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REVIEW ARTICLE

Isolated greater tuberosity fractures of the proximal humerus: anatomy, injury patterns, multimodality imaging, and approach to management

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Abstract

The greater tuberosity is an important anatomic structure and its integrity is important for shoulder abduction and external rotation. Isolated fractures of the greater tuberosity are often subtle and may not be detected on initial radiographs. Clinically, these patients display symptoms which mimic a full thickness rotator cuff tear. It is important to differentiate these two entities, as their treatment is different (typically nonsurgical management for minimally displaced fractures versus rotator cuff repair for acute full thickness rotator cuff tears). When greater tuberosity fractures are significantly displaced and allowed to heal without anatomic reduction, they can lead to impingement. This article will review greater tuberosity anatomy and function, as well as the clinical presentation and multimodality imaging findings of greater tuberosity fractures. Imaging optimization, pitfalls, and clinical management of these fractures will also be discussed.

Keywords Greater tuberosity fracture · Proximal humerus fracture · Isolated fracture · Avulsion fracture · Imaging evaluation

Introduction

Proximal humeral fractures are common injuries seen in the emergency setting [1] typically involving older patients with osteoporotic bone after low velocity trauma. Women are affected three times more often than men [2]. Greater tuberosity fractures may also occur in younger men with normal bone following high-velocity trauma and make up one fifth of all proximal humerus fractures [3, 4]. When a greater tuberosity fracture is present, it typically occurs along with other proximal humeral fractures [5]. Isolated fractures of the greater tuberosity account for 2–19% of proximal humerus fractures [3, 6, 7]. Minimally displaced fractures of the greater tuberosity are the most frequent isolated fractures in skiing-related trauma [8].

The radiographic appearance of these fractures can be subtle; however, poor functional outcomes can result from these injuries if not detected or if treated inappropriately [4]. A study by Ogawa et al. revealed that 64% of these fractures were not detected on initial evaluation [9]. If a fracture is suspected, but not identified on radiographs, computed tomography (CT) may be obtained. Alternatively, these patients may present with symptoms of rotator cuff tear and may undergo magnetic resonance imaging (MRI) or evaluation with ultrasound. It is therefore important to be familiar with the imaging findings of isolated greater tuberosity fractures on all imaging modalities to ensure an accurate diagnosis and appropriate management. In this article, we discuss the clinical and imaging findings of greater tuberosity fractures, as well as an approach to their management.

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Anatomy

It is important to understand the normal anatomy to understand the difference between the normal imaging appearance and the potentially subtle fracture findings which may be not detected or misinterpreted. The greater tuberosity is an apophysis of the proximal humerus which is located lateral to the humeral head, and posterolateral to the lesser tuberosity. The normal greater tuberosity is 6 to 8 mm inferior to the most superior aspect of the humeral head [10]. The lateral cortex of the greater tuberosity is convex and continuous with the lateral surface of the shaft of the humerus [11].

The superior margin of the greater tuberosity is marked by three distinct flat impressions: the superior, middle, and inferior facets (Fig. 1) [12]. Recent anatomic studies demonstrate that the insertions of the rotator cuff tendons on the greater tuberosity are more complex than those previously described [12–14] and this topic is controversial. An earlier anatomic study found that the supraspinatus inserts on the superior facet, the superior half of the middle facet, while the infraspinatus inserts on the entire middle facet covering part of the supraspinatus tendon [12]. More recently, an anatomic study described the supraspinatus insertion localized to the anteromedial aspect of the highest impression of the superior facet, and the infraspinatus inserts on the anterolateral aspect of the highest impression of the superior facet and all of the middle facet [13]. The disagreement of over these insertions may be due to anatomic variation and is beyond the scope of this article. The direction of displacement of a greater tuberosity fracture is determined by the soft tissue attachments of the rotator cuff (Fig. 1). The force vector of the supraspinatus and anterosuperior aspect of the infraspinatus results in superior displacement of the fragment. The force vector of the posteroinferior aspect of the infraspinatus and teres minor results in posterior displacement [10].

The vascular supply to the greater tuberosity (Fig. 2) is predominately through the posterior humeral circumflex artery [15] with intraosseous connections between the arcuate artery, the metaphyseal vessels, and the vessels of the greater and lesser tuberosities [16]. This arterial network provides an excellent blood supply to the greater tuberosity, which provides a good healing environment for fractures. In contradistinction from anatomic neck fractures of the proximal humerus, greater tuberosity fractures do not compromise the vascular supply to the humeral head [16].

Mechanisms of injury

An understanding of the mechanisms of injury is important because understanding the way an injury occurred may be key to identifying this fracture which may be subtle or occult. Different mechanisms of injury for isolated greater tuberosity fractures have been proposed. The morphology of the fracture fragment may help determine the mechanism in a given patient (Fig. 3). Avulsion fractures are likely the result of a forceful contraction of the rotator cuff against a humeral head that is distracted from the glenoid or in an anteriorly subluxed or an anteriorly dislocated position [17]. The split-type fracture has been hypothesized to result from an impaction of the posterior greater tuberosity on the anterior glenoid during glenohumeral dislocation or from a rotator cuff muscle contraction following glenohumeral dislocation that shears off the greater tuberosity using the anterior glenoid as a fulcrum [18]. The depression-type fracture has been hypothesized to result from hyperabduction and traction of the humerus that causes impaction of the lateral aspect of the acromion into the greater tuberosity [19].

The fracture may occur as a result of a glenohumeral dislocation [19], an extreme pull of the infraspinatus and teres minor [20], after abduction and external rotation of the arm [8], as a result of a direct blow to the lateral aspect of the

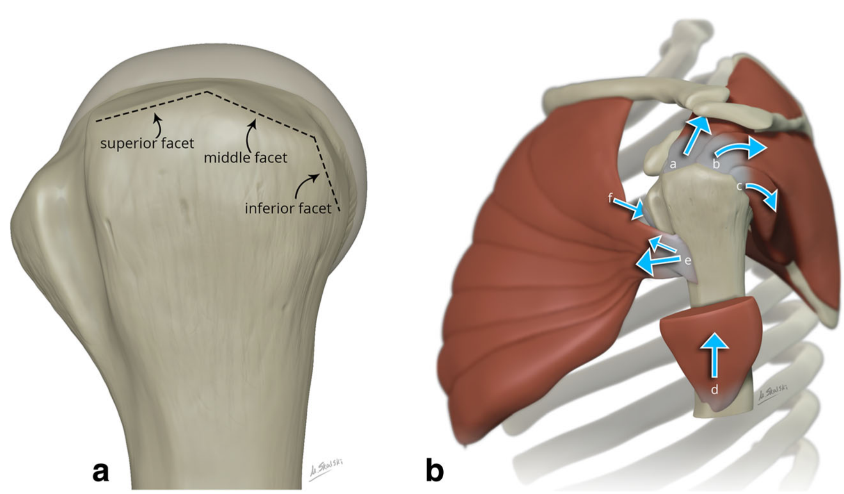


Fig. 1 **a** Greater tuberosity facets. Illustration of the proximal lateral humerus shows the facets of the greater tuberosity. **b** Muscular deforming forces on the proximal humerus. Direction of arrows demonstrates the direction of deforming force by each muscular insertion. (a) Supraspinatus, (b) infraspinatus, (c) teres minor, (d) deltoid, (e) pectoralis major, and (f) subscapularis

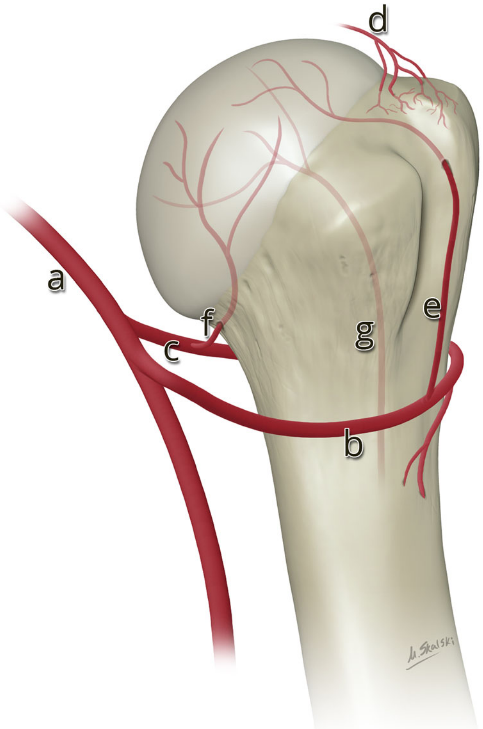


Fig. 2 Vascular supply to the proximal humerus. (a) Axillary artery, (b) anterior humeral circumflex artery, (c) posterior humeral circumflex artery, (d) small vessels via rotator cuff insertions, (e) anterior ascending branch, (f) posterior ascending branch, and (g) intraosseous metaphyseal artery

shoulder [8], after a fall on the outstretched hand with the elbow in full extension or flexion [20], or as a result of a seizure [21]. Osteoporosis and weak trabecular bone are thought to play a major role in the pathogenesis of these fractures [20].

Pathophysiology

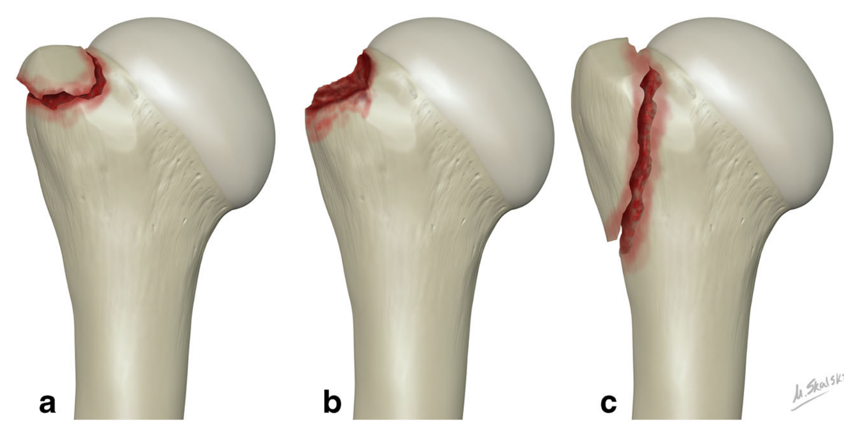
The greater tuberosity fragment is typically pulled superiorly by the supraspinatus and/or infraspinatus. If the fracture fragment is displaced greater than 5 mm into the subacromial space, a mechanical block to abduction and forward elevation can occur [22, 23]. The fragment may also be pulled posteriorly by the teres minor and infraspinatus which may result in a block to external rotation [22, 23]. In one series, patients who followed up after displaced greater tuberosity fracture showed evidence of subacromial impingement in 57% of 43 patients [24].

Alteration of the rotator cuff attachment can cause abnormal shoulder mechanics in addition to weakness of the rotator cuff. Biomechanical studies have shown that 1 cm of posterosuperior displacement of the greater tuberosity increases the necessary deltoid muscle force required for shoulder abduction by 29%. Superior displacement of 5 mm increases the deltoid force by 16%, while 1 cm of superior displacement increases it by 27% [25].

Diagnosis

The diagnosis of greater tuberosity fractures is based on history, physical examination, and imaging. Important information to obtain includes the position of the arm at the time of the injury, the occurrence of a dislocation, and symptoms of numbness, tingling, or weakness, which could indicate neurovascular injury [26]. Garg et al. reported nerve injury after greater tuberosity fracture–dislocation in 34% (16/47) of patients [27]. The anterior apprehension test and posterior relocation test can be performed to evaluate for instability if the patient's pain permits. With regard to the presence of instability, the apprehension, relocation, and release tests have sensitivities ranging from 91.7 to 98.3% while anterior drawer and load and shift tests have specificities of 92.7 and 98.3% respectively [28]. Shoulder range of motion may be limited as a result of persistent fracture displacement, pain, or the presence of concomitant adhesive capsulitis. Rotator cuff strength can be assessed by comparing active external rotation, internal rotation, abduction, and forward flexion strength with the contralateral side [26].

Fig. 3 Illustration of the morphologic classification of greater tuberosity fractures. (**a**) The avulsion type involves a smaller fracture fragment with a horizontal fracture line. (**b**) The depression type involves an impacted greater tuberosity. (**c**) The split type is a large fragment characterized by a vertical fracture line



Radiography and CT

Radiography plays a major role in diagnosing greater tuberosity fractures (Fig. 4). It is important to recognize that this injury is often very subtle and may not be detected on radiographs. Alternatively, it may be misinterpreted as enthesophytosis of the tuberosity from rotator cuff disease or calcification near the greater tuberosity (such as calcific tendinosis) [20, 29]. In patients with a traumatized shoulder, these fractures are frequently not detected radiographically (38–42%) and can be reliably detected with other imaging modalities such as MRI [21, 30], CT [31, 32], and ultrasound [19, 33].

An anteroposterior (AP) radiograph in external rotation has been suggested to help avoid this misinterpretation [34]. De Smet suggested that the AP projection with external rotation was essential for evaluation of the injured shoulder because the greater tuberosity was only visualized tangentially in this projection [35]. Since these patients present clinically with decreased abduction and external rotation due to pain [21], the greater tuberosity can overlap the humeral head on attempted AP projection with external rotation, and thus the fracture may not be visible. In a recent study, adding an apical oblique projection led to increased detection of acute traumatic shoulder abnormalities, including fractures of the greater tuberosity [36].

At the author's institution, a routine complete radiographic study includes AP external rotation, Grashey, scapular Y, and axillary projections. Optimization of radiographic technique and patient positioning, as well as careful inspection of the greater tuberosity region, may help to increase the detection rates of these fractures. While the eventual conservative management of nondisplaced/minimally displaced fractures may not change, identification of subtle fractures can prevent unnecessary CT, MRI, or arthroscopy.

Identification of a minimally displaced fracture on radiography may obviate the need for MR examination. In one series, none of the patients with isolated greater tuberosity fractures had rotator cuff lesions that required early surgery [21]. It is important to mention that radiographs can underestimate the amount of posterior displacement of the fracture fragment on AP and Grashey views [37]. Therefore, close evaluation of the scapular Y view and axillary radiograph is essential. If radiographs show that the greater tuberosity fragment is displaced greater than 5 mm, then surgical management may be considered. In cases with less displacement (3–5 mm) or that are unclear on plain radiographs, CT may be used to clarify the precise amount of displacement and characterize the morphology of the fracture (Figs. 5 and 6) [38].

Ultrasonography

Patients may present for ultrasound evaluation for a suspected rotator cuff tear after initial radiographs are equivocal or interpreted as normal. A high degree of suspicion is required

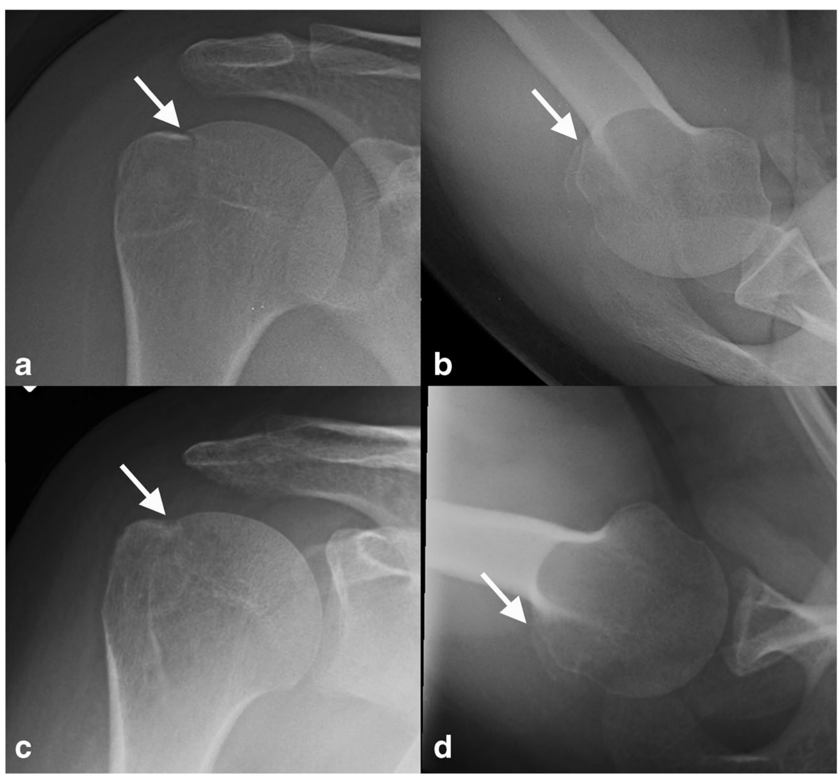


Fig. 4 Minimally displaced greater tuberosity fracture with subsequent healing. A 28-year-old woman presenting 10 days after a ground-level fall with pain. (a) AP external rotation and (b) axillary radiographs show a minimally displaced avulsion-type greater tuberosity fracture (arrows). The patient was treated conservatively, with a sling with instructions including no weight bearing or overhead activities. (c, d) Follow-up radiographs 2.5 months later reveal a healed fracture with mild residual deformity (arrow). The patient was pain free and had full range of motion

Fig. 5 A 55-year-old woman presenting after a fall with glenohumeral joint dislocation which was reduced. (a) Grashey view and (b) coronal reformatted CT image show a split-type fracture of the greater tuberosity with 10 mm of displacement. (c) Grashey view obtained after fixation with a laterally applied plate and screws shows near anatomic reduction of the fracture fragment

to identify a minimally displaced fracture in these patients. The normal humeral head cortex should have a smooth, echogenic, curvilinear, reflective surface with posterior acoustical shadowing [19]. A fracture can be recognized when there is a sharply demarcated defect of the cortical bone or discontinuity of this normal smooth arc-shaped configuration. (Fig. 7). Detection of occult fractures is possible using these findings [19]. The fracture has also been described as a step-off deformity, with one or more hyperechoic reflections (avulsed, displaced, or impacted bone fragments) and the "double line sign" (the presence of two parallel hyperechoic lines) [33]. If a cortical disruption is visualized, one should search actively for a double line sign by rotating the transducer 90° at the location of the cortical bone irregularity or discontinuity [33]. In one series, 42% of confirmed fractures were detected with sonography that were not apparent or not detected on initial review of the radiographs [19].

It may be difficult to distinguish calcifications of the supraspinatus (such as in calcific tendinosis, or enthesopathy) from an occult fracture. In this setting, comparison with the reference radiographs is important for the final diagnosis (Fig. 8) [39]. Ultrasonography provides a rapid, non-invasive, inexpensive evaluation that can help distinguish between rotator cuff injury and greater tuberosity fracture. It is important

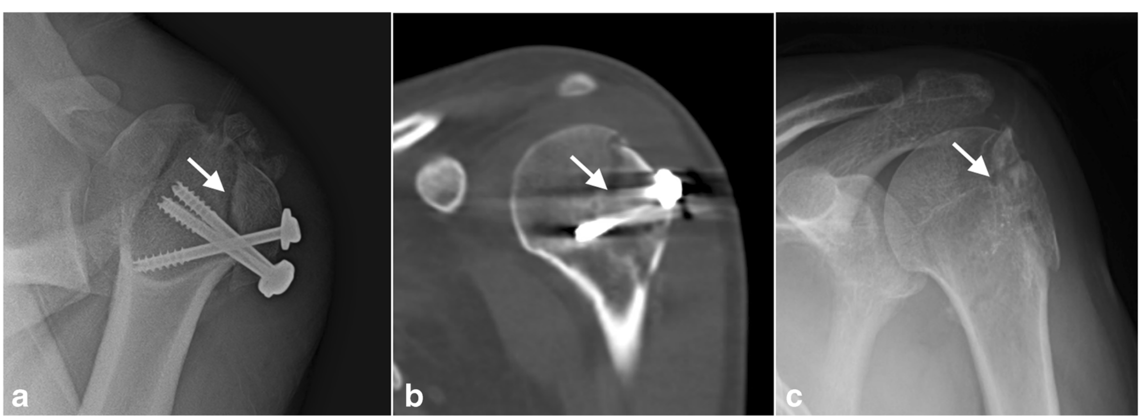


Fig. 6 Displaced fracture with suspicion of progressing to nonunion. A 27-year-old man who presented after a motor vehicle accident to an outside institution, where a greater tuberosity fracture was fixed with three cancellous screws and washers. The patient was transferred to our institution and imaging was performed. (a) Axillary radiograph and (b) coronal reformatted CT image demonstrate the split-type greater tuberosity fracture (arrows) with up to 5 mm of displacement of the major fracture fragment. While the patient did not have impingement, the orthopedic surgery team was concerned for possible malunion and planned for surgery to obtain improved fixation. At surgery, the screws were removed, and greater tuberosity was found to be stable, and no additional fixation was performed. Follow-up AP external rotation view (c) 4 months after the injury demonstrate interval healing of the fracture, with a mild residual deformity

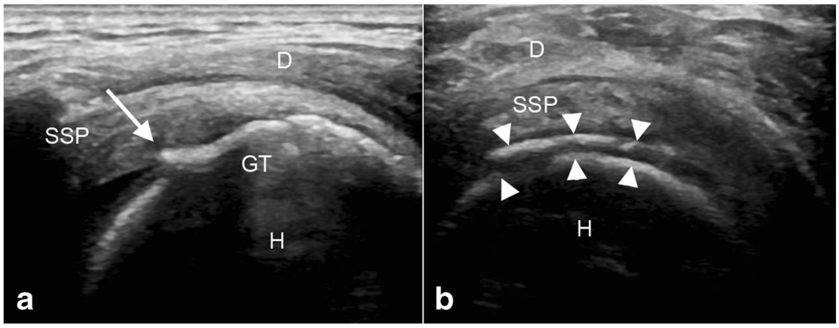


Fig. 7 Ultrasound findings. A 24-year-old woman with pain (same patient in Fig. 9). (a) A minimally displaced fracture of the greater tuberosity (GT). Long axis image of the supraspinatus tendon (SSP) shows discontinuity of the cortical bone with a step-off deformity (arrow). The insertion of the supraspinatus is normal. *D* deltoid muscle, *H* humeral head. (b) The "double line sign" (arrowheads). Short axis image of the supraspinatus tendon, which is perpendicular to the image in (a). Parallel lined hyperechoic reflections (arrowheads) of the fractured cortical bone are present

to distinguish these entities, as early surgical repair of rotator cuff tears is optimal for recovery of shoulder function [40]. When a greater tuberosity fracture is identified, ultrasound can also provide additional information about the presence or absence of rotator cuff tear at the time of the examination. Limitations of ultrasound include that it is operator dependent, and degenerative irregularity/enthesophytosis of the tuberosity from rotator cuff disease may mimic a fracture [29].

MRI

MRI may be obtained to evaluate for rotator cuff abnormalities in patients whose initial radiographs have fractures that are not detected or not visible. These fractures can be confidently diagnosed with MR imaging. The findings are typically crescentic or oblique lines of T1 hypointense and T2 hyperintense signal extending to the cortical bone with adjacent edema in the affected medullary bone (Fig. 9) [30, 41, 42]. This should not be mistaken for neoplasm or other pathology, for example chondrosarcoma (Fig. 10), or intraosseous calcific tendinosis. When evaluating an MR study in these patients, reviewing initial radiographs with close attention to the greater tuberosity may help increase diagnostic accuracy. In one series, a review of 712 shoulder MR examinations identified 11 patients with greater tuberosity fractures that were not detected on initial radiographs, 3 of which showed partial thickness rotator cuff tears that were confirmed arthroscopically [21]. The degree of superior displacement is best evaluated on the coronal oblique T1-weighted images. The degree of posterior displacement is evaluated on the axial T1- or proton density-weighted images [21].

When greater tuberosity fractures are identified on MR imaging, a search for additional associated injuries should be performed. Subtle Hill–Sachs deformities may not be apparent on radiographs. Labral and/or cartilage injury (Fig. 11) may be present and should be described. Partial thickness articular-sided rotator cuff tears are associated with isolated greater tuberosity fractures [21]; therefore, the rotator cuff should be evaluated for tear. A greater tuberosity fracture which is

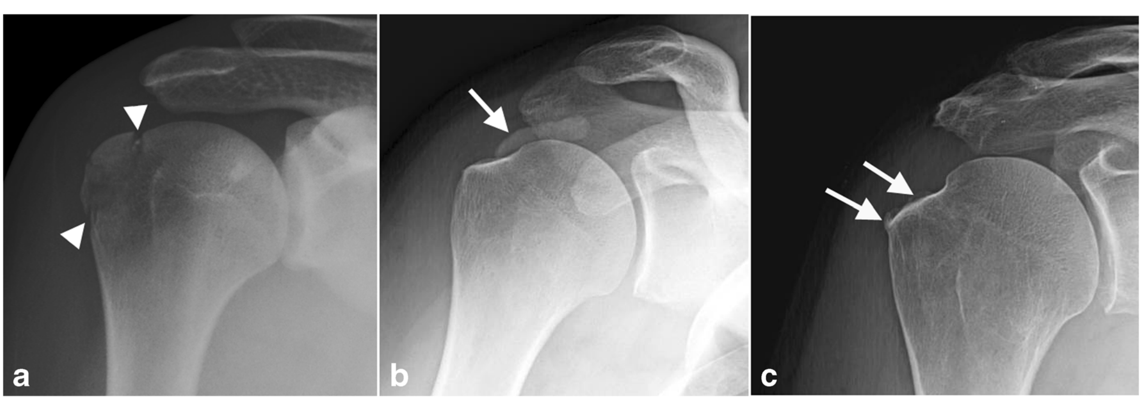


Fig. 8 Radiographs can help distinguish between greater tuberosity fracture, calcific tendinosis, and enthesopathy. (a) AP external rotation view shows a minimally displaced greater tuberosity fracture, with sharp margins and cortical step off. (b) Grashey view of a different patient shows calcific tendinosis, with rounded margins and lower attenuation of the calcific deposit than the cortical bone. (c) Grashey view of a third patient shows enthesophyte formation at the greater tuberosity

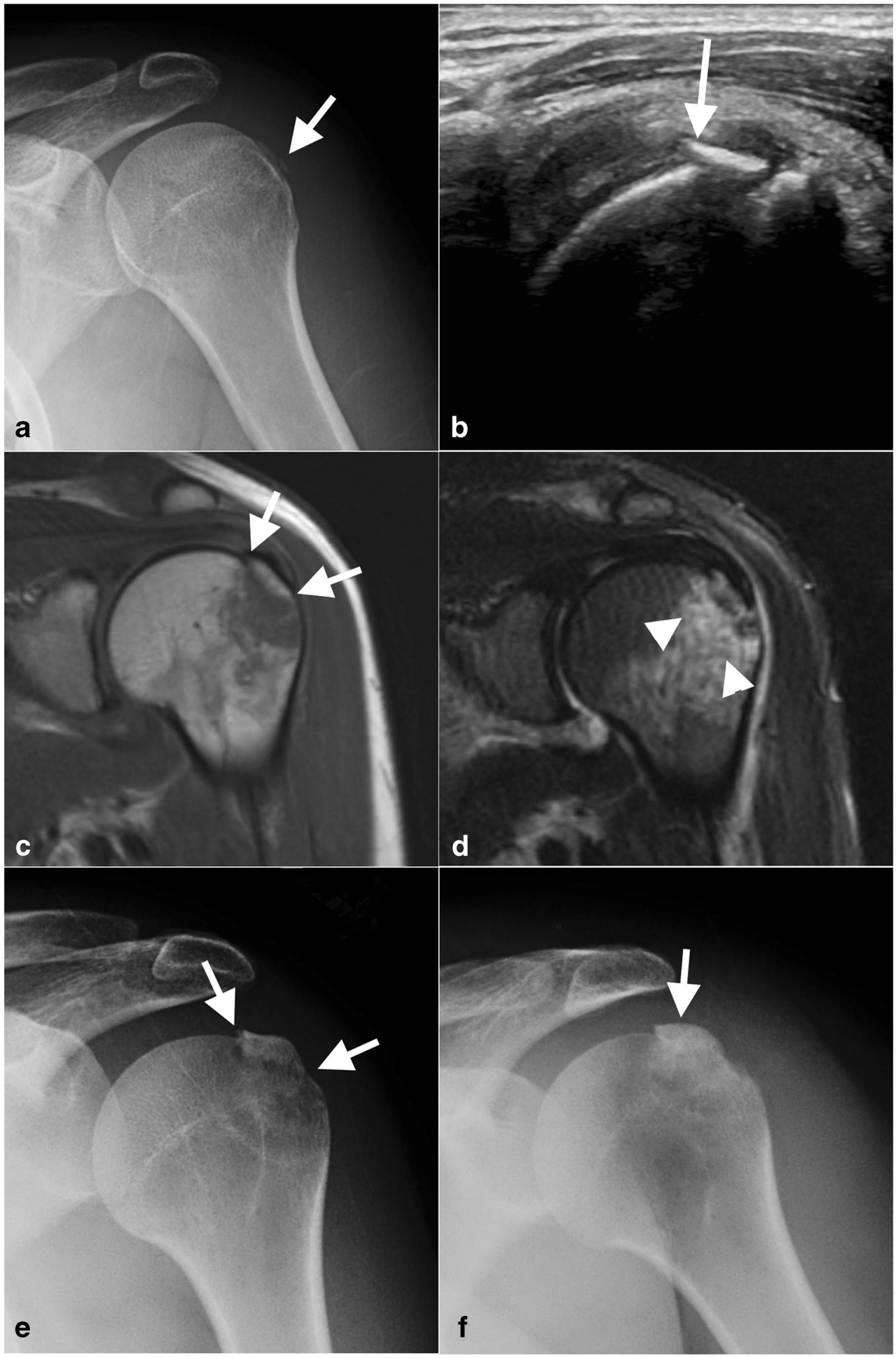


Fig. 9 Subtle greater tuberosity fracture that was initially interpreted as negative. A 24-year-old woman status post possibly auto vs. pedestrian injury. Initial radiographs were interpreted as negative (no external rotation view was obtained). However the (a) AP internal rotation view obtained as part of that series shows a subtle avulsion-type greater tuberosity fracture. (b) Ultrasound was performed revealing a minimally superiorly displaced greater tuberosity fracture (arrow). (c) Coronal T1 and (d) coronal STIR MR images show a minimally displaced greater tuberosity fracture (arrows) with adjacent marrow edema (arrowheads). (e) AP external view obtained 1 month after the injury shows the fracture to better advantage. (f) AP external view obtained 3 months after the injury shows a healed fracture with mild residual deformity

displaced more than 1 cm has been reported to be pathognomonic of a longitudinal tear involving the rotator cuff, typically occurring at the rotator interval [22]. When only the posterior aspect of the greater tuberosity is retracted, a longitudinal tear of the supraspinatus or infraspinatus is typically present [22].

Approach to management

It is imperative to accurately identify and report this injury, as precise characterization of fractures is important with regard to optimal treatment.

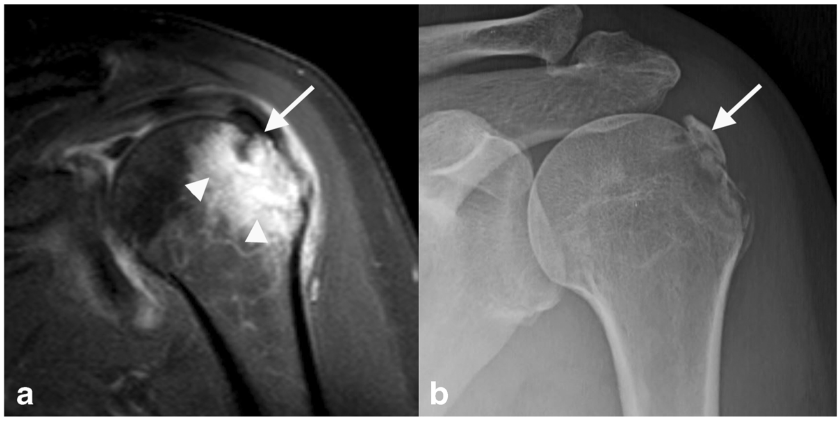
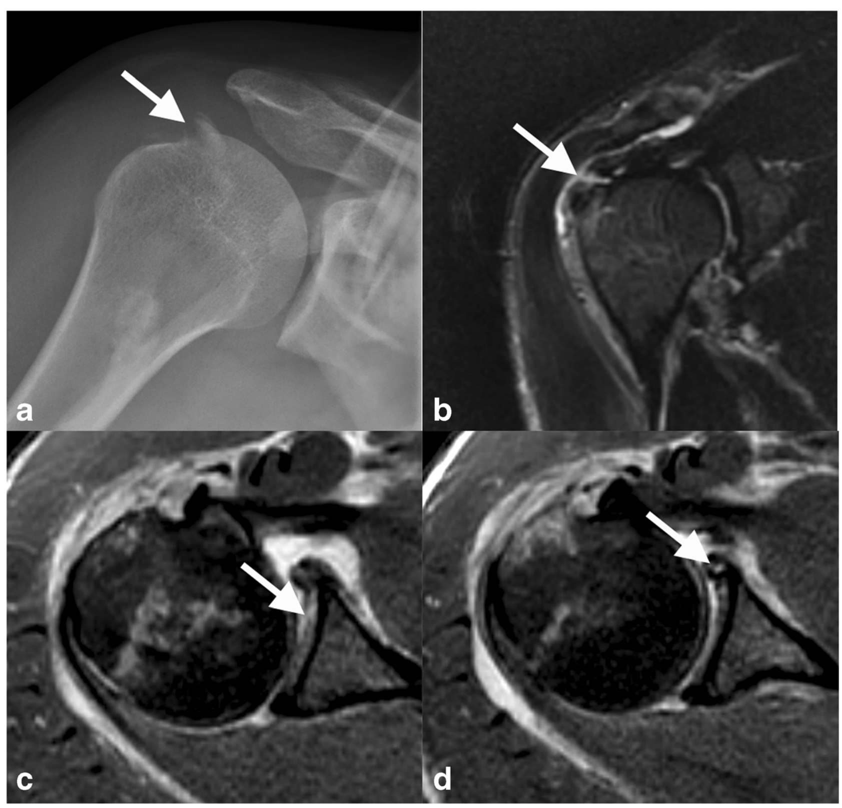


Fig. 10 A 40-year-old woman with shoulder pain. She presented to an outside institution and an MRI was obtained. (a) Coronal PDFS image shows a greater tuberosity fracture (arrow) with adjacent edema (arrowheads). This was interpreted as possible chondrosarcoma. She presented to the ortho tumor clinic at our institution and received an AP radiograph (b) which showed an isolated avulsion of the greater tuberosity (arrow in b). When questioned, she reported a history of shoulder trauma. These imaging findings should not be mistaken for neoplasm

Proximal humeral fractures are most commonly classified according to the Neer or Association for Osteosynthesis/Association for the Study of Internal Fixation (AO/ASIF) classification systems. The Neer classification is based on the number of displaced or angulated fracture fragments which are defined by involvement of the humeral head, humeral shaft, greater tuberosity, and lesser tuberosity [22, 23]. The AO/ASIF classification is based on the relationship of the fracture fragments to the articular surface of the humeral head [43]. These classification systems do not have criteria specific for isolated greater tuberosity fractures. Historically, treatment decisions have been made based on the amount of fracture displacement, regardless of which system is used to classify the fracture.

In 2006, Bahrs et al. classified greater tuberosity fractures by multiple criteria including whether or not the fracture was radiographically occult, fragment size, number of fracture fragments, and fracture displacement on the AP and axillary views [5]. In 2014, a morphologic classification of fractures of the greater tuberosity was described. This included three

Fig. 11 Greater tuberosity fracture with associated labral and cartilage injuries. A 30-year-old man presenting after auto vs. bicycle injury. (a) Grashey radiograph image shows a comminuted avulsion-type fracture of the greater tuberosity (arrows). (b) Coronal STIR MR image shows the avulsion (arrow) with minimal marrow edema. (c, d) Consecutive axial PDFS images shows fluid signal extending into the anterior glenoid cartilage (arrow) consistent with cartilage injury. This extended into the anterior labrum on the next axial image (arrow) consistent with a glenolabral articular disruption (GLAD) lesion



fracture types: avulsion, split, and depression [44]. The relative frequency of these fracture types was 39% (77/199), 41% (81/199), and 20% (41–199) respectively. An avulsion fracture involves small fragments of bone with a horizontal fracture line. A split-type fracture involves a larger fragment with a vertical fracture line. A depressed fracture involves an impaction deformity, with a fragment that may be displaced inferiorly [44]. This morphologic classification complements the standard greater tuberosity fracture evaluation of displacement and comminution and may help guide the technique of surgical treatment.

Treatment

Treatment of greater tuberosity fractures is controversial and may include nonsurgical or surgical management. In addition to the imaging findings, the treatment of these fractures depends on many clinical factors, such as the presence of shoulder instability, other associated shoulder injuries, and individual patient comorbidities, functional demands, and patient expectations [26].

Nonsurgical

Many greater tuberosity fractures that are minimally displaced may be treated conservatively. There is no broadly accepted protocol about the duration of immobilization or the position of the shoulder during immobilization. Most surgeons treat non-operative greater tuberosity fractures with a brief period of immobilization, followed by early passive motion with active motion and strength training initiated after signs of radiographic union. Some surgeons advocate weekly radiographs to assess for early displacement allowing providers to intervene surgically before a displaced fracture malunites [45]. MRI or ultrasonography may be of benefit in patients that have persistent pain or loss of function 3 to 6 months after injury. In one series of 43 patients followed up after displaced greater tuberosity fracture, 16% had full thickness rotator cuff tears and 53% had atrophy of either the supraspinatus or infraspinatus [24].

Surgical

Greater tuberosity fractures that are displaced posteriorly and superiorly by the rotator cuff more than 5 mm generally require anatomic reduction and internal fixation. If not reduced, the fragment may heal with significant superior displacement which narrows the subacromial space and may result in impingement on elevation of the arm. If the fragment heals with significant posterior displacement, the malunion may create a bony block that limits external rotation [40, 46]. When these fractures are complicated by rotator cuff tear, surgical repair of the cuff is typically delayed until the fracture has healed [19, 47].

While there is disagreement regarding the amount of displacement that warrants surgical fixation, most authors agree that 5 mm or more of posterosuperior displacement can lead to healing of the fracture fragment in a location that is more posterior or superior than anatomic (malunion) (Fig. 12). This can result in shoulder pain and limited range of motion [4, 25]. Angulation of the fracture fragment of 45° or more is another reported indication for surgical management [18, 48]. A more recent recommendation suggests that if displacement

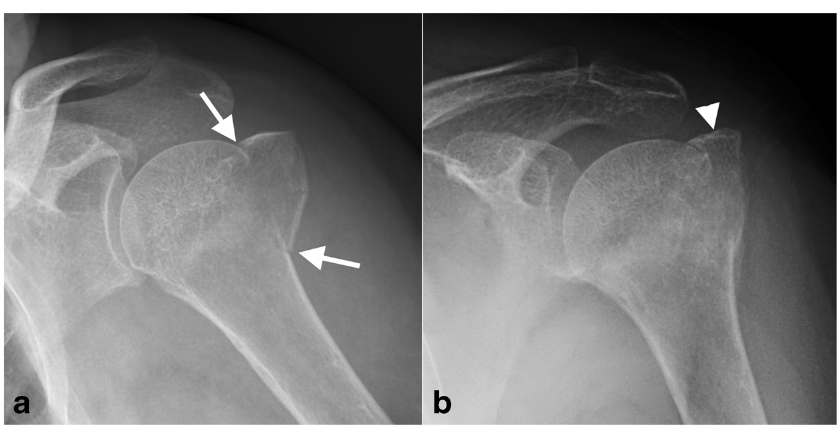


Fig. 12 Malunion resulting in decreased ROM and impingement. An 80-year-old woman who presented with pain and restriction of motion after she tripped and fell. (a) AP external rotation radiograph shows a mildly comminuted split-type greater tuberosity fracture with superior positioning of the fracture fragment (arrowhead). Mild sclerosis is noted along the surgical neck which may represent a nondisplaced surgical neck fracture (the patient did not receive CT or MRI). The findings were discussed with the patient and her daughter that without surgery, she would likely lose some shoulder abduction and have impingement symptoms with overhead motion. The patient had other medical comorbidities including dementia, and surgery was deferred. (b) Follow-up AP external view 2 months later shows the fracture had healed with unchanged superior positioning of the greater tuberosity. The patient's pain improved and she did have loss of abduction

Fig. 13 Nonunion. A 53-year-old woman with recurrent glenohumeral joint dislocations. (a) Scapular Y view shows an avulsion-type greater tuberosity fracture with displacement. (b) Sagittal reformatted CT image obtained 2 years later shows unchanged displacement of the fragment with sclerotic margins

is more than 3 mm in athletes and laborers with demand for overhead activity, the fracture should be repaired [48]. Nonunion (Fig. 13) presents and can be surgically treated similar to malunion; however, if the tuberosity is displaced posteriorly, it can be challenging to mobilize the fragment and achieve stable fixation, while avoiding limitation of internal rotation [10].

Multiple surgical techniques have been described in the literature to treat displaced greater tuberosity fractures with the ultimate goal of anatomic reduction. These include both open and arthroscopic surgical techniques depending on the fracture type, pattern, and preference of the surgeon [49–51].

Surgical management may include an arthroscopic or open surgical technique (Fig. 14). Avulsion fractures may be treated with arthroscopic fixation, similar to full thickness rotator cuff tears with a double row suture anchor technique [50]. Isolated screw fixation of the fracture has been described; however, it is not feasible if the fragment is comminuted [10]. A split-type fracture may be fixed with a laterally applied plate and screws [50]. When fractures are fixed with larger plates or spiked washers, impingement may occur. One report suggested the use of low-profile mesh plate to address this potential issue [51]. Depression-type greater tuberosity fractures are rarely treated surgically, as the fragments are impacted on the humeral head and are generally nondisplaced. If displacement occurs subsequently, the surgical approach for the avulsion-type fractures can be performed [50]. Osteotomy and re-fixation may be performed in patients with malunited greater tuberosity fractures [52].

Conclusion

Isolated greater tuberosity fractures of the proximal humerus may have subtle findings on imaging and may be not detected on radiographs. Close examination of the greater tuberosity on the AP external and Grashey views can improve detection of this injury. Additional imaging should be performed in patients with negative or equivocal radiographs but continued clinical suspicion for fracture. Patients may present with symptoms of rotator cuff tear, and the initial imaging obtained may be ultrasound or MRI. It is important to be familiar with these injuries, as they have been implicated in the development of impingement if not detected, particularly when

Fig. 14 Greater tuberosity fracture fixed with suture anchors. A 64-year-old man who sustained a fall resulting in a fracture–dislocation, which was reduced at an outside institution. (a) Grashey view shows a split-type greater tuberosity fracture (arrow in a) with 28 mm of superior displacement. (b) Post-op Grashey view shows reduction of the fracture fragment. (c) Follow-up radiograph shows healing with mild residual deformity and some resorption of the fracture fragment. On physical exam, the patient had good function, with full range of motion and good strength with regards to abduction and external rotation

displaced. If minimally displaced fractures are detected on radiographs, it can help prevent unnecessary MR imaging and arthroscopic surgery.

Characterization of these fractures with regard to type of fracture (avulsion, split, or depression), fragment size, presence or absence of comminution, and amount of displacement is important to help guide management. Correct identification and characterization of these injuries can help facilitate appropriate management, including both nonsurgical and surgical options. It is important for the emergency radiologist to be familiar with the imaging findings, mechanism of injury, and associated shoulder injuries of isolated greater tuberosity fractures to help patients receive improved functional outcomes and prevent patient morbidity.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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