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Isolated Greater Tuberosity Fractures of the Proximal Humerus: Validation and Clinical Implications for a New Radiologic Measurement Method and Classification

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Isolated Greater Tuberosity Fractures of the Proximal Humerus:

Validation and Clinical Implications for a New Radiologic

Measurement Method and Classification

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SOMMAIRE

Les fractures isolées de la Grosse Tubérosité (GT) de l'humerus proximal sont rares et peu étudiées. Trois problèmes importants existent: **1:** Même si 5mm + de déplacement supérieur du GT est cité comme indication chirurgicale, les mesures basées sur radiographie peuvent errer de plus que 10mm. **2:** Les classifications de Neer et l'AO décrivent seulement un type de fracture de GT (gros fragment, ligne de fracture verticale). Deux autres types de fracture existent: type fracture-avulsion avec petit fragment osseux et type Hill-Sachs très latéral. **3:** On manque d'études de pronostic ou de traitement des fractures de GT selon la morphologie.

Article 1 montre et évalue une méthode simple de mesurer le déplacement supérieur de la GT (le GT ratio) sur les radiographies standard; ceci corrèle très bien avec tomographie (CT). Article 2 introduit une méthode de classification Morphologique des fractures de GT (Avulsion, Split, Dépression) qui a une fiabilité de bonne à excellente. Les données échographiques, radiologiques, et cliniques de 54 patients porteurs de fracture de GT (suivie moyenne 2.5 années) sont aussi incluses. Les patients <50 ans ont eu plus de déchirures de la coiffe et ceux avec fractures déplacées (≥ 5mm) avaient plus d'atrophie du susépineux. Les déchirures complètes de la coiffe et l'atrophie du susépineux augmentaient l'atteinte permanente.

La morphologie des fractures de GT n'a pas eu un impact significatif sur le pronostic. Cependant, l'âge, le sexe, et le taux de luxation glénohumérale étaient différents selon le type de fracture et ceci pourrait refléter la pathophysiologie. Une évaluation plus précise de l'impact de la Morphologie des fractures de GT sur le pronostic et traitement nécessitera une étude prospective multicentrique.

MOTS CLÉS

Humérus proximal

Grosse tubérosité

Fracture

Déplacement

Radiographie

Classification

Échographie

Coiffe des rotateurs

Résultats cliniques

Traitement

SUMMARY

Isolated fractures of the Greater Tuberosity (GT) of the proximal humerus are rare and a challenge to study. Three main problems arise: **1:** Though 5mm+ superior GT displacement is often a surgical indication, measurement errors on radiographs may surpass 10mm. **2:** The Neer and AO classifications describe only one type of GT fracture (large fragment, vertical fracture line). Two other fracture types have been described: an avulsion-type (small fragment), and a very lateral Hill-Sachs-type. **3:** There are no studies on the treatment or prognosis of GT fractures according to fracture morphology.

Article 1 introduces and tests a simple method to measure superior GT displacement (the GT ratio) using standard radiographs; this correlates very well with computed tomography (CT). Article 2 presents the Morphologic classification for GT fractures. It describes three fracture types (Avulsion, Split, Depression) and has good to excellent reliability. The ultrasonographic, radiologic, and clinical results of 54 patients (average follow-up 2.5 years) with isolated GT fractures are then described. Patients <50 years had higher rates of rotator cuff tears and displaced (≥ 5mm) GT fractures were associated with supraspinatus atrophy. Both full rotator cuff tears and supraspinatus atrophy resulted in poor outcomes.

The impact of fracture morphology on prognosis was not significant. However, age, sex, and associated glenohumeral dislocation differed by fracture type and this may reflect their pathophysiology. A more thorough evaluation of the prognosis and treatment of GT fractures by morphologic type would require a prospective multicenter study.

KEY WORDS

Proximal humerus

Greater tuberosity

Fracture

Displacement

Radiographs

Classification

Ultrasound

Rotator cuff

Clinical outcome

Treatment

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LIST OF TERMS/ ABBREVIATIONS

AHD – Axis of the Humeral Diaphysis

AO – Arbeitsgemeinschaft Osteosynthese or the Association of the Study of Internal Fixation (ASIF)

AP – Anteroposterior

cf – *Confer* in latin, as in "please see" the referred to section or document

CT – Computed Tomography

GT – Greater Tuberosity of the Proximal Humerus

GT Ratio – A ratio measured on the anteroposterior (or Neer) shoulder radiograph representing the superior (or posterior) displacement of the greater tuberosity in isolated greater tuberosity fractures of the proximal humerus

HHT – Humeral Head Tangent

ICC – Intraclass Correlation

mm – millimeters

Morphologic Classification – A proposed classification of isolated greater tuberosity fractures that categorizes fractures as Avulsion type, Split type, or Depression type based on morphology

MRI – Magnetic Resonance Imaging

mSv – millisievert (a measurement of radiation dose)

Neer – The standard Lateral radiographic view of the proximal humerus

PACS – Picture Archive Computer/ Communication System

*Quick*DASH – Disabilities of the Arm, Shoulder and Hand Outcome Measure (Shortened version)

ROM – Range of Movement

SF-12® v2 – SF-12® Health Survey version 2.0

SI – Superior or Inferior

US – Ultrasound

VAS – Visual Analog pain Scale

WORC – Western Ontario Rotator Cuff Index

XR – Standard Radiograph (or Roentgenogram)

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Last but not least, to my family. You now know more than you likely ever wanted to know about shoulder fractures and yet have refrained from changing the locks on the door. There is no stronger evidence of your love and support.

INTRODUCTION

Epidemiology of Greater Tuberosity Fractures of the Proximal Humerus

Fractures of the proximal part of the humerus are relatively common injuries with a reported incidence of 73 cases per 100 000 individuals per year[1]. Although these fractures represent only 3-5 percent of all fractures overall[2,3], their incidence increases sharply with age and is expected to triple over the next three decades[4,5] Proximal humerus fractures generally occur in an osteoporotic population following a low-velocity trauma and females are affected three times as often as males[6]. They are second in frequency only to distal radius fractures for the upper extremity and third for all fracture types (after hip and distal radius) in patients over the age of 65 years[7]. Fortunately, approximately 80% of these fractures may safely be treated conservatively[1,8].

Greater tuberosity fractures, by contrast, occur with greater frequency in the younger population. They constitute one fifth of all proximal humerus fractures[1,9-12]and are more often associated with high velocity trauma[2]. Men are more likely to suffer greater tuberosity fractures than women and 5 to 7% of these injuries are the result of a glenohumeral dislocation[12,13]. Additionally, 15 to 30% of all anterior glenohumeral dislocations[14-17] are associated with a greater tuberosity fracture.

As with other proximal humerus fractures, a minority of isolated greater tuberosity fractures are displaced[8,18]. In the statistics published by the AO (Arbeitsgemeinschaft Osteosynthese) on operatively treated fractures of the proximal humerus, less than two percent involved isolated displaced fractures of the greater tuberosity[19]. However, due to the higher demands in this patient population and the anatomic constraints of the greater tuberosity beneath the acromion, considerable debate has emerged as to what should constitute “displacement” in this particular fracture[9].

Current Study on Isolated Greater Tuberosity Fractures of the Proximal Humerus

The motivation for this project stems therefore from the following observations: 1) isolated greater tuberosity fractures of the proximal humerus are poorly understood; 2) the current methods for measurement of fracture displacement on plain radiography are unreliable; 3) the morphology of greater tuberosity fractures is variable; 4) the prognosis of greater tuberosity fractures is highly variable and not fully explained by fragment displacement.

This thesis is comprised of eight chapters. The first chapter summarizes the literature available for shoulder fractures and specifically addresses the evaluation, prognosis, and treatment of isolated greater tuberosity fractures of the proximal humerus. Chapter 2 lists the objectives and hypotheses for this project and chapter 3 describes the methodology used to address them. Chapters 4 through 6 present the results of our study, with the first 2 in the form of journal articles and the last as complementary findings. The first article (Chapter 4) explores the limitations of current imaging modalities, in particular plain radiography, for the evaluation of isolated greater tuberosity fractures of the proximal humerus. It describes and validates a new measure for superior displacement on the anteroposterior roentgenogram, the GT ratio, and tests its applicability in the clinical setting. The second article (Chapter 5) proposes and validates a classification system for isolated greater tuberosity fractures based on fracture morphology. This Morphology Classification is further correlated (in Chapter 6) with ultrasonographic findings of soft tissue injury, shoulder function and quality of life. Finally, a discussion of all the results can be found in Chapter 7 and conclusions in Chapter 8.

CHAPTER 1 – LITERATURE REVIEW

1.1 – ANATOMY OF THE SHOULDER JOINT

Bony Anatomy of the Shoulder

The shoulder joint is one of the most mobile and complex articulations in the human body. As a result the equilibrium between mobility and bony, ligamentous, and muscular support in this joint may be perturbed by even minor injury. The shoulder girdle consists of three bones and four major articulations. The three bones, the clavicle, scapula, and humerus, articulate with each other and the thoracic cage to form the sternoclavicular, acromioclavicular, scapulothoracic, and glenohumeral articulations (Figure 1)[20,21].

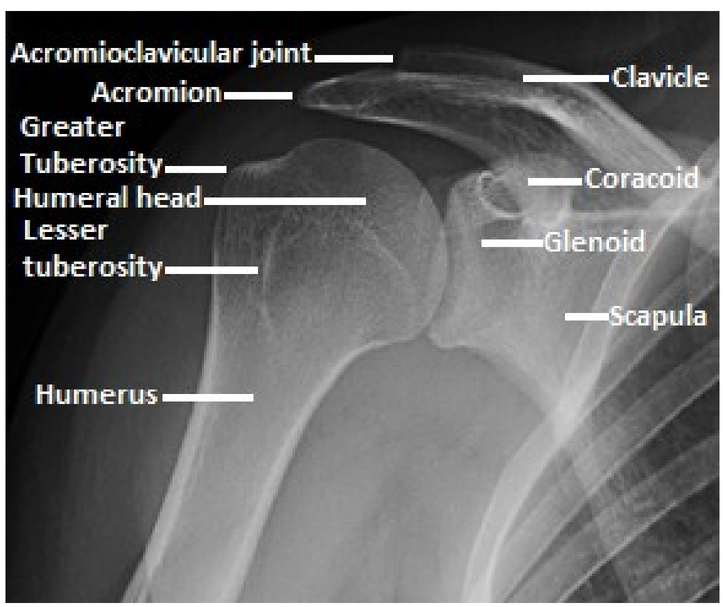


Figure 1: Bony anatomy of the shoulder girdle

Range of Motion (ROM) around the Shoulder Joint

These four joints (sternoclavicular, acromioclavicular, scapulothoracic, glenohumeral) execute an intricate series of movements to allow a normal shoulder ROM of: 160 to 180 degrees abduction; 160 to 180 degrees forward flexion; 30 degrees adduction; and 40 to 60 degrees extension. Internal and external rotation is highly variable among individuals and may be tested at 0 or 90 degrees of shoulder abduction. Although the opposite limb is generally used as a control, external rotation at 90 degrees is normally about 20 degrees greater in the dominant extremity and may be up to 135 degrees in the throwing athlete (Figure 2)[22].

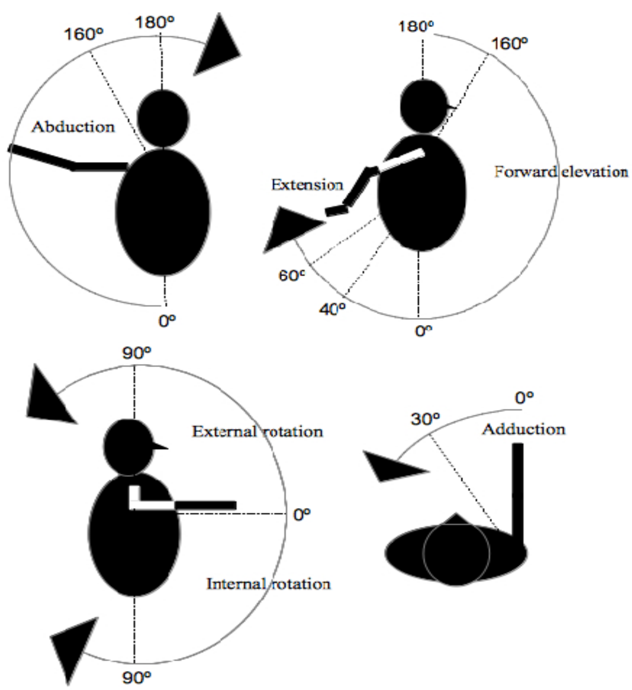


Figure 2: Range of Motion around the Shoulder Joint: Flexion/Extension, Abduction/Adduction, and External/Internal Rotation

The combination of translation, rotation, and angulation necessary for normal shoulder motion was first described by Codman in 1934 as “scapulohumeral rhythm”[23]. He discussed the vague descriptions of shoulder motion advanced by previous anatomists and physicians and although he recognized the difficulty of defining scapulohumeral rhythm, he was equally incapable of adequately illustrating it. Advances in the mathematic and mechanical understanding of scapulohumeral rhythm have been made in the past 80 years but we are far from fully understanding this sophisticated joint[23].

Muscular Anatomy of the Shoulder

The intricate movements arising in the shoulder are controlled and supported by a multitude of muscles and ligaments. A full review of the bony, muscular, and ligamentous constraints of the entire shoulder girdle is beyond the scope of this study, so we will concentrate primarily on the glenohumeral joint. This “large ball-small socket” articulation offers very little intrinsic bony stability and is consequently the most frequently dislocated joint in the human body[20]. The surface of the glenoid is augmented radially by a dense fibrocartilagenous tissue called the labrum. This increases the depth of the shoulder socket by 50 percent and contributes to stability of the joint. The ligamentous constraints of the shoulder include the superior glenohumeral ligament, middle glenohumeral ligament, and inferior glenohumeral ligament. These ligaments stabilize the glenohumeral joint in the extremes of motion and resist inferior translation (in abduction), external rotation (in lower ranges of abduction), and posterior or anterior translation (in greater than 45 degrees of abduction), respectively[20,24].

The muscles acting on the glenohumeral joint serve to create shoulder motion and dynamically stabilize the humeral head in the glenoid[25,26]. The rotator cuff envelops the humeral head and consists of the subscapularis, supraspinatus, infraspinatus, and teres minor muscles. The subscapularis originates on the anterior surface of the scapula and inserts along the anterior aspect of the humeral head at the lesser tuberosity. This muscle acts as an internal rotator of the humerus and serves to dynamically inhibit antero-inferior humeral head displacement. The supraspinatus, infraspinatus, and teres minor all originate on the posterior surface of the scapula, wrap posteriorly around the humeral head and insert along the greater tuberosity. These muscles externally rotate the humerus, stabilise the shoulder posteriorly, and participate in a “force couple” with the subscapularis to stabilise the glenohumeral joint in abduction from 60 to 150 degrees. The supraspinatus muscle additionally initiates the shoulder abduction moment[24,25,27].

The long head of the biceps passes over the anterior aspect of the humerus through the bicipital groove between the greater and lesser tuberosities to insert in the supraglenoid tubercle. It enters the glenohumeral joint through the “rotator interval” (a triangular infolding of capsule between the supraspinatus and subscapularis muscles) and is stabilized in its groove by the transverse humeral, superior glenohumeral, and coracohumeral ligaments as well as the pectoralis major muscle[28]. The biceps tendon creates a significant anterior stabilising force on the shoulder, particularly in abduction[29], but its location puts it at risk for injury.

Tendonitis, tears, and subluxation of the long head of the biceps tendon have been found in association with rotator cuff tears, osteoarthritis, and proximal humerus fractures[28,30].

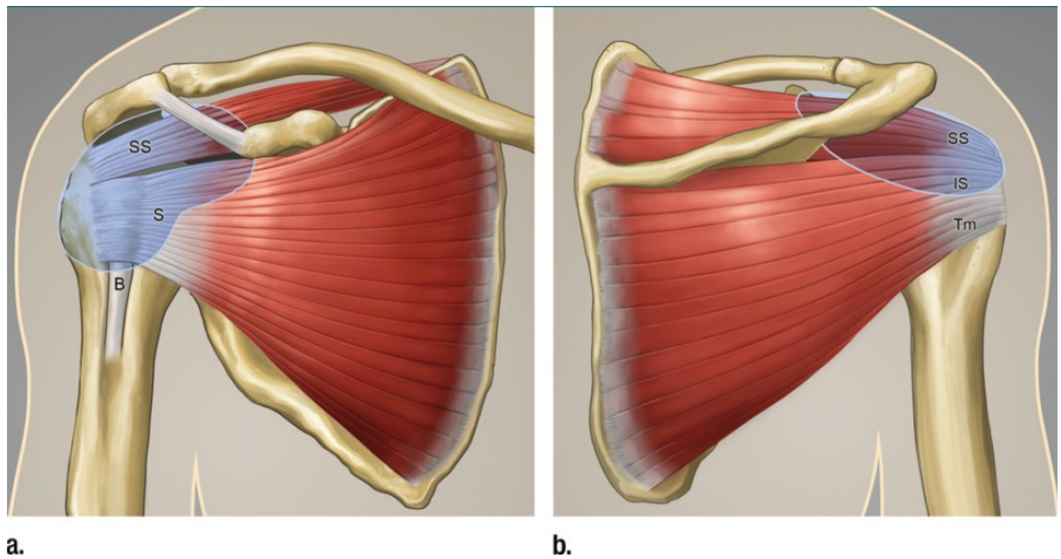


Figure 3: Muscular Anatomy of the Glenohumeral Joint: Illustrations of (a) anterior and (b) posterior shoulder show supraspinatus (SS), infraspinatus (IS), subscapularis (S), teres minor (Tm), and long head of the biceps brachii tendon (B). Subacromial-subdeltoid bursa is overlying the rotator cuff (light blue) [reproduced with permission, © Carolyn Nowak, Ann Arbor 2011]

Other muscles acting around the glenohumeral joint include the deltoid, pectoralis major, teres major, and latissimus dorsi. These are the power movers of the shoulder and act as abductors, flexors, extensors, adductors, and internal or external rotators depending on the position of the upper limb.

1.2 – FRACTURES TO THE SHOULDER (PROXIMAL HUMERUS)

Fractures to the proximal humerus may have a substantial impact on motion, stability, and force of the glenohumeral joint. These generally occur along the physeal lines of the proximal humerus and split the humeral head into up to 4 parts: the greater tuberosity, lesser tuberosity, head and diaphysis[25,31]. The fragments then displace according to the pull of their relative musculature; the greater tuberosity is pulled posteriorly and superiorly by the supraspinatus and infraspinatus muscles; the lesser tuberosity is pulled medially by the subscapularis muscle; the head generally remains in close contact with the glenoid unless there is an associated glenohumeral dislocation; and the diaphysis is pulled anteriorly, medially, and proximally by the pectoralis major and deltoid muscles[2].

Figure 4: Deforming Forces in 4-Part Fractures of the Proximal Humerus

[reproduced with permission, Gruson 2008]

Numerous studies have demonstrated the negative impact of multiple fragments, increasing displacement, and associated tendon or ligamentous injury[8,30,32-38] on the functional outcome in proximal humerus fractures. As for greater tuberosity fractures, despite having garnered a significant amount of attention over the past 40 years, the appropriate evaluation and management of these fractures is still not clear. Even minimal displacement of greater tuberosity fractures can have a significant impact on post injury pain, strength and motion[39]. Unfortunately, the radiographic evaluation of greater tuberosity displacement is problematic, leading some authors to recommend computed tomography in this population[40].

Recommendations for surgical fixation of isolated greater tuberosity fractures have decreased over time from 1cm[8,35,41,42] to 5mm[9,40] to 3mm of displacement in overhead workers or athletes[39], yet no author has addressed the morphology of greater tuberosity fractures in their recommendations. Further complicating the issue, a wide variety of fixation techniques/strategies have been proposed for these fractures. We believe this is due in part to the differing morphology of greater tuberosity fractures and leads to confusion when all types of greater tuberosity fractures are considered together.

1.3 – CLASSIFICATION OF SHOULDER FRACTURES

In 1934, Codman was the first to describe the four major fragments and deforming forces in proximal humerus fractures[31].

The first fragment, the humeral shaft, was created through fracture in the region between the surgical and anatomic humeral necks with the arm in abduction and elevation and with the acromion serving as the fulcrum for the long lever arm of the humerus. It would tend to displace medially due to the pull of the pectoralis major tendon[31].

The second fragment, the humeral head, was created when the tuberosities were sheared off at the transverse epiphyseal scar. With the arm in abduction, the superior edge of the glenoid would act as a wedge between the tuberosities and the articular humeral head, with the acromion as the fulcrum at the base of the greater tuberosity. The subsequently freed humeral head (no soft-tissue attachments) could rotate or dislocate depending on the magnitude of the trauma[31].

The third and fourth fragments, the tuberosities, would fracture apart lateral to the bicipital groove which follows the line of the vertical epiphyseal scar. The lesser tuberosity would displace medially due to the pull of the subscapularis muscle. The greater tuberosity would displace superiorly due to the pull of the supraspinatus muscle[31].

Interestingly, even in Codman's original description of proximal humerus fractures, he warns readers that fractures of the greater tuberosity, and avulsions of the supraspinatus facet in particular, are among the most serious types of humeral fractures. He recommended immediate surgical treatment[2].

In 1970, Neer published his four-part fracture classification of the proximal humerus. He used the same four fragments described by Codman but considered a fragment to be a "part" only if it was displaced more than 1cm or angulated more than 45 degrees. This classification was a major advancement in the understanding of proximal humerus fractures because it considered the vascularity in the humeral head fragments as well as then tendency for patients with non-displaced fractures to do well[8,43].

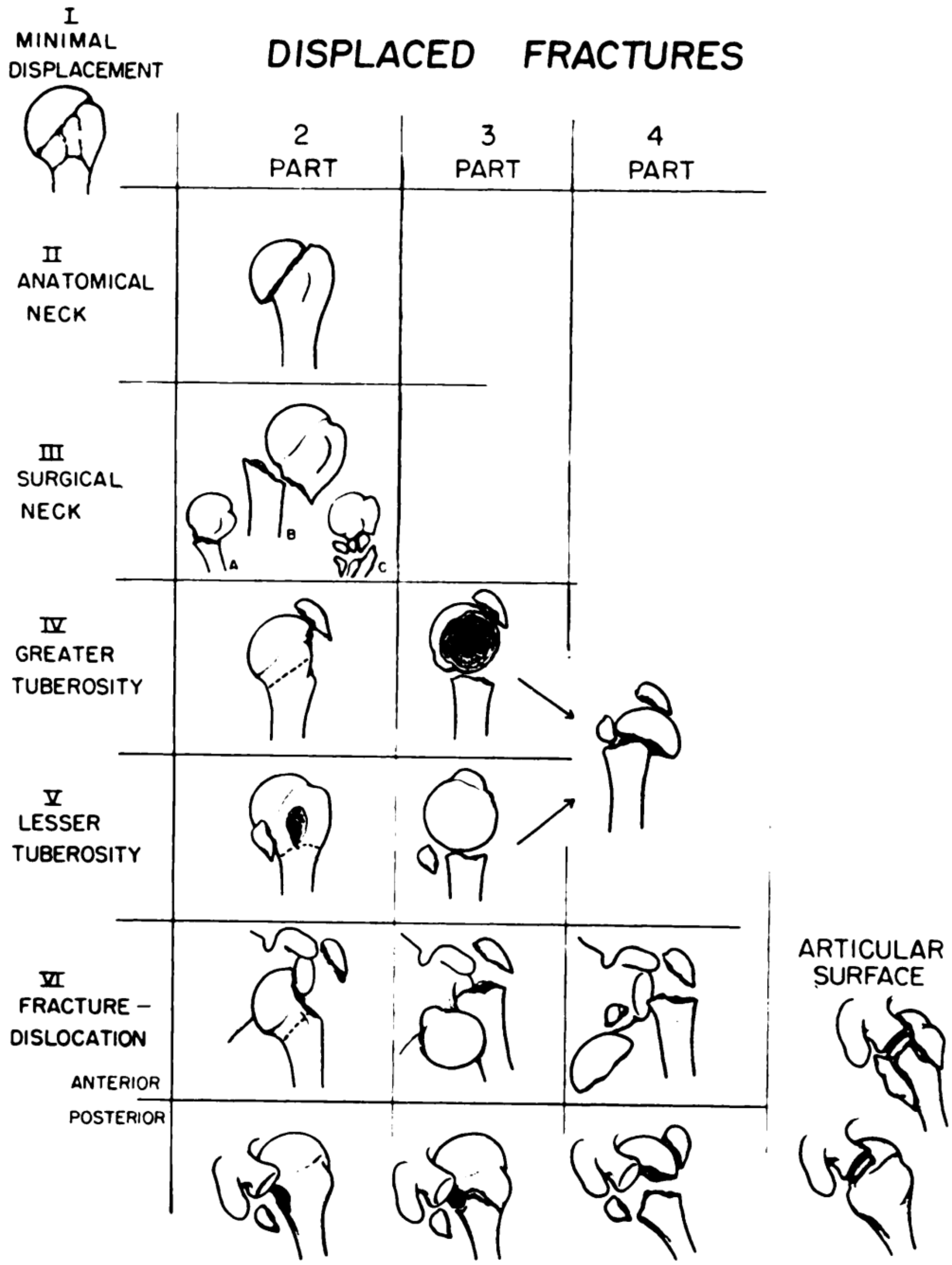


Figure 5 = Neer's 4-Part Classification of Proximal Humerus Fractures [reproduced with permission, Neer 1970]

The definition of displacement, however, was arbitrarily set and greater tuberosity fractures received no special attention in this classification. It has been the source of a fair amount of criticism for its poor intraobserver and interobserver reliability[44-49], particularly if based on simple radiography.

Neer responded to these criticisms in 2002 and noted that greater tuberosity fractures could often be missed[50]. He recommended the use of computed tomography to assist in the application of his classification, but the efficacy of this has also been questioned[51,52].

It has been noted by several authors that patients with greater tuberosity fractures displaced more than 5mm may do poorly with non-surgical management[9,39,40,53-55]. Both Codman[31] and Neer[8,43] observed that these injuries were difficult to treat and frequently resulted in inferior outcomes following non-surgical management. They hypothesized that this was due to the deforming force of the rotator cuff but no clinically validated cutoff for surgical management was presented by either author[8,31]. Platzer et al. evaluated 135 patients with minimally displaced (1-5mm) greater tuberosity fractures at an average 3.7 years following injury[39]. Ninety-seven percent of these patients had good to excellent results with non-surgical management but patients with 3mm or more of displacement trended towards worse outcomes. The authors concluded that most patients with 1-5mm of greater tuberosity displacement could successfully be managed non-surgically but agreed with Park et al.[54] that surgical management could be considered in heavy labourers or overhead workers with greater tuberosity displacement of more than 3mm[39].

The current expert consensus is that patients with > 5mm of greater tuberosity displacement would likely benefit from surgical management, in particular if they are young and physically active[9,40]. Displacement greater than this significantly negatively impacts the biomechanics of the shoulder[55]. Bono et al. developed a dynamic biomechanical model of greater tuberosity malunion and demonstrated that 5mm of superior greater tuberosity displacement increased the abduction force by 16%. Deltoid abduction force increased by 27% with 1cm of superior displacement and mechanical abutment on the undersurface of the acromion occurred. Although no bony abutment occurred with 5mm of displacement, they postulated that subacromial pressures would likely increase (through the decrease in volume) with abduction and noted this as a weakness in their model[55].

Various other authors have added contributions to the Neer Classification over the years and numerous other classifications have been proposed[56-62]. Since they have not been adapted into current use and, as a whole, contributed little to the understanding or treatment of greater tuberosity fractures, they will not be described here.

The AO group developed a comprehensive classification of long bones with the aid of Mueller et al. in 1990[63]. It classifies fractures into A(extra-articular), B(partial-articular), or C(articular) groups with multiple sub-groups, leading to 27 possible fractures types in the proximal humerus alone[64]. In this classification, isolated fractures of the greater tuberosity are divided into 3 groups according to displacement (more or less than 5mm) and associated glenohumeral dislocation.

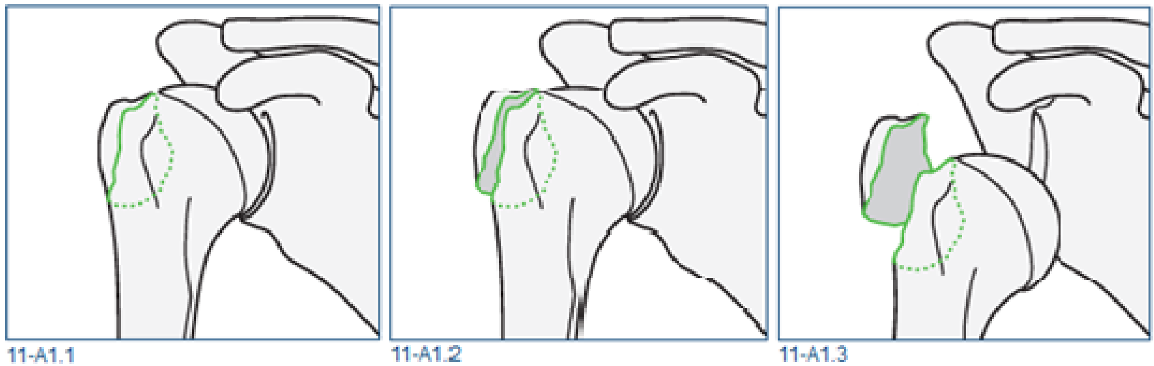


Figure 6 = AO Classification of Greater Tuberosity Fractures: 11-A1.1 non-displaced GT fracture; 11-A1.2 displaced GT fracture; 11-A1.3 GT fracture with glenohumeral dislocation [reproduced with permission, ©AO Foundation, Switzerland]

Similar to Neer, the AO Classification has also received numerous criticisms for poor intraobserver and interobserver reliability[46,47,51,60,65].

To date, Bahrs et al. are the only group to devote a significant amount of effort to the understanding and classification of isolated greater tuberosity fractures[66,67]. They also proposed a classification for proximal humerus fractures known as the Modular Topographic-Morphologic Classification[66]. However, in this classification they still fail to adequately discuss the variable morphology of greater tuberosity fractures.

In another paper, this same group later identified multiple possible mechanisms for greater tuberosity fracture including: avulsion through pull of the external rotators, a direct blow to the lateral shoulder, shearing by the glenoid rim during glenohumeral dislocation, and extreme rotation and abduction leading to impaction on the acromion[67]. They also noted the presence of inferiorly displaced greater tuberosity fractures in the literature[53,68] and in their practice, and noted the contradiction this represented with the generally accepted avulsive mechanism of greater tuberosity fractures. They did not, however, translate this discussion of potential mechanisms into a viable classification using fracture morphology, nor were they able to demonstrate its clinical impact.

1.4 – RADIOLOGIC EVALUATION OF GREATER TUBEROSITY FRACTURES

Isolated greater tuberosity fractures of the proximal humerus are notoriously difficult to diagnose. In a study of 163 shoulders, Ogawa et al. noted that 60% of greater tuberosity fractures were missed at the first consultation and this rate increased to 75% in minimally or non-displaced fractures[68]. Since the treatment of greater tuberosity fractures may change with as little as 3mm of displacement[39], complementary studies such as additional radiographic views, computed tomography, ultrasound, and MRI have been explored in the literature.

1.4.1 – PLAIN RADIOGRAPHY (XR)

In his original study, Neer recommended a minimum of two perpendicular radiographic images for the evaluation of proximal humerus fractures[8]. These are the anteroposterior(AP) Grashley view and the scapular Y view(Neer view). The axillary view was later added to better evaluate glenohumeral dislocation and greater tuberosity fracture[69]. In a comparative study by Sidor et al. of 50 radiographic series of the proximal humerus, the axillary view was shown to be more reliable than the scapular Y view and when combined with an AP, identified the final diagnosis in 99% of cases[70]. These three views (AP, Neer, Axillary) together comprise the standard trauma series[9,69].

The AP view is taken with the humerus in neutral rotation and the patient facing the XR source. The trunk is rotated 30 degrees to obtain a true AP of the glenoid.

The Neer view is taken with the injured shoulder against the plate and the XR source behind the patient. The trunk is rotated 30 degrees away from the source and the scapula forms a characteristic "Y" shape centered on the humeral head.

The Axillary view is taken with the patient supine with the plate at the superior aspect of the shoulder. The affected extremity is abducted 30 degrees and the image is taken through the axilla[64]. (This can be quite painful in the acute setting, so an alternative view, the Velpeau axillary view has been described.)

The Velpeau axillary view is taken with the shoulder sling in place. The patient stands in front of the radiographic table and the image is taken from above as the patient leans back 20 to 30 degrees over the XR plate[71].

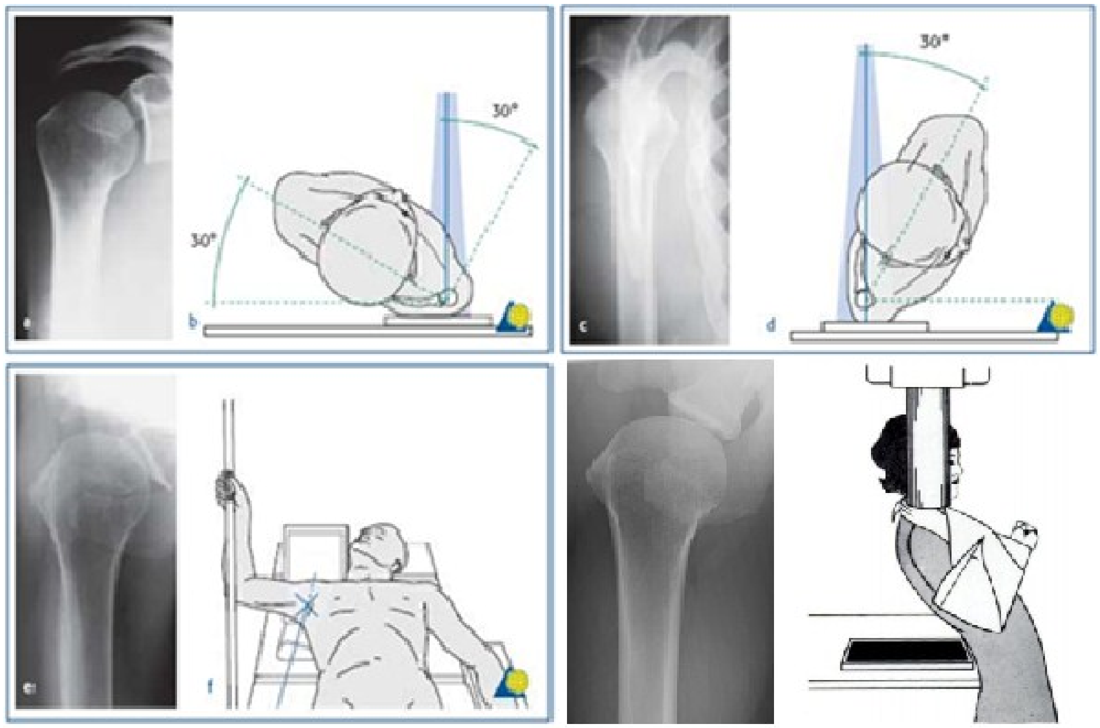


Figure 7 = Common Radiographic Views of the Proximal Humerus: Anteroposterior(a,b), Neer(c,d), Axillary(e,f), and Velpeau [reproduced with permission, ©AO Foundation, Switzerland and Bloom 1967]

This standard trauma series may be insufficient to adequately evaluate proximal humerus fractures due to bony overlap. In a radiographic study of 44 proximal humerus fractures, Bahrs et al. demonstrated a 72% overlap of the fractured regions on the transcapular Y view and 56% on the axillary view[72]. They concluded that computed tomography provided a better assessment of relevant structures regardless of fragment number or fracture severity.

The addition of internal and external rotation Grashley radiographs has been suggested[21,73] but Parsons et al. calculated up to 10mm of error in measuring greater tuberosity displacement on these views[74]. In this cadaveric study, they did identify the AP view in external rotation as the most accurate for measuring greater tuberosity displacement of 2mm but this was surpassed in accuracy by the AP view with 15 degrees of caudal tilt for displacement of 5 to 10mm. They concluded by recommending multiple radiographic views for the assessment of greater tuberosity fractures.

1.4.2 – COMPUTED TOMOGRAPHY (CT)

Computed tomography has been suggested by some authors to improve the evaluation of proximal humerus fractures[40,75-77] and yet others have demonstrated that it is of little additional clinical utility[46,51,52,78].

Due to the aforementioned difficulties in measuring fracture displacement, CT has been recommended specifically for the evaluation of greater tuberosity fractures [39,40,50,52,75,79]. In the cases where plain radiographs are of poor quality, when there is a diagnostic or therapeutic uncertainty, or when physical conditions such as obesity make radiographic evaluation difficult, standard CT with coronal and sagittal plane reconstructions should be obtained[9]. Superior displacement of the greater tuberosity fracture is best obtained with the sagittal or coronal plane reconstructions while posterior displacement is best evaluated on the standard axillary view.

The increased exposure of the patient to radiation, however, cannot be ignored. A standard CT of the shoulder uses 2.06 mSv of radiation while a standard shoulder series uses 0.04 mSv[80]. This a 50-fold greater exposure to radiation and the equivalent of one year exposure to background radiation in the average human[81]. Thus, while CT of the shoulder is a reasonable diagnostic step in the evaluation of greater tuberosity fractures and may help identify associated injuries such as glenoid fracture, it should be used only after a standard radiographic series has failed to provide diagnostic certainty.

1.4.3 – MAGNETIC RESONANCE IMAGING (MRI)

MRI is rarely, if ever, necessary for the diagnosis of proximal humerus fractures[82] but may provide some interesting information about associated soft tissue injury. Gallo et al. prospectively evaluated 30 patients with an MRI following proximal humerus fractures[83] and found that forty percent of patients under the age of 65 years had an associated complete rotator cuff tear or avulsion injury. This was positively correlated with an increasing number of fracture segments and displacement. Nanda et al. undertook a similar study with 85 proximal humerus fractures and confirmed the high incidence of rotator cuff tears in this population[84]. However, their population was slightly older and the presence of a full rotator cuff did not have an effect on functional outcome. They recommended against systematic screening for rotator cuff tears in proximal humerus fractures.

Isolated greater tuberosity fractures of the proximal humerus, however, tend to occur in a younger and more active population than proximal humerus fractures as a whole. These patients may be more negatively impacted by an associated rotator cuff tear and benefit from further imaging but the literature is silent on this subject. In the same study above, Gallo noted that complete rotator cuff tears were more common in greater tuberosity fractures with more than 5mm of displacement. None of the patients in Mason et al.'s series of 12 occult fractures of the greater tuberosity had significant associated rotator cuff pathology[85]. While they concluded that it was unlikely for the two pathologies to occur concurrently, it should be noted that all of the fractures were minimally or non-displaced. MRI is not currently recommended in the initial evaluation of isolated greater tuberosity fractures[9] but can be useful to evaluate for associated labral tears or rotator cuff injury in the patient with persistent shoulder pain following injury[79,86-88].

1.4.4 – ULTRASOUND (US)

Ultrasonography is a non-invasive and inexpensive test that shares many of the advantages and disadvantages of MRI with respect to proximal humerus fractures[9]. As with MRI, it is not currently recommended for the initial evaluation of these fractures and may, additionally, be too painful to perform in the acute setting.

Occult isolated greater tuberosity fractures have also been detected on ultrasound by looking for discontinuity and irregularity of the humeral cortex[89]. Associated rotator cuff tears were noted in 5% of the acute and 33% of the subacute trauma patients. Ultrasonography is a dynamic evaluation and affords the advantage of being able to assess for subacromial impingement[90], which has not yet been evaluated in greater tuberosity fractures.

Ultrasonography can additionally be used to evaluate for rotator cuff muscle atrophy. In the hands of an experienced radiologist, ultrasonography can reliably be used to calculate the “occupation ratios” of the rotator cuff muscles which range in value from 0.07(severe atrophy) to 0.81(normal). Khoury et al. calculated the occupation ratios using the “Y” view on both US and MRI and showed excellent correlation[91]. This atrophy has very important prognostic implications for rotator cuff repair[92,93] but, as is often the case with ultrasonography, is operator-dependent[94,95] and should be interpreted with caution.

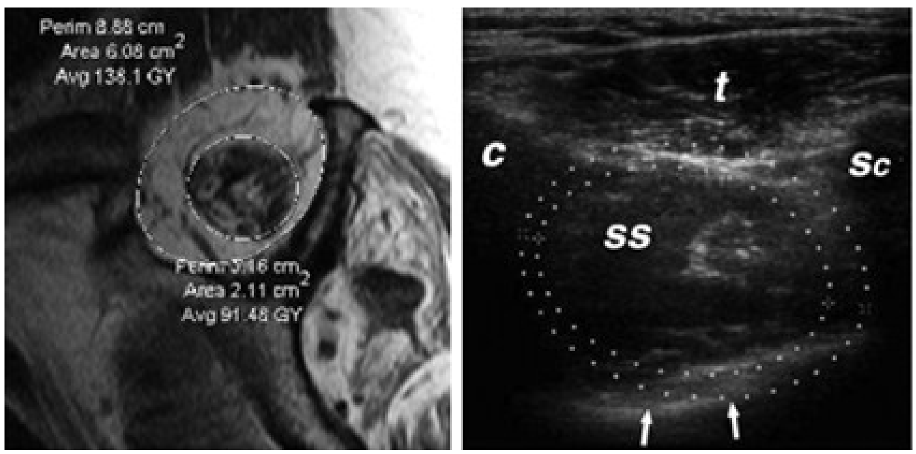


Figure 8 = The Occupation Ratio on MRI (left) and Ultrasound (right) [reproduced with permission, Khoury 2008]

1.5 – ADDITIONAL CONSIDERATIONS FOR GREATER TUBEROSITY FRACTURES

Before evaluating or treating any fractures of the greater tuberosity, the anatomic particularities of this region must be taken into consideration. Due to the well-developed vascular network surrounding the proximal humeral head, ischemic complications following isolated greater tuberosity fractures are rarely a concern[9]. The proximity to neural structures, however, is an issue and isolated greater tuberosity fractures may be associated with neurologic injury in up to 33% of cases[79]. This incidence increases with age and glenohumeral dislocation. The axillary nerve courses posteriorly in close proximity to the surgical humeral neck and gives off, among others, a motor branch to the deltoid muscle and a sensory branch to the lateral aspect of the shoulder[96]. This is the most commonly injured nerve in greater tuberosity fractures and should be tested prior to the initiation of any treatment.

The most superior aspect of the greater tuberosity is situated 3 to 8mm inferior to the highest point of the humeral head[97-99]. This inferior offset allows for the unobstructed passage of the greater tuberosity beneath the acromion through a full range of movement. Anatomic variations in the shape of the acromion, coracoacromial arch and coracoid process may influence the incidence of subacromial impingement and rotator cuff tear[100]. Consideration should also be given to the position of the greater tuberosity and its role in the pathophysiology of subacromial impingement, particularly in the context of greater tuberosity fractures.

As previously mentioned, the greater tuberosity serves as the attachment site for three tendons of the external rotator cuff. The supraspinatus, infraspinatus and teres minor insert on distinct facets located at the superior-anterior, the posterior, and the posterior-inferior aspects of the greater tuberosity, respectively (this creates the rotator cuff "footprint")[100]. These tendinous insertions may suffer differing degrees of injury depending on the size and location of the greater tuberosity fracture.

Figure 9 = Insertion sites for the Muscles of the Rotator Cuff: Supraspinatus (green), Infraspinatus (red) and Teres Minor (black) on the Greater Tuberosity [reproduced with permission, Curtis 2006]

Superior and posterior displacement is the generally accepted rule for these fractures[9,40,79] due to the pull of the rotator cuff. However, a recent study by Edelson et al. using the 3D CT reconstructions of 248 proximal humerus fractures demonstrated that posterior displacement of the greater tuberosity is often grossly underestimated[101]. The impact of superior displacement on rotator cuff mechanics and subacromial impingement is well described[33,40,54,74,79,102] but the impact of posterior displacement is much less clear and would benefit from further studies.

Bahrs et al.[67] also identified several greater tuberosity fractures with inferior displacement, which contradicted the commonly believed mechanism of bony avulsion of the rotator cuff. These fractures may reflect an alternative mechanism for greater tuberosity fracture or may reflect an associated rotator cuff tear (due to the absence of posterior-superior pull of the rotator cuff).

Relative osteopenia of the greater tuberosity is also a consideration, particularly in the older patient and the patient with pre-existing rotator cuff pathology[100]. This may predispose patients to fracture through impaction of the greater tuberosity underneath the acromion although the exact pathobiomechanics are not well understood[67].

It is important not to confuse an impaction fracture of the greater tuberosity with the grooved defect of the humeral head described by Hill and Sachs in 1940[103]. While both may be associated with glenohumeral dislocation, the Hill-Sachs lesion does not involve the greater tuberosity. Also, a fracture involving the greater tuberosity would not be expected to engage with the glenoid since it would take approximately 120 degrees of external rotation to do so[104].

1.6 – TREATMENT OF GREATER TUBEROSITY FRACTURES

Isolated fractures of the greater tuberosity are rare, comprising approximately 1% of all fractures[1-3,9,10-12]. Well-designed prospective clinical studies for these injuries are therefore lacking.

1.6.1 – CONSERVATIVE TREATMENT

Over 95% of greater tuberosity fractures are non or minimally displaced[39]. While displacement was historically defined as fragments with more than 1cm of translation or 45 degrees of angulation[8,35,41,42], 5mm is currently the most widely accepted cut-off[9,40]. Of additional consideration in these fractures is the increased incidence of high-velocity trauma, glenohumeral dislocation, and young active patients when compared to the population of proximal humerus fractures in general[2,12-17]. Greater tuberosity fractures must therefore be considered injuries distinct from proximal humerus fractures and should be studied in isolation.

Neer traditionally treated greater tuberosity fractures displaced less than 1cm with "early functional exercises" and reported satisfactory results[8]. Very few details are provided as to the demographics of the greater tuberosity fracture population and patient outcomes are reported for two-part fractures as a whole rather than being considered in isolation. Other than to advise against closed manipulation in displaced greater tuberosity fractures, Neer lends no specific consideration to this injury group.

Jellad et al.[105] retrospectively evaluated the outcome of 22 isolated greater tuberosity fractures displaced less than 5mm following conservative management. The patients were majoritarily female and averaged 47 years of age. Physiotherapy was begun at one week post injury and consisted of cryotherapy, passive ROM for three weeks then active ROM with strengthening exercises delayed until normal ROM was achieved. Overall, patients did very well at one and three months post injury with 90% achieving “good” or better results. Return to work was not assessed.

Mattyasovszky et al.[106] similarly studied 14 patients with fractures displaced less than 5mm. Patients began oscillating movements of the arm after one week of immobilisation and were permitted active ROM three to four weeks post injury. Muscle strengthening was delayed for 6 to 8 weeks and the patients did well with 100% “good” to “excellent” results at an average of three years follow-up. These results should be interpreted with caution, however, as three patients underwent operative treatment and over half of the study population was lost to follow-up.

Obviously, there is a need for higher-quality studies in this area.

Platzer et al. are currently the only group that have adequately addressed the clinical impact of conservatively treated minimally displaced fractures of the greater tuberosity[39]. They evaluated 135 patients at a mean follow-up time of 3.7 years, using radiographic measurement of greater tuberosity displacement and the Vienna Shoulder, Constant, and UCLA scores. Their conservative treatment protocol was 3 weeks of immobilisation followed by a rehabilitation regimen of physiotherapy, range of motion, and rotator cuff strengthening exercises.

Only cases with less than 6mm of displacement were included in the study and 97% had good to excellent clinical results. The average age was 56 years, more than half the patients were male, and 20% had an associated glenohumeral dislocation.

Younger patients demonstrated an increased tendency for further fragment displacement over time and patients with fractures displaced more than 3mm had worse results. This was not statistically significant. These results led the authors to conclude that greater tuberosity fractures displaced less than or equal to 5mm could be treated conservatively good to excellent clinical results 97% of the time. They agreed with Park et al.[54], however, that overhead athletes or workers may be considered for surgical fixation with displacement of 3mm or more.

1.6.2 – SURGICAL TREATMENT

The traditionally accepted indication for greater tuberosity fixation is fragment displacement of 1cm or more. The outcome for patients with 6 to 10mm of displacement is still not clear but the current trend is towards surgical fixation in this group, particularly in young patients[9,39,40,53-55]. In active overhead athletes or workers, surgical intervention has been suggested for displacement as little as 3mm[39,54].

Unfortunately, any discussion of surgical outcomes following greater tuberosity fractures is necessarily confused by the multitude of fixation strategies that have been proposed. Given the wide variety of surgical strategies, clinical results from the literature cannot be correlated or compiled in a meaningful manner. I will therefore provide a summary of the fixation methods proposed in the literature, as well as their reported results.

Suture Fixation

Suture fixation is the most frequent method reported in the literature for greater tuberosity fixation. The described techniques, however, vary and include direct parallel suture fixation[9,107], open 5-point transosseous suture fixation[108-110], open double row suture[111], and arthroscopic double-row or suture bridge techniques[112-116].

Direct parallel suture fixation was assessed by Park et al. in their study involving 13 isolated greater tuberosity fractures[107]. All patients underwent open reduction and internal fixation of their fracture using a deltoid split approach under interscalene bloc anesthesia. Four to five polyester, number two sutures were passed from superior (incorporating the rotator cuff) to inferior (through drilled bone tunnels) and tied off separately.

The average age of patients in this study was 64 years. They were followed post-operatively for an average of 4.4 years and no greater tuberosity fractures displaced following fixation. Overall, there were 89% of good to excellent results, as assessed by the pain scores (average 1), activities of daily living scores (average 25), and American Shoulder and Elbow Surgeons scores (average 87). The results were combined with some three-part fractures, however, so the results specific to isolated greater tuberosity fractures were difficult to isolate. One patient with greater tuberosity lysis had an excellent result and the only three patients with unsatisfactory outcomes did not comply with their post-operative therapy.

Dimakopoulos et al. proposed another suture fixation technique for proximal humerus fractures[109]. They treated 34 patients with displaced greater tuberosity fractures following anterior shoulder dislocation with heavy, non-absorbable suture, using a 5-point transosseous technique. The average age was 53 years, average follow-up was 4.8 years, and over 90% of patients have a good or excellent result according to the Constant score. Partial lysis of the greater tuberosity was noted in 4 patients but this had no clinical impact.

Flatow et al. employed a very similar technique of suture fixation to Dimakopoulos. They evaluated 12 patients treated with this technique and reported similarly excellent results[110].

Ishak et al. raised concerns for the use of suture fixation in greater tuberosity fractures[117]. They evaluated suture fixation of greater tuberosity fractures using a figure-of-eight pattern in a biomechanical, cadaveric study and the results were abysmal. Fracture displacement of 6.5 to 8.5mm was recorded following initial loading regardless of suture type. The authors recommended against this technique for greater tuberosity fixation.

A number of other authors continue to use suture fixation for greater tuberosity fractures but add a double-row or a bridge technique for improved mechanical fixation[111-116]. This can be performed either open[111] or arthroscopically[112-116].

Bhatia et al. evaluated 21 patients following open, double-row, suture-anchor fixation for displaced and comminuted fractures of the greater tuberosity[112]. The patients were 51 years old on average and were followed for 3.5 years. Twenty of the greater tuberosity fractures healed without displacement and results were reported as good or excellent in 86% of patients. A reaction to fixation material resulted in severe, persistent pain in one patient.

While the arthroscopic methods of greater tuberosity fracture fixation are interesting, only technical notes and case reports are available for consultation. Arthroscopy allows for the concomitant treatment of associated labral pathology or rotator cuff tear[113,116], but the clinical results are not reported. Additionally, two of the technical notes described arthroscopic fixation of greater tuberosity fractures that were only minimally displaced[114,115]. The surgical indication in these cases is debatable.

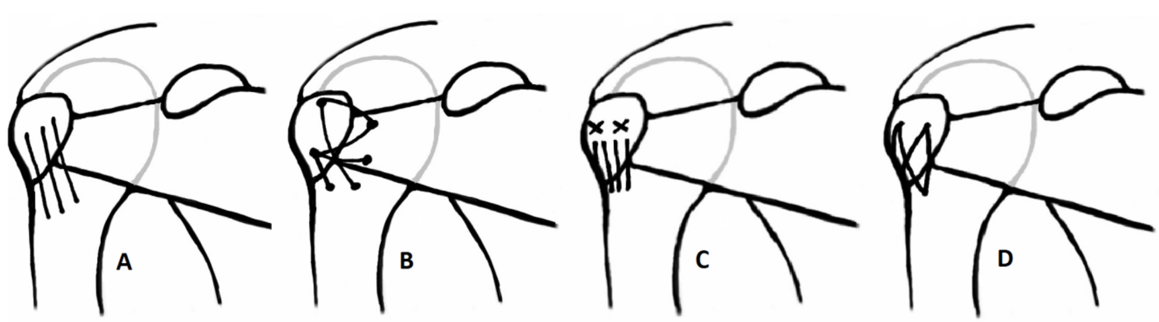


Figure 10 = Suture Fixation of Greater Tuberosity Fractures: straight suture (A), 5 hole transosseous (B), open double row (C), arthroscopic double row suture bridge (D)

Tension Band and Screw Fixation

Tension band and/or screw fixation has been proposed by several authors to improve the biomechanic fixation of greater tuberosity fractures[102,118-121].

Braunstein et al. evaluated the biomechanic strength of greater tuberosity fixation in a cadaveric model[122]. They compared three methods: wire tension banding, two cancellous screws, and transosseous sutures, in 21 fractures and demonstrated the clear inferiority of the transosseous sutures. Of the three techniques, tension band wiring provided the most solid fixation but this was not statistically different from the two cancellous screws.

Platzer et al. used both of these techniques (tension band wiring and percutaneous screws) in their clinical study of 52 patients[102]. Their results were generally favourable (80% were good to excellent), but patients treated with closed reduction and percutaneous screw fixation had a tendency towards better clinical results. This may have been due to the lesser amount of soft tissue dissection required in this group. Overall, the works of Carrera, Xiang, Jiang and Taverna[118-121] support the clinical success of percutaneous screw fixation. Suggestions, such as the use of a washer[118] in osteoporotic bone and concurrent arthroscopic evaluation of the rotator cuff, were added.

In a study of 17 patients with isolated greater tuberosity fractures, Yin et al. performed a variety of fixation techniques and evaluated the results as a whole. They determined that the presence of rotator cuff tears requiring repair, history of dislocation, or delay of surgery (≥ 10 days) had no effect on final outcome[123].

Taverna, in contrast, recommended arthroscopic evaluation for all their cases of displaced greater tuberosity fractures[121].

Plate Fixation

Lastly, Schoffl et al reported their experience with the “Bamberg plate” in 10 patients with greater tuberosity fractures[124]. This is a low-profile plate that allows for the passage of multiple sutures through the rotator cuff, as well as solid fixation in bone. The patients in this series all had an excellent result.

Figure 11 = The Bamberg-type plate: comminuted GT fracture before (left) and following fixation with Bamberg-type plate (right) [reproduced with permission, Schoffl 2011]

CHAPTER 2 – OBJECTIVES AND HYPOTHESES

2.1 – SUMMARY OF THE PROBLEM

Fractures of the proximal part of the humerus are common[1] and represent 3-5 percent of all fractures[2,3]. They typically occur in an elderly, osteoporotic, female population[4-6] and may safely be treated non-operatively in a majority of cases[1,8].

In contrast, isolated greater tuberosity fractures occur in a younger, male population following more significant trauma[2]. They constitute one fifth of all proximal humerus fractures[1,9,10-12] and are associated with 15 to 30% of anterior glenohumeral dislocations[14-17]. Very few of these fractures are significantly displaced[8,18,19] but the higher physical demands in this particular patient population may require a more aggressive approach to surgical treatment[9].

Two major classification systems exist for greater tuberosity fractures: the Neer and the AO Classifications[8,43,63]. Both of these classifications use fragment displacement as the basis for their different categories and have been highly criticised for poor interobserver and intraobserver reliability[44-49,51,52,60,64,65].

This poor reliability is due in part to the difficulty of measuring greater tuberosity displacement on plain radiography[68,69,72-74].

CT has been recommended by some authors for the evaluation of displacement in this population[40,75-77] while others have suggested that CT has no added clinical utility[46,51,52,78]. CT exposes the patient to 50 times the radiation dose of a standard shoulder series[81] and so should be used only in cases of diagnostic or therapeutic uncertainty[39,40,50,52,75,79].

MRI and ultrasound are rarely indicated in the acute evaluation of greater tuberosity fractures despite the high incidence of rotator cuff tears identified in this population[83,84]. In the patient with persistent pain following greater tuberosity fracture, advanced imaging such as MRI or ultrasound is indicated[79,86-88,90].

Conservative treatment in non or minimally displaced isolated greater tuberosity fractures results in good to excellent results in the majority of cases[8,39,105]. However, active overhead workers or athletes may benefit from surgical reduction in fractures with as little as 3mm of displacement[39,54].

Five millimeters is generally accepted as a surgical indication in isolated greater tuberosity fractures [9,39,40,53-55] and multiple techniques have been described. These include suture fixation[9,107-117], tension band and/or screw fixation[102,118-122], and suture-plate osteosynthesis[124].

The mechanism or morphology of greater tuberosity fractures is an interesting avenue of research that has been explored little in the literature. The typical injury has been described with superior and posterior displacement due to avulsion by the rotator cuff. This is likely oversimplified[66,67] and Bahrs et al. identified other possible mechanisms for greater tuberosity fracture. These include impaction underneath the acromion, direct trauma, and shear on the rim of the glenoid[67]. However, the impact of greater tuberosity fracture morphology on clinical outcome has not been studied.

2.2 – GLOBAL OBJECTIVE

The overall objective of this study was to examine the relationship between patient demographic variables, fracture characteristics/displacement, and soft tissue injury of the shoulder girdle and the final clinical outcome following isolated fractures of the greater tuberosity of the proximal humerus. The purpose of this is to identify demographic or fracture characteristics that would place the patients at risk for a poor clinical result.

In order to do this we needed to develop valid tools to accurately measure fracture characteristics such as greater tuberosity displacement and GT fracture morphology. The development of these two tools therefore became prerequisite objectives for the principle clinical goal.

2.3 – SPECIFIC OBJECTIVES

Objective 1: To develop and validate a reliable and accurate method of measuring greater tuberosity displacement on plain radiography. This will subsequently be referred to as the GT Ratio.

Objective 2: To develop and validate a simple and reliable classification for greater tuberosity fractures based on morphology. This will be called the Morphologic Classification.

Objective 3: To describe the incidence of rotator cuff pathology in patients following isolated fractures of the greater tuberosity and to evaluate its effect on shoulder function and quality of life.

Objective 4: To evaluate the association of patient demographic variables, greater tuberosity displacement, and glenohumeral dislocation with fracture morphology and, additionally, to evaluate the effect of these on patient prognosis.

2.4 – HYPOTHESES

Hypothesis 1: The GT Ratio on plain radiography is a reliable method of measuring superior/inferior greater tuberosity displacement and correlates well with displacement measured on computed tomography.

Hypothesis 2: The Morphologic Classification is valid and performs at least as well as the Neer and AO classifications for intra- and inter-observer reliability.

Hypothesis 3: Isolated greater tuberosity fractures of the proximal humerus result in decreased strength and range of motion compared to the uninjured limb.

Hypothesis 4: The presence of a full-thickness rotator cuff tear is associated with a poor prognosis.

Hypothesis 5: Significant rotator cuff muscle atrophy is associated with a poor functional result.

Hypothesis 6: Avulsion type fractures are associated with a poor functional result.

2.5 – PRESENTATION OF THE ARTICLES

The first article (Chapter 4) addresses Objective 1 and Hypothesis 1. It deals with the development of the GT Ratio to measure greater tuberosity displacement on plain radiography and describes the interobserver and intraobserver reliability of this ratio for superior GT displacement on AP radiographs. A cohort of 40 radiologic records identified from the PACS system at our trauma hospital is used. The GT ratio is then correlated with GT displacement measured on CT for the entire cohort and its ability to differentiate displaced (≥5mm) versus non-displaced (<5mm) fractures is tested.

The second article (Chapter 5) addresses Objective 2 and Hypothesis 2. It presents the Morphologic Classification for isolated greater tuberosity fractures of the proximal humerus and discusses the likely pathophysiology, as well as association with age, sex, fracture displacement and glenohumeral dislocation. The interobserver and intraobserver reliability of the Morphologic Classification is tested using the Kappa statistic and compared with the AO and Neer Classifications.

The additional results section addresses Objectives 3 and 4 and Hypotheses 3 through 6. The clinical cohort of 65 patients is described in terms of demographic variables, fracture displacement, fracture type, rotator cuff pathology, and clinical outcome. The effect of full rotator cuff tears, rotator muscle atrophy, biceps pathology and subacromial impingement on shoulder function is evaluated.

The association of fracture morphology type with age, trauma, glenohumeral dislocation, rotator cuff pathology and clinical outcome is also evaluated.

CHAPTER 3 – MATERIALS AND METHODS

In this section a summary of the methods used for articles 1 (chapter 4) and 2 (chapter 5) will be presented. The materials and methods for the additional results section (chapter 6) will also be reviewed.

3.1 – RETROSPECTIVE REVIEW

Following ethics board approval, a retrospective review was performed of all shoulder radiographs ordered by the 13 practicing orthopaedic surgeons at Sacré-Coeur Hospital from July 2007 to April 2011. All radiographs were reviewed using the PACS (Picture Archive Computer/ Communication System) technology installed at this institution in July 2007.

Only radiographs ordered by orthopedic surgeons were included in the review to increase the percentage of radiographs with pathologic findings. Sacré-Coeur Hospital is a level 1 trauma center that serves the majority of the greater Montreal area and is a tertiary referral center for the eastern part of Quebec, Canada. As such, thousands of shoulder radiographs are performed monthly. However, all cases of shoulder fracture evaluated by a physician at Sacré-Coeur Hospital are subsequently referred to the Orthopedics Department with a follow-up radiograph 7-10 days post injury. Therefore, barring death or travel to another country or province before the

1st follow-up visit, all patients with a shoulder fracture diagnosed at Sacré-Coeur Hospital would be included in our review.

For the review, all cases of isolated fractures of the greater tuberosity of the proximal humerus (GT) were identified. At a minimum, adequate anteroposterior (AP) and lateral (Neer view) radiographs of the injured shoulder within 3 weeks of injury were required for inclusion in the study. All cases with isolated Hill-Sachs lesions, open physes, or evidence of previous bony injury to the proximal humerus were excluded. Cases with concurrent humerus fracture or evidence or glenohumeral arthritis were also excluded [table 1]. All cases of isolated GT fractures with glenohumeral dislocation were included if adequate post-reduction radiographs were available.

Inclusion criteria	***Exclusion criteria***
Isolated fractures of the greater tuberosity	Local tumor, infection or significant glenohumeral arthritis
Operative or conservative treatment	Previous injury of the same upper limb
Skeletal maturity	Presence of prior neurologic deficit of either upper limb
Minimum 1 year of follow-up	Patient or unable or unwilling to collaborate due to psychiatric illness or language barrier
Good quality radiographs of the acute fracture with minimum AP and lateral views	

Table 1: Inclusion and exclusion criteria

All radiographs were performed according to the standard protocol for the AP and Neer views of the shoulder[8] with the affected limb held in internal rotation (immobilised in a sling or a thoracobrachial brace).

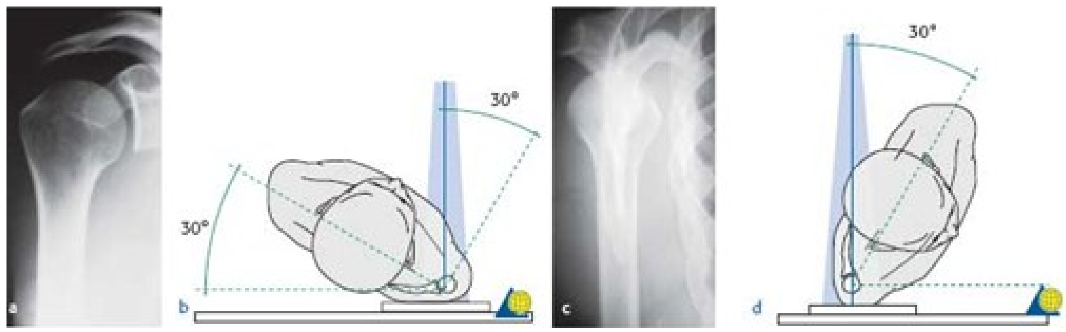


Figure 12 = The AP(a,b) and Lateral or Neer(c,d) views of the Proximal Humerus

[reproduced with permission, ©AO Foundation, Switzerland]

Basic demographic variables for all identified cases were obtained using information provided from the radiographs, official radiographic reports, and the computerised admission and discharge reports. These included age, sex, side of injury and the presence or absence of glenohumeral dislocation.

Additionally, cases identified using the search criteria above who also received a computer tomography (CT) scan of the shoulder within 24 hours of their initial shoulder radiographs, were set apart for further analysis (cf. section 3.2). All CT scans were performed with standard 0.625mm cuts and coronal and sagittal reconstructions. As with the radiographs, these images were obtained with the affected limb held in internal rotation.

3.2 – MEASUREMENT OF GREATER TUBEROSITY DISPLACEMENT

Due to the aforementioned unreliability of the current measurement methods for greater tuberosity displacement on plain radiography, we proposed and validated a displacement ratio (GT Ratio) on XR, using displacement measured on CT as the gold standard. We chose to use a ratio, as opposed to direct measurement, because shoulder radiographs performed in the trauma and standard follow-up settings often lack calibration markers. Additionally, the use of the patient's own anatomy for calibration ensures identical calibration across serial radiographs and may represent a more clinically relevant measure of GT displacement. Numerous authors [9,39,40,53-55] have suggested that loss of the lever arm for the rotator cuff, as well as impingement underneath the acromion are the main sources of pain and shoulder weakness with displaced GT fractures. If this is the case, patients with smaller bony anatomy or patients whose GT is normally positioned in a more superior position would be expected to be more adversely affected by superior GT displacement than their larger (or lower positioned GT) counterparts. This would be reflected in the GT Ratio.

Displacement Measured on Radiographs

The superior or inferior (SI) and anterior or posterior (AP) displacement of the GT fragment were calculated on XR. A brief review of the measurement techniques is provided below. For full details on the methods applied, please refer to article 1 (Chapter 4).

Displacements recorded in the superior or anterior directions have positive values, while displacements recorded in the inferior or posterior directions have negative values.

Superior/Inferior Displacement

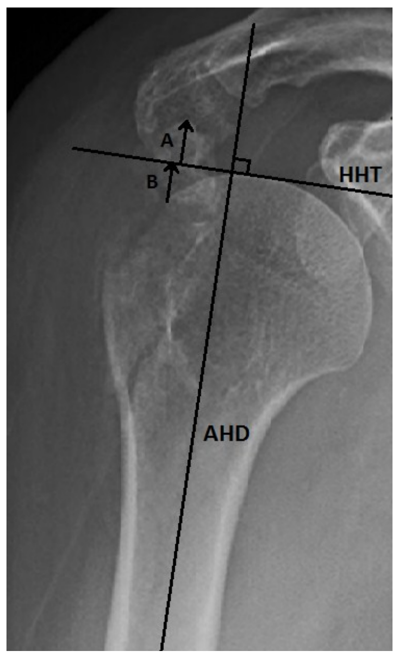


Figure 13 – Measurement of the GT Ratio on Plain Radiography for Superior/ Inferior Displacement

On the AP shoulder XR, the axis of the humeral diaphysis (AHD) and the HHT (humeral head tangent) are drawn as described in Chapter 4. Distance A (in mm) is the superior displacement of the GT fragment with respect to HHT. Distance B represents the distance from the anatomic location of the GT (most lateral aspect of the humeral head) to the HHT.

The GT Ratio is then calculated using the formula: (A+B)/B.

ratios >1 represent GT fragments situated superior to HHT

ratios 0-1 have GT fragments displaced superior (but inferior to HHT)

ratios <1 have GT fragments displaced inferiorly

Anterior/Posterior Displacement

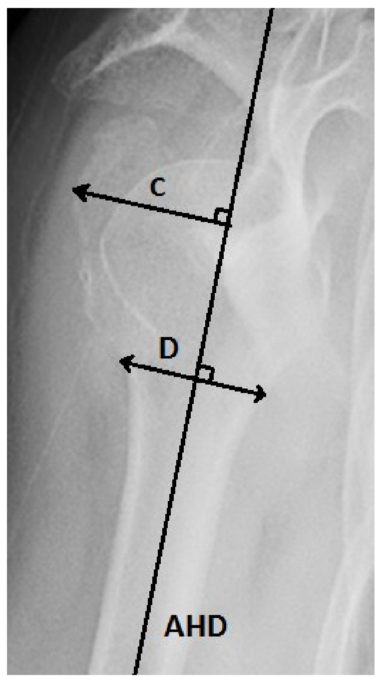


Figure 14 – Measurement of the GT Ratio on Plain Radiography for Anterior/ Posterior Displacement

On the Neer shoulder XR the AHD is drawn as described in Chapter 4. Distance C represents the posterior displacement of the GT fragment with respect to AHD. Distance D is the width of the surgical humeral neck.

The Ratio is obtained using the formula: C/D.

ratios >0 have GT fragments situated anterior to AHD

ratios <0 have GT fragments situated posterior to AHD

The GT Ratios described above were measured for all cases of GT fracture with adequate XR and CT identified. These measurements were performed by two reviewers (one orthopedic resident and one orthopedic fellow) on two occasions, with a minimal interval of 6 weeks.

Displacement Measured on Computed Tomography

The SI and AP displacement of the GT fragment are calculated on CT using the measures described briefly below, and in detail in Chapter 4.

Displacements recorded in the superior or anterior directions are positive, while displacements recorded in the inferior or posterior directions are negative.

Superior/Inferior Displacement

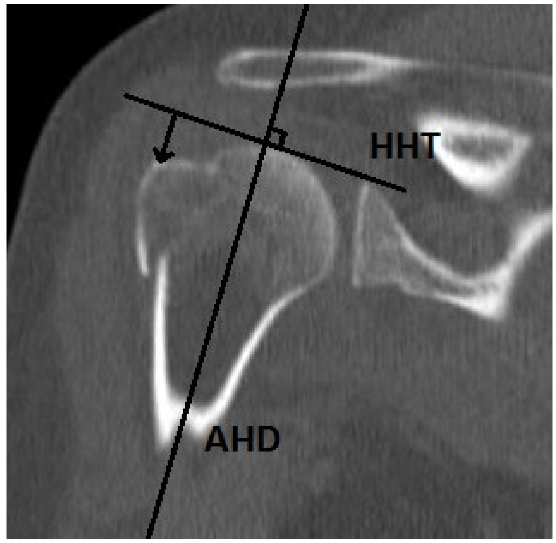


Figure 15 – Measurement of Superior/Inferior GT Displacement relative to HHT on Coronal CT Reconstruction

Standard coronal reconstructions of the shoulder CT are used and the cuts showing the most superior point of the humeral head as well as the greatest amount of superior (or inferior) GT displacement are used. The AHD and HHT are traced on the CT cuts of interest, as described for plain radiography and in Chapter 4. The superior GT displacement (in mm) is measured from the GT fracture bed (the most lateral aspect of the humeral head ending in a fracture line) to the most superior aspect of the GT fragment. The distance from the HHT to the most superior aspect of the GT fragment is also measured.

Anterior/Posterior Displacement

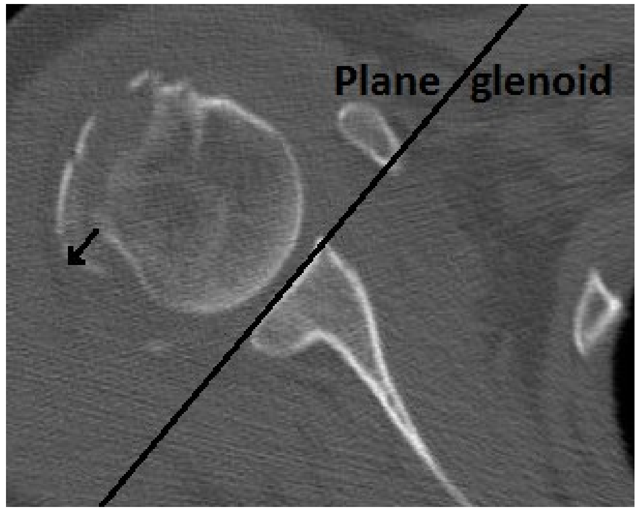


Figure 16 – Measurement of Anterior/Posterior GT displacement along the Plane of the Glenoid Articular Surface

Standard axial CT images are used to identify the cut with the greatest degree of anterior/posterior GT fragment displacement. The posterior/ anterior GT displacement is measured directly from the GT fracture bed to the GT fragment in a plane parallel to the articular surface of the glenoid.

3.3 – CLASSIFICATION OF ISOLATED GREATER TUBEROSITY FRACTURES OF THE PROXIMAL HUMERUS

As previously mentioned, no classification system to date has addressed the variable morphology of GT fractures. In fact, the existing classification systems do little to take into account the biomechanical importance or anatomic relationships of the greater tuberosity other than to accept less fragment displacement [8,50,56-64]. GT fragment size, morphology and orientation not only influence treatment and fixation strategies but likely are also reflections of the mechanism of fracture and may be associated with differing risks of associated injury (such as rotator cuff tear, glenoid fracture and glenohumeral dislocation). Therefore, using the work of Bahrs et al.[66,67] on GT fracture mechanism and our own experience, we propose a Morphologic Classification of isolated GT fractures. A brief overview of the Morphologic Classification is presented below and a full description is found in article 2 (Chapter 5):

Avulsion Fracture: This fracture type involves small fragments of bone and the fracture line is typically horizontal. [figure 17]

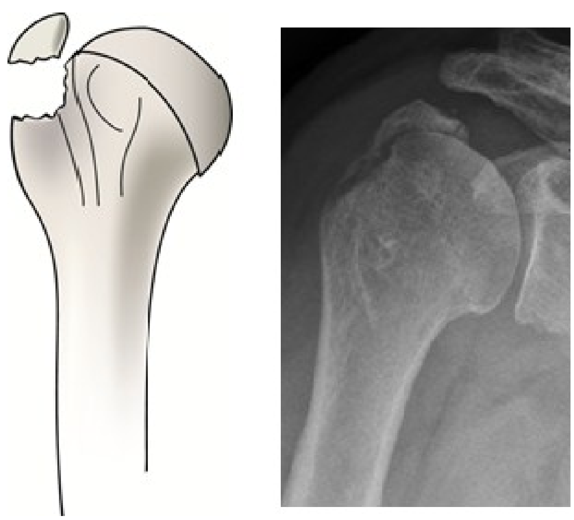
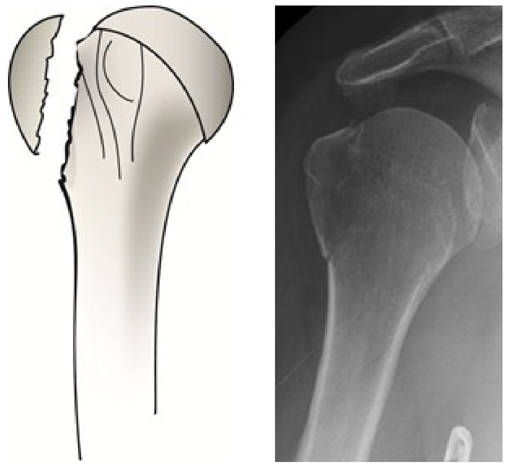


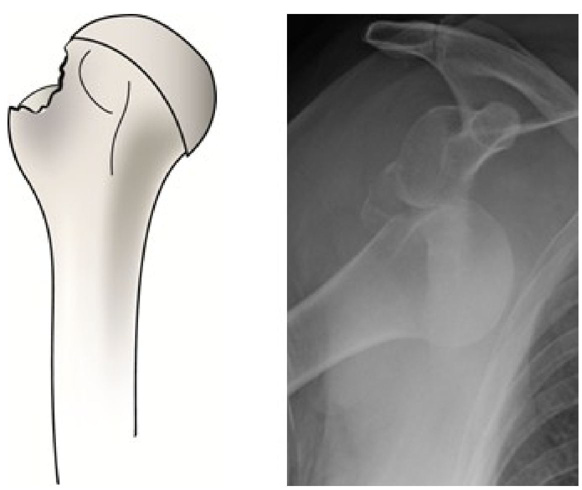
Figure 17 – Drawing and AP Radiograph of an Avulsion Fracture

Split Fracture: This fracture involves a large GT fragment with a vertical fracture line. [figure 18]



Figures 18 – Drawing and AP Radiograph of a Split Fracture

Depression Fracture: This GT fracture is displaced inferiorly and should not be confused with the classic Hill-Sachs lesion [104] as it involves the greater tuberosity rather than the posterior aspect of the humeral head. [figure 19]



Figures 19 – Drawing and AP Radiograph of a Depression Fracture

The intraclass correlation coefficient (ICC) was then calculated for the Morphologic, AO, and Neer Classifications using the AP and Neer radiographs of all consecutive GT fractures from July 2007 to December 2010. Four reviewers classified all fractures on two occasions with a minimum interval of four weeks. A more detailed description of the methods for this can be found in Chapter 5 (article 2).

3.4 – CLINICAL IMPACT OF ISOLATED GREATER TUBEROSITY FRACTURES

All patients with isolated GT fractures who were identified with the retrospective review (cf. section 3.1) and who were able to communicate and read in English or French, were contacted by phone and invited to participate in a clinical study. This study was comprised of patients returning for two clinical appointments: one at the Sacré-Coeur Orthopedic Clinic for a clinical examination and the other at a private radiology clinic for a shoulder ultrasound.

Orthopedic Clinic

Patients were first questioned about their shoulder trauma and about basic demographic information including age, gender, employment, and tobacco use. Their charts were reviewed for information about treatment modality, immobilisation period, glenohumeral dislocation and other associated injuries.

A shoulder physical exam was performed by a certified physiotherapist or a senior orthopedic resident and included range of motion and abduction strength determination. The Constant score [125, appendix B.1] was calculated.

Patients also completed the following quality of life and shoulder function questionnaires: Western Ontario Rotator Cuff Index (WORC) [126, appendix B.3], Disabilities of the Arm, Shoulder and Hand Outcome Measure – Shortened version (*Quick*DASH) [127, cf. appendix B.5], a Visual Analog pain Scale (VAS from 0-10, appendix B.6), and the SF-12® Health Survey version 2.0 (SF-12 v2) [128, cf. appendix B.8].

Finally, patients underwent a standard shoulder radiograph series (cf. section 3.1) and their old radiographs were pulled up for review. All fractures were classified according to the Neer, AO, and Morphologic Classifications (cf. section 3.3) and greater tuberosity displacement was measured (in mm) using maximal displacement, superior/inferior, and anterior/posterior displacement. The GT Ratio was also calculated on the AP radiographs (cf. section 3.1). These measurements were repeated for the initial, the follow-up and the final radiographs.

This data was collected and compiled using a standard document [Appendix A] and stored according to the ethics guidelines at our institution for information safety. The information was subsequently transferred to an Excel document (Excel 2010, Microsoft Inc.) and anonymized for statistical analysis.

Radiology Clinic

All shoulder ultrasound exams were performed by one experienced musculoskeletal radiologist. The presence of fatty infiltration, tendinitis, partial or full tears of the supraspinatus, infraspinatus and subscapularis muscles were noted and measured. Muscle thickness and fatty atrophy of the supraspinatus and infraspinatus muscles were calculated according to the technique of Khoury et al.[91] and compared to the unaffected shoulder. The long head of the biceps was examined for tenosynovitis, tears and subluxation or dislocation. Finally, a dynamic evaluation of subacromial impingement was performed.

All findings were recorded on a standardized document [appendix C] and later added to the anonymized Excel document.

3.5 – STATISTICS

Retrospective Review

The age, sex, side of injury, and presence of glenohumeral dislocation was noted for all identified cases of isolated GT fractures. The average and standard deviation (95% confidence interval) was calculated, where possible, for each of these variables.

Measurement of Greater Tuberosity Displacement

The reliability of the GT ratio was assessed by calculating the Intraclass Correlation (ICC). For the purposes of this study, ICCs ≥ 0.80 were considered excellent, 0.60-0.79 good, 0.40-0.59 moderate and < 0.40 poor. These were compared with previously published ICCs for the Neer and AO Classifications.

GT fractures were defined as displaced if their measured displacement on CT was $\geq$ 5mm in the superior or posterior direction. A two-tailed analysis of correlation was then carried out between GT displacement on XR and CT using the Pearson correlation coefficient. Statistical significance was set at $p < 0.05$.

Additionally, the reliability of the GT Ratio to differentiate "surgical" GT fractures (superior displacement on CT $\geq$ 5mm) from "non-surgical" GT fractures (superior displacement on CT $<$ 5mm) was tested with a student-t distribution. The minimum number of cases necessary for significance was confirmed as 34 using a power study (minimum detectable difference 5mm, $\alpha = 0.05$, $\beta = 0.8$, two-sided t-test) and statistical significance was set at $p < 0.05$.

Classification of Isolated Greater Tuberosity Fractures of the Proximal Humerus

The inter- and intra-observer reliabilities of the Neer, AO, and Morphologic Classifications were calculated using the Kappa statistic. A score of ≥ 0.8 was considered excellent, 0.6-0.79 good, 0.4-0.59 moderate, and < 0.4 poor.

The average and standard deviations (95% confidence interval) for the demographic variables and associated injuries were calculated for each fracture type. ANOVA and chi-squared tests were then used where appropriate to compare and contrast between morphologic fracture types. Statistical significance was set at $p<0.05$.

Clinical Impact of Isolated Greater Tuberosity Fractures

Before the clinical study was undertaken, a power study was performed to determine the minimum number of patients required for clinical significance (minimum detectable difference of 15 points on the WORC scale, $\alpha = 0.05$, $\beta = 0.8$, two-sided t-test). This provided our minimum recruitment goal of 48 patients.

Statistical analysis was performed including averages with standard deviation (95% confidence interval), the two-tailed student t-test, ANOVA, and chi-squared tests where appropriate. Significance was set at $p < 0.05$.

The variables considered were:

- patient demographics and employment;
- fracture classification, displacement, treatment and follow-up;
- rotator cuff pathology, biceps abnormality, and subacromial impingement;
- functional and quality of life questionnaires.

All data analysis was performed with SPSS v19(IBM, USA).

CHAPTER 4 – ARTICLE 1: ACCURATE MEASUREMENT OF GREATER TUBEROSITY DISPLACEMENT WITHOUT COMPUTED TOMOGRAPHY: VALIDATION OF A METHOD ON PLAIN RADIOGRAPHY TO GUIDE SURGICAL TREATMENT

4.1 – PRELUDE

Data stemming from previous versions of this article was accepted and presented at various congress and research meetings.

These include poster presentations at the 14th Congress of the CRCHUM (Centre de Recherche du Centre Hospitalier de l'Université de Montréal) in Montreal, Canada in December 2011; at the 32nd Annual Research Day of the POES (Programme d'Orthopédie Édouard-Samson) in Montreal, Canada in May 2012; at the Sacré-Coeur Hospital Research Day in Montreal, Canada in May 2012; at both the COA (Canadian Orthopaedic Association) and the CORA (Canadian Orthopaedic Residents Association) meetings in Ottawa, Canada in June 2012; at the Annual OTA (Orthopaedic Trauma Association) Meeting in Minneapolis, USA in October 2012; and at the 12th annual ICSES (International Congress of Shoulder and Elbow Surgery) meeting in Nagoya, Japan in April 2013.

This also includes a podium presentation at the 26th International CARS (Computer-Assisted Radiology and Surgery) Congress in Pisa, Italy in June 2012.

The following manuscript was submitted to the Journal of Orthopaedic Trauma, according to their standards, in November 2012 and is currently under revision.

4.2 – ARTICLE

Accurate Measurement of Greater Tuberosity Displacement without Computed Tomography: Validation of a method on Plain Radiography to guide Surgical Treatment

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Accurate Measurement of Greater Tuberosity Displacement without Computed Tomography: Validation of a method on Plain Radiography to guide Surgical Treatment

Abstract

Introduction: Residual displacement of greater tuberosity GT) fractures has been shown to negatively impact shoulder function. However, accurate measurement of GT displacement remains a problem with errors up to 13mm on plain radiography (XR).

A new GT ratio for measuring fracture displacement on XR is described, validated, and correlated with computed tomography (CT) and surgical decision-making.

Methods: A retrospective review of shoulder radiographs was performed from 2007-2010 to identify all cases of isolated GT fractures with both XR and CT.

The GT ratio was performed on all XR and correlated with superior GT displacement measured on CT. The GT ratio was then correlated with surgical decision-making using 5mm superior displacement on CT as the cut-off.

Finally, the inter- and intraobserver reliability of the GT ratio was calculated and compared with the Neer and AO Classifications.

Results: Forty cases of acute GT fractures with XR and CT were identified.

The GT ratio correlated very well with superior displacement on CT (Pearson=0.852, $p<0.01$) and accurately classified GT fractures as “surgical” (n=9, 23%) or “non-surgical” (n=31, 77%).

GT ratios≤0.00 were non-surgical, ≥0.50 were surgical, and 0.00-0.50 warranted further imaging ($p<0.01$).

The GT ratio performed as well as or better than the AO and Neer classifications for inter- and intraobserver reliability.

Conclusion: The GT ratio described in this study correlates very well with CT for superior GT fracture displacement. It involves significantly less radiation and accurately classifies GT fractures as non-surgical(ratio<0.00), surgical(ratio>0.50), or as benefiting from further imaging(0.00-0.50). It performs as well as or better than the Neer or AO Classifications.

Introduction

Fractures of the proximal humerus are the second most common fracture affecting the upper extremity[12] and occur in both young and aging populations. Displaced isolated fractures of the greater tuberosity (GT) may significantly impact limb function.

The measured displacement of GT fractures plays an essential role in the evaluation of these injuries. As little as 2mm of superior displacement of GT fractures significantly increases the force required for abduction[3] and leads to sub-acromial impingement[4,5,6,7,8]. Greater than 5mm of superior displacement is associated with increased severity of rotator cuff injury[9] and functional impairment and is generally considered an indication for surgery. In some cases, reduction and fixation has been recommended for as little as 3mm of displacement[8].

Unfortunately, the accurate measurement of greater tuberosity displacement on plain radiography (XR) is problematic and errors of up to 13mm have been described.[10] Therefore adjuncts such as computed tomography (CT) and 3-dimensional CT reconstructions (3DCT) in cadaveric and saw bone models have been explored in the literature.

This study is the first to analyse the correlation of GT displacement measured using a standardised method on XR and CT in a consecutive series of 40 in-vivo GT fractures. A ratio method for measuring GT fracture displacement on XR is described and validated. This GT ratio is then correlated with GT displacement measured on CT. Its impact on surgical decision-making is analysed using 5mm of superior displacement on CT as the gold standard.

Methods

A retrospective review of all shoulder trauma series ordered by 13 orthopedic surgeons at a single level 1 trauma center between July 2007 and December 2010 was performed. All cases of isolated GT fractures with adequate acute (≤3 weeks of injury) XR and CT were identified. Cases with isolated Hill-Sachs lesions, open physes, and evidence of previous bony injury to the proximal humerus were excluded. All XR were performed in internal rotation, as were the CT scans. A maximum of 24 hours between imaging modalities was accepted.

All CT scans were performed with standard 0.625mm cuts and coronal and sagittal reconstructions.

Basic demographic variables such as age and sex were recorded, as well as side of injury and the presence of dislocation. The supero-inferior and antero-posterior displacement of the GT fragment was calculated for XR and CT as described below. Displacements recorded in the superior and anterior directions were assigned positive values, and displacements recorded in the inferior and posterior directions were assigned negative values.

Simple Radiographs

The displacement of the GT fragment was measured using a new method that defines displacement as a ratio. This approach circumnavigates the errors due to magnification associated with the rare use of calibration markers in most clinical follow-ups. It makes use of the patients own anatomy for calibration and control across radiographs.

The measures were taken as follows:

1) On the AP (Grashey) view, the axis of the humeral shaft (AHD) is defined by tracing a line that bisects the surgical humeral neck and the humeral diaphysis. All measurements are taken parallel to this axis.

   A tangent is drawn along the most superior aspect of the humeral head and perpendicular to the AHD (*figure 1*). This is the humeral head tangent (HHT).

   The distance between HHT and the most superior aspect of the GT fragment is measured (distance A). The most superior fragment in multifragmented GT fractures is used.

   The distance between HHT and the most lateral aspect of the humeral head is also measured (distance B).

The ratio is obtained using the following formula: (A+B)/B.

- ratio > 1 for fragments situated superior to the HHT

  0-1 for fragments superiorly displaced but inferior to the HHT

  < 0 for fragments displaced inferiorly

2) On the lateral (Neer) projection, the AHD is defined as in 1). All measurements are taken perpendicular to this axis.

   Distance C is measured between the most posterior aspect of the GT fragment and the AHD. This measure was chosen because the AHD is constant and easily identifiable regardless of bony overlap or shoulder rotation.

   Distance D is the width of the humerus at the level of the surgical humeral neck (*figure 2*).

   The ratio is obtained using the following formula: C/D

   - ratio > 0 for fragments anterior to the AHD

     < 0 for fragments posterior to the AHD

Figure 1 = The Ratio Method in the AP (Grashley) view. A line is traced along the center of the humeral shaft and humeral surgical neck. All measurements are taken parallel to this axis. A tangent is then drawn perpendicular to this line along the most superior aspect of the humeral head. Distance A is measured from this tangent to the most superior aspect of the greater tuberosity fragment, as shown. Distance B is measured from this tangent to the most lateral aspect of the humeral head articular surface, as shown. The ratio is then calculated using the formula (A+B)/B.

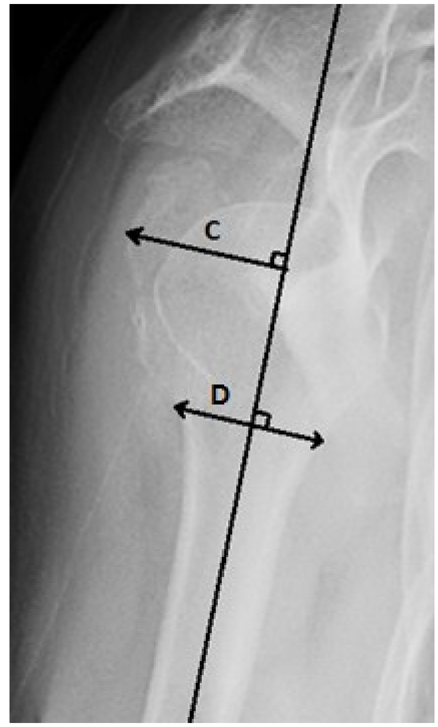

Figure 2 = The Ratio Method in the Lateral (Neer) view. A line is traced along the center of the humeral shaft and humeral surgical neck. All measurements are taken perpendicular to this axis. Distance C is measured from this line to the most posterior aspect of the greater tuberosity fragment. Distance D is measured as the width of the surgical humeral neck. The ratio is then calculated using the formula C/D.

<u>Computed Tomography</u>

Superior/inferior displacement was measured on coronal CT. As with XR the displacement was measured parallel to the AHD. The coronal cut with the greatest amount of superior/inferior displacement was identified and the following measurements were taken:

1) Distance from the GT fracture bed (most lateral aspect of the humeral head ending in a fracture line) to the most superior aspect of the GT fragment.
2) Distance from a tangent along the most superior aspect of the humeral head (defined as for HHT with simple radiographs) to the most superior aspect of the GT fragment (*figure 3)*.

Anterior/posterior displacement was measured on axial CT. The axial cut with the greatest degree of anterior/posterior displacement was identified and the GT displacement was measured in millimeters parallel to the plane of the glenoid *(figure 4)*.

Figure 3 = Superior/Inferior displacement calculated in the coronal plane of computed tomography scans. The slice with the greatest fragment displacement is identified and a line is traced along the center of the humeral shaft and humeral surgical neck. All measurements are taken parallel to this axis. A tangent perpendicular to this line is drawn along the most superior aspect of the humeral head. The distance between this tangent and the most superior aspect of the greater tuberosity fragment is then measured, as shown. Additionally, the greater tuberosity displacement was also measured directly from the fracture bed to the displaced fragment (not shown).

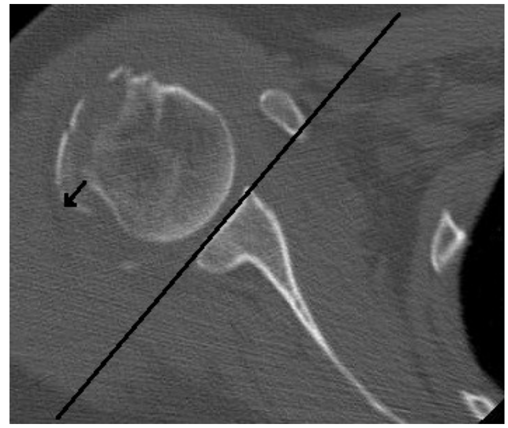

Figure 4 = Anterior/Posterior displacement calculated in the axial plane of computed tomography scans. The plane of displacement was defined parallel to a tangent drawn along the surface of the glenoid. Anterior/Posterior displacement was then directly measured on the slice demonstrating the greatest fragment displacement, as shown.

<u>Validation of the GT ratio</u>

The GT ratio was validated with repeated measures by two independent observers using all cases at a minimum interval of 6 weeks.

Statistical analysis

The means and standard deviations (95% confidence) were calculated for the basic demographic variables as well as GT displacement on XR and CT. A two-tailed analysis of correlation was carried out using the Pearson correlation coefficient and statistical significance was set at $p<0.05$.

Additionally, the reliability of surgical decision-making using the ratio method was calculated. A power study was performed using 5mm as the detectable difference ($\alpha=0.05/\beta=0.8$/two-sided) and determined that 34 was the minimum sample size for significance.

All fractures displaced superiorly 5mm or more on CT were classified as "surgical" because this is the most commonly accepted surgical indication reported in the literature[4,5,8,9]. The Mann-Whitney U test was then performed for the "surgical" and "non-surgical" groups with significance set at $p<0.05$.

The reliability measures for validation of the GT ratio were calculated using intraclass correlation (ICC). ICCs of 0.40-0.59 were considered moderate, 0.60-0.79 good, and greater than 0.80 excellent. These were compared with previously published ICCs for the Neer and AO Classifications. Historically the calculated inter and intraobserver reliabilities for the Neer and AO Classifications of shoulder fractures on plain radiography have been poor to moderate (Neer=0.32-0.53 and AO=0.58-0.64[11,12,13,14,15]).

Data analysis was performed with SPSS v19 (IBM, USA).

Results

Forty cases of acute isolated GT fractures with adequate initial XR and CT imaging were identified.

Demographics of our Study Population (n=40)

The age, sex, side of injury and the presence of associated glenohumeral dislocation or glenoid fracture are in Table 1.

Table 1: Demographics of our Study Population (n=40)

Age (years)	mean=57 (23-83)
Sex	19 male (47.5%)
Side	21 right (52.5%)
Glenoid fracture	5 (12.5%)
Dislocation	13 (32.5%)

[Glenoid fracture=presence of concurrent glenoid fracture, Dislocation=presence of glenohumeral dislocation]

Greater Tuberosity displacement as measured on Plain Radiography using the Ratio Method

The displacement of the greater tuberosity fragment was measured in the anteroposterior (AP/Grashley) and lateral (Neer) projections using the ratio method.

On the AP view, the greater tuberosity was displaced superiorly in 19 of the 40 cases. The average ratio for superior displacement was 0.54 (95%CI: 0.32 to 0.76) and was similar for inferior displacement (-0.59(95%CI: -0.79 to -0.38)). On the lateral view, the greater tuberosity was displaced posteriorly in 31 cases and was undetermined in 9 cases due to bony overlap. The average ratio was -0.77 (95%CI: -0.84 to -0.71)[Table 2].

Table 2: Greater Tuberosity displacement measured on Plain Radiography using the Ratio Method

Radiographic projection	Direction of displacement	Number of cases	Ratio mean	95% CI
AP (Grashey)	Sup (+)	19	0.54	0.32 to 0.76
	Inf (-)	21	-0.59	-0.79 to -0.38
	NA	0	-	-
Lateral (Neer)	Ant (+)	0	-	-
	Post (-)	31	-0.77	-0.84 to -0.71
	NA	9	-	-

[AP=anteroposterior; NA=not applicable/not measurable; CI=confidence interval]

Greater Tuberosity displacement as measured with Computed Tomography

The displacement of the greater tuberosity fragment was measured on both coronal and axial projections. On the coronal projection the greater tuberosity was displaced superiorly in 22 of the cases (average 4.80mm; range 1.00-18.00mm) and inferiorly in 18 (average -5.03mm; range -13.00 to -1.70mm). On the axial projection the greater tuberosity was displaced posteriorly in 30 of the cases (average -

5.69mm; range -18.00 to -1.00) and anteriorly in 10 (average 2.14mm; range 0.00-6.70mm)[Table 3].

Table 3: Greater Tuberosity displacement as measured with Computed Tomography

CT cut (coronal vs axial)	Direction of displacement	Number of cases	Mean (in mm)	Range (in mm)
Coronal	Sup (+)	22	4.80	1.00 to 18.00
	Inf (-)	18	-5.03	-13.00 to -1.70
Axial	Ant (+)	10	2.14	0.00 to 6.70
	Post (-)	30	-5.69	-18.00 to -1.00

*External rotation of the GT fragments was noted in 19 (47%) of the cases.
[CT=Computed Tomography; Sup=Superior; Inf=Inferior; Ant=Anterior; Post=Posterior]

Correlation between Greater Tuberosity displacement measured on Plain Radiography and Computed Tomography

Correlations in the superior-inferior plane were calculated between the ratio obtained from plain AP radiographs and the two supero-inferior displacement measures calculated from coronal CT. The ratio method correlated very well with the supero-inferior displacement measured with CT for both the fragment displacement (0.852, $p<0.01$) and the relationship to the humeral head tangent (0.767, $p<0.01$).

Correlations in the antero-posterior plane were also calculated but no significant correlations were found [Table 4/5].

Table 4: Analysis of correlation between Greater Tuberosity displacement measured on Plain Radiography and Computed Tomography: Superior/Inferior Plane

		CT sup-inf (mm)	CT to head (mm)
XR sup ratio	Pearson Correlation	0.852	0.767
	Sig. (2-tailed)	$p < 0.001$	$p < 0.001$
	N	40	

[XR sup ratio=ratio calculated from plain radiographs on the anteroposterior projection, CT sup-inf=greater tuberosity fragment displacement measured from the coronal cut of Computed Tomography, CT to head=distance from the greater tuberosity fragment to the tangent of the humeral head measured from the coronal cut of Computed Tomography]

Table 5: Analysis of correlation between Greater Tuberosity displacement measured on Plain Radiography and Computed Tomography: Anterior/Posterior Plane

		CT ant-post (mm)
XR post ratio	Pearson Correlation	-0.133
	Sig. (2-tailed)	$p = 0.477$
	N	31

[XR post ratio=ratio calculated from plain radiographs in the lateral projection, CT ant-post=anterior or posterior displacement of the greater tuberosity fragment measured on axial cut of Computed Tomography]

Analysis of surgical decision-making using the Ratio Method on Plain Radiography

Using CT scan, nine fractures with ≥5mm superior displacement were classified as "surgical" and 31 fractures with <5mm superior displacement were classified as "non-surgical".

The means and 95% confidence intervals for the GT ratio “non-surgical” and “surgical” groups were -0.32 (-0.52 to -0.12) and 0.91 (0.54 to 1.28), respectively. The GT ratio accurately distinguished between “non-surgical” and “surgical” groups and this was statistically significant (U test, p<0.001).

In fact, if a GT ratio of ≤0.00 is used as the cut-off for non-surgical treatment and ≥0.50 is used as the cut-off for surgical treatment, only 1 case is misclassified as non-surgical. This was a severely comminuted GT fracture. The remaining GT ratios (0.00-0.50) would likely benefit from further imaging [Figure 5].

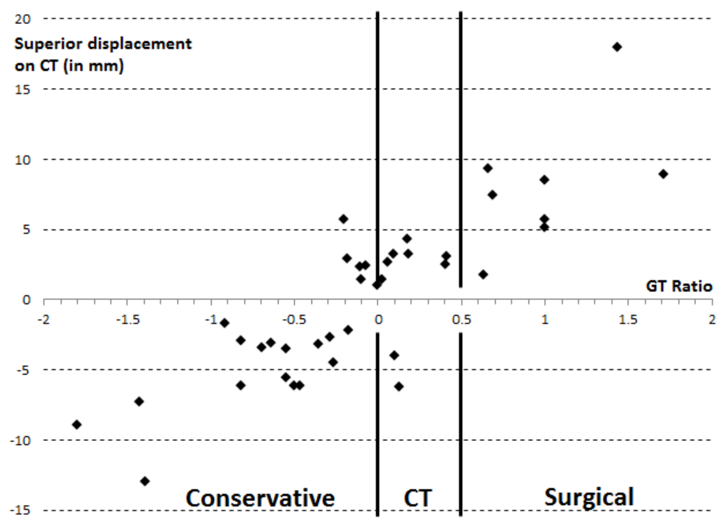

Figure 5 = Clinical implications of the ratio method on plain radiography. On the X-axis is the GT ratio values and on the Y-axis is the corresponding greater tuberosity superior displacement measured on Computed Tomography. Two vertical lines have been drawn to represent the cut-offs for conservative treatment (≤0.0) and surgical treatment (≥0.5) with a statistical significance of p<0.01. GT ratio values between 0.0 and 0.5 would benefit from Computed Tomography.

Validation of the Ratio Method on Plain Radiography

The ICCs for the ratio method were 0.51 (0.41-0.61) and 0.71 (0.61-0.81) for inter- and intraobserver reliability, respectively. The ratio method thus performs as well as or better than the existing classification systems and notably better than direct measurement (error 0.9-13mm).[10]

Summary

The GT ratio described here correlates very well with superior/inferior displacement measured on CT. It adequately differentiates surgical from non-surgical fractures using a ratio of ≤0.00 for non-surgical and ≥0.50 for surgical treatment ($p < 0.001$). The GT ratio is valid and performs as well as or better than the Neer and AO Classifications.

Discussion

In 1970, Neer defined a displaced GT fragment as one that was displaced more than 1cm or angulated more than 45 degrees.[16] The AO (Arbeitsgemeinschaft fur Osteosynthesefragen) group later lowered this to 5mm in recognition of the poor clinical outcome observed in many patients with GT fractures and the likely benefit of surgical intervention in this group.[17]

However, current imaging modalities used to evaluate GT fractures have important limitations. Simple radiographs are inexpensive and easy to perform but difficulties in evaluating the GT on plain radiographs have been reported[18,19,20,21] with errors in measurement up to 13mm.[10] An additional AP view in external rotation has been suggested[22,23] but errors of measurement range from 0.7 to 9.7mm. [10]

CT of the shoulder is currently the gold standard for measuring minimally displaced proximal humerus fractures. [16,24,25,26, 27,28,29] but it involves 50 times the radiation dose of XR (2.06mSv vs. 0.04 mSv).[30]

The use of a ratio on XR was used in this study because calibration markers are often not present on standard shoulder trauma series and this creates error due to magnification.

The ratio method also allows for the calibration of the images with the patient's own anatomy. While the distance used as the denominator in this study (distance from the humeral head tangent to the GT bed) is variable (8mm SD3.2mm),[31] it is possible that patients in whom this distance is naturally smaller may be more susceptible to impingement syndromes with superior fragment displacement.

The new ratio method showed moderate to good inter- and intraobserver reliability and performed as well as or better than the AO and Neer Classifications,[16,17,18,19,20] and better than direct measurement.[10] The ratio method correlated well with GT fragment displacement measured on CT for superior/inferior displacement (Pearson

= 0.852, p<0.01). Additionally, the ratio method allowed for the accurate classification of GT fractures into surgical and non-surgical groups (p<0.001).

Anterior/posterior displacement did not correlate with CT measurements. This is likely due to the multiple bony structures that overlap on the lateral view as well as error due to humerus rotation. Rotation was not a problem with superior/inferior displacement because any rotation around the humeral axis does not change the ratio.

In the present study, the GT fragment was displaced superiorly in 22 cases and inferiorly in 18 cases. This differs from the classic description of GT fractures where fragments are displaced superiorly due to the pull of the supraspinatus muscle. Reasons why GT fractures may be displaced inferiorly could include a mechanism of impaction, or an associated rotator cuff tear. However, studies elucidating such a relationship as well as the clinical impact of the direction of displacement of the GT are currently lacking.

Conclusion

This is the first radiologic study done on in-vitro greater tuberosity fractures. The classic postero-superior displacement of GT fractures was present in only 50% of cases. Inferior and anterior displacement was observed and may represent a subset of GT fractures with a different mechanism of injury and/or an associated rotator cuff tear. More studies are needed to further elucidate this relationship and to investigate its impact on clinical outcome.

The ratio technique described in this study represents an attractive option for the measurement of supero-inferior displacement of isolated GT fractures on plain radiography. It is simple to perform, correlates very well with CT and requires 50 times less radiation.

Also, this ratio may accurately classify GT fractures into surgical (ratio ≤0.00) and non-surgical (ratio ≥0.50) groups with intermediate ratios (0.00-0.50) benefitting from CT. Practically speaking, this would mean that any GT fractures found between the most lateral aspect of the humeral head and halfway to a tangent at the summit of the humeral head would benefit from CT. The clinical impact of this new measure remains to be demonstrated and would require further studies.

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CHAPTER 5 – ARTICLE 2: A NEW MORPHOLOGIC CLASSIFICATION FOR GREATER TUBEROSITY FRACTURES OF THE PROXIMAL HUMERUS: VALIDATION AND CLINICAL IMPLICATIONS

5.1 – PRELUDE

This work was accepted and presented at various congress and research meetings including podium presentations at the 32nd Annual Research Day of the POES (Programme d'Orthopédie Édouard-Samson) in Montreal, Canada in May 2012; at the Sacré-Coeur Hospital Research Day in Montreal, Canada in May 2012; at the COA (Canadian Orthopaedic Association) Annual Meeting in Ottawa, Canada in June 2012; and at the 12th annual ICSES (International Congress of Shoulder and Elbow Surgery) meeting in Nagoya, Japan in April 2013.

The following manuscript was submitted to the Bone and Joint Journal (formerly Journal of Bone and Joint Surgery – British), according to their standards, in May 2013.

5.2 – ARTICLE

A New Morphologic Classification for Greater Tuberosity Fractures of the Proximal Humerus: Validation and Clinical Implications

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JM – received support for research and travel from an orthopedic resident research support organisation and Synthes

GYL – received institutional grants/payments from Synthes, Stryker

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A New Morphologic Classification for Greater Tuberosity Fractures of the Proximal Humerus: Validation and Clinical Implications

Abstract

In this study, we propose and validate a Morphologic classification for Greater Tuberosity(GT) fractures of the proximal humerus. This classification divides GT fractures into three types: **Avulsion**(Small fragment, horizontal fracture line, mechanism similar to rotator cuff tear), **Split**(Large fragment, vertical fracture line, likely through impaction on the anterior glenoid lip with shoulder dislocation/subluxation), and **Depression**(Inferiorly displaced fragment, through impaction beneath the glenoid during antero-inferior glenohumeral dislocation). A retrospective review(July 2007-July 2012) of all shoulder radiographs performed at a level 1 trauma center was done to identify isolated GT fractures. Basic demographic variables were recorded and charts/radiographs were reviewed. The morphologic classification was validated by three reviewers on two occasions using the Kappa statistic and compared with the AO and Neer classifications. A total of 199 cases were identified. The inter- and intraobserver reliability of the Morphologic classification was 0.73-0.77 and 0.69-0.86, respectively. This was superior to the Neer[0.31-0.35/0.54-0.63] and AO[0.30-0.32/0.59-0.65] classifications. The relative frequency of Avulsion, Split, and Depression type fractures was 39, 41, and 20%, respectively. The Morphologic classification of GT fractures of the proximal humerus is more reliable than the Neer or AO

classifications. These distinct fracture morphologies may have implications for pathophysiology and surgical technique.

Introduction/Objectives

Three percent of upper extremity fractures occur in the proximal humerus[1] and affect both young and aging populations. The greater tuberosity serves as the insertion site for part of the rotator cuff. Isolated injuries represent approximately 20% of proximal humerus fractures[2] and are challenging. As little as 2mm of superior displacement of the greater tuberosity significantly increases the force required for abduction[3] and leads to sub-acromial impingement.[4,5,6,7,8,9]

In order to guide treatment, multiple classification systems have been proposed[10,11] but the most popular are those by Neer[12,13] and the AO foundation.[14] Neer originally classified greater tuberosity fractures as 2-part if they were displaced more than 1cm but due in part to the work by Platzer et al. [8,15,16] and Park et al.[6], fragments displaced more than 5mm superiorly are considered for surgical treatment. The AO classification maintained this 5mm cut-off for greater tuberosity fragments and added an additional category of displaced fractures associated with glenohumeral dislocations.[17]

Both of these classifications address only one type of GT fracture (large fragment with a vertical fracture line) and while the recommendation for surgical fixation with ≥ 5mm of superior displacement is valid, it does not adequately consider the prognostic or technical implications of the variable morphology of these fractures. Fragment size, shape and orientation of GT fractures may reflect different mechanisms and velocity of injury. Additionally, the technical aspects of GT fragment fixation are affected by fracture morphology. The GT fracture by avulsion was described by Bhatia in 2007[18] and Fahmy in 2011.[19] Additionally, a GT fracture by impaction was described by Davies[20] and Kaspar[21] as a very lateral Hill-Sachs type lesion that was found outside of the articular humeral head. Bahrs et al. proposed 3 mechanisms for greater tuberosity fracture:[22] avulsion, acromial impaction, and impaction on the glenoid. Using these studies and our experience with greater tuberosity fractures and their radiographs, we propose the following morphologic classification:

1) An **avulsion** involves small fragments of bone and the fracture line is horizontal. The mechanism would be similar to rotator cuff tear (Figure 1/Radiograph 1).

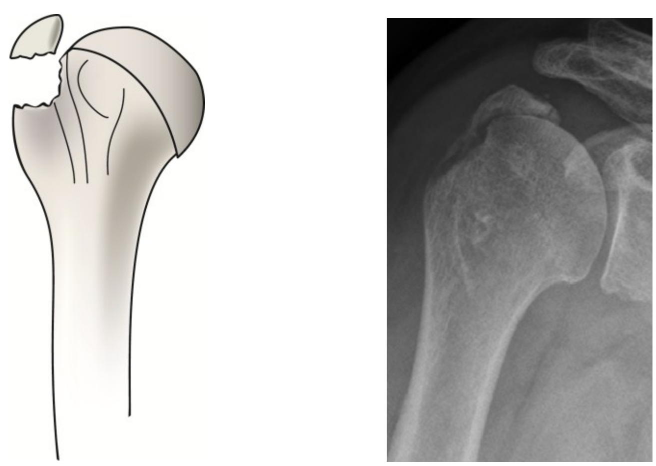
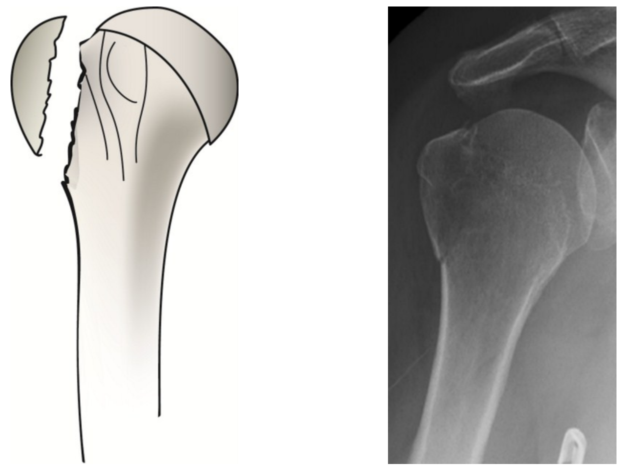


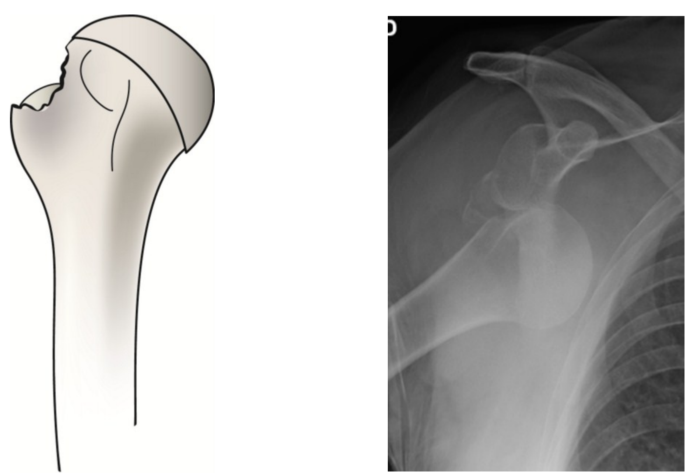
Figure 1/Radiograph 1: An artist's rendition and anteroposterior radiograph of the typical Avulsion-type fracture. As seen here, the fragment is small, the fracture line in horizontal, and displacement is superior and medial.

2) A **split** fracture generally involves a large fragment with a vertical fracture line. This likely occurs through impaction on the anterior surface of glenoid with dislocation or subluxation of the shoulder (Figure 2/Radiograph 2).



<u>Figure 2/Radiograph 2:</u> An artist's rendition and anteroposterior radiograph of the typical Split-type fracture. The fragment is large and the fracture line is vertical, extending to or distal to the level of the surgical humeral neck.

3) A **depression** fracture involves a fragment that is displaced inferiorly. This likely occurs through impaction beneath the inferior surface of the glenoid while the humerus is dislocated or beneath the inferior surface of the acromion with extreme abduction (Figure 3/Radiograph 3).



<u>Figure 3/Radiograph 3:</u> An artist's rendition and anteroposterior radiograph of the typical Depression-type fracture. The entire greater tuberosity is impacted into the humeral head and individual fragments are displaced inferiorly.

A primary goal of this study is to propose and validate this simple Morphologic Classification for isolated GT fractures of the proximal humerus. This classification may help guide the Orthopaedic surgeon with the technical aspects of GT fracture fixation. A secondary goal is to describe the prevalence of these Morphologic fracture types as well as the demographics and associated injuries of the respective populations.

Methods

A retrospective review of all shoulder radiographs ordered by 13 orthopaedic surgeons at a single level 1 trauma center was performed using the picture archiving and communication system (PACS) that was instituted in July 2007. The review was carried out until July of 2012 and identified all cases of isolated greater tuberosity (GT) fractures of the proximal humerus.

Cases with closed physes and adequate acute (within 3 weeks of injury) antero-posterior (AP) and lateral (Neer) radiographs were selected for analysis. Radiographs were obtained according to a standard protocol: the AP view taken with the shoulder in neutral rotation and the patient standing in front of the radiographic plate turned 30-35° towards the side being imaged. The Neer view was performed with the anterior aspect of the injured shoulder against the radiographic plate and the other shoulder rotated 40° away from the beam projected posteriorly along the scapular spine. Any cases with evidence of prior bony injury to the shoulder girdle, concurrent fractures of the proximal humerus, or Hill-Sachs lesions were excluded.

The acute AP and Neer radiographs of all consecutive cases from July 2007-December 2010 were used to determine the reliability of the Morphologic, Neer, and AO classifications for GT fractures. The radiographs were marked with a calibration line and then anonymized. Three reviewers (1 orthopedic surgeon, 1 orthopedic trauma fellow, 1 orthopedic resident) were introduced to the Morphologic classification using a brief slide show (under 5 minutes) that included figures and illustrative examples (from cases after December 2010). The criteria for a fracture to be called “avulsion”, “split”, or “depression” were alluded to previously: “avulsion” fractures involve a small GT fragment with a horizontal fracture line; “split” fractures involve a large GT fragment with a vertical fracture line; and “depression” fractures involve the impaction of the GT into the humeral head. The lateral view was closely examined in all cases to identify posteriorly retracted fragments (often avulsion types) that could be mistakenly classified as depression types if only the AP view was used.

These three reviewers then classified all fractures according to the Neer, AO, and the Morphologic classification on two occasions with a minimum interval of 4 weeks. The Inter- and Intra-observer reliability was calculated using the Kappa statistic. A score of 0.81 or more was considered excellent, of 0.61 to 0.80 as good, of 0.41 to 0.60 as moderate, and of less than 0.4 as poor to fair[23].

Basic demographic variables including age, sex, and side of injury were recorded for the entire cohort of GT fractures (from July 2007 to July 2012). Charts/ radiographs were reviewed for evidence of displacement, surgical intervention, or glenohumeral dislocation. All GT fractures were classified according to the Neer, AO and Morphologic Classifications according to consensus of majority vote by four authors (JM, AC, YL, DR) for cases prior to December 2010 and by the primary author (JM) for cases from December 2010 to July 2012.

ANOVA and chi-squared tests were carried out where appropriate to compare age, sex, GT displacement and the incidence glenohumeral dislocation between fracture types. Statistical significance was set at $p<0.05$. All data analysis was performed with SPSS v19 (IBM, USA).

Results

Demographics

A total of 199 cases of isolated greater tuberosity fractures of the proximal humerus were identified over the 5-year period (July 2007-July 2012). The relative frequency of Avulsion, Split, and Depression type fractures for all 199 cases was 0.39, 0.41, and 0.20 respectively. The average age was 58 years (range 23–96) and this did not vary significantly with fracture type ($p=0.333$). The population was predominantly female (60%) except for Avulsion type fractures where males and females were equally affected (p=0.112). The side of injury was evenly distributed (52% right, 48% left). Fractures in patients over 60 years were significantly more displaced (41% vs 21% under 60; p=0.002).

Glenohumeral dislocation was present in 28% of cases overall but was twice as likely to occur in Depression (46%) than in Avulsion (21%) or Split (25%) type fractures and this was statistically significant (p=0.009). Additionally, Depression type fractures were rarely displaced (7%). When depression type fractures were surgically treated (7%), it was for reasons other than fracture displacement (such as irreducible dislocation or rotator cuff tear) and after a failure of conservative treatment (2 cases with rotator cuff tear). Otherwise, Avulsion and Split type fractures were displaced approximately one-third of the time with no statistical difference between the two. Surgical intervention was performed in 28% of Split-type fractures, 20% of Avulsion-type fractures and 7% in Depression-type fractures [table 1]. The rate of surgical fixation was not dependent on age in this series.

Table 1

Demographics, displacement and outcome of greater tuberosity fractures of the proximal humerus : consideration by fracture morphology type (Avulsion, Split, Depression)					
	All types	Avulsion type	Split type	Depression type	Significance (p < 0.05)
Number of cases (%)	199 (100%)	77 (39%)	81 (41%)	41 (20%)	NA
Age [Range] in years	58 [23-96]	56 [23-94]	59 [28-96]	59 [23-85]	p = 0.333
Sex - Male (%)	80M (40%)	38M (50%)	28M (35%)	14M (34%)	p = 0.112
Side - Right (%)	103R (52%)	38R (50%)	37R (46%)	28R (68%)	p = 0.053
Dislocation present - # (%)	55 (28%)	16 (21%)	20 (25%)	**19 (46%)**	**p = 0.009**
Displaced 5mm+ - # (%)	61 (31%)	27 (35%)	31 (38%)	**3 (7%)**	**p = 0.001**
Surgical treatment - # (%)	41 (21%)	15 (20%)	23 (28%)	**1 acute, 2 late (7%)**	NA

Classification Reliability

The interobserver reliability was determined using 139 consecutive cases of GT fracture from July 2007 to December 2010. The intraclass correlation coefficient (ICC) for the Neer, AO, and Morphologic classifications were 0.31-0.35, 0.30-0.32, and 0.73-0.77 respectively. The intraobserver reliability for the Neer, AO, and Morphologic classifications was 0.54-0.63, 0.59-0.65, and 0.69-0.86 respectively [table 2].

Table 2

Interobserver and Intraobserver reliability of the Neer, AO, and Morphologic classifications : as determined in this study and previously in the literature				
	Neer (5mm)	AO	**Morphologic**	Literature (Neer/AO)
Interobserver	0.31 – 0.35	0.30 – 0.32	**0.73 – 0.77**	0.11 – 0.53
Intraobserver	0.59 [0.54 – 0.63]	0.62 [0.59 – 0.65]	**0.78 [0.69 – 0.86]**	0.58 – 0.66 (ref 24-30)

Discussion/Conclusions

We have presented here a classification of greater tuberosity fractures of the proximal humerus that is based on fracture morphology. It separates fractures into 3 types (Avulsion, Split, Depression) that are easily identifiable on plain radiographs and performs better than the Neer or AO classifications for inter- and intraobserver reliability.

The Neer and AO classifications perform poorly for the classification of GT fractures,[24,25,26,27,28,29,30] even when the subgroup of GT fractures is evaluated in isolation. Brien et al. found a reliability of only 0.35[24] for the GT subgroup of the Neer classification. Similarly, in our study the GT subgroup was the only category of interest but the Neer and AO classifications still performed poorly to moderately (0.30-0.35 interobserver, 0.54-0.65 intraobserver).

We have shown that the Morphologic classification performs with good to excellent reliability (0.73-0.77 interobserver, 0.69-0.86 intraobserver) on plain radiography and propose it as an adjunct to the standard evaluation of these fractures. It is simple, uses the standard radiographic views of the shoulder, and involves no additional radiation exposure or cost.

Additionally, the Morphologic classification has important implications in terms of mechanism of injury as well as the technical aspects of surgical management. While a GT fracture with a large fragment (split type) can be fixed with a rigid compression system like a plate and screw (radiograph 4a + b), this would almost certainly fail with a small horizontal fragment (avulsion type). In this case a tension band fixation may be more appropriate. This is discussed by fracture type:

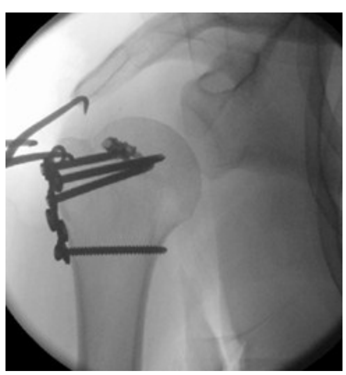
Avulsion type fractures involve a small fragment of bone and the fracture line is horizontal (Figure 1/Radiograph 1). These represent 39% of GT fractures. As noted by Barhs et al[22], the mechanism is likely similar to rotator cuff tears with the tendon avulsing a fragment of bone rather than suffering an intrasubstance tear.

Because of the small fragment size and the likely intact rotator cuff, these fractures have been followed closely at our center if undergoing conservative treatment.

Should fixation be required for displaced fractures, a double row suture or suture bridge technique has been previously described in the literature[31,32,33,34,35].

Split type fractures involve a large fragment with a vertical fracture line and most resembles the classic description of greater tuberosity fractures[13,36]. These represent 41% of GT fractures. We are in agreement with Barhs et al[22] that this likely occurs through impaction on the anterior surface of glenoid with dislocation or subluxation of the shoulder (Figure 2/Radiograph 2).

Twenty-eight percent of these fractures underwent surgical reduction and fixation in this series. This is significantly higher than avulsion type (20%) and may be due in part to a slightly higher percentage of initially displaced fractures in this group (38% split vs 35% avulsion). For surgical fixation of this type of fracture a low-profile "Bamberg"-type suture plate[37] (Radiograph 4a + b) may be used but multiple techniques including heavy suture fixation[38,39], tension band, screws[9], and conventional plate[40] fixation have been previously described.



Radiograph 4a + b: Anteroposterior and lateral fluoroscopic views of a Split-type fracture after reduction and fixation. A low-profile plate was used to decrease the chance of impingement and fixation was supplemented with anchors/heavy sutures through the rotator cuff

Depression type fractures involve a fragment that is displaced inferiorly. In contrast to Barhs et al[18] we believe that this lesion is essentially a very lateral Hill-Sachs type lesion that involves the entire greater tuberosity. This is supported by the nearly 50% incidence of dislocation noted in this group and the fragment impaction likely occurs beneath the inferior surface of the glenoid while the humerus is dislocated (Figure 3/Radiograph 3a +b). These fractures are distinct from Hill-Sachs lesions[41], however, in that the region affected (GT) is the insertion site for the tendons of the rotator cuff and not the posterolateral articular surface of the humeral head.

These fractures were rarely displaced in this series (7%) and rarely treated surgically (7%). In fact, 2 of the 3 cases treated surgically were only operated after failure of conservative management and subsequent demonstration of rotator cuff tear on magnetic resonance imaging (MRI). Therefore these fractures are typically treated surgically only after failed conservative treatment. Lateral radiographic views are essential at initial presentation to avoid mistakenly classifying avulsion fractures with posterior fragment retraction as depression type. In the case of doubt, a CT scan should be performed.

In conclusion, the Morphologic classification of greater tuberosity fractures of the proximal humerus has a good to excellent inter- and intraobserver reliability. It may serve as an adjunct to the Neer and AO classifications with no additional cost or radiation exposure. Three distinct fracture morphologies are described (Avulsion, Split, Depression) which may have important implications in terms of pathophysiology and surgical fixation technique. Prospective studies are needed to better understand the precise mechanism of these fracture types as well as their clinical and prognostic implications.

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CHAPTER 6 – ADDITIONAL RESULTS

6.1 – PRELUDE

This section on results concerns the demographics and clinical impact of isolated greater tuberosity fractures of the proximal humerus (cf. 3.4). These results have been presented in part at several congress and research meetings:

Poster presentations were made at the 32nd Annual Research Day of the POES (Programme d'Orthopédie Édouard-Samson) in Montreal, Canada in May 2012; the 24th Annual Meeting of the ESSSE (European Society for Surgery of the Shoulder and Elbow) in Dubrovnik, Croatia in September 2012; the 28th Annual Meeting of the OTA (Orthopaedic Trauma Association) in Minneapolis, USA in October 2012; the AAOS (American Academy of Orthopaedic Surgeons) Meeting in Chicago, USA in March 2013; and at the 12th annual ICSES (International Congress of Shoulder and Elbow Surgery) meeting in Nagoya, Japan in April 2013.

Podium presentations were given at the COA (Canadian Orthopaedic Association) meeting in Ottawa, Canada in June 2012 and the 28th Annual Meeting of the OTA (Orthopaedic Trauma Association) in Minneapolis, USA in October 2012.

The results presented in this section will be written up, in part or in whole, for submission to the Journal of Orthopaedic Trauma.

6.2 – REVIEW OF OBJECTIVES

In this chapter the results of the clinical study are presented. The overall objective was to examine the relationship between patient demographics, fracture characteristics/displacement, and associated injuries of the shoulder girdle and the final clinical outcome following isolated fractures of the greater tuberosity.

Secondary objectives were to describe the incidence of rotator cuff pathology in these patients as well as its impact on outcome. This incidence of Avulsion, Split, and Depression type GT fractures is also described and the relationship between GT fracture type and demographics, fracture displacement, dislocation, rotator cuff pathology and functional outcome is examined.

6.3 – DEMOGRAPHICS OF THE STUDY POPULATION

A total of 153 cases of isolated greater tuberosity fractures were identified from July 2007 to April 2011 and 101 patients met the inclusion criteria. A patient recruitment flow diagram [figure 20] and the inclusion/exclusion criteria [table 1] for the study are shown here. Forty-nine patients were recruited to participate in the full clinical study (minimum recruitment goal = 48 patients). An additional 5 patients agreed to participate in the study but did not undergo shoulder ultrasound (total = 54 patients).

Inclusion criteria	*Exclusion criteria*
Isolated fractures of the greater tuberosity Operative or conservative treatment Skeletal maturity Minimum 1 year of follow-up Good quality radiographs of the acute fracture with minimum AP and lateral views	Local tumor, infection or significant glenohumeral arthritis Previous injury of the same upper limb Presence of prior neurologic deficit of either upper limb Patient or unable or unwilling to collaborate due to psychiatric illness or language barrier

Table 1: Inclusion and exclusion criteria

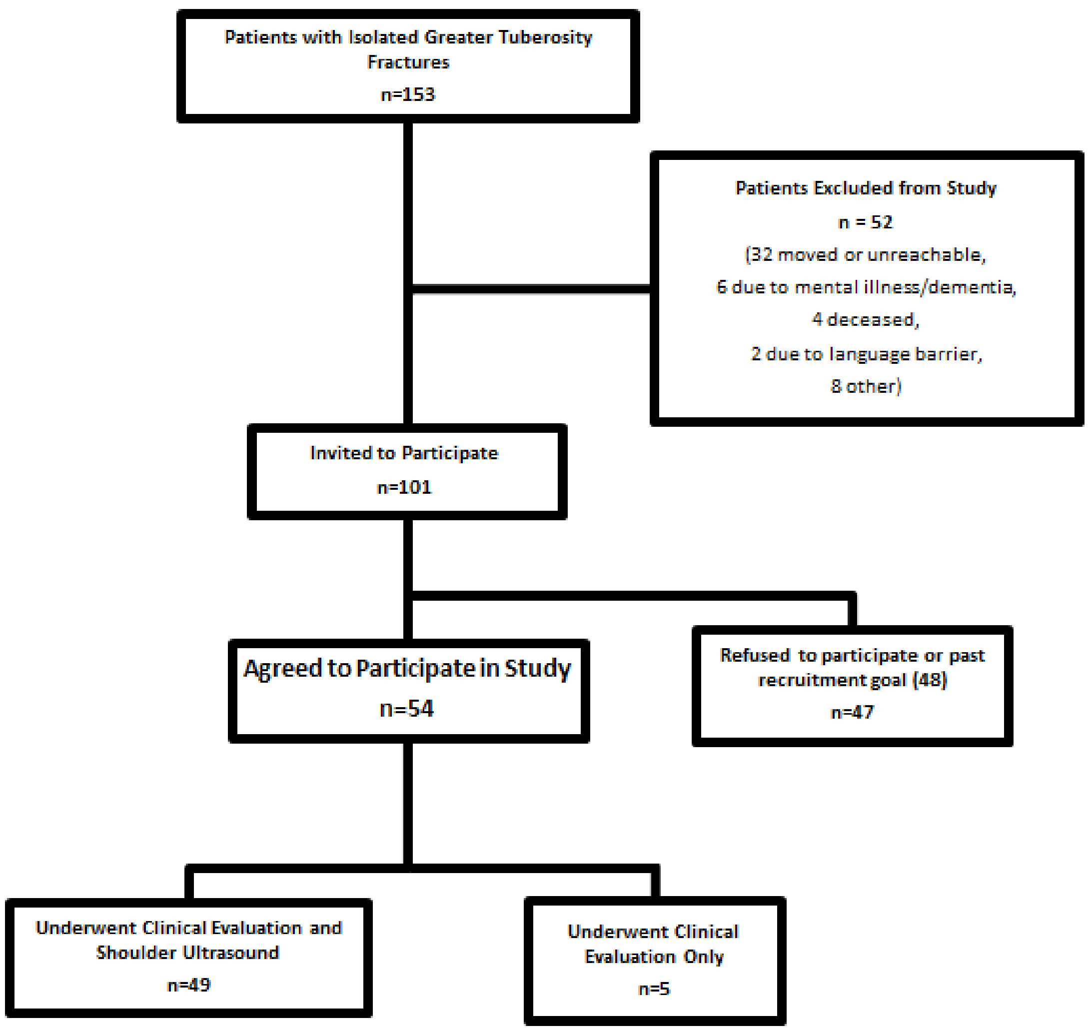

Figure 20 = Patient Recruitment Flow Diagram

The demographic profile, fracture displacement, associated glenohumeral dislocation, and treatment modality are presented in table 2. These variables were compared between patients who agreed to participate in the study and those who refused and there were no statistically significant differences.

Demographics	Participants (n=54)	Non-Participants (n=47)	P value
Age (in years)	57 years SD 13 ; Range 31-90	58 years SD 15 ; Range 23-84	0.72
Gender	Male: 23 (43%) Female: 31 (57%)	Male: 16 (34%) Female: 31 (66%)	0.38
Fracture side	Left: 29 (54%) Right: 25 (46%)	Left: 18 (38%) Right: 29 (62%)	0.12
Treatment	Surgery: 11 (20%) Non-Surgical: 43 (80%)	Surgery: 4 (9%) Non-Surgical: 43 (91%)	0.10
Glenohumeral dislocation	Yes: 16 (30%) No: 38 (70%)	Yes: 16 (34%) No: 31 (66%)	0.64
Superior displacement	1.61mm SD 3.99; Range: -9 to 14mm	1.07mm SD 6.53; Range: -19 to 18mm	0.61

Table 2: Study Population Description and Comparison with Non-Participants

The average follow-up for the study population was 2.5 years (range: 1.0 – 6.9 years).

6.4 – PATHOLOGY ON ULTRASOUND

A total of 49 patients completed the full clinical study including shoulder ultrasound. The presence of biceps tendon pathology, rotator cuff tears and/or atrophy, and subacromial impingement (on dynamic testing with ultrasound) was noted and the results are presented below. Additionally, the incidences of the aforementioned pathologies were compared and contrasted between young patients (under 50 years) and older patients (50 years and older).

The supraspinatus tendon presented with the greatest number of full and partial tears (14% and 57%, compared to 6% and 16% for the infraspinatus, 4% and 6% for the subscapularis, and 0% and 4.3% for the biceps, respectively). On the other hand, despite having fewer tears, the infraspinatus muscle demonstrated more atrophy and fatty infiltration (atrophy in 45% and fatty infiltration in 61% of patients, compared to 15% and 22% for the supraspinatus). In the long head of the biceps, 6.5% of patients showed signs of acute tenosynovitis and biceps tendon subluxation occurred in 31% of patients [table 3].

	Supraspinatus	**Infraspinatus**	**Subscapularis**	**Biceps**
Partial tears	57%	16%	6%	4.3%
Full tears	14%	6%	4%	0%
Atrophy	15%	45%		
Fatty Infiltration	22%	61%		
Acute tenosynovitis				6.5%
Subluxation				31%

Table 3: Supraspinatus, Infraspinatus, Subscapularis and Biceps Pathology

Subacromial impingement was also found on dynamic testing in more than a half of patients (57%).

When comparing patients below 50 years of age with those 50 years of age and above, increased incidence was found in the younger age group of both full rotator cuff tears (23% vs 14%) and subacromial impingement on ultrasound (69% vs 53%). The incidence of biceps pathology, however, increased with increasing age (33% vs 40%).

6.5 – POPULATION AS PER FRACTURE DISPLACEMENT

All patients were classified into two groups according to fracture displacement at initial presentation. Fractures displaced less than 5mm superiorly were considered non-displaced and fractures displaced 5mm or more superiorly were considered displaced. There were no significant differences in age or in sex between the non-displaced and the displaced groups.

Glenohumeral dislocation, however, was three times more likely to be associated with GT fractures that were displaced (70% for ≥5mm vs 23% for <5mm, $p=0.003$). Additionally, atrophy or fatty infiltration of the supraspinatus muscle was more likely to occur in fractures that were displaced ≥5mm. There was a trend towards a greater incidence of subacromial bursitis (83% for ≥5mm vs 43% for <5mm, $p=0.064$) in the displaced GT fracture group but this was not statistically significant. A detailed breakdown may be found in table 4.

	<5mm	≥5mm	P value
Age at first presentation (yrs)	60	59	0.763
Sex (% female)	62%	50%	0.468
Dislocation (% rate)	23%	70%	0.003
Supraspinatus atrophy	11%	50%	0.013
Supraspinatus fatty infiltration	15%	50%	0.045
Subacromial bursitis	43%	83%	0.064
Subacromial impingement	50%	40%	0.703

Table 4: Demographics and Rotator Cuff Pathology by Fracture Displacement

6.6 – POPULATION AS PER THE MORPHOLOGIC CLASSIFICATION

The relative frequency of the Avulsion, Split and Depression type fractures was 42.5%, 42.5%, and 15% respectively. There was a trend towards patients with Depression type fractures to be older (66 years vs 57-60 years, p=0.172) and female (75% vs 46-69%, p=0.122) but this was not statistically significant. Avulsion type fractures presented with the greatest amount of initial displacement (2.4 mm vs -3.8 to 1.4mm, p<0.001) on average but displaced little over time (<1mm). Split type fractures were associated with an elevated incidence of subacromial bursitis (76% vs 24-33%, p=0.001). There were no significant relationships between rotator cuff muscle atrophy and fracture type although there was a tendency towards decreased infraspinatus muscle cross-sectional area with split type fractures (687 vs 731-840, p=0.62). A detailed breakdown can be found in table 5.

		Avulsion	Split	Depression	P value
Number of cases N (%)		23 (42.5%)	23 (42.5%)	8 (15%)	
Age at first presentation (yrs)		60	57	66	0.172
Sex (% female)		46%	69%	75%	0.122
Years smoking		13	8	29	0.046
Dislocation (% rate)		25%	29%	50%	0.285
Initial displacement (mm)		2.4	1.4	-3.8	<0.001
Displacement over time (conservatively treated fractures)		0.91	1.27	2.2	0.639
Surgically treated		8%	24%	8%	0.187
Supraspinatus tears	**Full**	3 (14%)	3 (14%)	0 (0%)	
	Partial	15 (68%)	10 (48%)	4 (67%)	
Infraspinatus tears	**Full**	1 (5%)	2 (10%)	0 (0%)	
	Partial	5 (23%)	3 (14%)	0 (0%)	
Supraspinatus muscle	**Area**	808	815	849	0.398
	Thickness (mm)	20	19	21	0.564
Infraspinatus Muscle	**Area**	840	687	731	0.062
	Thickness (mm)	19	17	17	0.079
Subacromial bursitis		24%	76%	33%	0.001
Subacromial impingement		35%	63%	64%	0.238

Table 5: Demographics, Fracture Characteristics, and Rotator Cuff Pathology by Fracture Type

6.7 – FUNCTIONAL IMPACT

Demographics

Globally, the demographic variables studied (age, sex, side of injury, smoking status, employment status) were not useful predictors of functional outcome according to the WORC, Quick DASH, SF12v2, Constant and Pain scores.

Ultrasound Pathology

The presence of abnormalities found on ultrasound examination was significantly negatively related to functional outcome. Full tears of the rotator cuff were associated with a significantly greater decrease (in relation to the uninjured extremity) in Constant score (18 vs 6 points, p=0.012) and external rotation (61 vs 75°, p=0.04) than partial tears or no tears. The presence of supraspinatus muscle fatty infiltration was associated with significantly lower Quick-DASH scores (16 vs 29 points, p=0.046) and higher abduction strength differences (6 vs 2ks, p=0.045). The presence of infraspinatus muscle fatty atrophy, however, had no significant impact on ROM or WORC, Quick-DASH, SF-12 v2, and VAS scores.

The presence of biceps pathology reduced the range of external rotation by approximately 10° (p=0.028) but no other significant relationships were found. The incidence of subacromial impingement was quite high (57%) but this did not impact functional outcome.

The breakdown of functional outcome scores (WORC, Quick DASH, SF12v2, Constant difference), strength difference, and ROM are presented in detail in tables 6 for rotator cuff tears and atrophy. Significant relationship are marked with the symbols *, ɨ, and ᵞ for the p=0.01, p=0.04, and p=0.05 levels of significance, respectively. These same functional outcome scores and clinical results are presented in table 7 for biceps pathology and subacromial impingement. The significant relationship is marked with the * symbol for a p=0.03 level of significance.

Table 6: The Functional Impact of Rotator Cuff Tears and Atrophy

		Tears in the rotator cuff (any)		Full tears in the rotator cuff		Supraspinatus atrophy (any)		Supraspinatus fatty infiltration (any)		Infraspinatus atrophy (any)		Infraspinatus fatty infiltration (any)	
		Without n=13	**With n=36**	**Without n=41**	**With n=8**	**Without n=40**	**With n=7**	**Without n=38**	**With n=11**	**Without n=26**	**With n=22**	**Without n=19**	**With n=29**
WORC (%)		82±6	75±5	79±4	68±11	77±4	79±11	78±4	72±9	77±4	79±6	78±4	75±5
Quick-Dash Main		16±5	19±3	17±3	28±10	18±3	21±8	**16±3** γ	**29±8** γ	19±4	16±4	16±4	20±4
SF-12	**Physical**	46±3	47±2	46±2	47±4	47±2	44±4	48±2	42±3	48±2	45±3	47±2	46±2
	Mental	51±3	51±2	51±1	48±4	50±1	56±3	50±1	53±3	50±2	52±2	51±2	51±2
Pain score		2±0	2±0	2±0	3±1	2±0	2±1	2±0	3±1	2±0	2±0	2±0	2±0
Constant score difference		9±3	8±2	**6±2***	**18±6***	7±2	14±6	7±2	14±4	7±2	8±2	8±2	8±3
Strength loss (kg)		3±1	3±1	3±1	6±2	3±1	3±2	**2±1** γ	**6±2** γ	2±1	3±1	1±1	4±1
ROM injured side (°)	**Flexion**	169±4	165±3	167±3	161±10	168±3	160±8	167±3	162±6	168±3	163±5	165±4	167±4
	Abduction	164±8	154±5	157±4	153±12	160±4	139±13	159±5	148±9	159±5	157±6	154±7	159±5
	External rotation	76±4	72±3	**75±2** ǂ	**62± 9** ǂ	75±3	62±8	75±3	65±6	75±3	73±5	71±3	75±4

* p=0.01, ǂ p=0.04, γ p=0.05

Table 7: The Functional Impact of Biceps pathology and Subacromial impingement

		Biceps pathology (any)		Biceps tendon subluxation		Subacromial impingement	
		Without n=29	**With n=18**	**Without n=31**	**With n=14**	**Without n=21**	**With n=28**
WORC (%)		78±4	78±6	74±5	96±4	75±5	79±5
Quick-Dash Main		17±3	17±5	18±4	12±4	22±4	16±4
SF-12	**Physical**	47±2	46±3	46±2	48±3	45±2	47±2
	Mental	51±2	51±2	50±2	54±2	51±2	50±2
Pain score		2±0	2±0	2±0	1±0	2±0	2±0
Constant score difference		5±2	1±3	6±2	8±2	11±3	6±2
Strength loss (kg)		2±1	3±1	3±1	2±1	3±1	3±1
ROM injured side (°)	**Flexion**	169±3	159±6	168±3	165±5	165±4	167±4
	Abduction	161±5	152±7	160±5	157±8	146±7	165±4
	External rotation	**78±3***	**67±5***	76±3	72±4	72±4	74±3

* p=0.03

Fracture Displacement

Fracture displacement was measured on the initial and follow-up radiographs and all patients were classified as having non-displaced GT fractures (<5mm) or displaced GT fractures (≥5mm). Two separate analyses were carried out: one including all patients and the other including only those patients having received a conservative course of treatment. Regardless of whether or not patients having received surgical treatment were included in the analysis, fracture displacement on initial of follow-up radiographs showed no significant relationships to the WORC, Quick DASH, SF12v2, Constant, or Pain scores at final follow-up.

Morphologic Classification

All 54 GT fractures were classified according to fracture type. The Avulsion, Split, and Depression type fractures comprised 23 (42.5%), 23 (42.5%), and 8 (15%) cases respectively. The average WORC, Quick DASH, SF12v2, Constant, and Pain scores were calculated for each fracture type and there were no significant differences.

CHAPTER 7 - DISCUSSION

The GT Ratio on Plain Radiography

A full discussion regarding the development, testing (intra and inter-observer reliability), and application of the GT Ratio can be found in article 1 (Chapter 4).

In brief, the GT Ratio on plain radiography correlates very well with superior GT fragment displacement measured on computed tomography. It also allows for the accurate classification of GT fractures into surgical (displaced $\geq$ 5mm superiorly; GT ratio ≤ 0.00) and non-surgical (displaced < 5mm superiorly; GT ratio ≥ 0.50) groups ($p < 0.001$). Advantages of the GT ratio include the simplicity of the method, the use of standard shoulder radiographs, the moderate to good inter and intraobserver reliability, and the avoidance of ionizing radiation due to computed tomography. A disadvantage of this technique is its inability to evaluate posterior displacement of the GT fragment.

The GT Ratio is clinically relevant as multiple previous studies have demonstrated a worse functional outcome in patients with 5mm or more of superior GT displacement[9,39,40,53-55] and have recommended surgical fixation in this group[9,39,40]. The clinical importance of posterior GT displacement is not clear.

The Morphologic Classification

A detailed discussion of the development, testing (intraclass correlation), basic demographics, and potential benefits of the Morphologic Classification may be found in article 2 (Chapter 5). Additional results concerning the demographics of the Morphologic Classification may also be found in Chapter 6, section 6.6.

In summary, the Morphologic Classification separates isolated GT fractures into three types: **Avulsion**, **Split** and **Depression**. These fracture types occur at a frequency of 39%, 41% and 20% respectively and may have implications in terms of GT fracture mechanism, treatment, and prognosis.

Avulsion type fractures involve a small fragment of bone and likely occur through a mechanism similar to rotator cuff tears. These fractures presented initially with the greatest amount of GT displacement and this may be due to the pull of the intact tendons of the rotator cuff. Interestingly, though, these fractures displaced little over time (< 1mm). The reasons for this are unclear as an intact rotator cuff would be expected to pull the fragment superiorly and medially over time. Patients at our center are systematically immobilized for the first two weeks post injury and this may help lower the incidence of late fragment displacement. It is possible as well that the muscles of the rotator cuff suffer a type of "pseudoparalysis" in the face of injury (much like the deltoid muscle) and this removes the pull on the GT fragment.

Should surgical treatment be performed, the small fragment size logically dictates a rotator cuff repair-type fixation. Both a double-row suture and suture bridge technique have been described with encouraging clinical results[88,111,113-115].

Split type fractures are the typical GT fractures described by Neer and the AO foundation, with a large bony fragment and a vertical fracture line. These fractures were associated with an elevated rate of subacromial bursitis (76 vs 24-33%, p=0.001) and this may be due the large fragment size that is typically displaced superiorly and may effectively reduce the available subacromial space[33,39,40,54,79,111].

This type of fracture was the most often treated surgically in our series (24-28%) and multiple techniques for fixation exist, including a low-profile suture/plate construct (preferred treatment at our center).

Depression type fractures are essentially very lateral Hill-Sach's lesions involving the entire greater tuberosity and are rarely treated surgically. They tended to occur in an older (66 vs 57-60 years, p=0.172), female (75% vs 46-69%, p=0.122), smoking (29 vs 8-13 pack-years, p=0.046) population and were associated with a 50% rate of glenohumeral dislocation. These factors together support the proposed mechanism for these fractures through dislocation and lateral impaction of a humeral head with likely poor bone quality. Rotator cuff tears were quite rare for this fracture type with no full tears found during the clinical study and only 2 full tears in the full radiologic cohort (41 depression fractures).

Interestingly, depression type fractures were associated with a nearly two-thirds incidence of subacromial impingement. While this is expected in the split type due to direct abutment of the bony fragment below the acromion, it is counterintuitive in the depression type fracture where additional clearance due to the depressed fragment would be expected to decrease the rate of subacromial impingement. Bahrs et al.

believed that the depression type fracture could result from a lateral impaction injury on the acromion[67]. If this is the case then patients with depression type fractures likely have pre-existing anatomic constraints (low acromial clearance, type 2-3 acromion) that put them at greater risk for lateral impaction and post-injury impingement. Alternately, the relative medialisation and distalisation of the rotator cuff insertion following the depression of the greater tuberosity fragment may lead to altered biomechanics in the shoulder and superior migration of the humeral head. This may contribute to the increased subacromial impingement in this group.

Patients with this type of fracture generally undergo a period (6-8 weeks) of conservative treatment at our center with advanced imaging (MRI or ultrasound) indicated in the rare cases of treatment failure. Close attention should be given to the lateral radiograph to avoid misclassifying Avulsion type fractures with posteriorly displaced fragments as Depression type.

Overall, the Morphologic Classification is simple, has good to excellent inter and intraobserver reliability (superior to the AO and Neer Classifications), uses the standard radiographic views for the shoulder, and may help guide the orthopaedic surgeon as to pathophysiology and surgical fixation technique. Prospective or biomechanical studies are needed to better elucidate the mechanism and prognosis associated with these fracture types.

The Incidence of Rotator Cuff and Biceps Pathology

A total of 54 patients participated in the clinical study and 49 underwent shoulder ultrasound. Many patients had partial (57% supraspinatus, 16% infraspinatus) or full (15% supraspinatus, 6% infraspinatus) rotator cuff tears and this may be explained, in part, by the relatively elevated age of the study population (57 years; range 31-90). Rotator cuff tears may represent a normal degenerative process[129] and up to 10% full rotator cuff tears can be found in an asymptomatic male population of 40 to 70 years[130].

However, when the study population was divided according to age (> 50 years and ≤ 50 years) younger patients had both a higher incidence of full rotator cuff tears (23 vs 14%) and subacromial impingement (69 vs 53%). This may reflect that a higher force, or velocity of trauma, is required in the younger patient population before fracture of the GT occurs (younger, stronger bone). This association was beyond the scope of this study, however, and could not be demonstrated.

In this study, displaced (≥ 5mm superior) GT fractures were associated with a three-fold greater incidence of glenohumeral dislocation and resulted in more rotator cuff muscle atrophy and fatty infiltration. The increased incidence of glenohumeral dislocation in displaced GT fractures may reflect a greater velocity of trauma in this group and greater GT displacement as a result.

The muscle atrophy and fatty infiltration in displaced GT fractures (≥ 5mm superior) may be due, in part, to the non-anatomic healing of the GT fragment. Though not previously assessed for isolated GT fractures, superior malposition of the greater tuberosity in shoulder hemiarthroplasty has been significantly correlated with supraspinatus and infraspinatus fatty atrophy[131]. This in turn was associated with a poor functional outcome[131]. Additionally, glenohumeral dislocation and GT fractures have been associated with neurological injury[79,96] and this may also contribute to muscular atrophy and fatty infiltration.

Alternately, it is possible that the fatty atrophy of the rotator cuff was a pre-existing condition in some patients. Gladstone et al. found a significant correlation between pre-operative rotator cuff fatty infiltration and the risk of rotator cuff retears following surgical treatment (22% retears with minimal atrophy vs. 67% retears with moderate to severe atrophy)[132]. Longstanding rotator cuff pathology and tendinopathy (leading to disuse atrophy) could explain these results and may have even predisposed these patients to their rotator cuff tears. Whether the rotator cuff atrophy is the cause or the result of a rotator cuff tear has not been determined. Goutallier et al. considered rotator cuff fatty atrophy to be quite specific to rotator cuff tears[91], and this regardless of age. In a study on the natural history of rotator cuff atrophy, Ashry et al. demonstrated a significant increase in rotator cuff fatty atrophy with increasing age in the absence of rotator cuff tear[133]. However, no rotator cuff muscle demonstrated more than Goutallier grade 2/4 fatty atrophy in the absence of a rotator cuff tear[133]. Therefore, while some fatty degeneration of the rotator cuff may occur naturally with aging, severe atrophy of the rotator cuff is necessarily pathologic and will occur following rotator cuff tear.

Determinants of Outcomes Following GT Fracture

In general, basic demographic variables (age, sex, smoking status, employment) were not useful predictors of functional outcome.

The presence of abnormalities found on ultrasound examination, however, was significantly related to a poorer outcome. While the majority of GT fractures may be treated conservatively [39], some patients may have sustained occult soft tissue injury. Therefore, patients who evolve poorly despite appropriate conservative care should undergo advanced imaging (MRI or ultrasound) to evaluate for the presence of rotator cuff tears.

In contrast to the above relationship, the presence of displaced vs. non-displaced GT fractures had no significant impact on functional outcome in this study. However, the association of displaced GT fractures (≥ 5mm superior) with poor outcome has been demonstrated in several other studies[9,39,40,53-55]. The absence of a significant difference in outcome between displaced (≥ 5mm superior) and non-displaced GT fractures in this study is likely due to selection bias. This is a retrospective study and patients with displaced GT fractures were more likely to receive operative treatment. The analyses were repeated with patients having received surgical treatment removed from the equation, but this resulted in small patient numbers and no statistically significant relationships were found.

Interestingly, though, displaced GT fractures (≥ 5mm superior) were associated with supraspinatus atrophy and this was in turn associated with a poor functional outcome. The association of supraspinatus atrophy with a poor functional outcome has been previously demonstrated in shoulder fractures treated by hemiarthroplasty[131] and a prospective multicenter study evaluating this in isolated GT fractures may be of interest.

Finally, the fracture type (Avulsion, Split, Depression) was not predictive of functional outcome. However, some other interesting relationships were found and have been previously mentioned. Avulsion type fractures were associated with the greatest amount of initial GT fragment displacement and Split fractures had the highest incidence of subacromial bursitis. Depression fractures tended to occur in an older, female population and were associated with a 50% glenohumeral dislocation rate. These relationships show that there are significant differences in patient and injury characteristics according to fracture type. The technical considerations for surgical fixation of the GT fragment is also, of necessity, different according to fracture type although this was not specifically addressed in this study. A biomechanical study evaluating GT fragment fixation by fracture type may be of interest.

This study is limited by its retrospective nature and small number of patients. Although the 54 patients recruited is more than what was necessary according to the sample size calculation, when these patients were analyzed in subgroups (according to fracture type, displacement, etc.) the numbers per group decreased and meaningful relationships may have been lost. Additionally, patients were treated differently according to fracture displacement and type and this can make reasonable comparisons difficult. A prospective multicenter study with a large number of patients may help to clarify the true impact of fracture type on functional outcome.

CHAPTER 8 – CONCLUSION AND FUTURE DIRECTIONS

In conclusion, we have developed a method (the GT Ratio) for measuring superior GT displacement on plain radiography that is reliable and that may aid the clinician in determining GT fracture displacement and may spare some patients the radiation due to a CT scan. We have also presented a Morphologic Classification for GT fractures that is highly reliable on plain radiography and that may have pathophysiologic, clinical, and technical implications.

Additionally, the incidence of rotator cuff pathology in this population is described and is elevated in patients < 50 years compared to patients ≥ 50 years. The determinants of functional outcome, however, are elusive and subject to bias and small subgroup numbers. Ideally, a prospective clinical study could help to answer some of the questions raised. Due to the relative rarity of this fracture, however, this study would be, by necessity, a multicenter cohort.

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APPENDICES

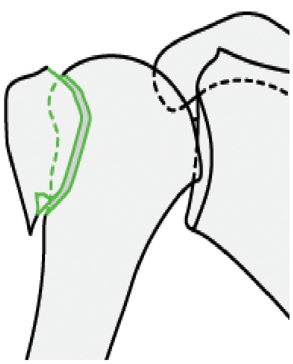
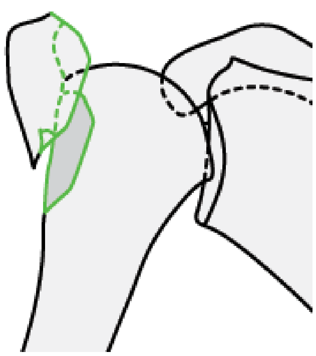
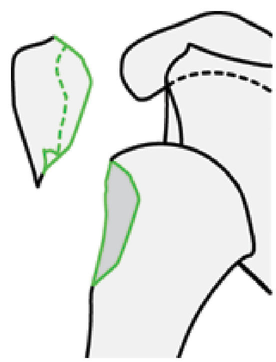
A – CLINICAL SOURCE DOCUMENT

Adressographe :

Date de la signature du formulaire de consentement	**Date**____ / _____ / _______ jj mm aaaa
Date de la visite à HSCM	**Date**____ / _____ / _______ jj mm aaaa
Date de l'échographie (clinique St-Martin)	**Date**____ / _____ / _______ jj mm aaaa

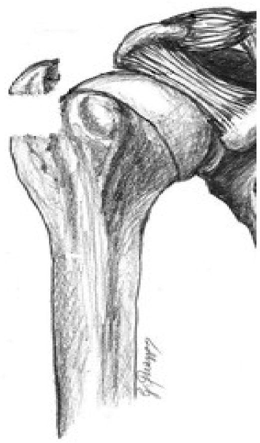
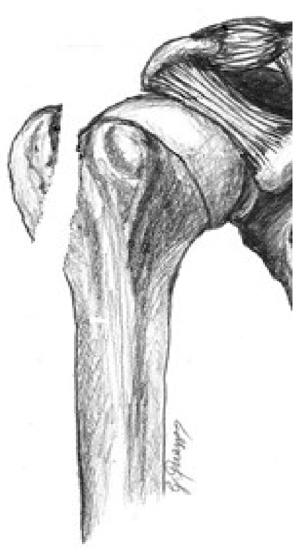
Évaluation		
Sexe	☐ Féminin	☐ Masculin
Poids : _____________ lbs ou kg	**Taille :** _____________pces ou m	
Tabac	____________ cigarette (s)/ jour, depuis _____________ d'années	
	☐ Cessé, depuis ___________ d'années	
Alcool	____________ consommation (s)/ jour – semaine (encercler)	

Date de l'accident	________/________/__________ jj mm aaaa		
Dominance manuelle	☐ Gauche	☐ Droite	☐ Ambidextre
Côté de la fracture	☐ Gauche	☐ Droite	
Mécanisme de l'accident	☐ Sports _______________	☐ Accident ou chute à vélo	
	☐ Accident d'auto	☐ Piéton (auto-piéton)	
	☐ Chute de sa hauteur	☐ Chute à basse vélocité	
	☐ En soulevant des objets lourds (en dehors du sport)		
	☐ Autre : ____		
Autre blessure au moment de l'accident	☐ Musculo- squelettique___________________________		
	☐ Abdominale____________________________		
	☐ Thoracique__________________________		
	☐ Cérébrale___________________________		
	☐ Colonne ________________________________		

<table>
<tr><th colspan="3">Classification de la fracture</th></tr>
<tr><td>Neer II part</td><td colspan="2" rowspan="3">
</td></tr>
<tr><td>□ Not displaced</td></tr>
<tr><td>□ Displaced (>5mm, >45 degrees)</td></tr>
<tr><td colspan="3">AO classification
<u>General principles :</u> A- Extra-articular unifocal fracture 1- Tuberosity</td></tr>
<tr><td>□ Type A 1.3. Greater tuberosity, not displaced
</td><td>□ Type A 1.2. Greater tuberosity, displaced
</td><td>□ Type A 1.3. displaced with glenohumeral dislocation
</td></tr>
</table>

Classification de la fracture

Radiographic (Morphologic) Classification

□ **Avulsion Type** 	□ **Depression Type** 
□ **Split Type** 	□ **Complex/ Unclassifiable**

Imagerie				
Rayon-X initial	☐ **Date** ____ / ____ / ____ dd mm aa	☐ Déplacement	☐ Latéral	
			☐ Supérieur	mm _____
Rayon-X post-op /suivi #1	☐ **Date** ____ / ____ / ____ dd mm aa	☐ Déplacement	☐ Latéral	
			☐ Supérieur	mm _____
Rayon-X final	☐ **Date** ____ / ____ / ____ dd mm aa	☐ Déplacement	☐ Latéral	
			☐ Supérieur	mm _____

Échographie:

Voir rapport en annexe

Traitements

☐ Conservateur		
☐ Attelle en abduction ☐ Stevenson / écharpe	Date de début ______/_______/________ jj mm aaaa	☐ Date de fin ____/_____/______ jj mm aaaa

☐Chirurgical			
☐ Date de la chirurgie ____/_____/______ jj mm aaaa		☐ Durée ______ hre ______ min	
☐ Date d'admission ____/_______/______ jj mm aaaa		☐ Date de congé ____/______/______ jj mm aaaa	
☐ **Approche**	☐ Deltopectoral	☐ Arthroscopie	☐ Deltoid split
	☐ Autre ____		
☐ **1 incision** _________cm		☐ **2 incisions** Proximal ______cm / distal ______cm	
☐ **Implant**____			

Chirurgie additionnelle **(ex : ROFI à un autre site)**	☐ Date ____/_______/______ jj mm aaaa
	☐ Type __________________________

<table>
<tr><th colspan="3">Post opératoire</th></tr>
<tr><td rowspan="3">Attelle post-opératoire</td><td colspan="2">☐ Oui ____________________________</td></tr>
<tr><td>☐ Début
_____ / _____ / _____
dd mm aa</td><td>☐ Fin
_____ / _____ / _____
dd mm aa</td></tr>
<tr><td colspan="2">☐ Non ____________________________</td></tr>
<tr><td rowspan="2">Status neurovasculaire des membres supérieurs</td><td colspan="2">☐ Intact</td></tr>
<tr><td colspan="2">☐ Déficit __________________________</td></tr>
<tr><td rowspan="2">Prophylaxie antibiotique</td><td colspan="2">☐ Cefazoline 1 g iv tid
☐ Autre: _________________________mg,</td></tr>
<tr><td>☐ Début
_____ / _____ / _____
dd mm aa</td><td>☐ Fin
_____ / _____ / _____
dd mm aa</td></tr>
</table>

Complications post-traitement		
Capsulite adhésive	☐ Non	☐ Oui, voir note de visite
Complications dû au matériel	☐ Non	☐ Oui, voir note de visite
Rupture de coiffe	☐ Non	☐ Oui, voir note de visite
Luxation/instabilité récidivante	☐ Non	☐ Oui, voir note de visite
Déplacement de la tubérosité	☐ Non	☐ Oui, voir note de visite
Non-union	☐ Non	☐ Oui, voir note de visite
Fracture dû à la chirurgie	☐ Non	☐ Oui, voir note de visite
Autre	____________________	

Compensations		
☐ CSST	☐ SAAQ	☐ Assurance personnelle

Occupation avant l'accident (cochez tout ce qui s'applique)	
☐ Employé, physique	☐ Employé, sédentaire
☐ Sans emploi	☐ Étudiant
☐ Retraité, actif	☐ Retraité, sédentaire

Niveau d'activité (sport) avant l'accident	
Type : ____________________________	Fréquence : _____________fois / semaine

Retour aux activités après l'accident		
Travail	☐ Non	☐ Oui, date____ / _____ / ______ (jj mm aaaa) Lesquels_________________
Sports	☐ Non	☐ Oui, date____ / _____ / _____ (jj mm aaaa) Lesquels_________________

Antécédents chirurgicaux	
☐	☐
☐	☐
Antécédents médicaux	
☐	☐
☐	☐
Maladie actuelle	
☐	☐
☐	☐
Médicaments	
☐	☐
☐	☐
☐	☐

Questionnaires de qualité de vie		
WORC	**Date** ___ / ___ / ___ jj mm aa	**Score** ____________
Quick-DASH	**Date** ___ / ___ / ___ jj mm aa	**Score** ____________
Sf-12 v2	**Date** ___ / ___ / ___ jj mm aa	**Score PCS** ____________ **Score MCS**____________
Constant	**Date** ___ / ___ / ___ jj mm aa	**Score** ____________
Échelle de douleur	**Date** ___ / ___ / ___ jj mm aa	**Score** ____________

Calcul des questionnaires: www.orthopaediscores.com

Calcul du Sf-12 v2 sur http://www.qualitymetric.com/demos/sf-12v2.aspx sf 12

Note de visite
Signature et date

B – PATIENT QUESTIONNAIRES

B.1 – Constant-Murley Shoulder Outcome Score

DOULEUR DE L'ÉPAULE (15 points)**: Faites un "x" sur la ligne**	
SOUS TOTAL	**______ / 15**

0 Sévère	**5** Modérée	***10*** *Légère*	**15** Aucune

ACTIVITÉS DE LA VIE QUOTIDIENNE (20 POINTS)		**DROITE**	**GAUCHE**
	SOUS TOTAL	**______/20**	
Handicap lors de l'activité professionnelle ou quotidienne **______ 4 points**	(0) TRAVAIL IMPOSSIBLE OU NON REPRIS		
	(1) GÊNE IMPORTANTE		
	(2) GÊNE MOYENNE		
	(3) GÊNE LÉGÈRE, limitation légère		
	(4) AUCUNE GÊNE, travail sans restriction		
Handicap lors de l'activité de loisir ou sportive **______ 4 points**	(0) ACTIVITÉS/SPORTS IMPOSSIBLE		
	(1) GÊNE IMPORTANTE		
	(2) GÊNE MOYENNE		
	(3) GÊNE LÉGÈRE		
	(4) AUCUNE GÊNE, sports ou activités		
Perturbation du sommeil par la douleur **______ 2 points**	(2) ACUNE PERTURBATION		
	(1) SOMMEIL INTERROMPU PAR LA DOULEUR		
	(0) DOULEURS INSOMNIANTES		
Niveau d'utilisation raisonnable du bras **______10 points**	(2) CEINTURE		
	(4) XYPHOIDE		
	(6) COU		
	(8) TÊTE		
	(10) AU DESSUS DE LA TÊTE		

DEGRÉ DE MOBILITÉ ROM° (40 points)		DROITE	GAUCHE
	SOUS TOTAL		______/40
FLEXION **Cochez** 1 seulement **NOTE :** tous les mouvements doivent être faits sans douleur et sans assistance ______**10 points**	(0) 0- 30°		
	(2) 31- 60°		
	(4) 61- 90°		
	(6) 90- 120°		
	(8) 121- 150°		
	(10) 151- 180°		
ÉLÉVATION LATÉRAL **ABDUCTION** **Cochez** 1 case seulement ______**10 points**	(0) 0- 30°		
	(2) 31- 60°		
	(4) 61- 90°		
	(6) 90- 120°		
	(8) 121- 150°		
	(10) 151- 180°		
ROTATION EXTERNE **Cochez toutes** les cases qui s'appliquent **NOTE :** main ne doit pas toucher la tête ou le cou ______**10 points**	(2) Main derrière la tête, coude en avant		
	(2) Main derrière la tête, coude en arrière		
	(2) Main sur la tête, coude en avant		
	(2) Main sur la tête, coude en arrière		
	(2) Élévation, complète depuis le sommet de la tête		
ROTATION INTERNE Cochez 1 case seulement ______**10 points**	(0) Dos de la main au côté de la cuisse		
	(2) Dos de la main à la fesse		
	(4) Dos de la main région lombosacré (sacrum)		
	(6) Dos de la main à taille (L 3)		
	(8) Dos de la main à dernière côte (T 12)		
	(10) Dos de la main à la région interscapulaire (T 7)		

<table>
<tr><td rowspan="4">**Cochez** 1 case seulement
☐
DYNAMOMÈTRE ÉLECTRONIQUE
☐
BALANCE À RESSORT STANDARD
☐
POIDS LIBRES</td><td colspan="4">**FORCE MUSCULAIRE (25 POINTS)**</td></tr>
<tr><td colspan="3">**SOUS TOTAL**</td><td>_____/25</td></tr>
<tr><td rowspan="2">**NOTE :** Nombre de livres de traction contre résistance (90 ° abduction dans le plan de l'omoplate)

1 POINT/ LIVRE, MAX. 25 LIVRES</td><td>**1er ESSAI**</td><td>**2e ESSAI**</td><td>**3e ESSAI**</td></tr>
<tr><td>**DROITE** _____

GAUCHE _____</td><td>**DROITE** _____

GAUCHE _____</td><td>**DROITE** _____

GAUCHE _____</td></tr>
</table>

CALCUL		
ÉPAULE AFFECTÉE		VALEUR ABSOLUE en points (sur 100) ______ **100**
☐ **DROITE**	☐ **GAUCHE**	VALEUR PONDÉRÉE (en %) _______ **%**

MESURES DU PHYSIOTHÉRAPEUTE (AVEC GONIOMÈTRE)		
ÉPAULE	**DROITE**	**GAUCHE**
ABDUCTION	_______°	_______°
FLEXION ANTÉRIEURE	_______°	_______°
ROTATION INTERNE	_______°	_______°
ROTATION EXTERNE	_______°	_______°
EXTENSION	_______°	_______°
COUDE		
EXTENSION	_______°	_______°
FLEXION	_______°	_______°
PRONATION	_______°	_______°
SUPINATION	_______°	_______°

B.2 – WORC (Western Ontario Rotator Cuff Index) – French

INDEX DU WESTERN ONTARIO

SUR LA COIFFE DES ROTATEURS

(WORC)©

Outil pour l'évaluation de la qualité de vie des patients souffrant de pathologie de la coiffe des rotateurs

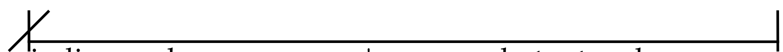
Exemple de référence : The Development and Evaluation of a Disease-Specific Quality of Life Measurement Tool for Rotator Cuff Disease: The Western Ontario Rotator Cuff Index , American Academy of Orthopaedic Surgeon’s Annual Meeting Book of Abstracts, 1998.

INSTRUCTIONS AUX PATIENTS

Dans le questionnaire suivant, nous vous demandons de répondre aux questions comme expliqué ci-dessous. Veuillez donner vos réponses en mettant une barre oblique "/" sur la ligne horizontale.

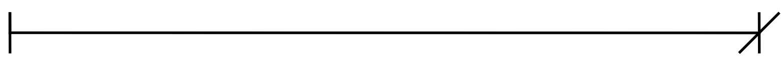
NOTE :

1. Si vous mettez la barre oblique "/" à l'extrémité gauche de la ligne, comme ceci :



vous indiquez alors que vous n'avez pas du tout mal.

2. Si vous mettez la barre oblique "/" à l'extrémité droite de la ligne, comme ceci :



vous indiquez alors que la douleur est extrêmement forte.

3. Veuillez noter que:

a) plus vous mettez la barre oblique "/" vers la droite, **plus** vous ressentez le symptôme décrit

b) plus vous mettez la barre oblique "/" vers la gauche, **moins** vous ressentez le symptôme décrit

c) merci de ne pas mettre la barre oblique "/" en dehors de la ligne

Dans ce questionnaire nous vous demandons d'indiquer à quel point vous avez ressenti les symptômes dus à votre problème à l'épaule au cours des 7 derniers jours. Si vous n'êtes pas sûr(e) de l'épaule concernée, ou si vous avez d'autres questions, veuillez les poser avant de répondre au questionnaire.

Si, pour une raison ou pour une autre, vous ne comprenez pas une question, veuillez lire les explications qui se trouvent à la fin du questionnaire. Vous pourrez alors mettre la barre oblique "/" sur la ligne horizontale, à l'endroit qui correspond à votre réponse. **Si vous n'êtes pas concerné(e) par une question ou si vous n'avez pas eu ce symptôme au cours des 7 derniers jours, veuillez imaginer la réponse qui correspondrait le mieux à votre cas.**

Section A : Symptômes Physiques

INSTRUCTIONS AUX PATIENTS

Les questions suivantes portent sur les symptômes physiques que vous avez ressentis liés de votre problème à l'épaule. Dans tous les cas, veuillez indiquer à quel point vous avez ressenti ces symptômes au cours de la dernière semaine. (Veuillez indiquer vos réponses en mettant une barre oblique « / »)

1. A quel point la douleur ressentie dans l'épaule a-t-elle été aiguë?

aucune douleur |————————————————| douleur extrême

2. A quel point la douleur ressentie dans l'épaule a-t-elle été constante, lancinante ?

aucune douleur |————————————————| douleur extrême

3. A quel point avez-vous senti une faiblesse dans l'épaule ?

aucune faiblesse |————————————————| faiblesse extrême

4. Avez-vous ressenti une raideur ou une diminution de la mobilité de l'épaule ?

aucune raideur |————————————————| raideur extrême

5. A quel point avez-vous été gêné(e) par des claquements ou des grincements dans l'épaule ?

pas du tout gêné(e) — extrêmement gêné(e)

6. A quel point avez-vous été gêné(e) au niveau des muscles du cou à cause de votre épaule ?

pas du tout gêné(e) — extrêmement gêné(e)

SECTION B : Sports / Loisirs

INSTRUCTIONS AUX PATIENTS

La section suivante porte sur les conséquences que votre problème d'épaule a eues sur vos activités professionnelles, sportives, ou vos loisirs au cours de la dernière semaine. Veuillez indiquer vos réponses en mettant une barre oblique « / ».

7. A quel point votre problème d'épaule a-t-il eu des conséquences sur votre forme physique ?

aucune conséquence — conséquences extrêmes

8. A quel point a-t-il été difficile pour vous de faire des pompes ou d'autres exercices sollicitant beaucoup l'épaule ?

pas du tout difficile — extrêmement difficile

9. A quel point votre problème d'épaule a-t-il eu des conséquences sur votre capacité à lancer quelque chose loin ou avec force ?

aucune conséquence — conséquences extrêmes

10. A quel point avez-vous eu peur que quelque chose ou quelqu'un cogne votre épaule ?

pas du tout peur — extrêmement peur

SECTION C : Travail et activités quotidiennes

INSTRUCTIONS AUX PATIENTS

La section suivante porte sur les conséquences que votre problème d'épaule a eu sur votre capacité à effectuer votre travail ou vos activités quotidiennes dans la maison ou à l'extérieur. Veuillez indiquer vos réponses, pour la semaine dernière, en mettant une barre oblique « / »).

11. A quel point a-t-il été difficile pour vous de réaliser vos tâches quotidiennes autour de la maison ou à l'extérieur ?

pas du tout difficile — extrêmement difficile

12. A quel point a-t-il été difficile pour vous de faire quelque chose les bras levés plus haut que les épaules?

pas du tout difficile — extrêmement difficile

13. A quel point avez-vous eu besoin de vous servir de votre autre bras à la place de celui qui vous fait mal ?

pas du tout besoin — tout le temps besoin

14. A quel point vous a-t-il été difficile de soulever des objets lourds à hauteur d'épaule ou en dessous du niveau de l'épaule ?

aucune difficulté — difficulté extrême

SECTION D : Mode de vie

INSTRUCTIONS AUX PATIENTS

La section suivante porte sur les conséquences que votre problème d'épaule a eu sur votre mode de vie. N'oubliez pas d'indiquer vos réponses, pour la semaine dernière, en mettant une barre oblique « / »).

15. A quel point avez-vous eu du mal à dormir à cause de votre épaule ?

aucune difficulté — difficulté extrême

16. A quel point avez-vous eu du mal à vous coiffer à cause de votre épaule ?

aucune difficulté — difficulté extrême

17. A quel point vous a-t-il été difficile de vous «bagarrer/chahuter» avec des personnes de votre famille ou des amis?

pas du tout difficile — extrêmement difficile

18. A quel point avez-vous eu du mal à vous habiller ou à vous déshabiller ?

aucune difficulté — difficulté extrême

SECTION E : Émotions

INSTRUCTIONS AUX PATIENTS

Les questions suivantes portent sur ce que vous avez ressenti au cours de la dernière semaine à cause de votre problème à l'épaule. Veuillez indiquer vos réponses en mettant une barre oblique « / ».

19. A quel point vous êtes-vous senti(e) frustré(e) à cause de votre épaule ?

pas du tout frustré(e) —————————— extrêmement frustré(e)

20. A quel point vous êtes-vous senti(e) déprimé(e) ou avez-vous eu le cafard à cause de votre épaule ?

pas du tout déprimé(e) —————————— extrêmement déprimé(e)

21. A quel point avez-vous été inquiet(-ète) ou préoccupé(e) par les conséquences de votre problème d'épaule sur votre travail?

pas du tout inquiet(-ète) —————————— extrêmement inquiet(-ète)

MERCI D'AVOIR REPONDU A CES QUESTIONS

Explications des questions de l'Index pour la coiffe des rotateurs du Western Ontario WORC

Section A : Symptômes Physiques

Question 1.

Fait référence à une douleur soudaine et de courte durée dans l'épaule, ou à une douleur que vous pourriez décrire comme fulgurante.

Question 2.

Fait référence à une douleur sourde, de fond, qui semble être toujours présente, contrairement à la douleur aiguë dont on parle dans la question 1.

Question 3.

Fait référence à un manque de force pour faire un mouvement.

Question 4.

Fait référence à la sensation que l'articulation ne peut pas bouger. Cette sensation est souvent présente le matin au lever, après avoir fait de l'exercice ou après un moment d'inactivité. Il peut également s'agir de l'impossibilité d'effectuer complètement un mouvement de l'épaule, quel que soit le sens de ce mouvement.

Question 5.

Fait référence aux bruits ou sensations que vous ressentez dans l'épaule lorsque vous faites un mouvement.

Question 6.

Fait référence aux tensions, aux douleurs ou aux spasmes ressentis(es) dans les muscles du cou et qui semblent être dus à votre problème d'épaule.

Section B : Sports/Loisirs

Question 7.

Fait référence à la forme physique que vous aviez avant votre problème d'épaule. Ceci comprend une diminution du tonus ou de la force musculaire, et de la forme ou de la résistance cardiovasculaire.

Question 8

Fait référence à toute activité qui demande de lever les bras au-dessus de la tête et qui nécessite de la force. Vous pouvez prendre en compte n'importe quelle activité telle que lancer un ballon ou une balle, smasher au volley-ball, envoyer un bâton à votre chien, nager le crawl, servir en tennis, etc.

Question 9

Fait référence à n'importe quel type d'exercice qui vous demande de la force dans l'épaule comme les pompes, ou les exercices sur un banc de musculation, etc.

Question 10.

Veuillez tenir compte des fois où vous avez peur ou faites attention à ce que rien ni personne ne vous cogne l'épaule, comme par exemple lorsque vous faites du sport, lorsque vous êtes dans une pièce pleine de monde, dans un ascenseur ou quand quelqu'un vous tape sur l'épaule pour vous dire bonjour.

Section C : Travail et activités quotidiennes

Question 11.

Fait référence aux activités telles que ratisser, se servir d'une pelle, passer l'aspirateur, faire la poussière (épousseter), désherber, biner, nettoyer les vitres ou laver les sols, etc…)

Explications des questions (suite)

Question 12.

Fait référence à toute activité qui vous demande de lever les bras plus haut que les épaules comme par exemple, ranger de la vaisselle dans un placard ou attraper un objet en hauteur, peindre un plafond ou peindre en levant les bras plus haut que les épaules, etc…

Question 13.

Il s'agit ici de savoir si vous vous servez de votre autre bras pour les activités ou travaux pour lesquels vous vous serviriez en temps normal du bras qui vous fait mal. Si votre autre épaule est également atteinte de la pathologie de la coiffe des rotateurs ou d'une autre maladie, répondez en imaginant à ce que vous auriez dit si cette épaule n'était pas touchée.

Question 14.

Ne fait pas référence au fait de lever quelque chose au-dessus de la tête, mais au fait de soulever quelque chose de lourd en dessous du niveau de l'épaule comme par exemple un sac de courses, une caisse de bouteilles, une valise, du matériel de travail, des livres, etc. ..

<u>Section D : Mode de vie</u>

Question 15.

Fait référence au fait de devoir changer de position pour dormir, de vous réveiller la nuit, d'avoir du mal à vous endormir ou de vous réveiller fatigué(e).

Question 16.

Fait référence à tout ce que vous faites à vos cheveux comme par exemple, les peigner, les brosser, les laver, tout ce qui vous demande de lever le bras qui vous fait mal.

Question 17.

Fait référence à tout type de jeu un peu musclé ou énergique, que vous feriez habituellement en famille ou avec des amis.

Question 18.

Il s'agit de savoir si vous pouvez faire ou défaire une fermeture éclair ou boutonner / déboutonner quelque chose dans le dos, mettre ou enlever un soutien-gorge, enfiler ou enlever un pull ou un tee-shirt en le passant par la tête, ou ajuster un vêtement dans le dos.

<u>Section E : Emotions</u>

Question 19.

Fait référence à la frustration que vous ressentez à cause de votre incapacité à faire les choses que vous aviez l'habitude de faire ou celles que vous souhaiteriez faire.

Question 20.

Les expressions «avoir le cafard» ou «être déprimé(e)» parlent d'elles-mêmes.

Question 21.

Il s'agit de savoir si vous craignez que votre problème d'épaule s'aggrave au lieu de s'améliorer ou de se stabiliser, et si vous vous inquiétez des conséquences sur vos occupations ou votre travail (que ce soit à la maison ou à l'extérieur).

TABLEAUX RECAPITULATIFS POUR L'INDEX DU WESTERN ONTARIO SUR LA COIFFE DES ROTATEURS (WORC)

1. Mesurez la distance de l'extrémité gauche de la ligne jusqu'à la barre oblique et calculez le score sur 100 (à 0.5 mm. près). Notez ce score dans l'espace prévu à cet effet.
2. Vous pouvez calculer un score total pour chaque section (Symptômes Physiques/600; Sports et loisirs/400; Travail/400 et Mode de vie/400;Emotions/400) ou bien un score total de toutes les sections sur 2100.
3. Certains trouvent qu'il est plus parlant de calculer les scores sur 100, autrement dit, de calculer le pourcentage équivalent au score obtenu. Etant donné que le score le moins bon est 2100, le score total est déduit de 2100 et divisé par 21. Par exemple, si le score total de votre patient est de 1625, le pourcentage du score sera

$$\frac{2100 - 1625}{21 \times 100} = 22.6\%$$

Procédez de la même manière pour chaque section.

SYMPTOMES PHYSIQUES	SPORTS / LOISIRS	TRAVAIL	MODE DE VIE
SP 1 ________.____	S 7 ________.____	T11________.____	MV 15 ______.____
SP 2 ________.____	S 8 ________.____	T12________.____	MV 16 ______.____
SP 3 ________.____	S 9 ________.____	T13________.____	MV 17 ______.____
SP 4 ________.____	S 10 _______.____	T14 _______.____	MV 18 ______.____
SP 5 ________.____	TOTAL______.____	TOTAL_____._____	TOTAL______.____
SP 6 ________.____			
TOTAL______._____			

EMOTIONS
E 19 ________.____
E 20 ________.____
E 21 ________.____
TOTAL _______.____

RÉSUMÉ
SP ________._____
S ________._____
T ________._____
MV ________._____
E ________._____
TOTAL:__________._____

B.3 – WORC (Western Ontario Rotator Cuff Index) – English

WESTERN ONTARIO

ROTATOR CUFF INDEX

(WORC)©

A disease-specific quality of life measurement tool for patients with rotator cuff disease

Suggested citation: The Development and Evaluation of a Disease-Specific Quality of Life Measurement Tool for Rotator Cuff Disease: The Western Ontario Rotator Cuff Index, Clinical Journal of Sport Medicine 13(2):84-92,2003.

INSTRUCTIONS TO PATIENTS

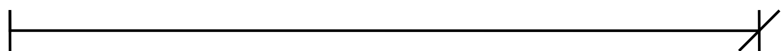
In the following questionnaire you will be asked to answer questions in the following format and you should give your answer by putting a slash "/" on the horizontal line.

NOTE:

1. If you put a slash "/" at the left end of the line i.e.

then you are indicating that you have no pain.

2. If your put your slash "/" at the right end of the line i.e.



then you are indicating that your pain is extreme.

3. Please note:

a) that the further to the right you put your slash "/", the **more** you experience that symptom.

b) that the further to the left you put your slash "/" , the **less** you experience that symptom.

c) please do not place your slash "/" outside the end markers

You are asked to indicate on this questionnaire, the amount of a symptom you have experienced in the past week as related to your problematic shoulder. If you are unsure about the shoulder that is involved or you have any other questions, please ask before filling out the questionnaire.

If for some reason you do not understand a question, please refer to the explanations that can be found at the end of the questionnaire. You can then place your slash "/» on the horizontal line at the appropriate place. **If an item does not pertain to you or you have not experienced it in the past week, please make your "best guess" as to which response would be the most accurate.**

Section A: Physical Symptoms

INSTRUCTIONS TO PATIENTS

The following questions concern the physical symptoms you have experienced due to your shoulder problem. In all cases, please enter the amount of the symptom you have experienced in the last week. (Please mark your answers with a slash "/")

1. How much sharp pain do you experience in your shoulder?

no pain — extreme pain

2. How much constant, nagging pain do you experience in your shoulder?

no pain — extreme pain

3. How much weakness do you experience in your shoulder?

no weakness — extreme weakness

4. How much stiffness or lack of range of motion do you experience in your shoulder?

no stiffness — extreme stiffness

5. How much are you bothered by clicking, grinding or crunching in your shoulder?

none — extreme

6. How much discomfort do you experience in the muscles of your neck because of your shoulder?

no discomfort — extreme discomfort

SECTION B: Sports/Recreation

INSTRUCTIONS TO PATIENTS

The following section concerns how your shoulder problem has affected your sports or recreational activities in the past week. For each question, please mark your answers with a slash "/".)

7. How much has your shoulder affected your fitness level?

not affected — extremely affected

8. How much has your shoulder affected your ability to throw hard or far?

not affected — extremely affected

9. How much difficulty do you have with someone or something coming in contact with your affected shoulder?

no fear — extremely fearful

10. How much difficulty do you experience doing push-ups or other strenuous shoulder exercises because of your shoulder?

no difficulty — extreme difficulty

SECTION C: Work

INSTRUCTIONS TO PATIENTS

The following section concerns the amount that your shoulder problem has affected your work around or outside of the home. Please indicate the appropriate amount for the past week with a slash "/".

11. How much difficulty do you experience in daily activities about the house or yard?

no difficulty — extreme difficulty

12. How much difficulty do you experience working above your head?

no difficulty — extreme difficulty

13. How much do you use your uninvolved arm to compensate for your injured one?

not at all — constant

14. How much difficulty do you experience lifting heavy objects at or below shoulder level?

no difficulty — extreme difficulty

SECTION D: Lifestyle

INSTRUCTIONS TO PATIENTS

The following section concerns the amount that your shoulder problem has affected or changed your lifestyle. Again, please indicate the appropriate amount for the past week with a slash "/".

15. How much difficulty do you have sleeping because of your shoulder?

no difficulty ——— extreme difficulty

16. How much difficulty have you experienced with styling your hair because of your shoulder?

no difficulty ——— extreme difficulty

17. How much difficulty do you have "roughhousing or horsing around" with family or friends?

no difficulty ——— extreme difficulty

18. How much difficulty do you have dressing or undressing?

no difficulty ——— extreme difficulty

SECTION E: Emotions

INSTRUCTIONS TO PATIENTS

The following questions relate to how you have felt in the past week with regard to your shoulder problem. Please indicate your answer with a slash "/".

19. How much frustration do you feel because of your shoulder?

no frustration extreme frustration

20. How "down in the dumps" or depressed do you feel because of your shoulder?

none extreme

21. How worried or concerned are you about the effect of your shoulder on your occupation?

not at all extremely concerned

THANK YOU FOR COMPLETING THE QUESTIONNAIRE

An Explanation of the Meaning of the Questions in the Western Ontario Rotator Cuff Index WORC

Section A: Physical Symptoms

Question 1

Refers to pain in your shoulder that is quick and sudden or that you might refer to as a catching type of pain.

Question 2

Refers to the dull background ache that always seems to be there as opposed to the sharp pain that is referred to in question 1.

Questions 3

Refers to a lack of strength to carry out a movement.

Question 4

Refers to the feeling of the joint not wanting to move. This is often experienced in the morning upon rising, after exercise or after a period of inactivity. It could also refer to not having full movement of your shoulder in all or any direction(s).

Question 5

Refers to any of these sounds or feelings that you experience in your shoulder with any type of movement.

Question 6

Refers to the amount of tension, pain or spasm that you experience in the muscles of your neck that seems to be caused by your shoulder problem.

Section B: Sports/Recreation

Question 7

Refers to the fitness level you maintained before your shoulder became a problem. Include a decrease in muscle tone or strength level, cardiovascular fitness or strength level.

Question 8

Refers to any overhead activity requiring you to use some force in its execution. If you do not throw a ball, please consider any other activity such as spiking in volleyball, throwing a stick to your dog, swimming the front crawl, serving in tennis, etc.

Question 9

Please consider whenever you have been afraid or wary of someone or something hitting or coming into contact with your affected shoulder such as in a sport, a crowded room, an elevator or someone slapping your shoulder in a greeting.

Question 10.

Refers to any exercise requiring you to put force on your shoulder such as push-ups, bench press etc.

Section C: Work

Question 11.

This refers to activities such as raking, shoveling, vacuuming, dusting, weeding, hoeing and washing windows or floors etc.

Explanation of Questions cont.

Question 12.

Refers to any activity requiring you to raise your arms above shoulder level ie. putting dishes in a cupboard, reaching for an object, painting a ceiling or painting above shoulder level etc.

Question 13.

Refers to if you now use your other arm for any activity or work where you would ordinarily have done it with the arm on the problematic side. If your other shoulder is also symptomatic from Rotator Cuff Disease or some other disease, then consider how you would answer the question if that shoulder was normal.

Question 14

This does not refer to lifting above your head but to lifting any heavy objects below shoulder level e.g. a bag of groceries, case of pop, suitcase, equipment at work, books, etc.

Section D: Lifestyle

Question 15

Refers to having to change your sleeping position, waking up during the night, trouble getting to sleep or waking up feelng unrested.

Question 16.

Refers to anything that you would do to your hair such as combing, brushing or washing that requires you to reach up with your problematic arm.

Question 17

Refers to any type of rough or vigorous play activity that you would normally engage in with your family or friends.

Question 18

Refers to reaching behind to do up or undo a zipper or button(s), do up or undo a bra, pulling on or removing a sweater or top over your head, or tucking in a shirt or top.

Section E: Emotions

Question 19.

Refers to the frustration you feel because of your inability to do things you used to do or that you want to do but can’t.

Question 20.

Down-in-the-dumps or depressed is self-explanatory

Question 21.

Refers to worrying about your shoulder getting worse instead of better or staying the same and being concerned about what effect that will have on your occupation or work (consider work inside or outside the home).

SCORING OF THE WESTERN ONTARIO ROTATOR CUFF (WORC) INDEX

4. Measure the distance from the left side of the line and calculate the score out of 100 (recorded to the nearest 0.5 mm.). Write it into the space provided for that question.
5. You can calculate a total score for each domain (Physical Symptoms/600; Sports and Recreation/400; Work/400 and Lifestyle/400;Emotions/300) or the total score for the domains can be summed for an aggregate score out of 2100.
6. Some find it more meaningful to report scores out of 100 i.e. a percentage of normal score. Since the worst possible score is 2100, the aggregate score is subtracted from 2100 and divided by 2100 x 100 for the %. e.g. if your patient's total aggregate score = 1625; then the percentage score would be

$$\frac{2100 - 1625}{2100} \times 100 = 22.6\%$$

The same applies for each domain.

PHYSICAL SYMPTOMS

SP 1 ________.____

SP 2 ________.____

SP 3 ________.____

SP 4 ________.____

SP 5 ________.____

SP 6 ________.____

TOTAL________.______

SPORTS / RECREATION

S 7 ________.____

S 8 ________.____

S 9 ________.____

S 10 ________.____

TOTAL_______.____

WORK

T11________.____

T12________.____

T13________.____

T14 ________.____

TOTAL_______.______

LIFESTYLE

MV 15 ______.____

MV 16 ______.____

MV 17 ______.____

MV 18 ______.____

TOTAL______.____

EMOTIONS

E 19 ________.____

E 20 ________.____

E 21 ________.____

TOTAL _______.____

SUMMARY

SP ________.______

S ________.______

T ________.______

MV ________.______

E ________.______

TOTAL:_________.____

B.4 – QuickDASH (Disabilities of the Arm, Shoulder, Hand) – French

Le QuickDASH

Fr. Canadien

INSTRUCTIONS

Ce questionnaire porte sur vos symptômes ainsi que sur votre capacité à réaliser certaines activités.

En vous basant sur votre condition de la dernière semaine, veuillez répondre à toutes les questions, en encerclant le numéro approprié.

Si vous n'avez pas eu l'occasion de réaliser une activité au cours de la dernière semaine, faites de votre mieux pour choisir la réponse qui serait la plus juste.

Répondez en vous basant sur votre capacité à réaliser la tâche sans vous soucier de comment vous l'effectuez ou de quelle main vous utilisez pour réaliser l'activité.

COTATION DU QuickDASH INCAPACITĒ/SYMPTÔME = somme des valeurs choisies -1 x 25
nombre de questions répondues

Un score du QuickDASH ne peut pas être calculé s'il y a plus qu'une réponse manquante.

COTATION DES MODULES OPTIONNELS : somme des valeurs encerclées -1 X multipliez par 25
Divisez 4(Nombre d'items)
Un score au module optionnel ne peut pas être calculé si des items ne sont pas répondus

French Canadian translation courtesy of Durand et al, Université de Sherbrooke, Longueuil, Canada

Mise en page Marie-France Poirier

QUESTIONNAIRE QuickDASH SUR LES INCAPACITÉS RELIÉES À UNE ATTEINTE AUX MEMBRES SUPÉRIEURS

Évaluez votre capacité à faire les activités suivantes au cours de la **dernière semaine** en encerclant le numéro dans la colonne appropriée. Répondez en vous basant sur votre capacité à réaliser la tâche sans vous soucier de comment vous l'effectuez ou de quelle main vous utilisez pour réaliser l'activité.

		Pas de difficulté	Difficulté légère	Difficulté moyenne	Difficulté sévère	Incapable
1	Ouvrir un pot neuf ou fermé serré.	1	2	3	4	5
2	Faire de gros travaux ménagers (ex.: laver les murs, laver les planchers).	1	2	3	4	5
3	Transporter un sac d'épicerie ou un porte document (valise).	1	2	3	4	5
4	Laver votre dos.	1	2	3	4	5
5	Utiliser un couteau pour couper des aliments.	1	2	3	4	5
6	Activités de loisirs durant lesquelles vous bougez votre bras librement (ex.: jouer au frisbee, au badminton, etc.).	1	2	3	4	5

		Pas du tout	Un peu	Moyennement	Beaucoup	Extrêmement
7	Au cours de la dernière semaine, dans quelle mesure votre problème au bras, à l'épaule ou à la main a-t-il nui à vos activités sociales habituelles avec votre famille, amis, voisins ou groupes ? (encerclez un chiffre).	1	2	3	4	5

		Pas limité du tout	Légèrement limité	Moyennement limité	Très limité	Incapable
8	Au cours de la dernière semaine, avez-vous été limité dans votre travail ou dans vos autres activités habituelles à cause de votre problème au bras, à l'épaule ou à la main ? (encerclez un chiffre)	1	2	3	4	5

Évaluez la sévérité des symptômes suivants au cours de la **dernière semaine**. (encerclez un chiffre)

		Aucune	légère	Modérée	Sévère	Extrême
9	Douleur au bras, à l'épaule ou à la main.	1	2	3	4	5
10	Picotements (fourmillements) au bras, à l'épaule ou à la main.	1	2	3	4	5

		Pas de difficulté	Difficulté légère	Difficulté moyenne	Difficulté sévère	Incapable
11	Au cours de la dernière semaine, dans quelle mesure avez-vous eu de la difficulté à dormir à cause de votre douleur au bras, à l'épaule ou à la main ? (encerclez un chiffre)	1	2	3	4	5

Calcul sur site web : www.orthopaedicscore.com et cliquez sur Quick-DASH

QUESTIONNAIRE QuickDASH SUR LES INCAPACITÉS RELIÉES À UNE ATTEINTE AUX MEMBRES SUPÉRIEURS

MODULE TRAVAIL (OPTIONNEL)

Les questions suivantes portent sur l'impact de votre problème au bras, à l'épaule ou à la main sur votre capacité à travailler (incluant « tenir maison » si cela est votre principale occupation).

Indiquez quel est votre travail même si votre problème au bras, à l'épaule ou à la main vous empêche de le réaliser actuellement : ______________________________________

□ **Je n'ai pas de travail. (Ne répondez pas à cette section.)**

Encerclez le numéro qui décrit le mieux votre capacité physique au cours de la dernière semaine. Si vous n'avez pas eu l'occasion de réaliser votre travail au cours de la dernière semaine, faites de votre mieux pour choisir la réponse qui serait la plus juste. Avez-vous eu de la difficulté à :

		Pas de difficulté	Difficulté légère	Difficulté moyenne	Difficulté sévère	Incapable
1	utiliser la même technique de travail que d'habitude ?	1	2	3	4	5
2	faire votre travail habituel à cause de votre douleur au bras, à l'épaule ou à la main ?	1	2	3	4	5
3	faire votre travail aussi bien que vous l'auriez voulu ?	1	2	3	4	5
4	passer le même nombre d'heures que d'habitude à réaliser votre travail ?	1	2	3	4	5

MODULE SPORTS/MUSIQUE (OPTIONNEL)

Les questions suivantes portent sur l'impact de votre problème au bras, à l'épaule ou à la main sur la pratique d'un instrument de musique, d'un sport ou des deux. Si vous pratiquez plus d'un sport ou d'un instrument (ou les deux), répondez en considérant l'activité qui est la plus importante pour vous.

Indiquez le sport ou l'instrument qui est le plus important pour vous peu importe si votre problème au bras, à l'épaule ou à la main vous empêche de le réaliser actuellement : ____________________

□ **Je ne pratique pas un sport ou un instrument. (Ne répondez pas à cette section.)**

Encerclez le numéro qui décrit le mieux votre capacité physique au cours de la dernière semaine. Si vous n'avez pas eu l'occasion de réaliser cette activité au cours de la dernière semaine, faites de votre mieux pour choisir la réponse qui serait la plus juste. Avez-vous eu de la difficulté à :

		Pas de difficulté	Difficulté légère	Difficulté moyenne	Difficulté sévère	Incapable
1	utiliser la même technique que d'habitude pour pratiquer votre instrument ou sport ?	1	2	3	4	5
2	pratiquer votre instrument ou sport habituel à cause de la douleur au bras, à l'épaule ou à la main ?	1	2	3	4	5
3	pratiquer votre instrument ou sport habituel aussi bien que vous l'auriez voulu ?	1	2	3	4	5
4	passer le même nombre d'heures que d'habitude à pratiquer votre instrument ou sport ?	1	2	3	4	5

Calcul sur site web : www.orthopaedicscore.com et cliquez sur Quick-DASH module Travail ou Sports/ Loisirs

B.5 – QuickDASH (Disabilities of the Arm, Shoulder, Hand) – English

QuickDASH

INSTRUCTIONS

This questionnaire asks about your symptoms as well as your ability to perform certain activities.

Please answer every question, based on your condition in the last week,by circling the appropriate number. If you did not have the opportunity to perform an activity in the past week, please make your best estimate of which response would be the most accurate.

It doesn't matter which hand or arm you use to perform the activity; please answer based on your ability regardless of how you perform the task.

Quick DASH DISABILITY/SYMPTOM SCORE = (sum of n responses) - 1 x 25, where n is equal to the number of completed responses. n

A QuickDASH score may not be calculated if there is greater than 1 missing item.

SCORING THE OPTIONAL MODULES: Add up assigned values for each response; divide by 4 (number of items); subtract 1; multiply by 25.

An optional module score may not be calculated if there are any missing items.

QuickDASH

Please rate your ability to do the following activities in the last week by circling the number below the appropriate response.

		NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE
1	Open a tight or new jar	1	2	3	4	5
2	Do heavy household chores (e.g., wash walls, floors)	1	2	3	4	5
3	Carry a shopping bag or briefcase.	1	2	3	4	5
4	Wash your bac k	1	2	3	4	5
5	Use a knife to cut food	1	2	3	4	5
6	Recreational activities in which you take some force or impact through your arm, shoulder or hand (e.g., golf, hammering, tennis, etc.).	1	2	3	4	5

		NOT AT ALL	SLIGHTLY	MODERATELY LIMITED	QUITE A BIT	EXTREMELY
7	During the past week, to what extent has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups?	1	2	3	4	5

		NOT LIMITED AT ALL	SLIGHTLY LIMITED	MODERATELY LIMITED	VERY LIMITED	UNABLE
8	During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem?	1	2	3	4	5

Please rate the severity of the following symptoms **in the last week.** (circle number)

		NONE	MILD	MODERATE	SEVERE	EXTREME
9	Arm, shoulder or hand pain.	1	2	3	4	5
10	Tingling (pins and needles) in your arm, shoulder or hand.	1	2	3	4	5

		NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	SO MUCH DIFFICULTY THAT I CAN'T SLEEP
11	During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand? (circle number)	1	2	3	4	5

WEBSITE calcul: www.orthopaedicscore.com

QuickDASH

WORK MODULE (OPTIONAL)

The following questions ask about the impact of your arm, shoulder or hand problem on your ability to work (including homemaking if that is your main work role).

Please i ndicate what your j ob/work is:_______________________________________

□ **I do not work. (You may skip this section.)**

Please circle the number that best describes your physical ability in the past week.

Did you have any difficulty:		NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE
1	using your usual technique for your work?	1	2	3	4	5
2	doing your usual work because of arm, shoulder or hand pain?	1	2	3	4	5
3	doing your work as well as you would like?	1	2	3	4	5
4	spending your usual amount of time doing your work?	1	2	3	4	5

SPORTS/PERFORMING ARTS MODULE (OPTIONAL)

The following questions relate to the impact of your arm, shoulder or hand problem on playing your musical instrument or sport or both. If you play more than one sport or instrument (or play both), please answer with respect to that activity which is most important to you.

Please indicate the sport or instrument which is most important to you:__________________________

□ **I do not play a sport or an instrument. (You may skip this section.)**

Please circle the number that best describes your physical ability in the past week.

Did you have any difficulty:		NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE
1	using your usual technique for playing your instrument or sport?	1	2	3	4	5
2	playing your musical instrument or sport because of arm, shoulder or hand pain?	1	2	3	4	5
3	playing your musical instrument or sport as well as you would like?	1	2	3	4	5
4	spending your usual amount of time practising or playing your instrument or sport?	1	2	3	4	5

WEBSITE calcul: www.orthopaedicscore.com

B.6 – Pain Scale – Bilingual

ÉCHELLE DE DOULEUR VERSION FRANÇAISE	**PAIN SCALE** **ENGLISH VERSION**
Consigne: Encerclez le chiffre correspondant au niveau de votre douleur actuelle et mettre vos initiales. L'extrémité **gauche** de l'échelle **aucune douleur**. L'extrémité **droite** correspond à la **pire douleur possible**.	**Instruction**: Circle the figure corresponding at the level of your actual pain and put your initials. The **left** end of the scale represents an **absence of pain.** The **right** end represents the **most severe pain possible**

Absence de douleur/ **No pain** ☐ **0**	☐ **1**	☐ **2**	☐ **3**	☐ **4**	☐ **5**	☐ **6**	☐ **7**	☐ **8**	☐ **9**	La pire douleur/ **Most severe pain** ☐ **10**

SATISFACTION **/ SATISFACTION**		
Avez-vous eu un analgésiant (calmant) ? / **Do you take a pain medication?**	☐ OUI/ **YES**	☐ NON/ **NO**
Êtes-vous soulagé par votre analgésiant (calmant) ? / **Was your pain relieved after you took the medication?**	☐ OUI/ **YES**	☐ NON/ **NO**
ANALGÉSIE UTILISÉE **/ ANALGESIA USED**		
Acétaminophène / **Acetaminophen**	☐ OUI/ **YES**	☐ NON/ **NO**
Acétaminophène + Tramadol / **Acetaminophen + Tramadol**	☐ OUI/ **YES**	☐ NON/ **NO**
Oxycodone / **Oxycodon**	☐ OUI/ **YES**	☐ NON/ **NO**
Morphine / **Morphine**	☐ OUI/ **YES**	☐ NON/ **NO**
Hydromorphone / **Hydromorphon**e	☐ OUI/ **YES**	☐ NON/ **NO**
Célécoxib / **Celecoxib**	☐ OUI/ **YES**	☐ NON/ **NO**

Autre, / **Other :** ____________________	Dose / **Dose** ______ mg	Total de mg/jour **/Total of mg by day) :** ________________________

B.7 – SF12v2™ Health Survey – French

Sf-12 v2

INSTRUCTIONS : Cette étude vous demande votre opinion sur votre santé. Ces informations vont nous permettre de suivre l'évolution de votre santé, ainsi que de votre capacité d'effectuer vos activités habituelles. Répondez à chaque question en cochant la réponse dans la case appropriée. Si vous n'êtes pas certain de la façon de répondre, s'il vous plaît, donnez la meilleure réponse possible.

1. En général, diriez-vous que votre santé est:

☐ Excellente ☐ Très bonne ☐ Bonne ☐ Passable ☐ Mauvaise

2. Les questions suivantes portent sur les activités que vous pourriez avoir à faire au cours d'une journée normale. Votre état de santé actuel vous limite-t-il dans ces activités ? Si oui, dans quelle mesure ?

	Mon état de santé me limite beaucoup	**Mon état de santé me limite un peu**	**Mon état de santé ne me limite pas du tout**
a. Dans les activités modérées comme déplacer une table, passer l'aspirateur, jouer aux quilles ou au golf	☐	☐	☐
b. Pour monter plusieurs étages à pied	☐	☐	☐

3. Au cours des quatre dernières semaines, avez-vous eu l'une ou l'autre des difficultés suivantes au travail ou dans vos autres activités quotidiennes à cause de votre état de santé physique ?

	Tout le temps	**La plupart du temps**	**Quelquefois**	**Rarement**	**Jamais**
a. Avez-vous accompli moins de choses que vous l'auriez voulu ?	☐	☐	☐	☐	☐
b. Avez-vous été limité(e) dans la nature de vos tâches ou de vos autres activités ?	☐	☐	☐	☐	☐

Sf-12 v2 (suite)

4. Au cours des <u>quatre dernières semaines</u>, avez-vous eu l'une ou l'autre des difficultés suivantes au travail ou dans vos autres activités quotidiennes <u>à cause de l'état votre moral</u> (comme le fait de vous sentir déprimé (e) ou anxieux (se) ?

	Tout le temps	La plupart du temps	Quelquefois	Rarement	Jamais
a. Avez-vous accompli moins de choses que vous l'auriez voulu ?	☐	☐	☐	☐	☐
b. Avez-vous fait votre travail ou vos autres activités avec moins de soin qu'à l'habitude ?	☐	☐	☐	☐	☐

5. Au cours des <u>quatre dernières semaines</u>, dans quelle mesure la <u>douleur</u> a-t-elle nui à vos activités habituelles (au travail comme à la maison)

☐ Pas du tout ☐ Un peu ☐ Moyennement ☐ Beaucoup ☐ Énormément

6. Ces questions portent sur les <u>quatre dernières semaines</u>. Pour chacune des questions suivantes, donnez la réponse qui s'approche le plus de la façon dont vous vous êtes senti(e)

	Tout le temps	La plupart du temps	Quelque fois	Rarement	Jamais
a. Vous êtes-vous senti (e) calme et serein(e)?	☐	☐	☐	☐	☐
b. Avez-vous eu beaucoup d'énergie?	☐	☐	☐	☐	☐
c. Vous êtes-vous senti(e) triste et abattu (e) ?	☐	☐	☐	☐	☐

7. Au cours des <u>quatre dernières semaines</u>, combine de fois votre état physique ou moral a-t-il nui à vos activités sociales (comme visiter des amis, des parents, etc.) ?

☐ Tout le temps ☐ La plupart du temps ☐ Parfois ☐ Rarement ☐ Jamais

B.8 – SF12v2™ Health Survey – English

SF-12 v2 Health and Well-Being

Instruction : This survey asks for your views about your health. This information will help keep track of how you feel and how well you are able to do your usual activities. Answer every question by selecting the answer as indicated. If you are unsure about how to answer a question, please give the best answer you can.

1. In general, would you say your health is:

☐ Excellent ☐ Very Good ☐ Good ☐ Fair ☐ Poor

2. The following questions are about activities you might do during a typical day. Does <u>your health now limit you</u> in these activities? If so, how much?

	Yes, limited a lot	Yes, limited a little	No, not limited at all
A. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf	☐	☐	☐
B. Climbing several flights of stairs	☐	☐	☐

3. During the <u>past 4 weeks</u>, how much of the time have you had any of the following problems with your work of other regular daily activities as a result of your physical health?

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
A. Accomplished less then you would like	☐	☐	☐	☐	☐
B. Were limited in the kind of work or other activities	☐	☐	☐	☐	☐

SF-12 v2 Health and Well-Being (suite)

4. During the past 4 weeks, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
A. Accomplished less than you would like	☐	☐	☐	☐	☐
B. Were limited in the kind of work or other activities	☐	☐	☐	☐	☐

5. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

☐ Not at all ☐ A little bit ☐ Moderately ☐ Quite a bit ☐ Extremely

6. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past 4 weeks

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
A. Have you felt calm and peaceful?	☐	☐	☐	☐	☐
B. Did you have a lot of energy?	☐	☐	☐	☐	☐
C. Have you felt downhearted and depressed?	☐	☐	☐	☐	☐

7. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting friends, relatives, etc.)?

☐ All of the time ☐ Most of the time ☐ Some of the time ☐ A little of the time ☐ None of the time

C – ULTRASOUND SOURCE DOCUMENT

FRACTURES GROSSE TUBÉROSITÉ – ÉCHOGRAPHIE DE L'ÉPAULE

COTÉ DROIT ☐ GAUCHE ☐

BICEPS GOUTTIÈRE IN ☐ SUBLUXÉ ☐ OUT ☐

BURSITE OUI ☐ NON ☐

TENDINOPATHIE OUI ☐ NON ☐

SUSÉPINEUX DÉCHIRURE PARTIELLE OUI ☐ NON ☐

Longueur (mm)

AP_____ Med-Lat _____

DÉCHIRURE TRANSFIXANTE OUI ☐ NON ☐

Longueur (mm)

AP_____ Med-Lat _____

INFILTRATION GRAISSEUSE NON ☐ <50% ☐ ≥ 50% ☐

ATROPHIE NON ☐ <50% ☐ ≥ 50% ☐

Surface (ratio)

Côté Fx_____ Contra_____

Épaisseur (mm)

Côté Fx_____ Contra_____

SOUSÉPINEUX DÉCHIRURE PARTIELLE OUI ☐ NON ☐

Longueur (mm)
AP_____ Med-Lat _____

DÉCHIRURE TRANSFIXANTE OUI ☐ NON ☐

Longueur (mm)
AP_____ Med-Lat _____

INFILTRATION GRAISSEUSE NON ☐ <50% ☐ ≥ 50% ☐

ATROPHIE NON ☐ <50% ☐ ≥ 50% ☐

Surface (ratio)

Côté Fx_____ Contra_____

Épaisseur (mm)

Côté Fx_____ Contra____

SOUSCAPULAIRE DÉCHIRURE PARTIEL OUI ☐ NON ☐

Longueur (mm)
AP_____ Med-Lat _____

DÉCHIRURE TRANSFIXANTE OUI ☐ NON ☐

Longueur (mm)
AP_____ Med-Lat _____

BURSITE SOUS ACROMIAL OUI ☐ NON ☐

ACCROCHAGE OUI ☐ NON ☐

AUTRES :

D – FIGURE PERMISSIONS

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FIGURE 3 : Jacobson JA. Shoulder US: Anatomy, Technique, and Scanning Pitfalls. Radiology. 2011; 260(1): 5-16. Permissions obtained via e-mail correspondence with Carolyn Nowak and Anne Arbor: 14th – 20th May 2013.

FIGURE 4 : Gruson KI, Ruchelsman DE, Tejwani NC. Isolated tuberosity fractures of the proximal humerus : current concepts. Injury. 2008; 39(3): 284-298.

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FIGURE 5 : Neer CS, 2nd. Displaced proximal humeral fractures. I: Classification and evaluation. J Bone Joint Surg Am. 1970; 52:1077-1089.

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FIGURE 7 : “Please refer to permissions from Figure 6” + Bloom MH, Obata WG. Diagnosis of Posterior Dislocation of the Shoulder with the Use of Velpeau Axillary and Angle-Up Roentgenographic Views. J Bone Joint Surg Am. 1967; 49: 943-949.

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FIGURE 8 : Khoury V, Cardinal C, Brassard P. Atrophy and Fatty Infiltration of the Supraspinatus Muscle: Sonography vs. MRI. AJR. 2008; 190(4): 1105-1111.

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FIGURE 11 : Schoffl V, Popp D, Strecker W. A simple and effective implant for displaced fractures of the greater tuberosity: the “Bamberg” plate. Arch Orthop Trauma Surg. 2011; 131:509-512.

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