



Review article

Outcomes of surgical fixation of greater tuberosity fractures: A systematic review



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ABSTRACT

Background: Isolated greater tuberosity fractures account for up to a fifth of all proximal humeral fractures. There have been several retrospective cohort studies and case series reporting outcomes after treatment of this pathology. This study aims to report on the clinical outcomes of surgically treated isolated greater tuberosity fractures, as well as diagnostic workup and complications associated with fracture fixation.

Methods: A systematic review was performed under PRISMA guidelines to identify studies that reported the results or clinical outcomes of isolated greater tuberosity fracture. The searches were performed using MEDLINE through PubMed, the Elsevier Embase database, and the Cochrane Database of Systematic Reviews.

Results: Sixteen studies met inclusion criteria comprising 345 patients and 345 shoulders. The mean age was 52.9 years and mean follow-up was 3.4 months. The mean postoperative American Shoulder and Elbow Surgeon Score, the most frequently utilized patient reported outcome measure across studies, was 90.1% of ideal maximum. All studies used standard shoulder radiographs in their initial workup and most commonly referred to a minimum of 5 mm displacement as an indication for surgery. Fifty five percent of patients were treated using open fixation and 35.9 with arthroscopic fixation. Ninety three percent of patients were able to return to work. A total of fifty-two (15.1%) complications were reported in the included studies.

Conclusions: The current literature describes overall satisfactory functional outcomes and minimal occupational morbidity following either open or arthroscopic fixation of isolated greater tuberosity fractures despite a notable rate of complications.

Level of Evidence: IV, systematic review.

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1. Introduction

Isolated greater tuberosity fracture is an injury that is primarily seen as a result of either impaction on the acromion, impaction on the glenoid during dislocation, or avulsion and shearing. Accounting for up to 20% of all proximal humeral fractures [1–3], these injuries present as acute shoulder pain with reduced range of motion and are typically diagnosed via standard radiographs.

While the vast majority of greater tuberosity fractures are minimally or non-displaced and can be treated without surgery [4,5],

there remains debate as to the degree of displacement that indicates surgical treatment [4,6,7]. The most common indication for surgical treatment in isolated greater tuberosity fractures is > 5 mm of fragment displacement [2,5,8]. However, some have suggested > 3 mm of displacement as the indication in certain overhead active and young patient populations [4,7]. Fractures associated with dislocation have a greater risk of secondary displacement [9]. Earlier studies described open techniques of fracture fixation, but with the more frequent use of arthroscopic techniques, recent studies have published the results of arthroscopic fixation [10–15]. It is unclear how differences in techniques may affect clinical outcomes due to the paucity of studies directly comparing them.

While a previous systematic review of 13 studies by Levy et al. focused on the management (operative versus non-operative)

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and fracture displacement of greater tuberosity fractures [16], the present review will focus on the outcomes of operative fixation of isolated greater tuberosity fractures in the literature. The primary aim is to report on the patient reported outcome scores and clinical outcomes of all surgically treated isolated greater tuberosity fractures as well as comparisons in outcomes between arthroscopic and open procedures. The secondary aim is to report on the diagnostic workup and complications associated with fracture fixation.

2. Materials and methods

The systematic review was performed following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The study was registered in PROSPERO.

2.1. Eligibility criteria

Studies were included if they reported the outcomes of surgical fixation of isolated greater tuberosity fractures. Results must have included patient reported clinical outcomes or objective range of motion and/or strength testing. The following types of studies were excluded: 1) case reports (<3 patients); 2) reviews, editorials, or technique papers; 3) cadaver or biomechanical studies; 4) studies with <6 months of patient follow-up; 5) papers with non-isolated fractures (i.e. injury to the same extremity); or 6) published in a language other than English.

2.2. Data sources

MEDLINE, through PubMed, the Elsevier Embase database, and the Cochrane Database of Systematic Reviews (CDSR) were searched for relevant publications. These online databases were searched in November 2019.

2.3. Searches

The search algorithm used in all databases was: ([isolated greater tuberosity fracture] or [Shoulder and “greater tuberosity” and fracture]) or (“proximal” humer* and “greater tuberosity” and fracture).

2.4. Study selection

The titles and abstracts were reviewed to determine the relevance of the study. After irrelevant papers were excluded, the full texts of studies were reviewed for inclusion. In addition, references were reviewed within these studies to identify any additional studies for inclusion. Study selection was performed independently by two investigators (SRH and EJJ). These same authors extracted relevant data from the studies. Discrepancies between selected studies were few and settled by the senior author (AMM). Due to the lack of consistency of outcome measures across the studies in our review, formal meta-analyses of all surgical outcomes as well as valid comparison testing of arthroscopic versus open techniques was not statistically appropriate. Weighted pooled means and ranges as well as percent ideal of each outcome measure were utilized as a mechanism of comparing the various outcome scores. The methodological index for non-randomized studies (minors) criteria [17] was used for appraisal of bias in the individual studies.

3. Results

The initial search returned 765 results in Pubmed, 21 results from the CDSR, and 498 results from Embase. After exclusion of non-relevant titles, 286 abstracts were reviewed. From these

abstracts, 53 full text articles were obtained. After reviewing the full text articles and applying exclusion criteria, 16 publications were identified for inclusion in the systematic review [18,10,11,19–31]. Two studies were retrospective cohort studies and the rest were either retrospective or prospective case series. No additional studies were included after evaluating references from the full text articles (Table 1 and Fig. 1).

3.1. Patient demographics

The 16 studies meeting criteria for the systematic review included 345 shoulders from 345 patients. Of these patients, 197 were male (57.1%) and mean age was 52.9 years (range, 18–83). Mean reported follow-up was 35.43 months (range, 6–132).

3.2. Outcome measures

A total of 9 different postoperative outcome measures were utilized in the included studies. The most commonly used outcome score, the American Shoulder and Elbow Surgeons Score, was used in 8 articles. The Constant–Murley and UCLA scores were used in 7 studies each while the VAS score used in 6 studies. In general, outcomes after operative fixation of isolated greater tuberosity fractures were favorable, with the majority of weighted outcome scores greater than 83% of ideal. The mean weighted pooled Constant–Murley score was 86.3%, the mean UCLA score was 30.9 (88.3% of ideal), and the mean ASES score was 90.1%. Outcome scores across all studies are summarized in Table 2.

Postoperative range of motion testing was performed in 12 studies. The most commonly measured metrics were forward flexion, abduction, internal rotation, and external rotation (Table 3). All studies reported satisfactory outcomes in passive or active range of motion after operative treatment, though the majority was not able to quantify this improvement because patients presenting with an acute fracture did not undergo range of motion testing. All studies used follow-up radiographs. In addition to standard follow-up radiographs, one study used CT in 6 of 30 patients and one study used CT or MRI for all 40 patients to evaluate for union rates and, with MRI, integrity of the rotator cuff and bony edema. These studies each measured slightly different outcomes in different ways, but in general, there was minimal postoperative displacement and favorable union rates.

Studies that reported outcomes for solely open or arthroscopic techniques were compared using weighted pooled means and percent ideal of patient reported outcome measures and objective range of motion (Table 4). There were patients from 10 studies that underwent open techniques and patients from 6 studies that underwent arthroscopic techniques of fracture fixation, including one study comparing the two techniques. There were five outcome scores available for comparison. Patients treated arthroscopically reported slightly superior outcomes compared with patients receiving open reduction internal fixation in all four of the five available outcome measures. The weighted pooled percent of ideal outcome scores for arthroscopic group was ranged from 83.3% to 91.7% as compared to 82.5 to 90.3% for the open group. Postoperative forward flexion and external rotation were better in the open group, but abduction was more favorable in the arthroscopic group. As previously stated, most studies did not have any preoperative measurements to compare the postoperative measurements, but noted that a majority of patients were satisfied with outcomes regardless of the technique used.

3.3. Diagnosis

Diagnostic workup was detailed in all 16 studies. All studies used standard shoulder radiographs in their initial workup. This

Table 1
List of studies included in systematic review.

Author	Year	Journal	Level of evidence	Technique	Number of shoulders	Outcome scores
Flatow	1991	<i>JBS Inc.</i>	IV	Open	12	Pain, satisfaction
Dimakopoulos	2006	<i>J Ortho Trauma</i>	IV	Open	34	Constant
Platzer	2008	<i>J Trauma</i>	III	Open, percutaneous	52	Constant, UCLA
Ji	2010	<i>Arthroscopy</i>	IV	Scope	16	VAS, UCLA, ASES
Mattyasovszky	2011	<i>Acta Orthopaedica</i>	IV	Open	12	DASH, constant
Wang	2012	<i>Chin Med J</i>	IV	Scope	23	Constant
Yin	2012	<i>Orthopedics</i>	IV	Both	17	ASES, VAS
Chen	2013	<i>Orthopedics</i>	IV	Open	19	Constant
Lu	2014	<i>Eur J Orthop Surg Traumatol</i>	IV	Open	11	Constant, UCLA, SST, VAS
Gillespie	2015	<i>Orthopedic Technologies & Techniques</i>	IV	Open	11	SANE, PSS
Liao	2016	<i>Clin Orthop Relat Res</i>	III	Both	32	VAS, ASES
Park	2016	<i>Knee Surg Sports Traumatol Arthrosc</i>	IV	Hybrid	9	UCLA, ASES, SST
Li	2017	<i>International Orthopaedics</i>	IV	Scope	14	UCLA, ASES, SST
Ji	2017	<i>Arch Orthop Trauma Surg</i>	IV	Scope	40	ASES, UCLA, SST, VAS, KSS
Yoon	2018	<i>J Shoulder Elbow Surg</i>	IV	Open	29	VAS, SSV UCLA, ASES
Jang	2018	<i>J Ortho Surg</i>	IV	Scope	14	ASES, constant, VAS

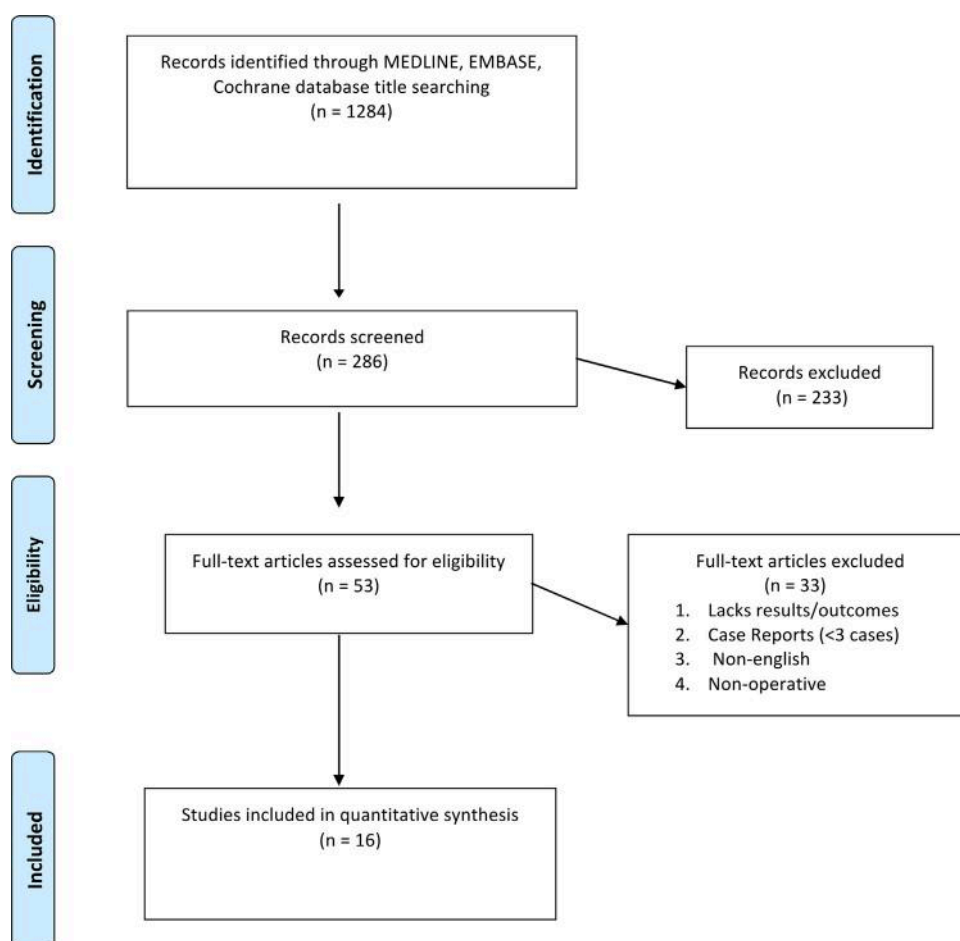


Fig. 1. Prisma diagram.

imaging modality was the primary modality used for measuring fracture fragment displacement and the decision to recommend surgery. In addition to radiographs, two studies used preoperative MRI, three studies used preoperative CT, and six studies used 3-dimensional CT. All studies commented on the amount of fracture

displacement in their patient population, though only thirteen studies reported the minimum amount of fracture displacement as an indication for surgical treatment. The most common indication was 5 mm of displacement in 11 studies. One study used a minimum of 3 mm of displacement, and one study used a minimum of

Table 2
Functional outcomes after surgically-treated greater tuberosity fracture.

Outcome measure	No. of studies	No. of shoulders	Mean weighted postoperative score	Percent ideal
American shoulder and elbow surgeons shoulder score	8	171	90.1	90.1
Constant–Murley score	7	165	86.3	86.3
UCLA shoulder score	7	171	30.9	88.3
Visual analog scale	6	142	0.99	90.1
Simple Shoulder Test (SST)	4	50	9.98	83.2
Disabilities of the Arm, Shoulder, and Hand (DASH)	1	12	12.8	87.2
Korean shoulder scoring system	1	40	90	90
Subjective shoulder value/single assessment numeric test	2	40	87.5	87.5
Penn shoulder score	1	11	79	79

Table 3
Range of motion after surgically-treated greater tuberosity fractures^a.

	Forward flexion	Abduction	Internal rotation	External rotation
Li	153.6	158.6	T12	38.6
Lu	143.8 ± 15.1		T9	33.2 ± 13.1
Liao (arthroscopic)	152.7 ± 13.3	146 ± 16.4	L1	30.7 ± 14.9
Liao (open)	137.7 ± 19.2	132.4 ± 20.5	L2	33.5 ± 16.2
Park	138.7	138	T12	7.6
Yin	150.3 ± 34.1		T11	46.5
Flatow	170.0		T9	63.0
Dimakopoulos	170.0		T10	55–75
Ji	155.0 ± 14.1	153.0 ± 14.9	L3	36.8
Chen	155.0	150.0	6–10 points	6–10 points
Gillespie	147.0			25.0
Ji	157.0	157.0		
Yoon	144.0 ± 16		13.3 ± 1.7 ^b	33.0 ± 11.0
Jang	170.4 ± 10.5			51.4 ± 18.3

^a Three studies are not included in this table because no range of motion measures were reported.

^b Vertebral levels were given a point system for ease of statistical analysis.

Table 4
Outcomes comparison of open versus arthroscopic treatment for isolated greater tuberosity fracture.

Outcome measure	Open				Arthroscopic			
	No. of studies*	No. of shoulders	Mean weighted score	Percent of ideal	No. of studies	No. of shoulders	Mean weighted score	Percent of ideal
UCLA								
Shoulder score	3	70	30.4	86.9	3	70	31.9	91.1
American shoulder and elbow surgeons shoulder score	3	61	88.6	88.6	6	101	91.7	91.7
Simple Shoulder Test (SST)	1	11	9.9	82.5	3	39	10.0	83.3
Visual analog scale	3	57	0.97	90.3	4	85	1.0	90
Constant–Murley score	5	106	86.15	86.15	2	37	90.3	90.3
Range of Motion (ROM)	Postoperative ROM				Postoperative ROM			
Forward flexion	7	137	154.8	–	6	101	157.7	–
Abduction	2	36	141.7	–	4	85	154.7	–
External rotation	4	69	39.7	–	4	83	38.6	–

*Excluded studies that included both techniques (arthroscopic and open). Included one study that compared arthroscopic and open techniques.

10 mm. In one study that compared outcomes of open and arthroscopic techniques, all fractures with displacement of > 5 mm were recommended for surgery, but only those with displacement < 1 cm were offered arthroscopic fixation with double row suture anchor. Those with > 1 cm of displacement were offered open fixation using a locking plate. The mean time from injury to surgery (13 studies, 310 shoulders) was 10.12 days (range, 1.3–38.9 days).

3.4. Technique

Surgical technique was detailed in all 16 studies. Thirteen studies utilized a single technique and 3 studies utilized two techniques. Seven studies utilized solely open techniques and 5 studies used only arthroscopic techniques. Two studies reported outcomes for patients treated with open or arthroscopic techniques. One

study utilized either ORIF with a deltoid split approach or closed reduction percutaneous fixation. A single study utilized a hybrid “arthroscopic-assisted open” technique, in which the initial steps of the surgery involved utilizing the arthroscope to restore the medial greater tuberosity footprint and subsequently convert to an open approach for plate fixation. This study was excluded from the comparison of open vs arthroscopic techniques. In total, there were 190 (55.1%) patients treated with open reduction internal fixation, 124 (35.9%) patients treated arthroscopically, 22 (6.4%) patients treated with closed reduction and percutaneous fixation, and 9 (2.6%) patients treated with a hybrid arthroscopic-open technique.

The open techniques involved a deltoid-splitting approach in eight of the 11 studies that utilized any open approach. Two other studies used a deltopectoral approach. The final open study, which

was described as “minimally-invasive” utilizing a 3 cm incision, did not describe the specific dissection plane. Either K-wires or probes through the arthroscope portals were used for temporary fracture reduction and/or fixation prior to placement of sutures and/or suture anchors (10 studies), locking plate (4 studies), screw and/or washer (4 studies), or tension wire (1 study).

The arthroscopic techniques typically involved a routine arthroscopic examination of the intraarticular space followed by debridement of the subacromial space using a shaver to facilitate better visualization of the fracture. Once the greater tuberosity fracture fragment was visualized, it was debrided on the undersurface and on the fracture bed site. Suture-bridge or double-row repair was used for fixation. The average number of suture anchors was 3.3 (range 2–4).

3.5. Return to work

Return to work data was available in 2 studies. Forty-three of 46 (93.5%) patients were able to return to work at some level. One study stratified the patients by sedentary versus manual labor and found that all patients in sedentary jobs returned to work while 14 of 16 patients (87.5%) in manual labor positions returned to work.

3.6. Complications

Complication data were reported in all 16 studies. There were 52 complications in total (15.1%). The most common complications included: 17 cases of long-term stiffness and pain, 5 cases of heterotopic ossification, 7 cases of anchor protrusion/pullouts, and 2 unplanned implant removals. There were also 15 cases of loss of reduction or malreduction, all but one of which were noted in patients that underwent open reduction internal fixation. There were only 9 complications reported in the arthroscopic treatment group: 7 cases of anchor protrusion or anchor pullout in osteoporotic bone, one loss of reduction, and 1 continued pain and stiffness after treatment. The remaining 43 complications across all studies occurred in the open treatment group. There were no cases of non-union reported across all studies.

4. Discussion

This is the most comprehensive systematic review of surgical management and outcomes after fixation of isolated greater tuberosity fractures, including sixteen papers and 345 shoulders. Previous studies examining the outcomes of this injury have been limited primarily to case series with few retrospective cohort studies. This is a common fracture that lacks a well-supported treatment algorithm. This review aims to synthesize the current literature examining the clinical outcomes of fixation of these common injuries. We specifically sought to synthesize the outcomes of acute surgical fixation of greater tuberosity fractures, but it is important to consider that the outcomes may not be equivalent to patients undergoing delayed surgical fixation, in which case the greater tuberosity fracture was occult or neglected. The mean time between injury and surgery in this review was 10.12 days.

The current literature describes overall satisfactory outcomes for fixation of isolated greater tuberosity fractures. The most commonly used outcome scores in the studies were the UCLA, ASES, and Constant–Murley scores. However, these scores were used in less than 50% of studies included in this review, and there were 9 different outcomes scores in total used in the studies. Standardization of clinical outcome scores will be useful in future studies to facilitate data pooling and allow for meta-analysis. Despite the heterogeneity of past scoring systems, the majority of data supports overall satisfactory outcomes in regard to pain and shoulder function associated with surgical fixation of isolated greater tuberosity fractures.

The pooled outcome scores of patients in this study were similar to functional outcome scores at an average of 31 months after rotator cuff repair (pooled mean percent of normal, 85%; range, 64–97%) [32], and slightly better compared to functional scores at an average of 24 to 50 months following fixation of 3- or 4-part proximal humerus fractures (mean percent of normal, 60–81%) [33–36]. In terms of range of motion postoperatively, patients in our review performed similar to patients at an average of 32 to 41 months following surgical rotator cuff repair [37,38], but better than patients 33 months following 3- or 4-part proximal humerus fracture fixation [33].

Isolated greater tuberosity fractures are generally diagnosed on radiographs alone, but multiple studies in our review utilized CT, 3D CT, or MRI as an adjunct [11,20,22,23,26,27,29,30]. The diagnostic workup of a patient with a greater tuberosity fracture is of interest because the treatment plan typically relies on the degree of displacement of the fragment. The rationale for advanced imaging reported in some studies included surgical planning and observation of concomitant soft tissue injuries, though rationale was not always presented. Jansen et al. [39] performed a survey of orthopedic surgeons which concluded the likelihood of recommending surgery for greater tuberosity fracture was not influenced by having either 2D or 3D CT compared to a radiograph alone. Another study found that the use of MRI in the diagnostic workup of isolated greater tuberosity fractures did not change the measurement of fragment displacement [40]. In the present review, multiple articles presented patients who underwent advanced imaging as an adjunct to radiograph. While it is clear that minimally displaced greater tuberosity fractures may be missed on radiograph [41], the use of advanced imaging in surgical planning of a displaced greater tuberosity fracture should be further studied as healthcare systems continue to search for ways to minimize or eliminate unnecessary costs.

With the increased frequency of arthroscopy, multiple studies have examined the role of less invasive techniques in the treatment of isolated greater tuberosity fractures. Potential advantages over open fixation include less trauma to soft tissues, lower risk of postoperative infections and adhesions, reduced intraoperative blood loss, better visualization of greater tuberosity fragments, better detection of accompanying soft tissue lesions, and improved cosmetic appearance [42–44]. Conversely, open fixation may offer lower cost, shorter surgical time, easier learning curve with less technical difficulty, and greater utility in a wider array of fracture types [42]. Only one study compared open versus arthroscopic fixation, reporting significantly better ASES scores among arthroscopically treated patients as compared to patients treated with open reduction and internal fixation [20]. Among the most commonly reported outcome scores (Constant–Murray, UCLA, ASES, and VAS), the pooled mean scores in patients treated arthroscopically (Percent of ideal; range, 86.0 to 91.7 percent) tended to be higher compared to patients who underwent open fixation (Percent of ideal; range, 82.5 to 90.2 percent). In terms of range of motion, open fixation performed better in pooled internal rotation (T10 versus L1), while the differences were minimal in pooled forward flexion (155.9 versus 154.7 degrees) and pooled abduction (152.2 versus 152.9) in patients treated with open and arthroscopic methods respectively. Due to the lack of standardization in outcome scores and the varying inclusion and exclusion criteria in past studies, there cannot be any clear conclusion as to which treatment is superior. The percent of ideal allows us to more easily visualize the comparisons of different outcome scores, although among individual scores, the minimally clinical important differences were not observed between arthroscopic and open weighted pooled means for the ASES, UCLA, Constant, SST and VAS scores [45,46].

Only 2 studies reported data on the patients' ability to return to work after their greater tuberosity fracture. Of patients included in

Table 5
Methodological items for non-randomised studies (MINORS) Scores for included studies.

	A ¹⁸	B ²⁰	C ²⁷	D ³⁰	E ³²	F ²⁰	G ¹⁹	H ²¹	I ²²	J ²³	K ²⁴	L ²⁵	M ²⁸	N ³³	O ²⁶	P ³¹
A clearly stated aim	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Inclusion of consecutive patients	2	2	2	2	2	2	2	2	2	1	2	2	1	2	1	2
Endpoints appropriate to the aim of the study	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Unbiased assessment of the study endpoint	1	1	1	1	1	1	1	2	1	1	1	1	1	2	1	1
Follow-up period appropriate to the aim of the study	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Loss to follow up less than 5%	2	1	2	2	2	2	1	2	2	2	1	2	2	2	2	2
Prospective calculation of the study size	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Additional criteria in the case of comparative study	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
An adequate control group	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A
Contemporary groups	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Baseline equivalence of groups	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Adequate statistical analyses	1	1	1	1	1	2	2	1	2	2	2	2	2	1	2	2
Total score	12	11	12	12	12	13	12	13	13	12	12	13	13	13	12	13

MINOR scores: 0 (not reported), 1 (reported but inadequate) and 2 (reported and adequate).

our review, 50 of 54 (92.6%) were able to return to work at some level, suggesting that there is minimal occupational morbidity associated with isolated greater tuberosity fracture fixation. However, the fact that only 13.3% of patients in this review had reported return to work data highlights an area of improvement for future studies.

Among the included studies the complication rate was 15.1%, with the most common complications being long-term stiffness/pain, followed by loss of reduction and heterotopic ossification. The overall complication rate with open surgery was 22.6% (43 of 190) compared to a rate of 7.3% (9 of 124) for arthroscopic surgery. Bony union was achieved in all cases.

A shortcoming of the current review that is inherent to all systematic reviews is a result of the quality of studies included. The majority of the studies in our review were case series with only two retrospective cohort studies. As noted in Table 5, appraisal of bias of individual included studies according to the MINORS criteria showed a variation in the quality of studies reviewed and weaknesses including small sample sizes and a majority of the studies being observational rather than comparative in nature. Another limitation was the lack of standardization of outcome measures reported across the studies, making it difficult to make comparisons between studies. Notably, many of the studies do not report measures of variance, which prevented the ability to run a formal meta-analysis. Also, past studies have not reliably classified the fracture type. This is valuable to include in future studies, as the 3 different types of isolated greater tuberosity fractures (avulsion, impaction, and split) each require individualized and adapted treatment for optimal outcomes [47–49]. Furthermore, it is difficult to assess the degree and direction of displacement of those greater tuberosity fractures undergoing fixation and how these variables affect clinical outcomes. Finally, we include only studies in which patient underwent fixation of the isolated greater tuberosity fracture. The indication for surgery may have been variable based upon the author of the study and some of the patients may have done well with non-operative treatment. Nonetheless, the current review seeks to understand clinical outcomes for patients undergoing greater tuberosity fixation and provides limited evidence of equivalent outcomes when comparing arthroscopic techniques to open fixation.

5. Conclusions

The current literature describes overall satisfactory functional outcomes and minimal occupational morbidity following either open or arthroscopic fixation of isolated greater tuberosity fractures, despite notable rates of complications. Open fixation with locking plate or mesh using a deltoid-splitting approach was the most commonly used technique. There appeared to be a trend toward slightly improved outcomes with arthroscopic techniques; however, due to heterogeneity between studies firm conclusions could not be made.

Disclosure of interest

The authors declare that they have no competing interest.

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Contribution

Huntley – Data collections, statistics.
Lehtonen – Data collections, statistics.

Robin – Writing, edits.

Arguello – Data collection, writing, edits.

Rouleau – Writing, edits.

Brabston – Study design, writing.

Ponce – Writing, edits.

Momaya – Writing, edits.

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