748-754.

12. Jo O., *et al*. "Prosthesis designs and tuberosity fixation techniques in reverse total shoulder arthroplasty: influence on tuberosity healing in proximal humerus fractures". *Journal of Clinical Medicine* 10.18 (2021): 4146.

13. Imiolczyk JP., *et al*. "Fracture-specific and conventional stem designs in reverse shoulder arthroplasty for acute proximal humerus fractures-a retrospective, observational study". *Journal of Clinical Medicine* 10.2 (2021): 175.

14. Peters MDJ., *et al*. "Updated methodological guidance for the conduct of scoping reviews". *JBI Evidence Synthesis* 18.10 (2020): 2119-2126.

15. Munn Z., *et al*. "Methodological quality of case series studies: an introduction to the JBI critical appraisal tool". *JBI Evidence Synthesis* 18.10 (2020): 2127-2133.

16. Moher D., *et al*. "Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement". *PLoS Medicine* 6.7 (2009): e1000097.

17. Ohl X., *et al*. "How the greater tuberosity affects clinical outcomes after reverse shoulder arthroplasty for proximal humeral fractures". *Journal of Shoulder and Elbow Surgery* 27.12 (2018): 2139-2144.

18. Takayama K., *et al*. "The clinical outcomes and tuberosity healing after reverse total shoulder arthroplasty for acute proximal humeral fracture using the turned stem tension band technique". *Journal of Orthopaedic Science* 27.2 (2022): 372-379.

19. Fischer J., *et al*. "Is malunion of the greater tuberosity after reverse shoulder arthroplasty in patients with complex proximal humerus fracture associated with worse clinical outcomes? A prospective cohort study". *Archives of Orthopaedic and Trauma Surgery* 143.11 (2023): 6527-6533.

20. Holschen M., *et al*. "Simultaneous removal of a locking plate and implantation of a reversed shoulder prosthesis in elderly patients suffering from fracture sequelae of the proximal humerus". *Musculoskeletal Surgery* 104.3 (2020): 295-301.

21. Reuther F., *et al*. "Reverse shoulder arthroplasty in acute fractures of the proximal humerus: does tuberosity healing improve clinical outcomes?" *Journal of Orthopaedic Trauma* 33.2 (2019): e46-e51.

22. Gunst S., *et al*. "Does healing of both greater and lesser tuberosities improve functional outcome after reverse shoulder arthroplasty for fracture? A retrospective study of twenty-eight cases with a computed tomography scan at a minimum of one-year follow-up". *International Orthopaedics* 45.3 (2021): 681-687.

23. Chandra Mohapatra N., *et al*. "Effect of tuberosity repair on functional outcome of reverse shoulder arthroplasty in proximal humerus fractures". *Chinese Journal of Traumatology* 26.2 (2023): 94-100.

24. Schmalzl J., *et al*. "Tuberosity healing improves functional outcome following primary reverse shoulder arthroplasty for proximal humeral fractures with a 135 degrees prosthesis". *European Journal of Orthopaedic Surgery and Traumatology* 30.5 (2020): 909-916.

25. Troiano E., *et al*. "A novel "7 sutures and 8 knots" surgical technique in reverse shoulder arthroplasty for proximal humeral fractures: tuberosity healing improves short-term clinical results". *Journal of Orthopaedics and Traumatology* 24.1 (2023): 18.

26. Boileau P., *et al*. "Reverse shoulder arthroplasty for acute fractures in the elderly: is it worth reattaching the tuberosities?" *Journal of Shoulder and Elbow Surgery* 28.3 (2019): 437-444.

27. Fortane T., *et al*. "Tuberosity healing in reverse shoulder arthroplasty in traumatology: Use of an offset modular system with bone graft". *Orthopaedics and Traumatology: Surgery and Research* 106.6 (2020): 1113-1118.

28. Marin R., *et al*. "Impact of tuberosity treatment in reverse shoulder arthroplasty after proximal humeral fractures: A multicentre study". *Journal of Orthopaedic Science* 28.4 (2023): 765-771.

29. Torrens C., *et al*. "Reverse shoulder arthroplasty for the treatment of acute complex proximal humeral fractures: Influence of greater tuberosity healing on the functional outcomes". *Journal of Orthopaedic Surgery (Hong Kong)* 26.1 (2018): 2309499018760132.

30. Simovitch RW., *et al*. "Effect of tuberosity healing on clinical outcomes in elderly patients treated with a reverse shoulder arthroplasty for 3- and 4-part proximal humerus fractures". *Journal of Orthopaedic Trauma* 33.2 (2019): e39-e45.

31. Jain NP., *et al*. "Tuberosity healing after reverse shoulder arthroplasty for complex proximal humeral fractures in elderly patients-does it improve outcomes? A systematic review and meta-analysis". *Journal of Shoulder and Elbow Surgery* 28.3 (2019): e78-e91.

32. Vrotsou K., *et al*. "Constant-Murley Score: systematic review and standardized evaluation in different shoulder pathologies". *Quality of Life Research* 27.9 (2018): 2217-2226.

33. Lopiz Y., *et al*. "The Spanish version of the constant-Murley shoulder score: translation, cultural adaptation, and validity". *Journal of Shoulder and Elbow Surgery* 32.7 (2023): 1348-1356.

34. Moher D., *et al*. "Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement". *PLoS Medicine* 6.7 (2009): e1000097.

35. Onggo JR., *et al*. "Improved functional outcome and tuberosity healing in patients treated with fracture stems than nonfracture stems during shoulder arthroplasty for proximal humeral fracture: a meta-analysis and systematic review". *Journal of Shoulder and Elbow Surgery* 30.3 (2021): 695-705.

36. Hess F., *et al*. "Tuberosity union in patients with proximal humerus fractures treated with reverse shoulder arthroplasty: a technical note and exploratory analysis". *International Orthopaedics* 44.12 (2020): 2711-2717.

37. Barbosa L., *et al*. "Reverse total shoulder arthroplasty for treatment of 3- and 4-part proximal humeral fractures: clinical and radiological analysis with minimum follow-up of 2 years". *Geriatric Orthopaedic Surgery and Rehabilitation* 11 (2020): 2151459320915321.

38. Sabesan VJ., *et al*. "The role of greater tuberosity healing in reverse shoulder arthroplasty: a finite element analysis". *Journal of Shoulder and Elbow Surgery* 29.2 (2020): 347-354.

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