Technical Note

Arthroscopic Reduction and Internal Fixation of Proximal Humerus Greater Tuberosity Fracture

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Abstract: Proximal humerus fractures are common fractures that may occur after ground level falls or other traumatic events resulting in a direct injury to the shoulder. Depending on the fracture morphology and the age of the patient, anatomic reduction can vastly improve outcomes, especially in fracture patterns that involve the greater tuberosity. In this case example, we performed a minimally invasive, arthroscopic reduction and fixation of a proximal humerus fracture that involved significant displacement of the greater tuberosity. The technique employed is reproducible and avoids the morbidity of a large open incision while simultaneously providing compression of the fracture fragment for excellent healing potential.

Proximal humerus fractures represent a significant portion of all fractures seen around the world, accounting for approximately 5.7% of fractures encountered.[1] There is considerable debate on fixation of proximal humerus fractures, especially in elderly patients, but displaced fractures in young, active patients are typically managed with surgical intervention. Anatomic fracture reduction is vital to restore the native congruity of the humerus, maximize healing potential, allow earlier range of motion, and prevent abnormal shoulder biomechanics that may otherwise potentially occur.[2,3]

Surgical treatment yields excellent results in isolated greater tuberosity fractures when compared with nonoperative treatment—and yet there is great debate on the amount of displacement that necessitates surgical treatment—ranging from 3 mm up to 10 mm in some literature reports.[4]

The 2 most common open surgical approaches for greater tuberosity fractures are the deltopectoral approach or the direct—lateral deltoid-splitting approach.[5] Although considerable debate remains on the most optimal of these 2 approaches for more complicated fracture patterns, an all-arthroscopic technique has been employed for isolated, displaced greater tuberosity fractures. Multiple different techniques for fixation of greater tuberosity fractures have been reported, including screw fixation, single- and double-row anchor fixation, and bridging constructs.[6,7] Regardless of the technique employed, arthroscopic fixation is minimally invasive and can preclude the morbidity of open surgery, which includes blood loss, pain, scarring, and postoperative adhesion formation.[8]

Surgical Technique (With Video Illustration)

The patient is positioned in the beach chair position, which allows for easy conversion to an open procedure, if necessary, and also allows for straightforward use of intraoperative fluoroscopy to confirm final fracture reduction (Video 1). Preoperative radiographs are reviewed before the time-out (Fig 1). After standard skin preparation and draping are performed, a standard posterior lateral viewing portal is made. A direct accessory anterior portal is then made through the rotator interval. A diagnostic arthroscopy is then performed to evaluate for any intra-articular pathology such as labral tears, biceps pathology, articular cartilage

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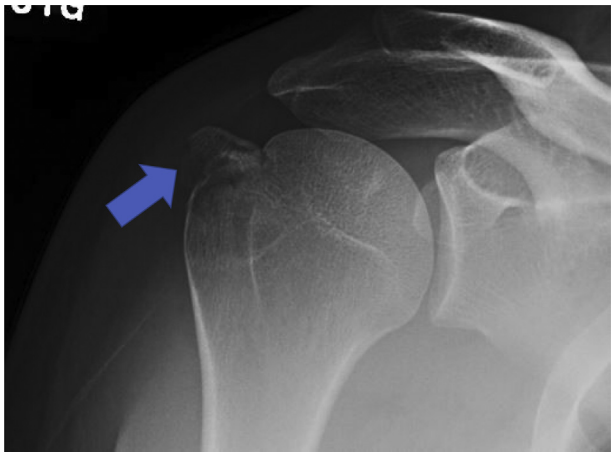

Fig 1. Anteroposterior radiograph view of the right shoulder demonstrating a displaced proximal humerus greater tuberosity fracture (depicted by blue arrow).

damage, and intra-articular assessment of the rotator cuff. Any possible intra-articular pathologies that are present may be addressed at this time.

Once completed, the arthroscope is then redirected into the subacromial space. A direct lateral portal is then made approximately 3 cm lateral to the edge of the acromion. A probe is then used to localize the fracture with the supraspinatus tendon completely attached to the displaced fracture fragment. A thorough debridement is then undertaken of the undersurface of the fracture fragment as well as the fracture bed as to remove any residual debris and to create a healthy bleeding surface for healing (Fig 2). Once completed, an

Fig 2. Intraoperative image of a right shoulder in the beach chair position when viewing from a posterolateral portal into the subacromial space toward the greater tuberosity fracture. The fracture fragment is evident above the motorized shaver (blue arrow) with the fracture bed of the greater tuberosity evident below the shaver.

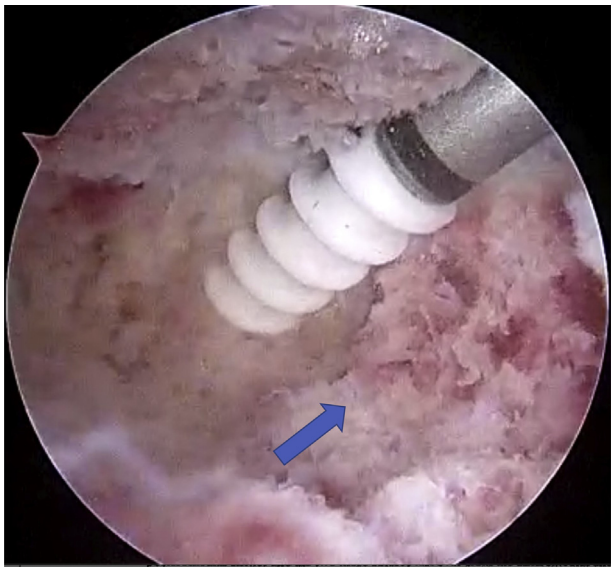

Fig 3. Intraoperative image of a right shoulder in the beach chair position viewing from a posterolateral portal in the subacromial space looking at the fracture bed (bed indicated by blue arrow). One of two individual 4.5-mm PEEK corkscrew anchors is inserted in the fracture bed medially just adjacent to the articular cartilage of the humeral head. (PEEK, polyether ether ketone.)

accessory lateral portal is made superior to the initial portal and a metal punch is brought in to create 2 pilot holes adjacent to the medial aspect of the fracture bed along the articular cartilage of the humeral head. It is

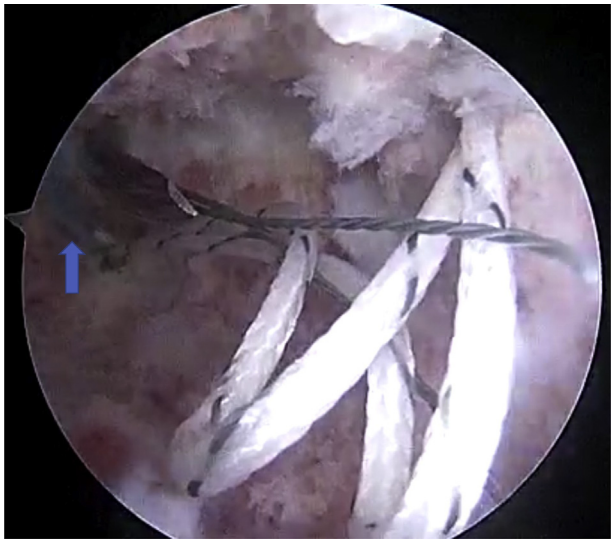

Fig 4. Intraoperative image of the right shoulder in the beach chair position viewing from a posterolateral portal in the subacromial space at the fracture bed directly inferior in this photo with a single doubly loaded Arthrex 4.5-mm Corkscrew PEEK anchor with white and blue FiberWire—blue FiberWire evident on the very left side of the screen (blue arrow). Nitinol wire, seen coming from the left side of the photo retrograde through the rotator cuff from a 90° suture lasso, allows for suture passage. (PEEK, polyether ether ketone.)

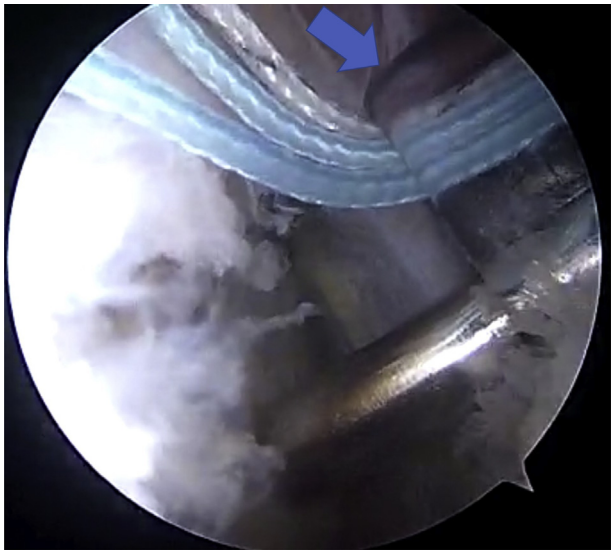

Fig 5. Intraoperative image of the right shoulder in beach chair position viewing from the subacromial space. Two FiberWire sutures from an anterior anchor (anterior white, middle blue) and a single suture from a posterior anchor (posterior blue) have been passed through the rotator cuff and are docked in the lateral portal (blue arrow). A punch is brought in to create a pilot hole along the humerus distal to the fracture bed.

important to ensure the area is just subchondral to punch pilot holes in strong bone, as much of the area is soft cancellous bone.

Two individual 4.5-mm biocomposite corkscrew anchors doubly loaded with FiberWire suture (Arthrex, Naples, FL) are then inserted (Fig 3). A 90° suture lasso is then brought in through the anterior portal, which is then transitioned into the subacromial space. The suture lasso is then passed in retrograde fashion through the rotator cuff tendon, medial to the fracture fragment, and the nitinol wire is deployed and retrieved out the lateral

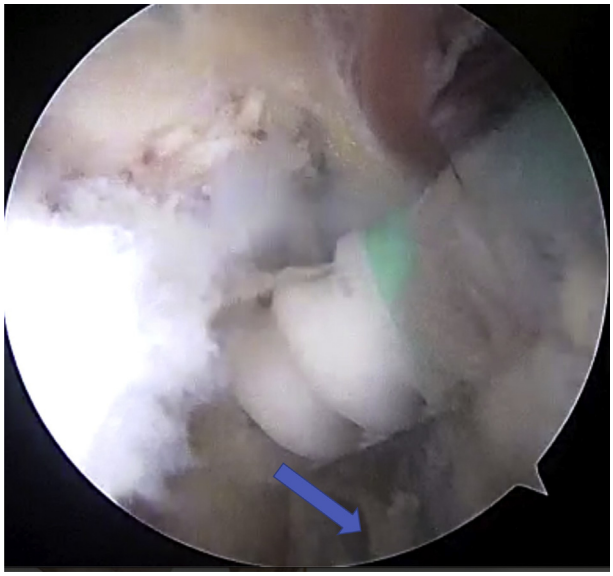

Fig 6. Intraoperative image of the right shoulder in the beach chair position viewing from a posterolateral portal into the subacromial space looking into the lateral gutter (blue arrow). A 4.75-mm SwiveLock anchor is visualized being inserted laterally along the humerus.

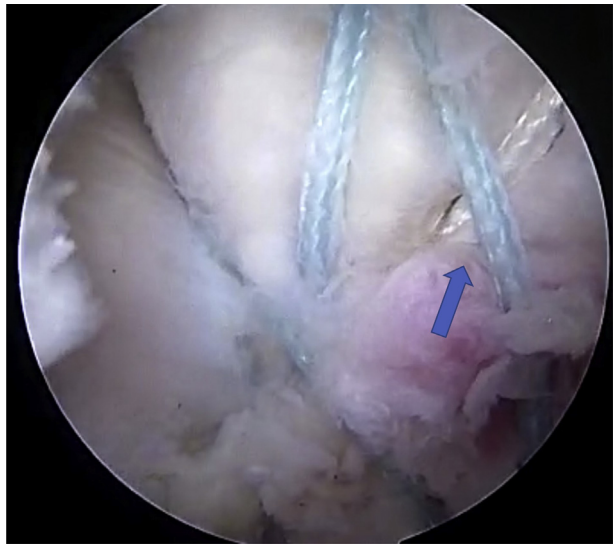

Fig 7. Intraoperative image of the right shoulder in beach chair position viewing from the lateral portal into the subacromial space towards the repaired greater tuberosity fracture fragment. An "X" configuration (blue arrow) is evident with crossing suture strands from the anterior/posterior anchors then placed laterally into lateral row SwiveLock anchors. Excellent fracture reduction is obtained and compression along the FiberWire.

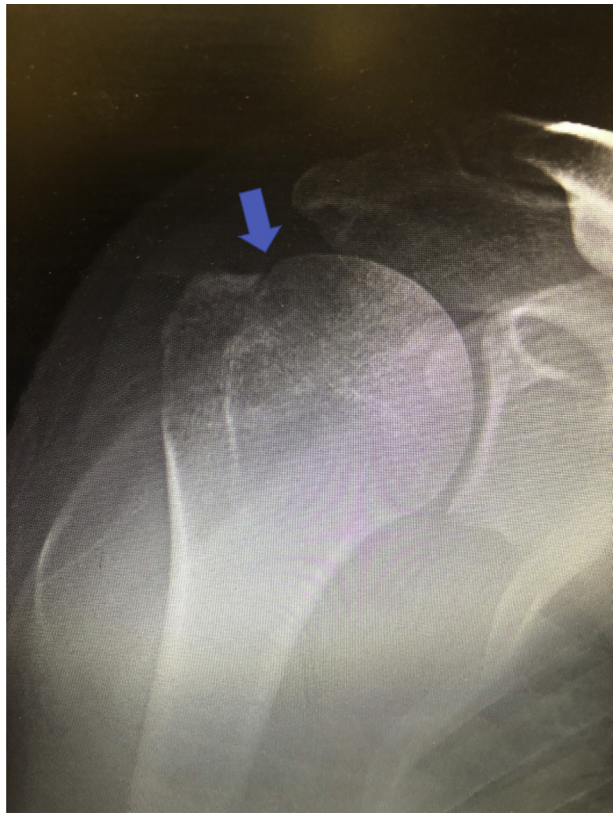

Fig 8. Postoperative anteroposterior radiograph of a right shoulder demonstrating reduced greater tuberosity fracture (blue arrow) after arthroscopic fixation.

Table 1. Clinical Recommendations for Arthroscopic Reduction and Internal Fixation of Proximal Humerus Greater Tuberosity Fractures

Pearls	Pitfalls
• Use the beach chair position to allow ease of intraoperative fluoroscopy • Check a fluoroscopic anteroposterior image before prepping the operative arm to ensure patient positioning is accessible • Use standard arthroscopic portal placement initially, adding accessory portals as necessary based on fracture location • Thoroughly debride the undersurface of the fracture fragment and the base to ensure bleeding bone • Use a suture lasso–type device to ensure suture passage immediately medial and adjacent to the bony fracture fragment • Place anchors as medial as possible and subchondral to ensure they are in strong bone to avoid pullout • Bring sutures from both medial anchors over to multiple lateral anchors in a crossing "X" fashion to maximize compression strength	• Multiple accessory portals may be required to allow appropriate suture passage around the fracture fragment(s) • Self-retaining suture-passing devices may have difficulty passing suture through or medial to bony fracture fragments • If anchors are placed solely in cancellous bone, the risk of pullout could be high • Non-equidistant, poorly spaced anchors, and/or suture passage could result in fracture malreduction

portal. The suture from the anchors are then also retrieved out the lateral portal and then pulled through the cuff tissue medial to the fracture with the nitinol wire.

Sutures are passed from the anterior anchor first followed by the posterior anchor (Fig 4). It should be noted that one of the sutures from the posterior anchor is discarded before passage in this case. A total of 4 sutures from the anterior anchor and 2 sutures from the posterior anchor are passed through the rotator cuff as described previously using the suture lasso. Once completed, a punch is used laterally along the humerus distal and lateral to the fracture bed and 2 sutures from the anterior anchor and a single suture from the posterior anchor is retrieved (Fig 5). These are loaded onto a 4.75-mm SwiveLock anchor (Arthrex) and inserted while assistance is provided to fracture reduction using a probe from the accessory lateral portal (Fig 6). The 2 remaining sutures from the anterior anchor and the one remaining suture from the posterior anchor are then loaded into a similar fashion onto a SwiveLock anchor and placed posterior along the humerus distal to the fracture bed after a pilot hole was created. This creates an "X" pattern for fracture reduction and compression (Fig 7).

Once completed, the shoulder can be gently ranged to assess for stability of the fracture fragment. A C-arm is then brought into confirm fracture reduction in orthogonal planes via intraoperative fluoroscopy (Fig 8). The remainder of the fluid is then flushed from the shoulder and any debris is suctioned with the arthroscope from the subacromial space. The portal sites are then closed in a figure-of-eight fashion and appropriately dressed. The patient is placed into an abduction pillow and sling and awoken from anesthesia.

Rehabilitation

The patient is placed in a sling with abduction pillow for a total of 3 weeks and kept non-weight bearing. Pendulums and passive range of motion to 90° of forward flexion and abduction only are allowed for 4 weeks while still remaining non-weight bearing. Following this, passive range of motion is increased to full between 4 and 8 weeks with active assisted below the shoulder starting at week 6. Full active range of motion and light strengthening beginning between weeks 8 to 10. Full clearance is given at 4 to 5 months to return to all activities.

Discussion

Proximal humerus fractures are a common fracture encountered in orthopaedics and are also difficult to treat. There remains much debate on operative versus nonoperative management for elderly patients. However, for the young patient with a displaced greater tuberosity fracture, there is robust evidence that demonstrates that fixation improves outcomes.[3] Initial reports by Neer[9] demonstrated that up to 10 mm of displacement and 45° of angulation could be tolerated and treated nonoperatively; however, recent data suggest that as little as 2 mm of displacement may cause subacromial

Table 2. Advantages and Disadvantages of an Arthroscopic Reduction and Internal Fixation of Proximal Humerus Greater Tuberosity Fracture Technique

Advantages
• Minimally invasive, with minimal risk to the deltoid musculature or surrounding neurovascular structures
• Cosmetic incisions
• Minimal risk of hardware prominence, breakage, or surrounding soft-tissue irritation
• Technically straightforward and reproducible technique
Disadvantages
• Requires surgeon comfort with arthroscopic management in the beach chair position
• Large or multiple fragment type fractures may make suture passage, anchor placement, and complete anatomic reduction difficult
• Suture anchors may be insufficient and fractures may require more robust fixation (bicortical screws) in older patients with poor-quality bone

impingement pathology as well as problems with overall range of motion.[10] Therefore, in younger active patients, surgical fixation is indicated in such cases.

Previous studies have demonstrated that there is no increased risk of adverse events or malreduction when using an arthroscopic technique compared with open reduction internal fixation.[11] There have been many techniques described, including an arthroscopically aided technique for reduction with percutaneous screw fixation.[12] However, there also has been a newer technique described that follows the logic of rotator cuff repair using a double-row technique for fixation.[7] There have been limited studies into the arthroscopic technique; however, from the data that are available, there have been excellent results in a small number of patients. Ji et al.[13] were able to demonstrate excellent results in a small group of patients treated with double-row fixation at short-term follow-up. Pardiwala and Maheshwari[14] were also able to describe excellent results in a small group of patients with radiographic union noted at approximately 3 months.

The technique offers several advantages when compared with the open reduction and internal fixation. First, it is minimally invasive, using only arthroscopic portals. Second, it is straight relatively forward and easy to learn. For those who are comfortable with arthroscopic rotator cuff repair, this technique employs the same principles as a standard double-row rotator cuff repair (Table 1). The technique also employs anchors that are buried into the bone, thus preventing potential irritating hardware that would necessitate a secondary surgery for removal. Direct fracture reduction is also obtained via arthroscopic visualization and compression of the bone—tendon interface to the fracture bed. One may also add additional anchors to fixation when larger fragments are encountered to aid and assist in reduction.[15]

Although arthroscopic fixation is an advantageous technique for fixation, there are some disadvantages that are potentially encountered with an arthroscopic technique (Table 2). There is a need to be skilled in arthroscopy to allow for efficient and anatomic reduction of the fracture. It has been previously demonstrated that arthroscopic fixation could take a longer amount of time than an open reduction and internal fixation.[11] There is also the potential for malreduction if the fracture site is not completely debrided with a shaver or burr to allow for anatomic reduction. Finally, if the fracture results in a very large fragment or multiple fragments, it may difficult to pass sutures through each individual fragment, making complete anatomic reduction difficult.

Arthroscopic fixation of displaced proximal humerus greater tuberosity fractures remains a technically straightforward, reliable, and reproducible technique that allows for excellent fracture fixation. The method avoids an open incision and potentially irritating hardware while providing outstanding compression at the fracture site to allow for early healing while also preventing further displacement.

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