Management of Isolated Greater Tuberosity Fractures: A Systematic Review

Authors:
David M. Levy, MD Brandon J. Erickson, MD Joshua D. Harris, MD Bernard R. Bach Jr, MD Nikhil N. Verma, MD Anthony A. Romeo, MD
Author Affiliation | Disclosures

Authors’ Disclosure Statement: Dr. Harris reports that he serves as a board or committee member for the American Academy of Orthopaedic Surgeons, American Orthopaedic Society for Sports Medicine, Arthroscopy, Arthroscopy Association of North America, and Frontiers in Surgery; he has received research support from DePuy Synthes and Smith & Nephew, royalties from SLACK Incorporated, and is paid by NIA Magellan, Ossur, and Smith & Nephew. Dr. Bach reports that he has received research support from Arthrex, Inc., CONMED Linvatec, DJ Orthopaedics, Ossur, Smith & Nephew, and Tornier as well as royalties from SLACK Incorporated. Dr. Verma reports that he serves as a board or committee member for the American Orthopaedic Society for Sports Medicine, American Shoulder and Elbow Surgeons, Arthroscopy Association Learning Center Committee, Journal of Knee Surgery, and SLACK Incorporated; he has received research support from Arthrex, Inc., ArthroSurface, DJ Orthopaedics, Smith & Nephew, Athletico, ConMed Linvatec, Miomed, and Mitek; he has received publishing royalties, financial, or material support from Arthroscopy and Vindico Medical-Orthopedics Hyperguide; he has received stock or stock options from Cymedica, Minvasive, and Omeros and serves as a paid consultant for Orthospace and Smith & Nephew. Dr. Romeo reports that he serves as a board or committee member for the American Orthopaedic Society for Sports Medicine, American Shoulder and Elbow Surgeons, Orthopedics, Orthopedics Today, SAGE, and Wolters Kluwer Health—Lippincott Williams & Wilkins; he has received research support from Aesculap/B.Braun, Arthrex, Inc., Histogenics, Medipost, NuTech, Orthospace, Smith & Nephew, and Zimmer Biomet; he has received other financial or material support from AANA, Arthrex, Inc., and Major League Baseball; he has received publishing royalties, financial and/or material support from Saunders/Mosby- Elsevier and SLACK Incorporated. The other authors report no actual or potential conflict of interest in relation to this article.

Take-Home Points

- Fractures of the greater tuberosity are often mismanaged.
- Comprehension of greater tuberosity fractures involves classification into nonoperative and operative treatment, displacement >5mm or <5 mm, and open vs arthroscopic surgery.
- Nearly a third of patients may suffer concomitant anterior glenohumeral instability.
- Stiffness is the most common postoperative complication.
- Surgery is associated with high patient satisfaction and low rates of complications and reoperations.

Although proximal humerus fractures are common in the elderly, isolated fractures of the greater tuberosity occur less often. Management depends on several factors, including fracture pattern and displacement.\textsuperscript{1,2} Nondisplaced fractures are often successfully managed with sling immobilization and early range of motion.\textsuperscript{3,4} Although surgical
intervention improves outcomes in displaced greater tuberosity fractures, the ideal surgical treatment is less clear.

Displaced greater tuberosity fractures may require surgery for prevention of subacromial impingement and range-of-motion deficits. Superior fracture displacement results in decreased shoulder abduction, and posterior displacement can limit external rotation. Although the greater tuberosity can displace in any direction, posterosuperior displacement has the worst outcomes. The exact surgery-warranting displacement amount ranges from 3 mm to 10 mm but is yet to be clearly elucidated. Less displacement is tolerated by young overhead athletes, and more displacement by older less active patients. Surgical options for isolated greater tuberosity fractures include fragment excision, open reduction and internal fixation (ORIF), closed reduction with percutaneous fixation, and arthroscopically assisted reduction with internal fixation.

We conducted a study to determine the management patterns for isolated greater tuberosity fractures. We hypothesized that greater tuberosity fractures displaced <5 mm may be managed nonoperatively and that greater tuberosity fractures displaced >5 mm require surgical fixation.

**Methods**

**Search Strategy**

We performed this systematic review according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) checklist and registered it (CRD42014010691) with the PROSPERO international prospective register of systematic reviews. Literature searches using the PubMed/Medline database and the Cochrane Central Register of Clinical Trials were completed in August 2014. There were no date or year restrictions. Key words were used to capture all English-language studies with level I to IV evidence (Oxford Centre for Evidence-Based Medicine) and reported clinical or radiographic outcomes. Initial exclusion criteria were cadaveric, biomechanical, histologic, and kinematic results. An electronic search algorithm with key words and a series of NOT phrases was designed to match our exclusion criteria:

```
(((((((((((greater[Title/Abstract]) AND tuberosity [Title/Abstract] OR tubercle [Title/Abstract]) AND fracture[Title/Abstract]) AND proximal[Title/Abstract] AND (English[lang]))) NOT intramedullary[Title] AND (English[lang]))) NOT nonunion[Title] AND (English[lang]))) NOT malunion[Title] AND (English[lang]))) NOT biomechanical[Title/Abstract] AND (English[lang]))) NOT cadaveric[Title/Abstract] AND (English[lang]))) NOT ((basic[Title/Abstract] AND science[Title/Abstract] AND (English[lang]))) NOT revision[Title] AND (English[lang]))) NOT pediatric[Title] AND (English[lang]))) NOT physeal[Title] AND (English[lang]))) NOT children[Title] AND (English[lang]))) NOT instability[Title] AND (English[lang]))) NOT imaging[Title]) NOT salter[Title]) NOT physis[Title]) NOT shaft[Title]) NOT distal[Title]) NOT clavicle[Title]) NOT scapula[Title]) NOT ((diaphysis[Title]) AND diaphyseal[Title])) NOT infection[Title]) NOT laboratory[Title/Abstract]) NOT metastatic[Title/Abstract]) NOT (((malignancy[Title/Abstract]) OR malignant[Title/Abstract]) OR tumor[Title/Abstract]) OR oncologic[Title/Abstract]) OR cyst[Title/Abstract]) OR aneurysmal[Title/Abstract]) OR unicameral[Title/Abstract]).
```

**Study Selection**
We obtained 135 search results and reviewed them for further differentiation. All the references in these studies were cross-referenced for inclusion (if missed by the initial search), which added another 15 studies. Technical notes, letters to the editor, and level V evidence reviews were excluded. Double-counting of patients was avoided by comparing each study’s authors, data collection period, and ethnic population with those of the other studies. In cases of overlapping authorship, period, or place, only the study with the longer follow-up, more patients, or more comprehensive data was included. For studies separating outcomes by diagnosis, only outcomes of isolated greater tuberosity fractures were included. Data on 3- or 4-part proximal humerus fractures and isolated lesser tuberosity fractures were excluded. Studies that could not be deconstructed as such or that were devoted solely to one of our exclusion criteria were excluded. Minimum follow-up was 2 years. After all inclusion and exclusion criteria were accounted for, 13 studies with 429 patients (429 shoulders) were selected for inclusion (Figure, Table 1).

### Data Extraction

We extracted data from the 13 studies that met the eligibility criteria. Details of study design, sample size, and patient demographics, including age, sex, and hand dominance, were recorded, as were mechanism of injury and concomitant anterior shoulder instability. To capture the most patients, we noted radiographic fracture displacement categorically rather than continuously; patients were divided into 2 displacement groups (<5 mm, >5 mm). Most studies did not define degree of comminution or specific direction of displacement per fracture, so these variables were not included in the data analysis. Nonoperative management and operative management were studied. We abstracted surgical factors, such as approach, method, fixation type (screws or sutures), and technique (suture anchors or transosseous tunnels). Clinical outcomes included physical examination findings, functional assessment results (patient satisfaction; Constant and University of California Los Angeles [UCLA] shoulder scores), and the number of revisions. Radiologic outcomes, retrieved from radiographs or computed...
tomography scans, focused on loss of reduction (as determined by the respective authors), malunion, nonunion, and heterotopic ossification. Each study’s methodologic quality and bias were evaluated with the 15-item Modified Coleman Methodology Score (MCMS), which was described by Cowan and colleagues. The MCMS has been used to assess randomized and nonrandomized patient trials. Its scaled potential score ranges from 0 to 100 (85-100, excellent; 70-84, good; 55-69, fair; <55, poor).

### Statistical Analysis

We report our data as weighted means (SDs). A mean was calculated for each study that reported a respective data point, and each mean was then weighed according to its study sample size. This calculation was performed by multiplying a study’s individual mean by the number of patients enrolled in that study and dividing the sum of these weighted data points by the number of eligible patients in all relevant studies. The result was that the nonweighted means from studies with smaller sample sizes did not carry as much weight as the nonweighted means from larger studies. We compared 3 paired groups: treatment type (nonoperative vs operative), fracture displacement amount (<5 mm vs >5 mm), and surgery type (open vs arthroscopic). Regarding all patient, surgery, and outcomes data, unpaired Student t tests were used for continuous variables and 2-tailed Fisher exact tests for categorical variables with \( \alpha = 0.05 \) (SPSS Version 18; IBM).

### Results

Demographic information and treatment strategies are listed in Table 2. Fifty-eight percent of patients were male, 59.0% of dominant shoulders were affected, and 59.2% of fractures were displaced <5 mm. Concomitant shoulder instability was reported in 28.1% of patients. Mechanism of injury was not reported in all studies but most commonly (n = 75; 49.3%) involved a fall on an outstretched hand; 31 patients (20.4%) had a sports-related injury, and another 37 (24.3%) were injured in a motor vehicle collision. Of the 429 patients, 217 (50.6%) were treated nonoperatively, and 212 (49.4%) underwent surgery. Open, arthroscopic, and percutaneous approaches were reported. No studies presented outcomes of fragment excision.
Postoperative physical examination findings were underreported so that surgical groups could be compared. Of all the surgical studies, 4 reported postoperative forward elevation (mean, 160°; SD, 9.8°) and external rotation (mean, 46.4°; SD 26.3°).\textsuperscript{14,15,18,22} No malunions and only 1 nonunion were reported in all 13 studies. No deaths or other serious medical complications were reported. Patients with anterior instability more often underwent surgery than were treated nonoperatively (39.2% vs 12.0%; \( P < .01 \)) and more often had fractures displaced >5 mm than <5 mm (44.3% vs 14.5%; \( P < .01 \)).

Table 3.
Comparisons of treatment type are listed in Table 3. Compared with nonoperative patients, operative patients had significantly fewer radiographic losses of reduction (\( P < .01 \)) and better patient satisfaction (\( P < .01 \)). Operative patients had a significantly higher rate of shoulder stiffness (\( P < .01 \)). Eight operative patients (3.8%) and no nonoperative patients required reoperation during clinical follow-up (\( P < .01 \)). All 12 reported cases of stiffness were in the operative group, and 3 required revision surgery. One patient required revision ORIF. There were 2 cases of postoperative superficial infection (0.9%) and 4 neurologic injuries (1.9%).

Table 4.
Comparisons of displacement amount are listed in Table 4. Compared with fractures displaced >5 mm, those displaced <5 mm had more radiographic losses of reduction (\( P < .01 \)) but fewer instances of heterotopic ossification (\( P < .01 \)). Fractures displaced >5 mm were significantly more likely than not to be managed with surgery (\( P < .01 \)) and significantly more likely to develop stiffness after treatment (\( P = .01 \)). One patient (0.4%)
with a fracture displaced <5 mm eventually underwent surgery for stiffness, and 6 patients (3.6%) with fractures displaced >5 mm required reoperation \( (P = .02) \).

Table 5. Comparisons of surgery type are listed in Table 5. All open procedures were performed with a deltoid-splitting approach. Screw fixation was used in 4 cases: 2 percutaneous\(^5,21\) and 2 open.\(^2,5\) The other open and arthroscopic studies described suture fixation, half with anchors (77/156 patients; 49.4%) and half with transosseous tunnels (79/156; 50.6%). There were no statistically significant differences between open/percutaneous and arthroscopic techniques in terms of stiffness, superficial infection, neurologic injury, or reoperation rate.

Fisher exact tests were used to perform isolated comparisons of screws and sutures as well as suture anchors and transosseous tunnels. Patients with screw fixation were significantly \( (P = .051) \) less likely to require reoperation (0/56; 0%) than patients with suture fixation (8/100; 8.0%). Screw fixation also led to significantly less stiffness (0% vs 12.0%; \( P < .01 \)) but trended toward a higher rate of superficial infection (3.6% vs 0%; \( P = .13 \)). There was no statistical difference in nerve injury rates between screws and sutures (1.8% vs 3.0%; \( P = 1.0 \)). There were no significant differences in reoperations, stiffness, superficial infections, or nerve injuries between suture anchor and transosseous tunnel constructs.

For all 13 studies, mean (SD) MCMS was 41.1 (8.6).

**Discussion**

Five percent of all fractures involve the proximal humerus, and 20% of proximal humerus fractures are isolated greater tuberosity fractures.\(^26,27\) In his classic 1970 article, Neer\(^6\) formulated the 4-part proximal humerus fracture classification and defined greater tuberosity fracture “parts” using the same criteria as for other fracture “parts.” Neer\(^6\) recommended nonoperative management for isolated greater tuberosity fractures displaced <1 cm but did not present evidence corroborating his recommendation. More recent cutoffs for nonoperative management include 5 mm (general population) and 3 mm (athletes).\(^7,17\)

In the present systematic review of greater tuberosity fractures, 3 separate comparisons were made: treatment type (nonoperative vs operative), fracture displacement amount (<5 mm vs >5 mm), and surgery type (open vs arthroscopic).

**Treatment Type.** Only 4 studies reported data on nonoperative treatment outcomes.\(^5,12,16,17\) Of these 4 studies, 2
found successful outcomes for fractures displaced <5 mm. Platzer and colleagues also found good or excellent results in 97% of 135 shoulders after 4 years. Good results were defined with shoulder scores of ≥80 (Constant), <8 (Vienna), and >28 (UCLA), and excellent results were defined with maximum scores on 2 of the 3 systems. Platzer and colleagues also found nonsignificantly worse shoulder scores with superior displacement of 3 mm to 5 mm and recommended surgery for overhead athletes in this group. Rath and colleagues described a successful 3-phase rehabilitation protocol of sling immobilization for 3 weeks, pendulum exercises for 3 weeks, and active exercises thereafter. By an average of 31 months, patient satisfaction scores improved to 9.5 from 4.2 (10-point scale), though the authors cautioned that pain and decreased motion lasted 8 months on average. Conservative treatment was far less successful in the 2 studies of fractures displaced >5 mm. Keene and colleagues reported unsatisfactory results in all 4 patients with fractures displaced >1.5 cm. In a study separate from their 2005 analysis, Platzer and colleagues in 2008 evaluated displaced fractures and found function and patient satisfaction were inferior after nonoperative treatment than after surgery. The studies by Keene and colleagues and Platzer and colleagues support the finding of an overall lower patient satisfaction rate in nonoperative patients.

Fracture Displacement Amount. Only 2 arthroscopic studies and no open studies addressed surgery for fractures displaced <5 mm. Fewer than 16% of these fractures were managed operatively, and <1% required reoperation. By contrast, almost all fractures displaced >5 mm were managed operatively, and 3.6% required reoperation. Radiographic loss of reduction was more common in fractures displaced <5 mm, primarily because they were managed without fixation. Radiographic loss of reduction was reported in only 9 operatively treated patients, none of whom was symptomatic enough to require another surgery. Reoperations were most commonly performed for stiffness, which itself was significantly more common in fractures displaced >5 mm. Bhatia and colleagues reported the highest reoperation rate (14.3%; 3/21), but they studied more complex, comminuted fractures of the greater tuberosity. Two of their 3 reoperations were biceps tenodeses for inflamed, stiff tenosynovitis, and the third patient had a foreign body giant cell reaction to suture material. Fewer than 1% of patients with operatively managed displaced fractures required revision ORIF, and <2% developed a superficial infection or postoperative nerve palsy. For displaced greater tuberosity fractures, surgery is highly successful overall, complication rates are very low, and 90% of patients report being satisfied.

Surgery Type. Patients were divided into 2 groups. In the nonarthroscopic group, open and percutaneous approaches were used. All studies that described a percutaneous approach used screw fixation; in addition, 32 patients were treated with screws through an open approach. The other open and arthroscopic studies used suture fixation. Interestingly, no studies reported on clinical outcomes of fragment excision. There were no statistically significant differences in rates of reoperation, stiffness, infection, or neurologic injury between the arthroscopic and nonarthroscopic groups. Patient satisfaction scores were slightly higher in the nonarthroscopic group (91.0% vs 87.8%), but the difference was not statistically significant.

With surgical techniques isolated, there were no significant differences between suture anchors and transosseous tunnel constructs, but screws performed significantly better than suture techniques. Compared with suture fixation, screw fixation led to significantly fewer cases of stiffness and reoperation, which suggests surgeons need to give screws more consideration in the operative management of these fractures. However, the number of patients treated with screws was smaller than the number treated with suture fixation; it is possible the differences between these cohorts would be eliminated if there were more patients in the screw cohort. In addition, screw fixation was universally performed with an open or percutaneous approach and trended toward a higher infection rate. As screw and suture techniques have low rates of complications and reoperations, we recommend leaving fixation choice to the surgeon.

Anterior shoulder instability has been associated with greater tuberosity fractures. The supraspinatus,
infraspinatus, and teres minor muscles all insert into the greater tuberosity and resist anterior translation of the proximal humerus. Loss of this dynamic muscle stabilization is amplified by tuberosity fracture displacement: Anterior shoulder instability was significantly more common in fractures displaced >5 mm (44.3%) vs <5 mm (14.5%). In turn, glenohumeral instability was more common in patients treated with surgery, specifically open surgery, because displaced fractures may not be as easily accessed with arthroscopic techniques. No studies reported concomitant labral repair or capsular plication techniques.

This systematic review was limited by the studies analyzed. All but 1 study\(^5\) had level IV evidence. Mean (SD) MCMS was 41.8 (8.6). Any MCMS score <54 indicates a poor methodology level, but this scoring system is designed for randomized controlled trials,\(^23\) and there were none in this study. Physical examination findings, such as range of motion, were underreported. In addition, radiographic parameters were not consistently described but rather were determined by the respective authors’ subjective interpretations of malunion, nonunion, and loss of reduction. Publication bias is present in that we excluded non-English language studies and medical conference abstracts and may have omitted potentially eligible studies not discoverable with our search methodology. Performance bias is a factor in any systematic review with multiple surgeons and wide variation in surgical technique.

**Conclusion**

Greater tuberosity fractures displaced <5 mm may be safely managed nonoperatively, as there are no reports of nonoperatively managed fractures that subsequently required surgery. Nonoperative treatment was initially associated with low patient satisfaction, but only because displaced fractures were conservatively managed in early studies.\(^16\) Fractures displaced >5 mm respond well to operative fixation with screws, suture anchors, or transosseous suture tunnels. Stiffness is the most common postoperative complication (<6%), followed by heterotopic ossification, transient neurapraxias, and superficial infection. There are no discernible differences in outcome between open and arthroscopic techniques, but screw fixation may lead to significantly fewer cases of stiffness and reoperation in comparison with suture constructs.

**Key Info**

**Figures/Tables**

**References**


**Multimedia**

**Product Guide**
Product Guide

- ATTUNE® Knee System
- Function, Post-Operative, and Bracing Undersleeves
- Game Ready® Wraps Collection
- Knotless Suture Anchors

Citation


David M. Levy, MD