

Arthroscopic Reduction and Suture Bridge Fixation of a Large Displaced Greater Tuberosity Fracture of the Humerus



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Abstract: Arthroscopic fixation of a greater tuberosity (GT) avulsion fracture by suture bridge repair has been described in several articles. However, all of them have used arthroscopic fixation of a small sized GT fracture fragment or have not used purely arthroscopic techniques. In this Technical Note, the authors describe another technique for large displaced GT fracture fixation by arthroscopy only, without any metal fixation. Standard anterior, posterior, lateral, and posterolateral viewing portals are established with an accessory portal for suture anchor insertion. During intra-articular examination, an anteroinferior capsulolabral tear, upper one-third subscapularis tendon tear, and posterosuperior displaced bony fragment are detected. A subscapularis tendon was repaired by a single-row technique. After repair, medial row anchors are inserted into the bare area of infraspinatus tendon and the posterior edge of supraspinatus tendon. A 1-PDS suture is used to pass strands of fiberwire. As with the remplissage procedure, the fiberwire was passed with an 18-gauge needle. Following the acromioplasty, the medial row tightening was done by reducing the fracture fragment. After that, the lateral row anchor was inserted into the bicipital groove, completing the suture bridge technique. This technique can effectively treat other pathologies, has less radiation hazard, and results in fewer soft tissue injuries.

The authors performed arthroscopic assisted reduction and fixation by a suture bridge technique of a large displaced greater tuberosity fracture of the humerus (Figs 1-3). Arthroscopic glenohumeral joint findings showed anteroinferior capsulolabral tear, nearly full detachment of subscapularis tendon at the first facet of lesser tuberosity, and displaced large greater tuberosity fracture.

The indication for surgery for a greater tuberosity fracture is displacement >1 cm.¹ Generally, minimally displaced (<5 mm) greater tuberosity fractures are treated by conservative management, but some

investigators argue that operative treatment is indispensable.²⁻⁴ The greater tuberosity fracture fragment tends to be reduced accurately and fixed rigidly when the fragment is large and displaced. Recent arthroscopic techniques have allowed us to reduce and fix this fracture by arthroscopy and have shown satisfactory clinical results in several studies.^{5,6} A hybrid technique for large displaced greater tuberosity fracture fixation was also introduced.⁷ However, all of these studies have used arthroscopic fixation of a small sized greater tuberosity fracture fragment or have not used purely arthroscopic techniques.

In this Technical Note, the authors describe another technique for large displaced greater tuberosity fracture fixation by arthroscopy only, without any metal fixation (plate or screw).

Surgical Technique

Under general anesthesia, the patient is placed in the beach chair position with longitudinal traction of the affected upper limb with an interscalene block. An arthroscope is inserted through the posterior portal, and a shaver is inserted through the anterior portal (Fig 4, Video 1). During intra-articular examination after debridement of a hematoma, an anteroinferior capsulolabral tear, upper one-third subscapularis tendon tear, and posterosuperior displaced bony fragment are

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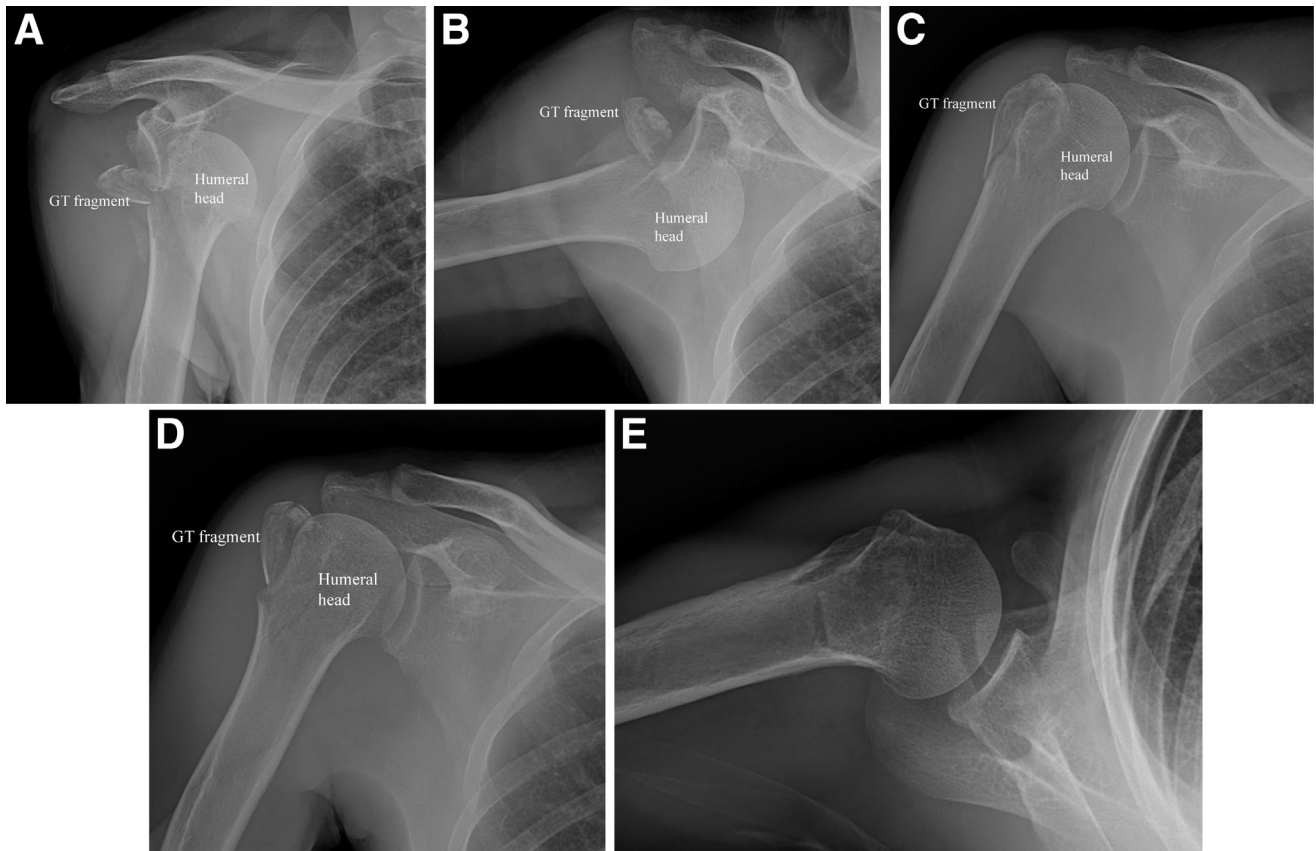


Fig 1. Initial plain radiography of the patient's right shoulder in emergency department. (A) Anteroposterior view of the right shoulder. (B) Lateral view of the right shoulder showing comminuted large greater tuberosity fracture combined with anterior dislocation. After reduction, radiographs of the patient's right shoulder, anteroposterior (C), lateral (D), and axillary (E) views, show superior migrated greater tuberosity fracture.

detected (Fig 5). The authors decided not to repair the anterior capsulolabral tear because the patient is not an active young patient and the labrum is not healthy enough to be repaired. At the shoulder flexion position, we prepare for subscapularis repair. The first facet is decorticated with ring curette, and single-row subscapularis repair is performed after insertion of a double-loaded suture anchor (2.8 mm Y-knot RC, Conmed) through the lateral portal via fracture gap (Fig 6). After subscapularis repair, debridement is performed on the fracture surface by a shaver. The shoulder joint is moved into maximal internal rotation position, and a triple-loaded suture anchor (5.5 mm HEALICOIL, Smith & Nephew) is inserted into the bare area of infraspinatus tendon through the intact rotator cuff through the posterior portal (Fig 7). The fracture fragment and rotator cuff are observed, and the exact locations of the suture passage are confirmed using the same 18-gauge needle percutaneously as in the remplissage procedure. A 1-PDS suture is passed through this needle, and then a strand of fiberwire was passed through the intact rotator cuff (infraspinatus) as with the outside-in shuttle relay technique (Fig 8).

After 6 strands of fiberwire are passed, the other double-loaded suture anchor (4.5 mm HEALICOIL) is inserted into the posterior edge of the supraspinatus tendon just medial to the upper portion of fracture line through the accessory portal just medial to the lateral portal (Fig 7). In the same way, using the same 18-gauge needle, the fiberwires are passed through the intact rotator cuff (posterior aspect of supraspinatus tendon).

Subsequently, the arthroscope is moved into the subacromial space. The authors use lateral and posterolateral viewing portals. Acromioplasty should be performed routinely because the fractured greater tuberosity fragment could be a source of impingement. The authors had limited bursectomy for better visualization to identify fiberwires of 2 anchors. The fractured fragments are reduced arthroscopically piece by piece by several instruments like the bone impactor or changing stick, as the puzzle pieces are aligned (Table 1). Thereafter, the medial row sutures are tightened with the SMC sliding knot. By bundling these strands, the medial footprint of the rotator cuff is restored. The authors use 2 lateral anchors (4.5 mm

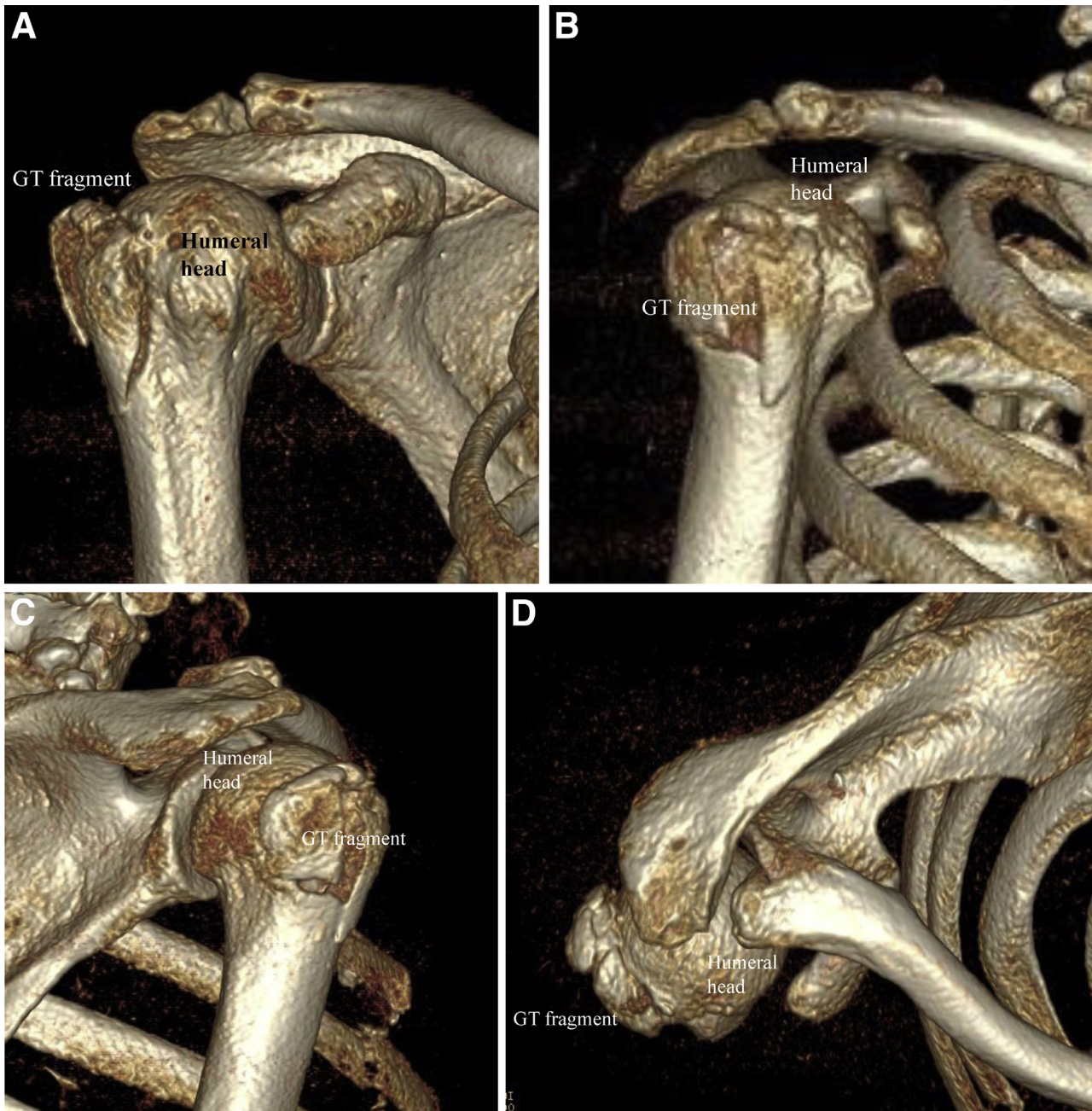


Fig 2. Postreduction 3-dimensional computed tomography images show comminuted large greater tuberosity fracture. (A) Anterior, (B) lateral, (C) posterior, (D) superior view of right shoulder.

PopLock, Conmed) to complete the suture bridge technique. The 2 lateral anchors are inserted along the bicipital groove, one of the hardest parts of the proximal humerus, to serve as a buttress for the fracture fragment (Fig 9). Before tightening these strands of fiberwire, the authors check whether reduction was maintained under the arthroscope. If there is not enough reduction, authors perform additional reduction with the changing stick or impactor. Then tightening of the lateral anchor is completed. 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 (Fig 10). After confirming that fracture fixation is well maintained through the rotation of the humerus internally and externally under the arthroscope, the arthroscope is moved again into the glenohumeral joint, and the authors examine whether the fragment is reduced normally. A postoperative simple radiograph shows an acceptable greater tuberosity reduction state (Figs 11 and 12).

The postoperative rehabilitation protocol is the same as for rotator cuff repair patients, immobilization for



Fig 3. Postreduction magnetic resonance images of the patient's right shoulder show an intact supraspinatus muscle tendon with posterosuperiorly displaced fracture fragment. Anterior labral tear with leading edge tear of subscapularis tendon is shown. (A) T1-weighted coronal image. (B) T2-weighted coronal image. (C) T2-weighted axial view of right shoulder.

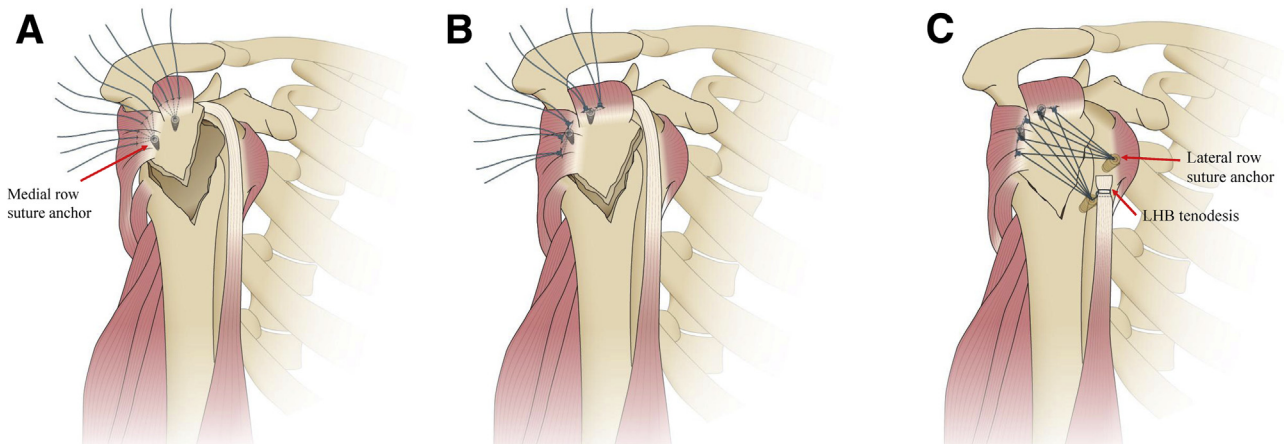


Fig 4. Illustrations of key surgical step. (A) Medial row suture anchor insertion and suture passage. (B) Medial row tightening after reducing the fracture fragment. (C) The suture bridge technique is completed by insertion of lateral row suture anchors in the bicipital groove.

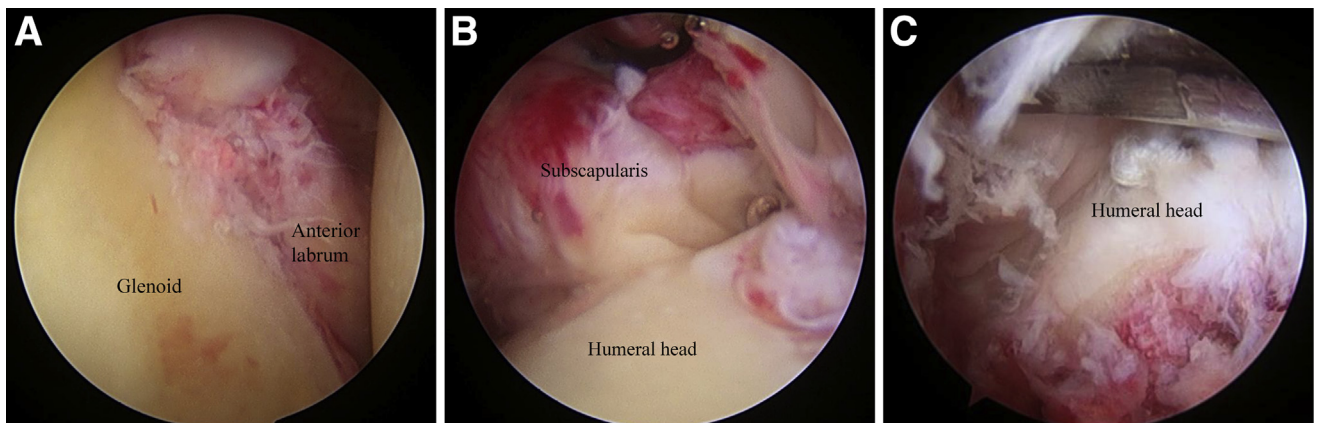


Fig 5. Right shoulder in the beach chair position. Arthroscopic view of the glenohumeral joint space from the posterior portal. There are anterior labral tear (A) and nearly full detachment of subscapularis tendon at the first facet of lesser tuberosity. (B) Arthroscopic view of the glenohumeral joint space from the lateral portal. (C) Fracture site of greater tuberosity.

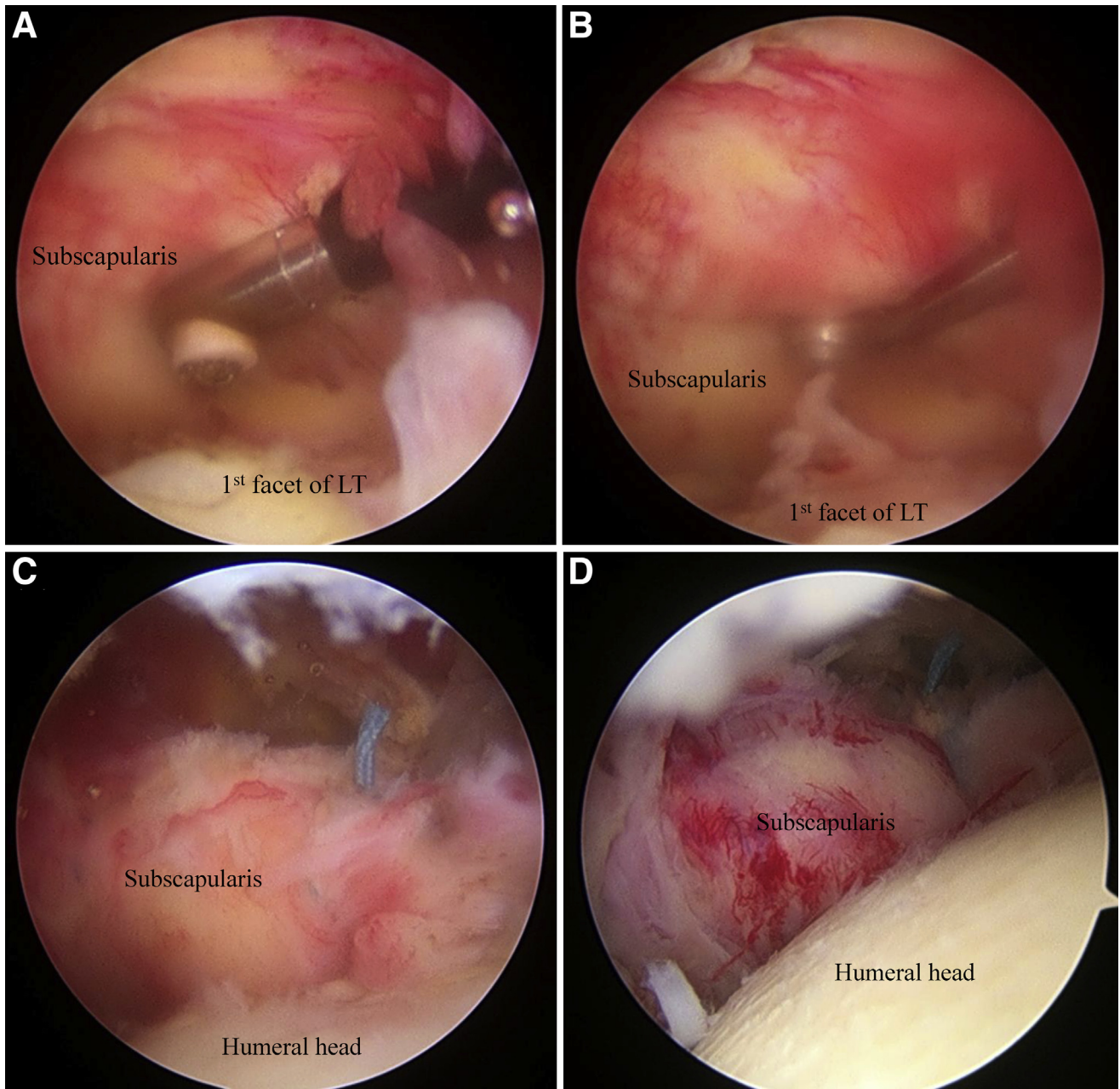


Fig 6. Right shoulder in the beach chair position. Arthroscopic view of the glenohumeral joint space from the posterior portal. There is a leading-edge tear of the subscapularis tendon. After decortication of the first facet of lesser tuberosity (A), (B), a double loaded suture anchor is inserted. Then single-row repair of the subscapularis tendon is done (C), (D).

4 weeks followed by passive shoulder range of motion exercise. At 12 weeks postoperatively, progressive muscle-strengthening exercise are added.

Discussion

It is known that the ratio of isolated greater tuberosity fracture in proximal humerus fracture is 17% to 21%.⁸ The mechanism of the greater tuberosity fracture is unclear, but it is presumably due to avulsion of the rotator cuff. The incidence of greater tuberosity fracture of the humerus is increasing because of the increased

incidence of osteoporosis due to the aging of the general population.⁹ Bahrs et al.¹⁰ reported the pathobiomechanics of greater tuberosity fractures in 103 patients, 59 patients as part of a traumatic shoulder dislocation and 44 patients as an isolated fracture. Of the patients, 47.6% reported direct mechanisms and 32% reported indirect mechanisms of injury.

Generally, the greater tuberosity fracture fragment is displaced posteriorly and superiorly. Small amounts of displacement could alter shoulder function, especially blocking external rotation and abduction.² In several

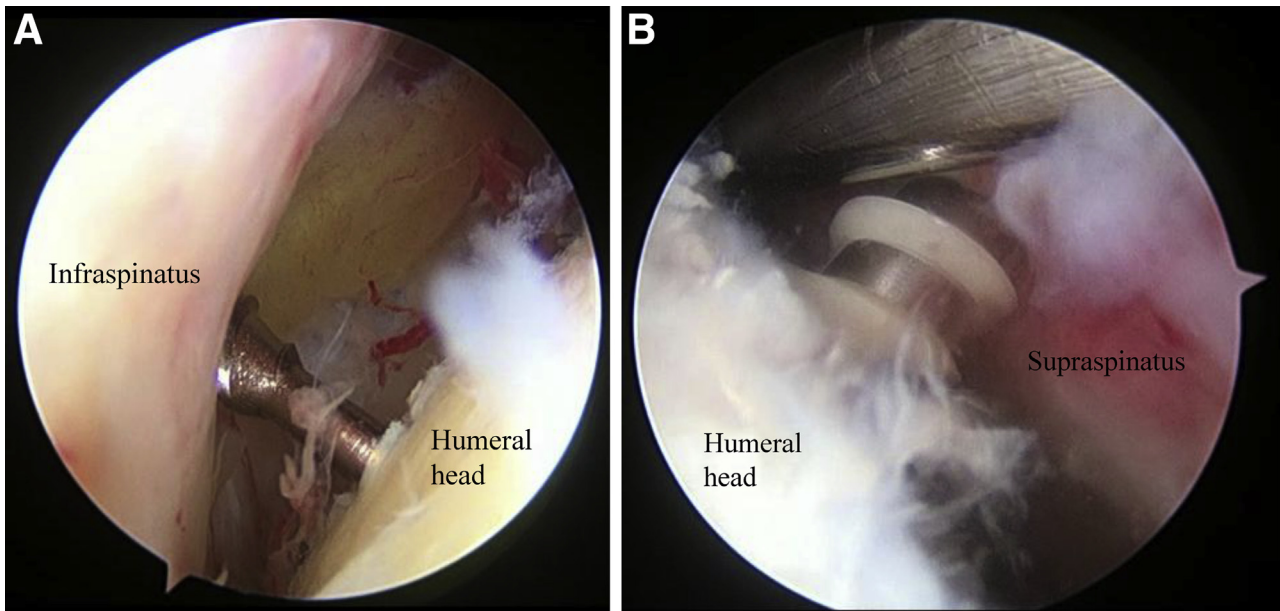


Fig 7. Arthroscopic view of the glenohumeral joint space from the lateral portal of the patient's right shoulder. The shoulder joint was moved into maximal internal rotation position, and a triple-loaded suture anchor was inserted into the bare area of the infraspinatus tendon through the intact rotator cuff through the posterior portal (A). A double-loaded suture anchor is inserted into the posterosuperior aspect of fracture site through the accessory portal just medial to the lateral portal (B).

studies, surgical indications for greater tuberosity fractures have been reported and the goal of surgical treatment is restoration of normal anatomy and the allowance of early motion via firm fixation.²⁻⁴ There are several surgical methods reported including cannulated screw fixation, plate fixation, and open or

arthroscopic suture anchor fixation.^{7,11} The cannulated screw fixation method alone is not sufficient for adequate reduction and fixation especially in osteoporotic patients. The plate fixation method is sufficient for fixation, but an avulsion fracture may occur through the screw hole if bone

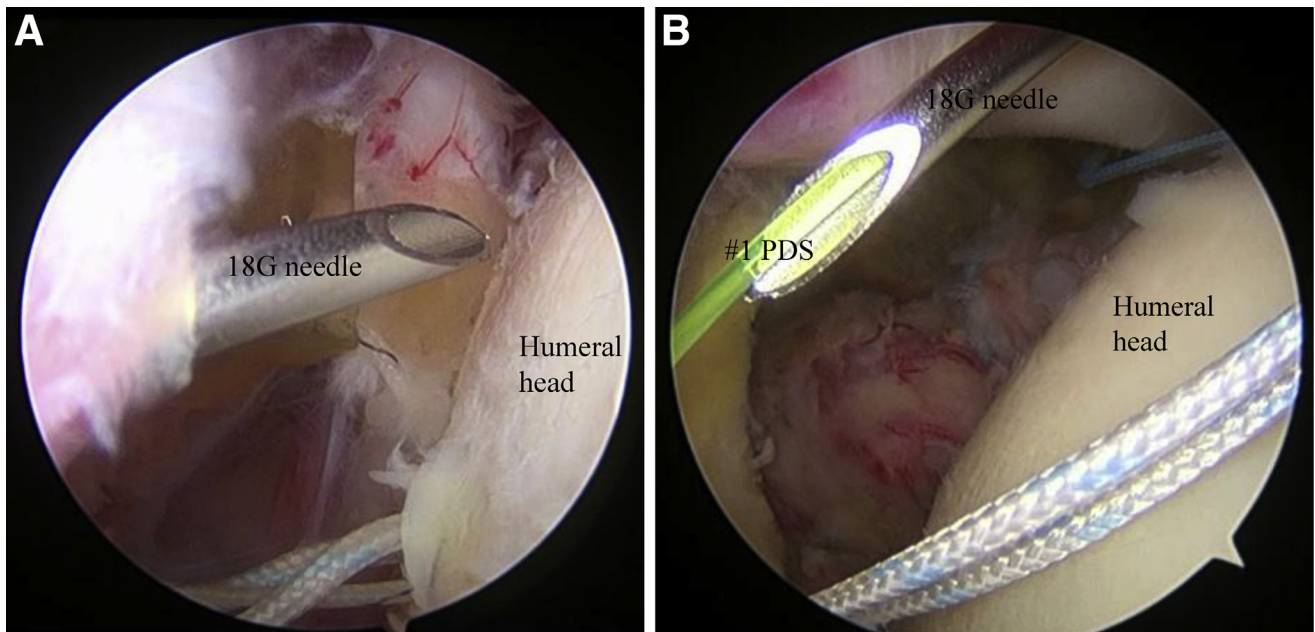


Fig 8. Arthroscopic view of the glenohumeral joint space from the lateral portal of the patient's right shoulder. The fracture fragment and rotator cuff were observed, and the exact location of the suture was confirmed using the same 18-gauge needle as with the remplissage procedure (A). A 1-PDS suture was passed through this needle, and then 10 strands of fiberwires were passed through the intact rotator cuff (infraspinatus and posterior aspect of supraspinatus tendon) (B).

Table 1. Pearls and Pitfalls of the Technique

Pearls	Pitfalls
Remove the hematoma and soft tissue around the fracture site for accurate reduction.	Poor visualization is inevitable due to a bleeding and displaced large greater tuberosity fragments.
A triple loaded anchor with many sutures is appropriate for strong compression of the greater tuberosity fragment	Performing bursectomy with a shaver after the anchors are inserted may cause the suture material to be cut.
The anchor inserted in the posterior aspect of fracture site (like the remplissage procedure) is important to reduce the externally displaced greater tuberosity fragment by applying pressure from the back to the front.	Anchor pullout occurs if the superior anchor is placed on the cancellous bone at the fracture site (especially when using soft anchors).
Place the medial anchor just on the edge of the fracture line for an accurate reduction of a posterosuperiorly displaced greater tuberosity fragment.	Inaccurate reduction may occur if clean visualization of the fracture site is not obtained.
Careful attention is required to maintain the fracture gap that is reduced when the lateral row anchors are inserted into the bicipital groove.	

quality is poor. Deltoid dissection is inevitable, and axillary nerve injury and inaccurate reduction due to the surrounding rotator cuff may be a concern with the open technique.

Arthroscopy enables (1) reduction of the posterosuperiorly displaced fracture fragment less invasively, (2) the evaluation and simultaneous treatment of other lesions like labral and rotator cuff injuries, and (3) reduction of the radiation hazard. There are some reports of concomitant rotator cuff injuries or capsulolabral injuries with isolated greater tuberosity fractures.^{12,13} Recent arthroscopic techniques have allowed us to reduce and fix this fracture by arthroscopy and have shown satisfactory early clinical results in several studies.^{5,6} But, these studies are of

small displaced greater tuberosity fractures. There are also several reports of large displaced greater tuberosity fractures with an arthroscopic technique, but not a purely arthroscopic technique.⁷

In the case of large greater tuberosity fragment such as in our case, lateral anchors are hard to fix compared with the conventional suture bridge technique because the lateral anchors should be more distally located. There may be an axillary nerve injury and a problem in lateral anchor placement because the distal part is harder and narrower. So the lateral anchor position in the bicipital groove is good for both fracture reduction and anchor placement because in most cases a greater tuberosity fragment is displaced posteriorly. The tenodesis of the long head of the biceps tendons may be

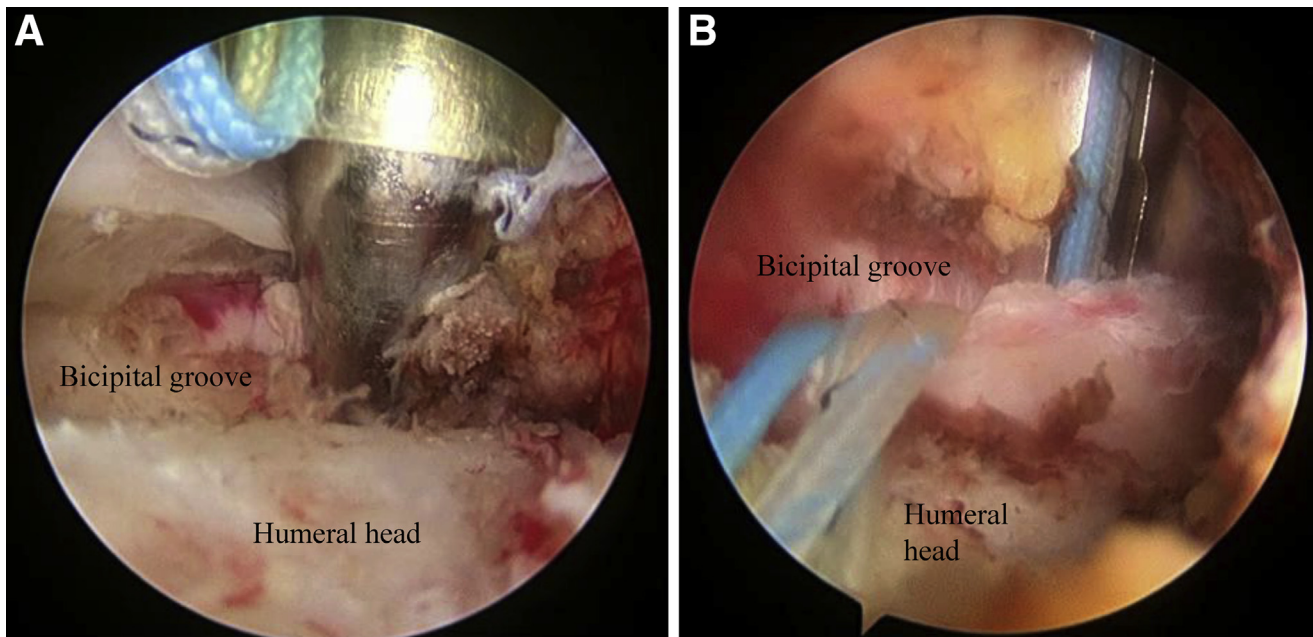


Fig 9. Arthroscopic view of the subacromial space from the posterolateral viewing portal of the patient's right shoulder. The authors used 2 lateral anchors to complete the suture bridge technique. The lateral anchors were inserted into the bicipital groove, one of the hardest parts of the proximal humerus, to serve as a buttress for the fracture fragment.

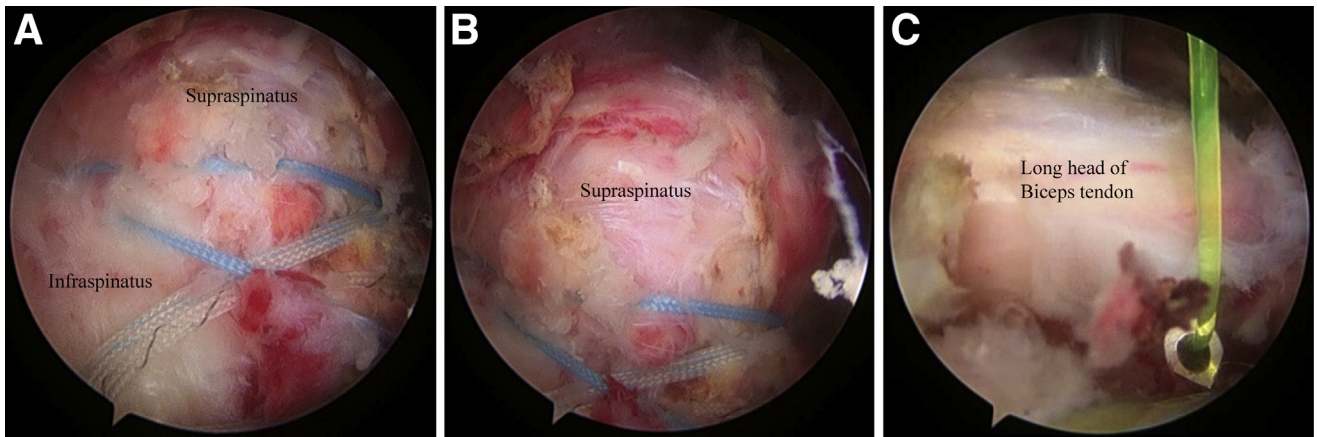


Fig 10. Arthroscopic view of the subacromial space from the posterolateral viewing portal of the patient's right shoulder (A), (B). Fractures have been reduced by changing stick and bone impactor arthroscopically. Thereafter, the medial row sutures were tightened with the SMC sliding knot. By bundling these strands, the medial footprint of the rotator cuff was restored. The authors used 2 lateral anchors to complete the suture bridge technique. Before tightening these strands, the authors checked whether reduction was maintained under arthroscope. The loop around the tenodesis of the long head of the biceps tendon was made with the remnant strands of fiberwire of the lateral anchor (C).

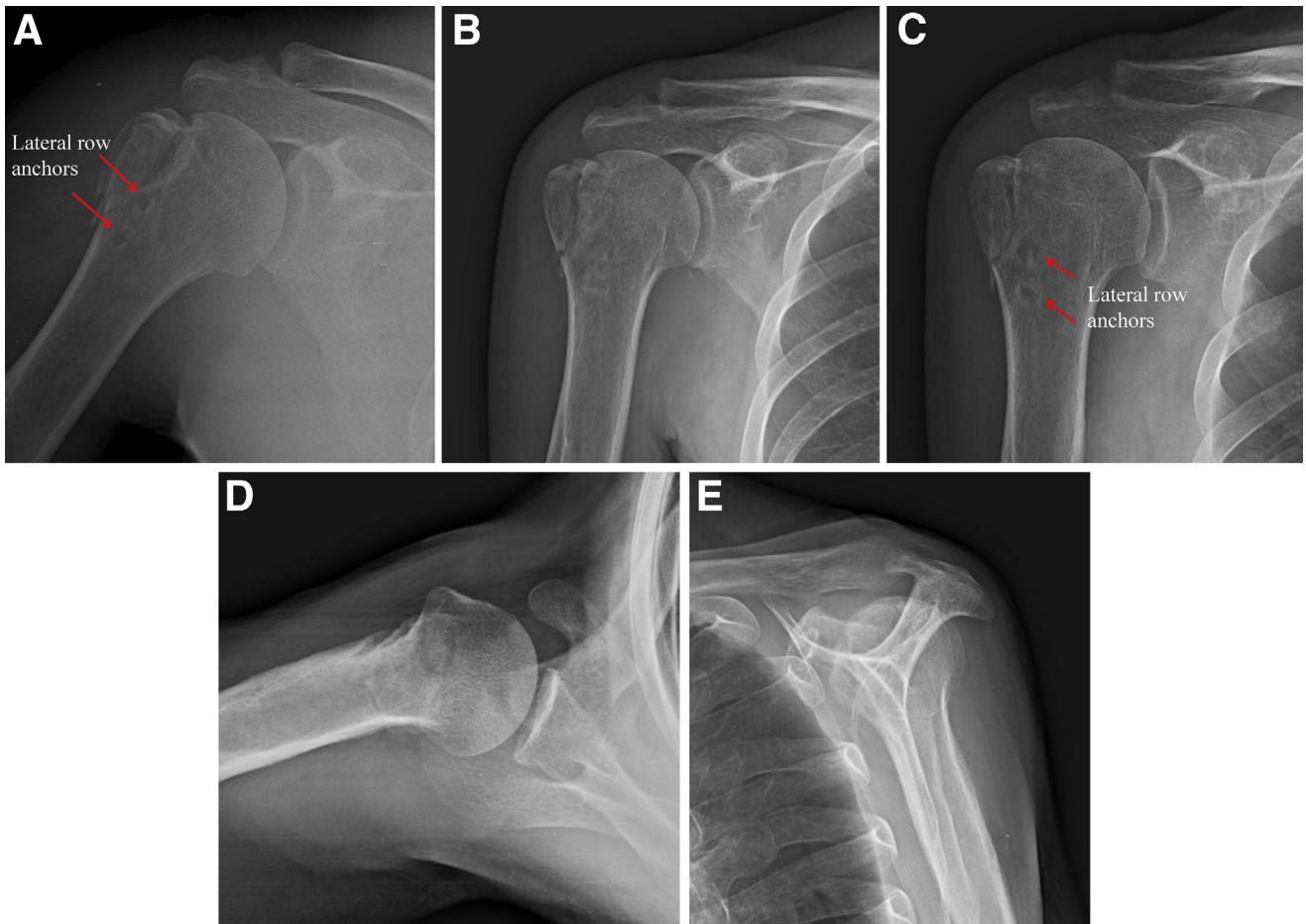


Fig 11. Postoperative serial plain radiograph of right shoulder. Greater tuberosity height was recovered normally lower than the top of the humeral head. The lateral row suture anchor holes along the bicipital groove (arrow) are shown. (A) Immediate, (B) 4 weeks, and (C), (D), (E) 6 weeks postop radiographs.

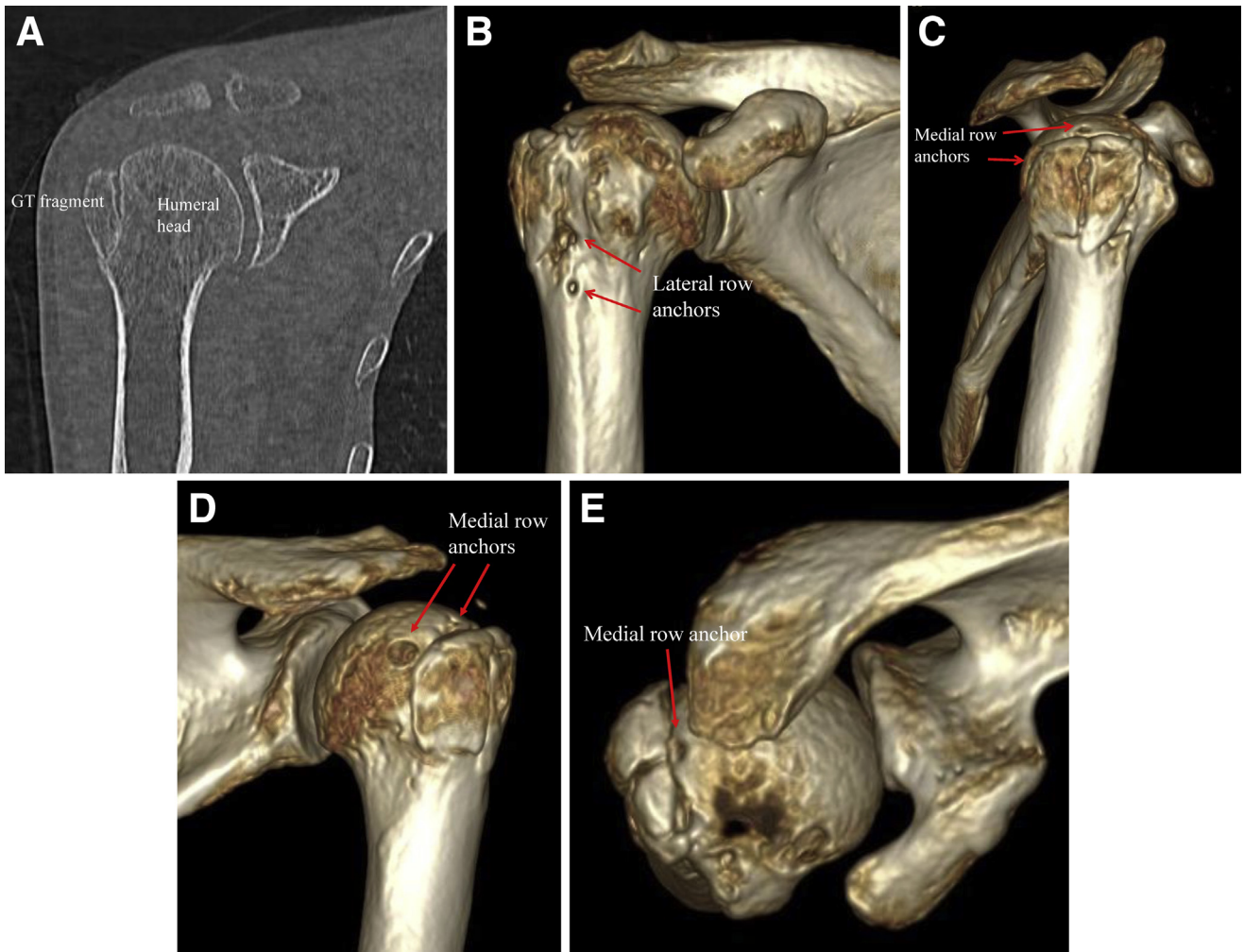


Fig 12. Three months postoperative 3-dimensional computed tomography images of the right shoulder. There is still a fracture gap, but no further displacement of fractured greater tuberosity fragment is found.

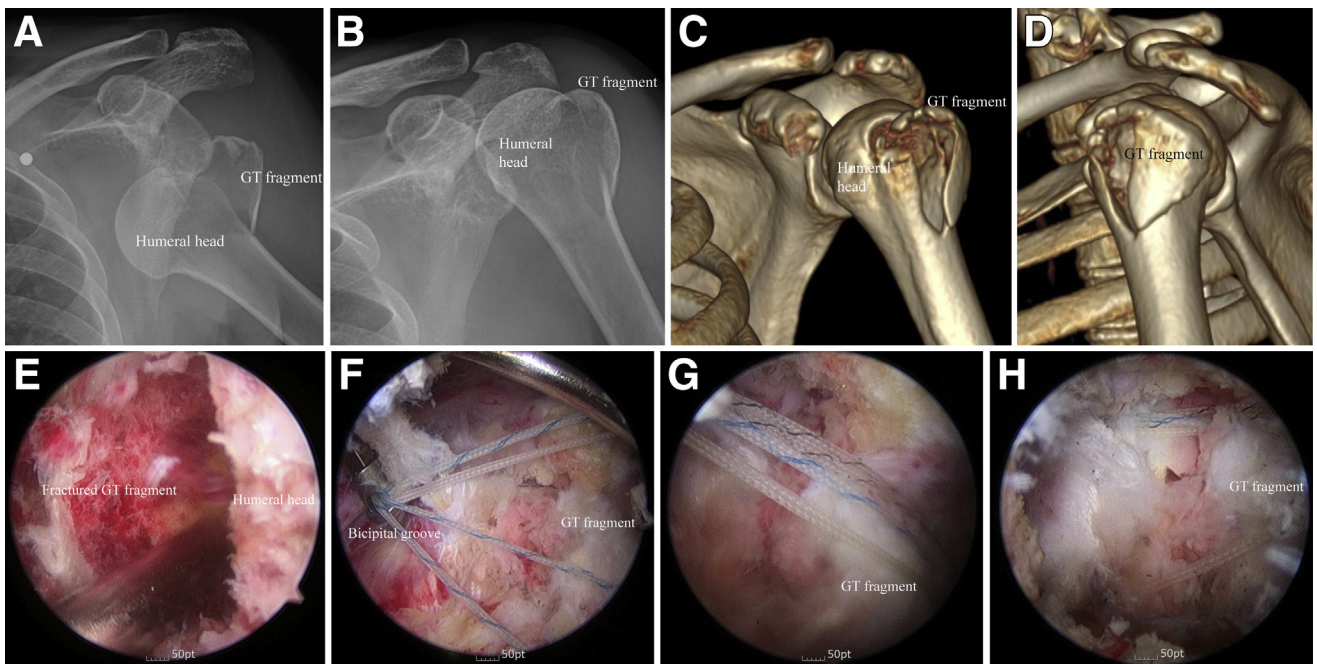


Fig 13. These images are the plain radiographs of the left shoulder of another patient, a 56-year-old female patient. (A) Initial anteroposterior view. (B) Anteroposterior view after reduction. (C), (D) Three-dimensional computed tomography images. (E), (F), (G), (H) Arthroscopic images during surgery, as with the previous patient.

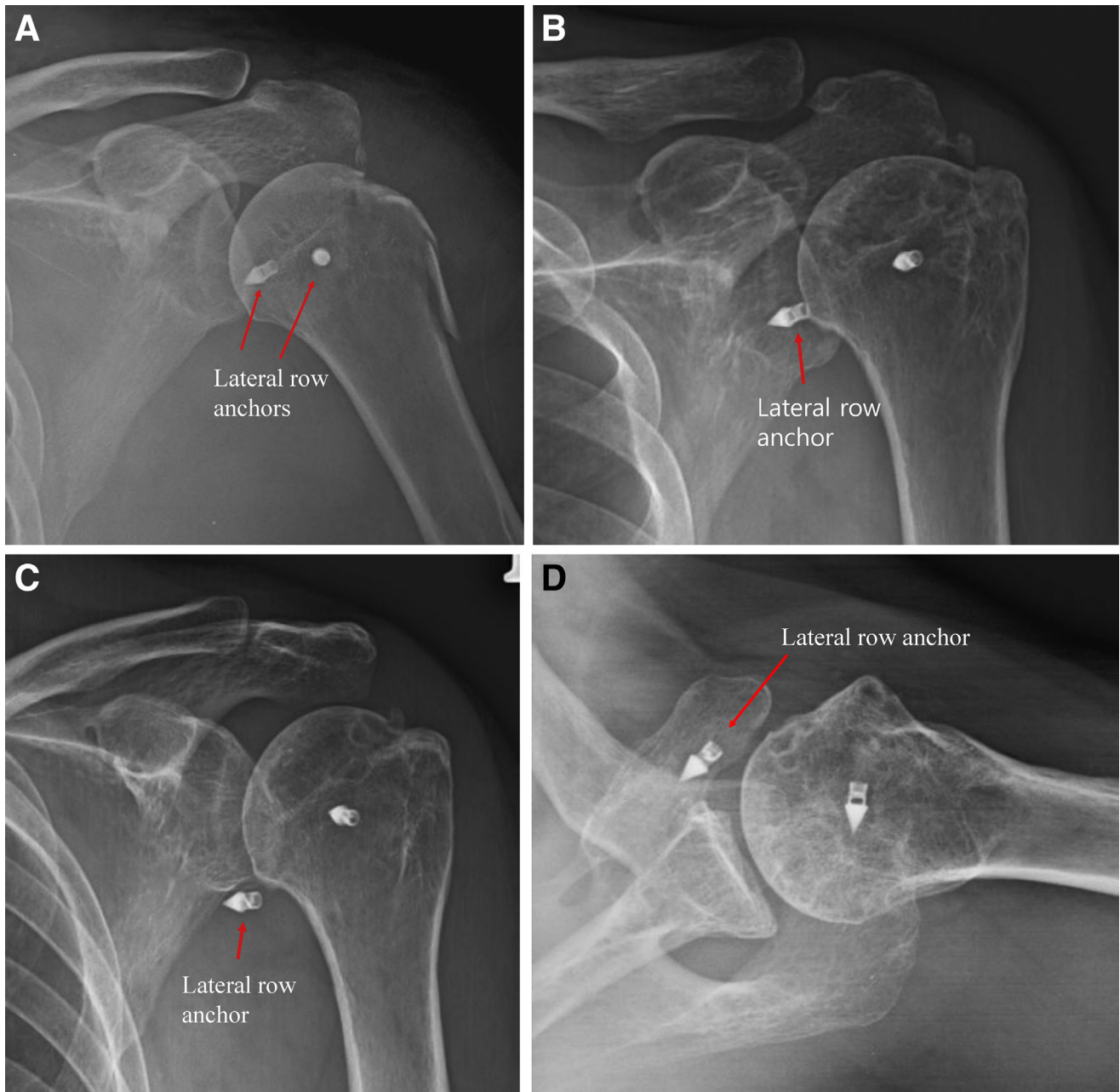


Fig 14. Plain radiographs of the left shoulder of a 56-year-old female patient. (A) Immediately postoperative anteroposterior view. One of the lateral anchors appears to be in the wrong position. (B), (C), (D) Postoperative 1-year plain radiographs. One of the lateral anchors is pulled out, but the patient does not complain of any discomfort and has full range of motion.

Table 2. Advantages and Disadvantages of This Technique

Advantages	Disadvantages
Low radiation hazard.	Need advanced arthroscopy skills.
Does not require additional surgery (plating or hardware removal surgery).	Irritation to long head of the biceps tendon because of the lateral anchor position (long head of the biceps tendon tenotomy or tenodesis is needed).
Low risk of infection.	Lower fixation power than with plate fixation is a concern.
Low soft tissue damage.	Longer operative time than open surgery.
Can solve concomitant intra-articular pathology at the same time.	

a concern, it is not a problem as many large split-type greater tuberosity fractures present in elderly patients with shoulder dislocation. All patients with a large displaced greater tuberosity fracture who underwent surgery with our technique were >50 years old.

Considering the fractures described in this report, the authors can fix large greater tuberosity fractures and effectively treat other pathologies without another incision and radiation exposure. The authors believe that the arthroscopic suture bridge repair technique with lateral anchor placed bicipital groove in a large greater tuberosity fracture with concomitant capsulolabral injury and subscapularis tear is one method to obtain good results with less soft tissue injury (Figs 13 and 14 and Table 2).

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