Technical Note

Arthroscopic Suture Bridge Anchor Repair of Comminuted Greater Tuberosity Fracture With Double-Row Biceps Tenodesis in Elderly Osteoporotic Patients

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Abstract: Isolated greater tuberosity fractures with displacement require usually open reduction and fixation to prevent poor outcomes, but high levels of morbidity have been reported. Recently, newer techniques describe arthroscopic fixation of greater tuberosity fracture for young patients; however, in elderly patients with comminuted osteoporotic fractures, this entity is more complex. A new arthroscopic technique is described through a minimally invasive approach that allows the evaluation of the glenohumeral joint and the treatment of associated pathology. These comminuted fractures can be treated using suture bridge technique. Postoperatively, rehabilitation consists of a similar regimen to that of a rotator cuff repair. With the appropriate surgical technique, good clinical outcomes can be obtained.

Isolated greater tuberosity (GT) fractures of the proximal humerus comprise a small number of the 2-part proximal humerus fractures.[1,2] Furthermore, the insertion of the rotator cuff tendon is on the GT; thus, fractures can lead to functional impairment. Conservative treatment of isolated GT fractures has shown good results when little (<3 mm) or no displacement is present.[3] Patient-reported satisfaction scores show good results, but the average time to full recovery is 8 months. Studies show that GT fragment displacement more than 3 mm but less than 5 mm had somewhat worse clinical outcomes than those with displacement less than 3 mm but was not significant statistically.[4] While slightly displaced GT fractures can be treated appropriately nonoperatively, the displacement of the GT has been shown to increase the required force for the glenohumeral joint abduction.[5] In addition, this displacement can lead to shoulder pain, anatomic impingement, and impaired shoulder range of motion, notably external rotation.[4] Clinical outcomes with a displacement of more than 5 mm also have been shown to be inferior.[4] The amount of displacement justifying operative fixation is controversial; however, significant (>10 mm) displacement almost always requires fixation. After plain radiographs (Fig 1), to better determine the displacement, computed tomography or magnetic resonance imaging is recommended[6] (Fig 2).

Satisfactory outcomes are reported with surgical fixation of a significantly displaced GT fractures.[7] The majority of GT fractures are accompanied by rotator cuff tears.[8] Operative treatment aims to restore normal GT anatomy with a stable fixation that allows early, functional range of motion. Multiple surgical procedures are available for the treatment of a displaced GT fracture fixation, including percutaneous pin fixation, cannulated screw fixation, open reduction and internal fixation with screws or a suture anchor, and arthroscopic suture anchor fixation.[9-18] Displaced GT fractures can be treated with a suture anchor construct especially with advances in arthroscopy and some clinical studies reported promising clinical and radiologic outcomes.[10,15] Furthermore, arthroscopic treatment allows assessment and simultaneous treatment of associated glenohumeral pathologies.[11,12] The aim of this study is to report an arthroscopic technique for the

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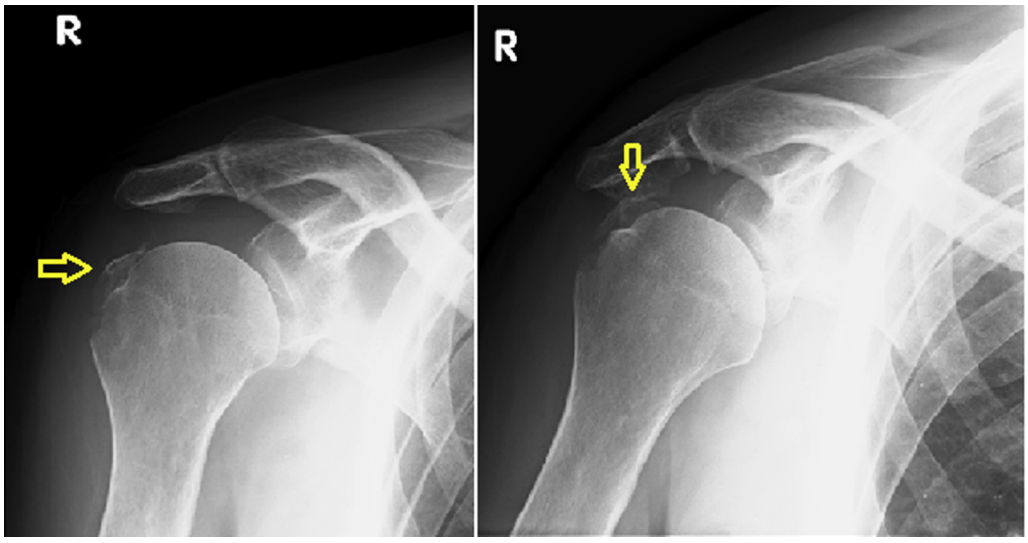

Fig 1. Radiograph of the right shoulder showing a greater tuberosity displaced avulsion fracture.

treatment of GT comminuted fracture in elderly osteoporotic patients. This technique has clear advantages, including less morbidity, ability to achieve anatomic reduction, ability to address associated glenohumeral pathologies, and stable fixation through tendon fixation.

Surgical Technique (With Video Illustration)

The patient is placed in the beach chair position with arm traction and 5-kg weights. In the beginning, an intra-articular arthroscopic examination is done through a posterior portal. Further intra-articular examination reveals normal subscapularis, unstable and friable biceps with complete pulley disruption as seen by palpation, and tear of the supraspinatus from the most anterior part of the GT. Using an anterior working portal, debridement of the fracture bed from fibrous tissue until reaching bleeding bone within the glenohumeral joint, the fracture configuration, and the fracture margin of the GT fracture are determined (Fig 3A). The main challenge with such fractures is the need for good bone-to-bone contact and restoring anatomical positioning, so care should be taken to not overdo the debridement so as not to weaken the porotic bone. The biceps tendon, seen friable and subluxated laterally, then is tagged with a suture before a biceps tenotomy is performed.

Switching to a lateral portal to access subacromial space, bursectomy and minimal acromioplasty are done. The GT fragment is identified and its

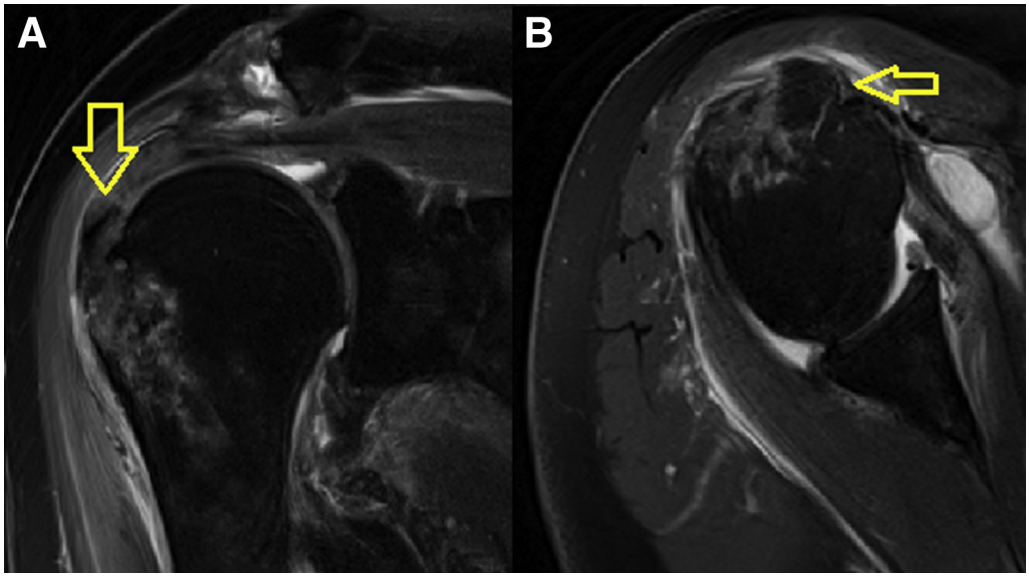

Fig 2. Magnetic resonance imaging of the right shoulder. (A) Coronal view showing greater tuberosity displaced fracture. (B) Sagittal view showing greater tuberosity displaced avulsion fracture.

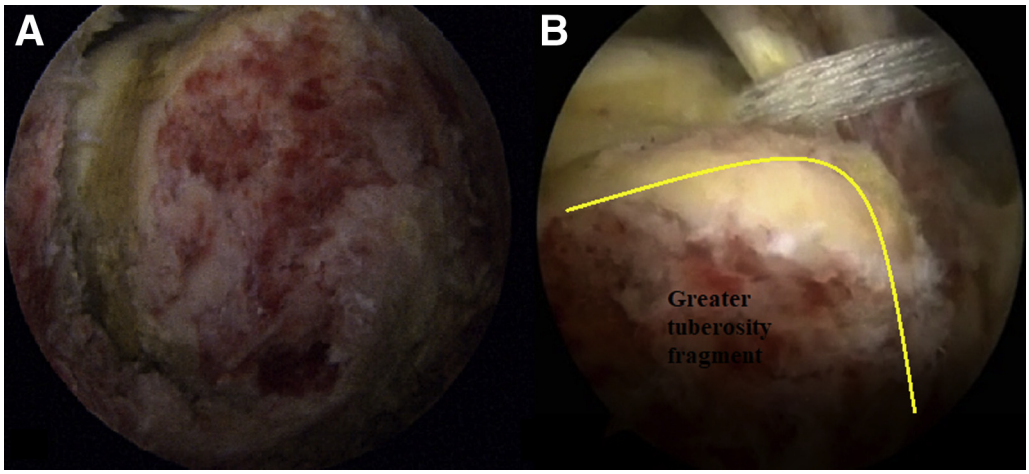

Fig 3. (A) Arthroscopic view of the right shoulder showing the debrided greater tuberosity site, (B) arthroscopic view showing the greater tuberosity fragment with the anchor placed medially.

undersurface is debrided, mobilized completely, and anatomical reduction is achieved (Fig 4A). An accessory anterosuperior lateral portal at the edge of the acromion is made for proper positioning of the anchors using an outside-in technique with a spinal needle. Three anchors are placed at the medial row (Fig 3B and 4B): the first one at the lateral edge of the bicipital groove for biceps tenodesis and supraspinatus repair, the second anchor at the most anterior and medial part of the bone defect just at the cartilage edge, and the third anchor is placed at the most posterior and medial aspect of the bone defect. A Scorpion needle device for suture passing is used to pass sutures through the biceps tendon and the supraspinatus tendon as well as a bird beak device and snare (Arthrex, Beirut, Lebanon). The proximal biceps is fixed with 2 stitches through the tendon, then distally an additional fixation is done with a 5.5-mm anchor about 20 mm distal to the first anchor in the bicipital groove to obtain a double-row stable fixation. All 4 limbs of one double-loaded anchor are inserted through the supraspinatus and infraspinatus tendon from anterior to posterior at the junction of tendon and bone interface while leaving a space of 10 to 15 mm between limbs. The medial row anchors are used for the anterior part of transtendon repair. Just like conventional transtendon repair for rotator cuff tears, the threads of the double-loaded suture anchor at the fracture site are retrieved through the rotator cuff and out through the skin using a PassPort cannula (Arthrex) and a suture shuttle relay technique, and the

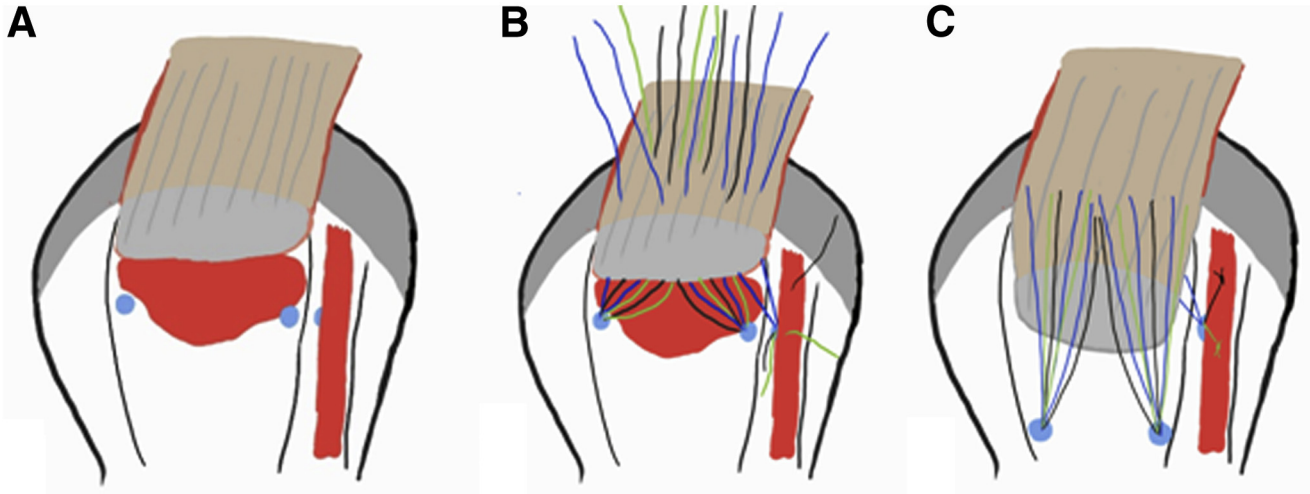

Fig 4. Red triangle shows the defect of the greater tuberosity. Gray area is the avulsed greater tuberosity, pink area is the rotator cuff tendon. Blue dots represent the anchors. Red line is the biceps tendon. (A) Showing the bony defect and the rotator cuff tendon as well as biceps tendon. The anchor placement points are shown. (B) Showing the different FiberWire of the anchors and their respective positions in the rotator cuff tendon and the biceps tendon. (C) The overlap of the greater tuberosity with the bone defect and the final anchors placed as well as biceps tenodesis.

stitches are inserted between the band for further application.

Upon further assessment of the size and posterior extension of the GT fracture, the arthroscope is moved to the anterior portal, and a second anchor is placed posteromedial through the posterior portal and sutures retrieved through the infraspinatus tendon. Upon suture anchor insertion, the anterosuperior or posterior portal is used to minimize rotator cuff damage. Next, the subacromial space is examined. The GT fracture is reduced using the medial row repair and sutures from the medial row are pulled over the fragment. Then the sutures are tensioned and secured laterally with knotless anchors (Arthrex) placed distal to the fracture. The 2 lateral row anchors are placed in the cortical bone of the proximal humerus along the bicipital groove, one of the toughest bones of the proximal humerus, to act as a buttress for the fracture fragment. A drill beat and awl are used to ease the insertion of the lateral row anchors. Using the arthroscope, the GT fracture is pulled far distally and easily inserted the lateral row anchors near the surgical neck with the help of the fluoroscopy. The critical border of the lateral row anchor insertion is near the surgical neck area. The loop around the tenodesis of long head of biceps tendon is made by the remnant strands of FiberWire of lateral anchor if tenodesis is needed. A final checking of the reduction status of the GT fracture under fluoroscopy is done as well as direct arthroscopic view of the repaired GT fracture surface in the glenohumeral joint (Fig 4C, Video 1).

Rehabilitation

There are different postoperative protocols described.[2,19,20] However, the majority of researchers state that the postoperative rehabilitation is analogous to that of a rotator cuff repair. There seems to be a consensus regarding the importance of passive range motion exercises and sling immobilization with early pendulum exercises to limit postoperative stiffness. Usually, at 4 to 6 weeks postoperatively, active range of motion is started followed by strengthening exercises at 8 to 12 weeks postoperatively. In most patients who underwent the described technique, immobilization for 3 weeks with only pendulum exercises were allowed followed by 3 weeks of passive range of motion. Finally, at 6 weeks, and after radiologic control (Fig 5), active range of motion commenced.

Discussion

It is unclear how GT fracture occur, but it is assumed that the likely mechanism is avulsion of the rotator cuff. Commonly, the fragment of the GT is displaced superiorly and posteriorly. Even minor amounts of displacement can affect shoulder function, especially hindering external rotation and abduction.[2] Multiple GT fixation methods are described. In osteoporotic patients, the cannulated screw fixation method alone is insufficient for proper reduction and fixation.[19] In addition, various suture configurations have shown greater load to displacement when compared with cannulated screw fixation in a biomechanical study.[21] Moreover, suture fixation benefits from using the strong bone−tendon junction instead of relying on the poor bone quality in elderly patients like in screw fixation.[22] Also, in very small or comminuted fracture where screws are ideal, suture fixation can be used either double row or suture bridge fixation are described.[16,18,23] Furthermore, plate fixation is usually

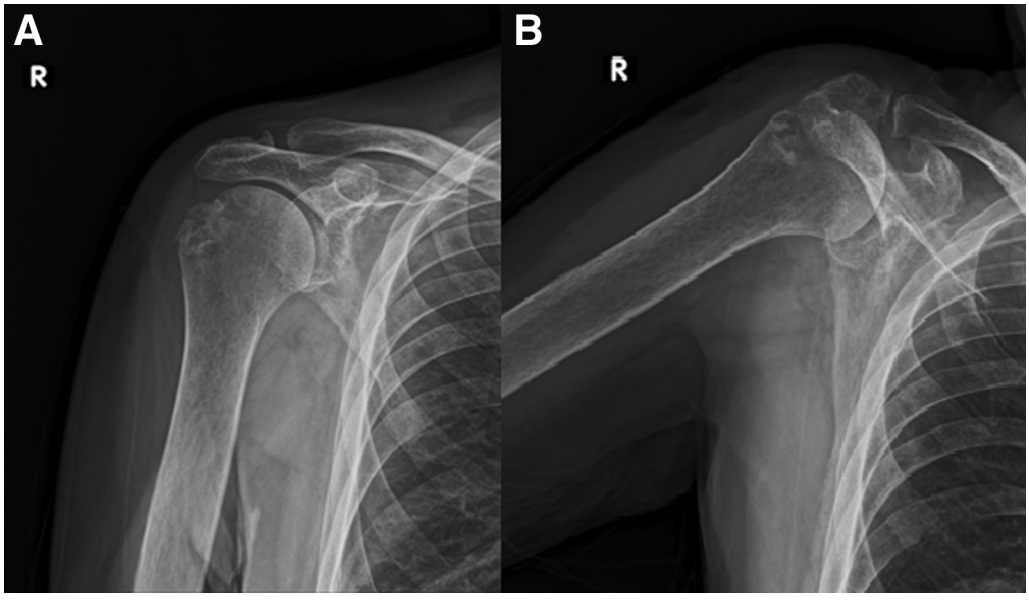

Fig 5. Follow-up radiograph at 6 weeks postoperatively with (A) AP view and (B) AP with abduction view, showing healing of the previously fracture greater tuberosity. (AP, anteroposterior.)

sufficient, nevertheless, an avulsion fracture may occur through the screw hole in poor bone quality.[22] By using the open technique, deltoid dissection is necessary, which puts the axillary nerve at risk of injury. Also, reduction may be inadequate because of the surrounding rotator cuff.[22] Arthroscopy provides multiple advantages including the reduction of the posterosuperiorly displaced fracture fragment in a minimal invasive way, the assessment of other lesions like labral and rotator cuff injuries, especially tears as they were seen as a continuous source of pain postop, followed by their treatment, cosmetic benefit of small incisions and a signification reduction of the radiation hazard.[2,4,8] Furthermore, the lack of deltoid retraction decreases the likelihood of an axillary nerve injury. Another advantage is direct visualization of the articular surface and ease of debridement of the fracture bed. There are some reports of concomitant rotator cuff injuries or capsulolabral injuries with isolated GT fractures.[20,24,25] The lateral anchor position in the bicipital groove is good for both fracture reduction and anchor placement because in most cases a GT fragment is displaced posteriorly.[22] Some malunions of the GT were reported during arthroscopic suture fixation.[26]

Thus, the increased diagnostic accuracy and the improved treatment of associated injuries while limiting the damage to the surrounding tissues makes arthroscopic fixation techniques attractive. In this case, treatment with an arthroscopic suture bridge technique was preferred due to the nature of the comminuted fracture in an elderly osteoporotic patient, which would have otherwise led to poor outcomes if fixed by screws. Overall, some of the major limitations of this technique are cost effectiveness, surgical demand, and experience, the risk of anchor pullout, and anchor site pain, In contrast, some of the advantages are less morbidity since minimally invasive, stronger tendon repair and access to biceps for tenodesis in cases of active patients, the ability to simultaneously treat other glenohumeral pathologies, and the absence of need for another surgery for removal of hardware (Table 1).

Table 1. Advantages and Disadvantages of the Surgical Technique

Advantages	Disadvantage
Minimally invasive, less morbidity	High cost relatively to other modalities
Rely on strong tendon repair	Technically demanding (high skill in arthroscopy)
Bone-to-bone application may increase healing	Risk of anchor pullout in osteoporotic bone
Treat associated glenohumeral pathologies	Pain from anchor site
Modified proximal row technique can increase the application of the tendon and increase the rate of healing	
No material removal required	

Conclusions

Even though isolated GT of the humerus fractures are uncommon, the literature provides ample evidence of how to deal with these fractures in terms of fixation and complications such as the detrimental effect of fracture fragment displacement on shoulder function. Traditionally, reduction and fixation showed good results, but the newer arthroscopic techniques allow for better visualization, stable fixation, and minimal damage to the surrounding tissues while better allowing associated injuries treatment. The arthroscopic suture bridge technique repair of the GT fracture with lateral anchor placement in bicipital groove and biceps tenodesis is recommended in elderly osteoporotic patients with displaced comminuted fracture. Finally, more clinical studies are needed to assess these new methods of arthroscopic fixation of GT fractures.

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