Technical Note

Revision Arthroscopic Greater Tuberosity Fracture Fixation and Implant Removal: An Open to Arthroscopic Approach

Vikram Arun Mhaskar, M.S., M.Ch.

Abstract: Failure of a greater tuberosity fracture fixation with screws can lead to stiffness, pain, and weakness of the rotator cuff. Management of a previously performed open greater tuberosity fracture fixation with screws involves implant removal and refixation of the fragment. Doing this arthroscopically in a previously performed open surgery has its own challenges but distinct advantages. Describe herein is a technique for performing this revision surgery arthroscopically.

Isolated greater tuberosity (GT) fractures can happen in isolation or along with dislocations of the shoulder. They are relatively uncommon in isolation and more often than not associated with proximal humerus fractures or an anterior shoulder dislocation.[1] The criteria to fix them are when the displacement is more than 5 mm in the general population or 3 mm in an athlete.[2] Fixation methods can be by open or arthroscopic techniques, with open techniques being relatively less technically demanding as compared with arthroscopic techniques. However, arthroscopic surgery has a distinct advantage of being minimally invasive and hence wound-healing time is faster with fewer chances of infection, less blood loss, soft-tissue trauma, and less scar tissue formation.[3,4] Open reduction internal fixation may use suture anchors or screws with washers to fix the GT fragment.[5]

Screws that are larger in size have the chance of comminuting the fractured GT while fixing it when the fragment is small in size. Also, screws ideally need to be used with a washer to evenly distribute the pressure over the fragment. An apparent disadvantage is also the possibility of impingement if the screws are left proud or back out.

Non-union of the GT are usually due to the fracture being missed or in a proximal humerus fracture where the GT was not fixed back properly. However, there are no reports of an isolated GT fracture that was improperly fixed leading to a symptomatic non-union. The GT fragment due to the pull of the rotator cuff muscles

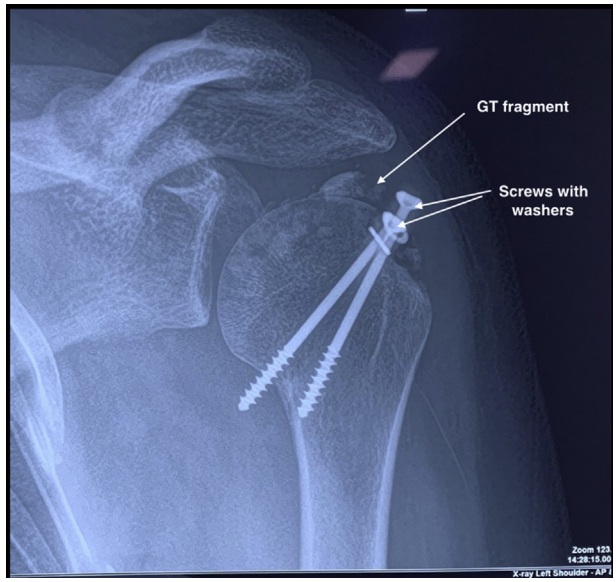

Fig 1. Anteroposterior-view radiograph of left shoulder showing unreduced comminuted greater tuberosity fragment with 2 cannulated cancellous screws with washers not passing through the fragments and one screw backed out.

From the Department of Orthopaedics, Max Smart Superspeciality Hospital, New Delhi, Knee & Shoulder Clinic, New Delhi, India.

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Address correspondence to Vikram Arun Mhaskar, M.S., M.Ch., Department of Orthopaedics, Max Smart Superspeciality Hospital, New Delhi, Knee & Shoulder Clinic, F7, East Of Kailash, New Delhi 110065, India. E-mail: drvikrammhaskar@gmail.com

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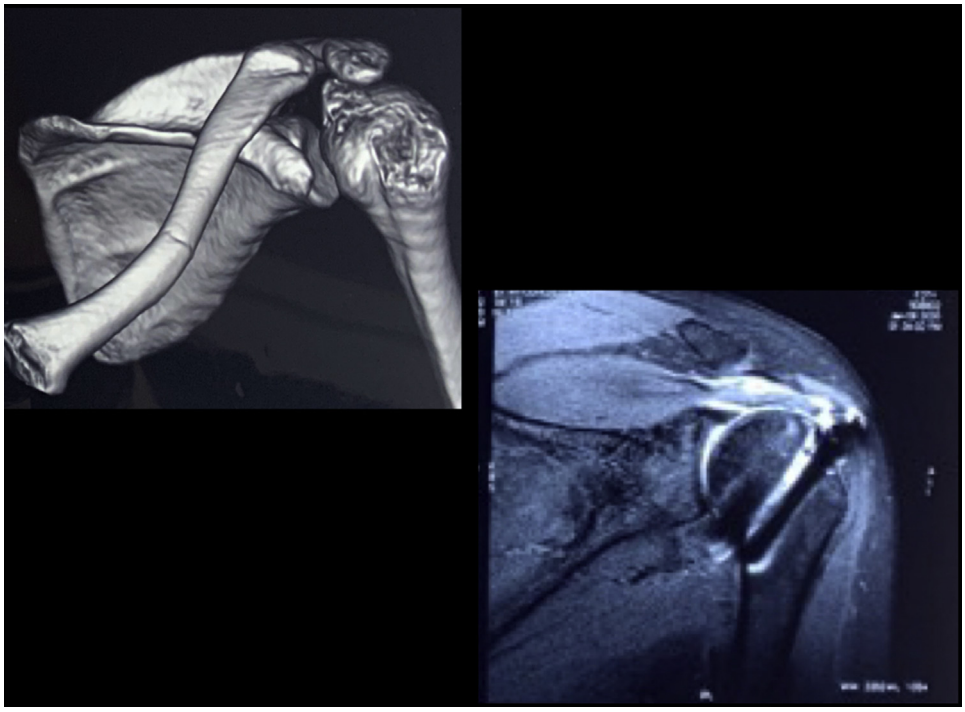

Fig 2. Three-dimensional computed tomography of shoulder joint showing displaced GT and magnetic resonance imaging of the left shoulder, coronal view, showing 2 screws over GT and supraspinatus tendon tear. (GT, greater tuberosity.)

displaces posteriorly, superiorly, and medially, and this restricts external rotation. The superior migration prevents full abduction, presenting as an impingement.

There have also been no reports of a GT fixed by open methods and revision surgery done arthroscopically. This poses a challenge, as open surgery produces more scarring in the joint and hence visibility can be impaired. Arthroscopic double-row fixation has been shown to produce better range of motion and American Shoulder and Elbow Surgeons scores as compared with open methods.[4] Presented herein is the treatment nonunion of a GT previously treated with arthroscopic implant removal, subacromial decompression, and revision GT fixation using double-row anchors.

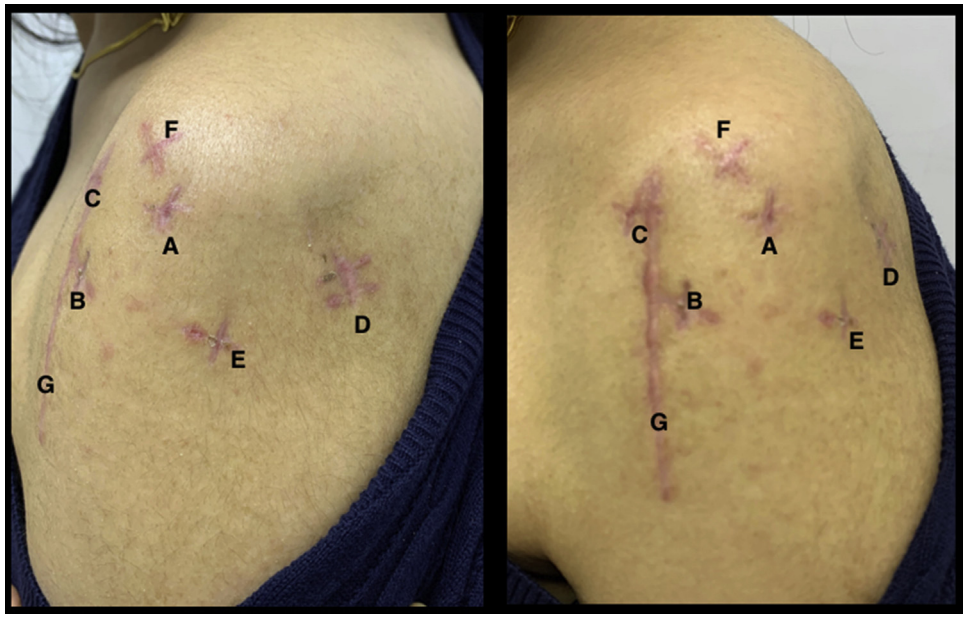

Fig 3. Lateral and oblique views of left shoulder showing portals used for the arthroscopic procedure (A-F) and the previous scar of open surgery (G).

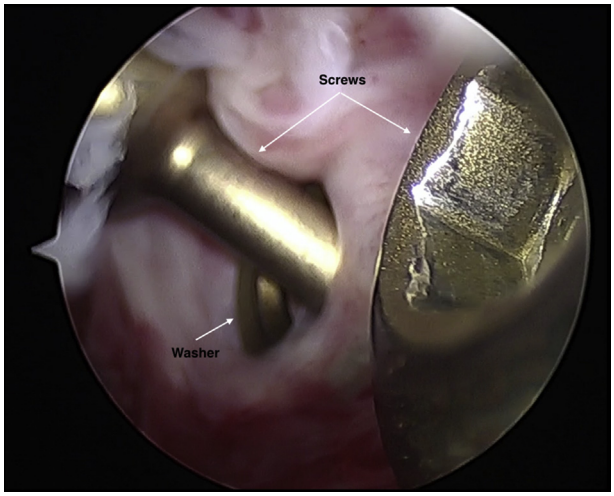

Fig 4. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A showing both screws and washer with the patient in a beach chair position.

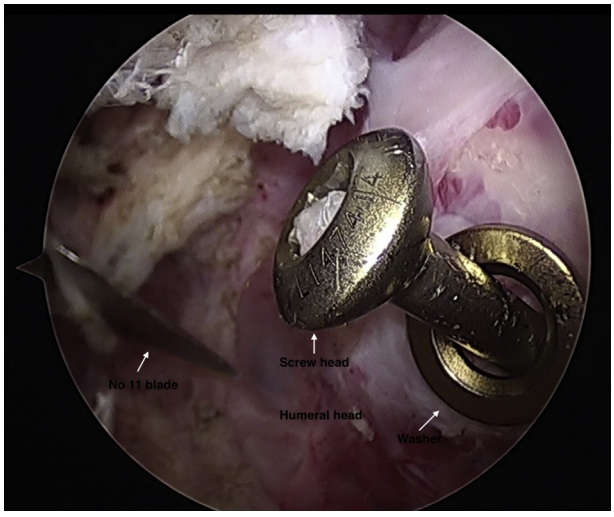

Fig 6. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A showing a No. 11 blade being introduced in line with the LP needle's direction to make Portal C with the patient in a beach chair position. (LP, lumbar puncture.)

Indications, Physical Examination, Blood Tests, and Imaging

The technique described is indicated in cases in which the GT has not united and has been fixed with hardware (screws and washers) previously. Physical examination should be done for impingement, strength of the rotator cuff tendons, and active as well as passive range of motion (ROM). Examination with the patient under anesthesia is done to determine whether it is true stiffness or restriction of ROM caused by pain. This is important as an arthroscopic shoulder release may be indicated if the passive ROM under anesthesia is present. Presence of an infection should be ruled out with standard tests such as the total leucocyte count, differential count, erythrocyte sedimentation rate, and C-reactive protein. Apart from these, radiographs (both anteroposterior (Fig 1) and axillary views) and a computed tomography scan for the position of the implants as well as the configuration of the fragment are done (Fig 2). Magnetic resonance imaging is done to see any associated rotator cuff tear and identify any other soft-tissue pathology in the shoulder (Fig 2).

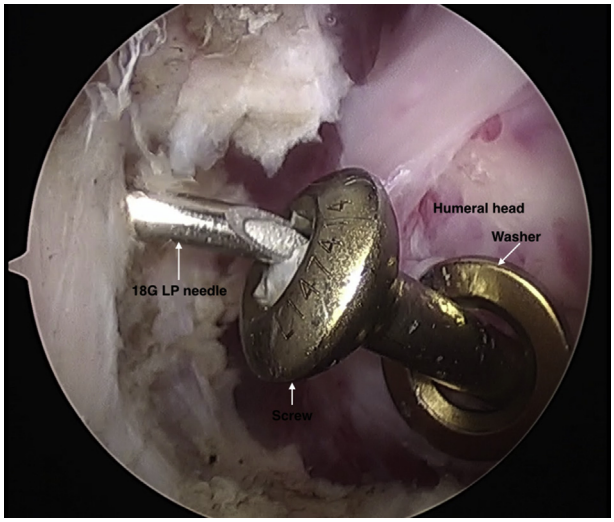

Fig 5. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A showing introduction of 18-G LP needle in line with the posterior screw head to make a portal with the patient in a beach chair position. (LP, lumbar puncture.)

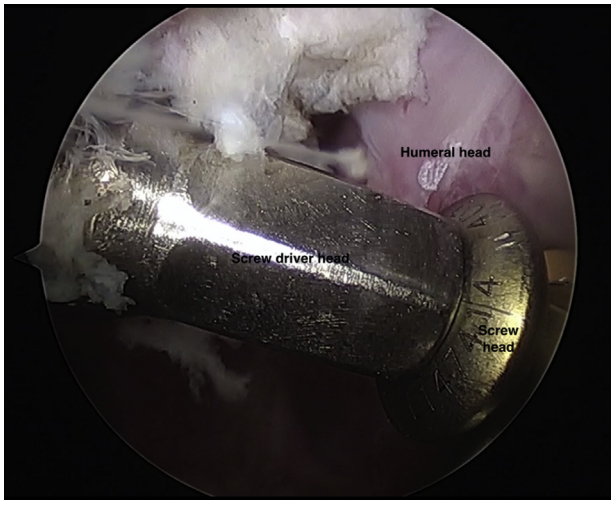

Fig 7. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A showing screw driver introduced through Portal C to engage the posterior screw head with the patient in a beach chair position.

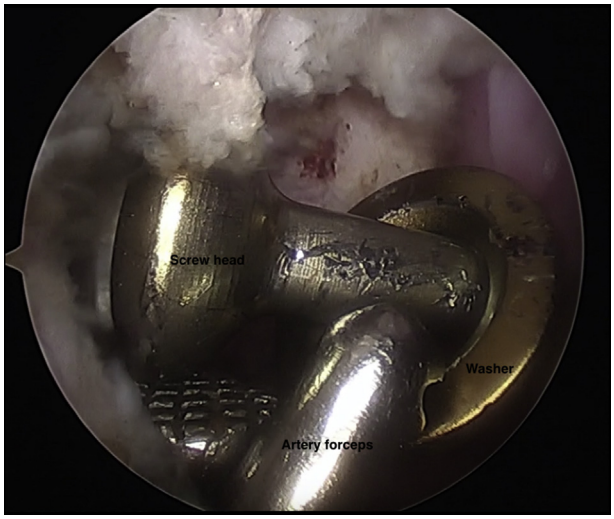

Fig 8. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A showing artery forceps introduced through Portal C engaging the head of the posterior screw and another artery forceps through Portal B to hold the washer with the patient in a beach chair position.

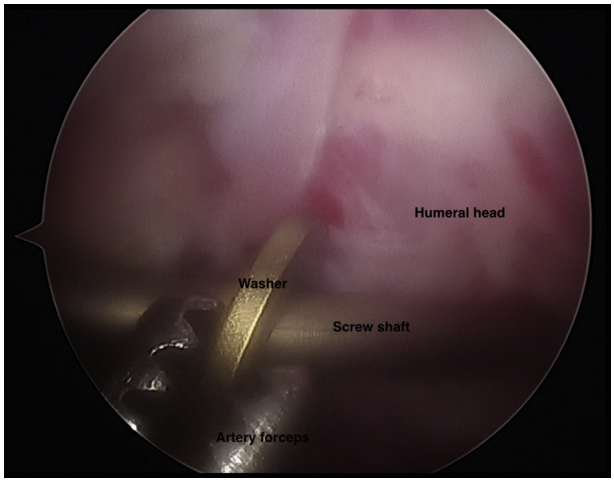

Fig 10. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A showing posterior screw being removed with washer held with an artery forceps introduced through Portal B with the patient in a beach chair position.

Surgical Technique (With Video Illustration)

The patient is positioned in the beach chair position (Video 1), and portals are created (Fig 3). Portal A is a viewing portal, 2 cm lateral to the anterior angle of the acromion and 1 cm below the slope of the acromion. Portal B is a working portal to introduce the shaver and burr for a subacromial decompression and debridement, and to apply the lateral anchor. It is also used to introduce an artery forceps to hold the washer during implant removal. Portal C is a working portal made at the anterior angle of the acromion 0.5 cm distal to it to introduce a screwdriver/artery forceps to remove the screw. Portal D is a working portal made posteriorly 2 cm below the angle of the acromion and 1 cm posterior to it. It is used to take bites through the cuff tissue attached to the GT fragment using a suture lasso. Portal E is a working portal made 4 cm below the anterior angle of the acromion It is used to take bites through the cuff tissue using a suture lasso, applying the lateral row anchor and to introduce a shaver to do a posterior sub acromial decompression. Portal F is used to

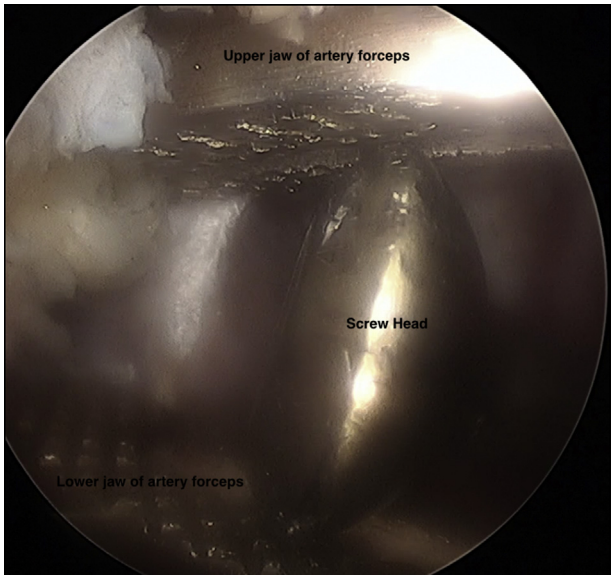

Fig 9. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A showing artery forceps introduced through Portal C to engage the posterior screw head to remove it through a rotatory motion with the patient in a beach chair position.

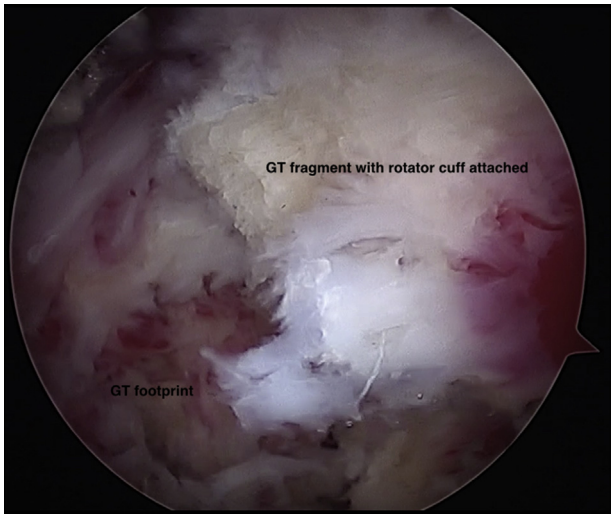

Fig 11. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A showing GT fragment and the GT footprint with the patient in a beach chair position. (GT, greater tuberosity.)

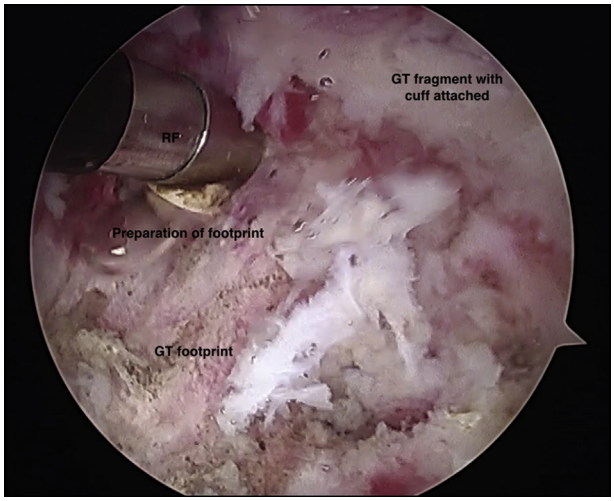

Fig 12. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A visualizing the GT footprint and cleaning it with a RF device with the patient in a beach chair position. (GT, greater tuberosity; RF, radiofrequency.)

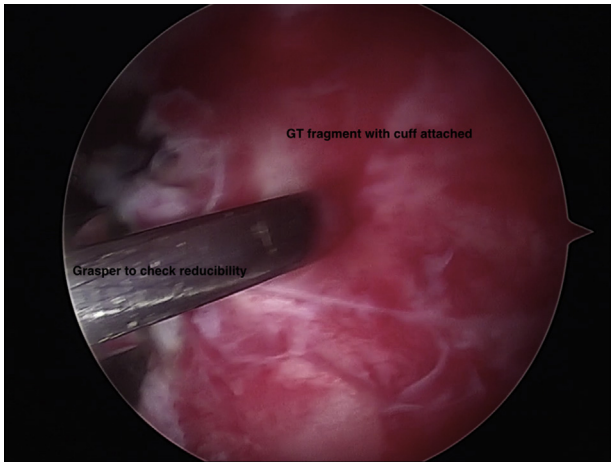

Fig 14. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A showing a grasper introduced through Portal C holding the GT fragment with cuff attached to it and reducing it on the footprint with the patient in a beach chair position. (GT, greater tuberosity.)

introduce the medial row anchors. Portal G is the previous scar from the open GT fixation done elsewhere.

Procedure

The subacromial space is entered using Portal A. Portal B is made so that the shaver can be introduced in line with the acromion so as not to have any obstruction while doing a subacromial decompression and debridement. The 2 screws and washers are then identified and found to be lying relatively anteriorly (Fig 4). A portal is made using an lumbar puncture needle in line with the head of the more lateral screw (Figs 5 and 6). The screw is found to be relatively loose. The washer is then identified. A screwdriver first and then an artery forceps is introduced through Portal C to engage the screw head and another artery forceps through portal B to engage the washer (Figs 7-9). A couple of turns in the head of the screw are made using the screwdriver to disengage the screw. An artery forceps is then introduced through Portal C to hold the head of the screw while simultaneously holding the washer with an artery forceps through Portal B. The screw and washer are then removed simultaneously (Fig 10).

The same Portal C is used to engage the head of the more medial screw using an artery forceps and similarly

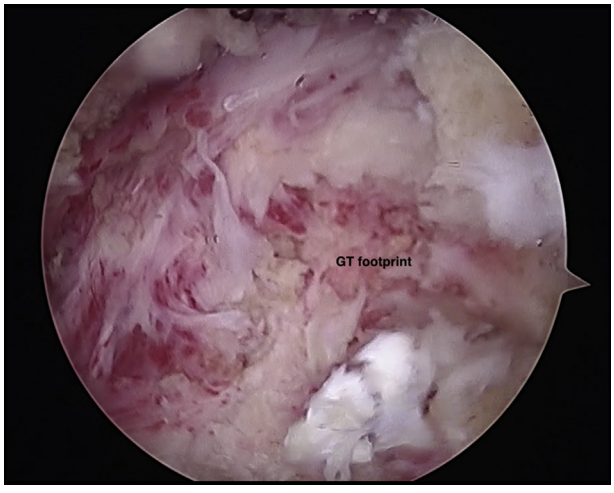

Fig 13. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A showing the cleaned GT footprint visualized with the patient in a beach chair position. (GT, greater tuberosity.)

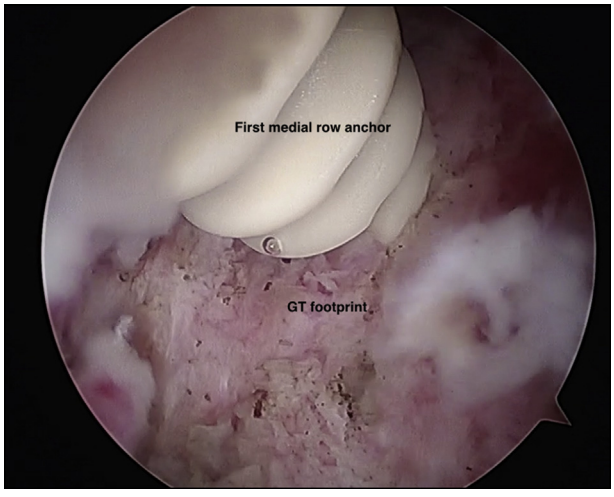

Fig 15. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A, introducing the first medial row anchor through Portal F with the patient in a beach chair position. (GT, greater tuberosity.)

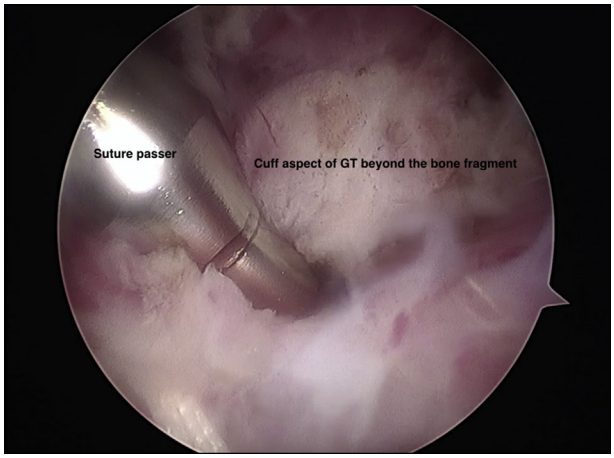

Fig 16. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A, showing the suture lasso passing through the anterior aspect of the rotator cuff attached to the GT with the patient in a beach chair position. (GT, greater tuberosity.)

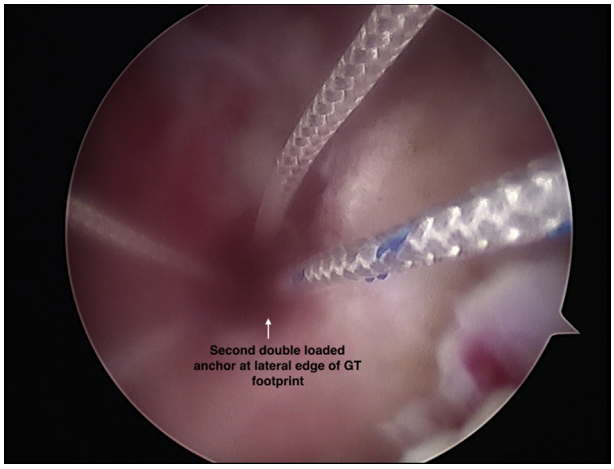

Fig 18. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A, showing second medial row anchor with threads coming out of it with the patient in a beach chair position. (GT, greater tuberosity.)

using portal B to engage the washer, the second screw and washer are then removed.

Once the screws are removed, the GT fragment is identified (Fig 11) and the footprint freshened by introducing a radiofrequency probe through Portal E (Figs 12 and 13). Reducibility of the GT fragment to the footprint is then assessed using a grasper introduced through Portal C (Fig 14). A subacromial decompression is then performed above the avulsed fragment to facilitate passage of the suture passer in the cuff tissue medial to the GT fragment. The first double-loaded anchor (TWINFIX; Smith & Nephew, Watford, United Kingdom) is then applied to the anterior end of the GT footprint using Portal F (Fig 15). Bites are taken from the cuff with threads coming out of the anterior anchor using a SutureLasso (Arthrex, Naples, FL) carrying a No 2 PDS suture introduced through Portal E in a mattress configuration (Figs 16 and 17). The second medial row anchor (TWINFIX; Smith & Nephew) is then applied to the posterior aspect of the GT footprint (Fig 18), and bites are taken through the cuff tissue medial to the bony GT fragment (Fig 19). All the sutures are tied with simple knots with 4 throws (Fig 20). Two threads of the extreme knots are not cut, loaded on a lateral anchor (FOOTPRINT; Smith & Nephew) and the anchor applied just distal to the footprint using Portal B

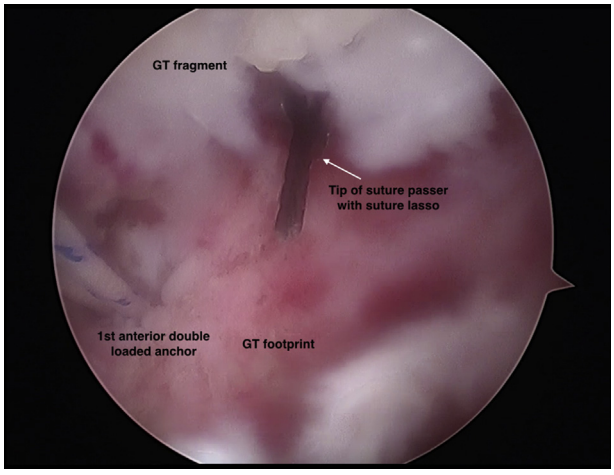

Fig 17. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A, showing the PDS suture being deployed from the suture lasso, under the rotator cuff after taking a bite with the patient in a beach chair position. (GT, greater tuberosity; PDS, polydioxanone.)

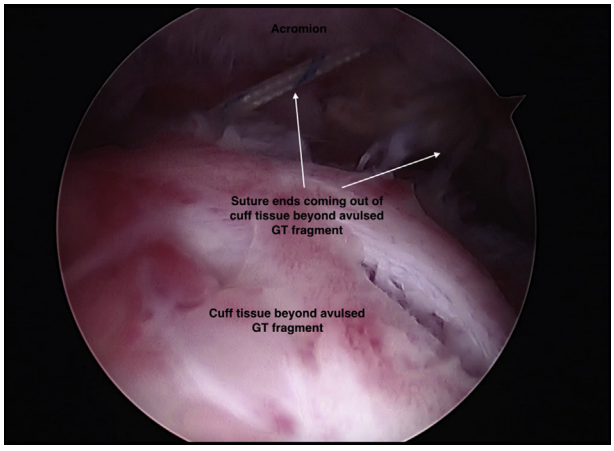

Fig 19. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A, showing threads coming out of the rotator cuff tissue beyond the GT fragment after bites were taken through it with the patient in a beach chair position. (GT, greater tuberosity.)

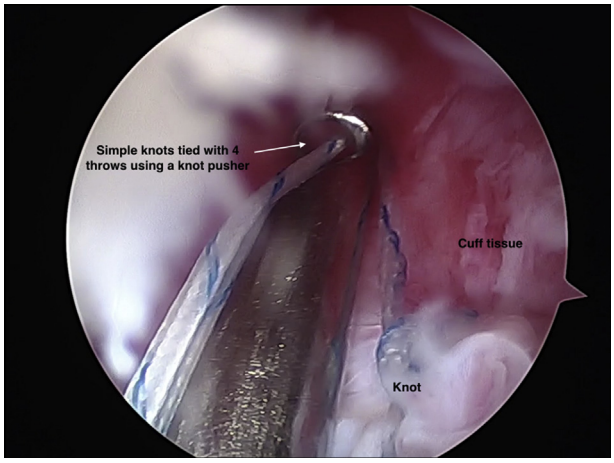

Fig 20. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A, showing knot pusher introduced through Portal E tying knots with the patient in a beach chair position. (GT, greater tuberosity.)

(Fig 21). The repair is then assessed arthroscopically and found to be secure (Fig 22). Further subacromial decompression is done to prevent impingement (Fig 23). A radiograph is taken while the patient is on the table to assess reduction of the fragment and is found to be satisfactory (Fig 24).

Postoperative Rehabilitation

The patient's arm is placed in an arm sling. No ROM exercises are started for 2 weeks, following which passive ROM exercises 0 to 90° abduction and forward flexion are begun. At 4 weeks, the sling is removed and active assisted exercises started to the full ROM. At 6 weeks, the patient is allowed full active ROM exercises, and strengthening exercises are started.

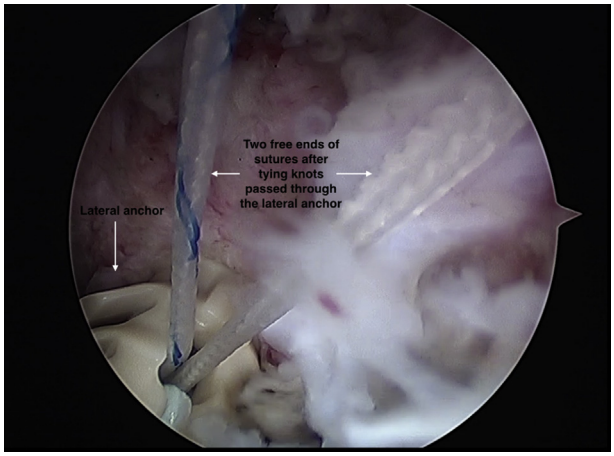

Fig 21. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A, showing lateral row anchor introduced through Portal B with the patient in a beach chair position.

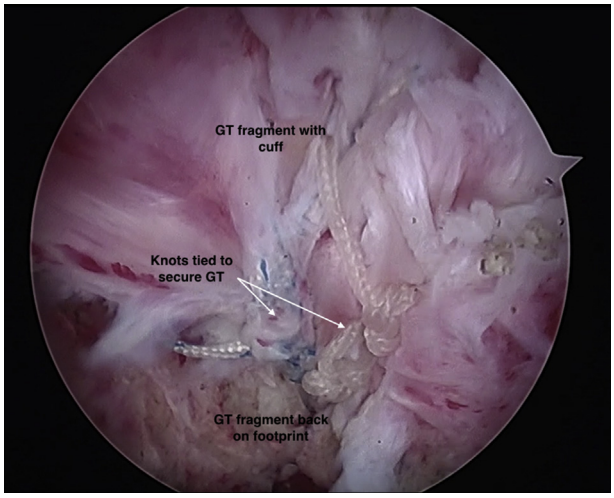

Fig 22. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A, showing repaired GT fragment with the patient in a beach chair position, (GT, greater tuberosity.).

Discussion

Isolated GT fracture nonunions are usually seen in developing countries due to nonoperative treatment or them being missed.[6] Open methods that are less technically demanding use anchors or screws. When screws are used, it is imperative that they are placed through the main fragment and not over-tightened so as to comminute the GT fragment. Fixation failure with screws can happen if the fragment is not pulled back to its footprint adequately and the bony chunk identified before placing the K wires and screws. This is important as the fragment is covered with cuff tissue and hence

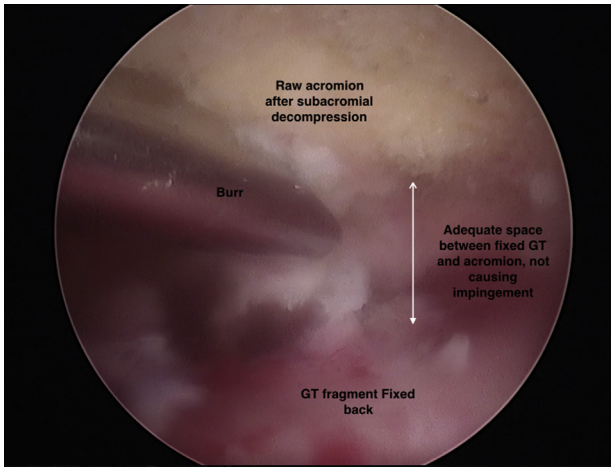

Fig 23. Arthroscopic view of the left shoulder's subacromial space, viewing from Portal A, showing burr introduced through Portal B for a subacromial decompression and adequate space being created between the cuff and acromion with the patient in a beach chair position. (GT, greater tuberosity.)

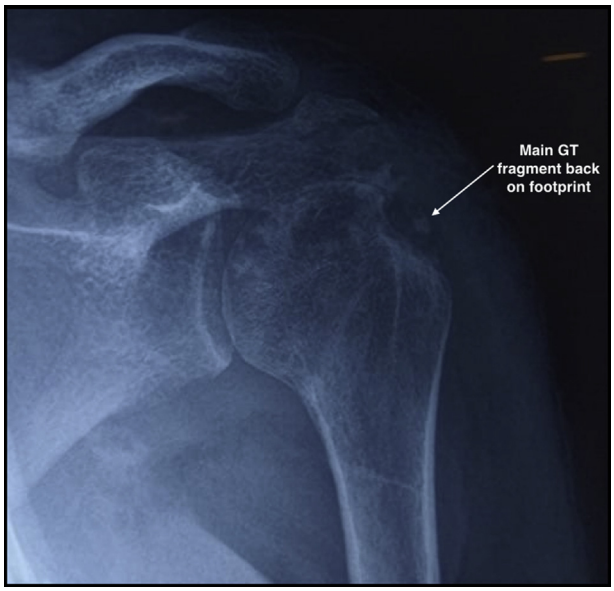

Fig 24. Anteroposterior-view radiograph of the left shoulder revealing reduced GT. (GT, greater tuberosity.)

the GT fragment may not be seen. Tactile techniques and imaging need to be used before the screws are passed through the fragment, especially in osteoporotic and small fragments, as it can shatter them. Hence, the use of double-row suture anchors offer the benefit of having smaller diameter passes through the cuff tissue beyond the fragment and hence indirectly reducing the fragment to its footprint. Osteoporotic bone and a shorter screw length not passing through the opposite cortex can cause a fixation failure and the screw to come out. Once the screw gives way and is pulled up, it impinges on the acromion on abduction, causing pain. The posterior migration of the GT in turn causes restricted external rotation.

Open surgery to fix such fractures in addition causes scarring that may make the arthroscopic salvage more technically challenging. The length of the incision and dissection also adds to the postoperative pain. Also, a

Table 1. Advantages and Disadvantages of the Procedure

Advantages	Disadvantages
Minimally invasive, less wound healing time	More technically demanding
Cosmetic	Mobilizing the GT fragment is more difficult due to fibrosis and scarring
No metallic implants in situ with stable fixation	Multiple portals required for the procedure
Indirect reduction in comminuted/osteoporotic fractures, does not further comminute the fragments	In larger and less-comminuted fragments, especially in a revision setting, reduction of the fragment can be more difficult arthroscopically through indirect reduction

GT, greater tuberosity.

Table 2. Pearls and Pitfalls of the Procedure

Pearls	Pitfalls
Portal placement for screw driver to engage the head is important; hence, using a LP needle is important before making the portal	If portal placement not accurate, the screw driver may not fit into the head properly and cause rounding off
Holding the washer with an artery forceps through another portal while removing the implant is important	If washer is not held, the chances of it being lost in the joint are greater
The use of an artery to engage the head of the screw after it has been disengaged from the bone helps remove the screw	After the screw is disengaged from the far cortex and is loose, the screwdriver engaging the head pushes the screw further back rather than screwing it out
Using 2 medial-row and 1 lateral-row anchor makes the large GT fragment sit more anatomically and have larger bone to bone contact area	If the medial-row anchors are not placed at either end of the footprint, the GT fragment will have less area of bone-to-bone contact
A subacromial decompression before taking bites through the cuff tissue improves maneuverability of the suture passers through the tissue	No subacromial decompression can lead to impingement, especially in comminuted GT fractures, as all bony fragments may not sit back anatomically

GT, greater tuberosity; LP, lumbar puncture.

cannulated screw that is free and not holding well precludes the screwdriver from getting a good hold on the head. Hence, improvisation using an artery forceps to engage the head and disengage the threaded portion before removing it is critical. While removing the screw, to arthroscopically manipulate the washer to come out using a second portal is critical so as not to lose it in the joint.

Once this is done, identification of the correct footprint is important, as scarring can preclude accurate identification. Checking the reducibility of the GT fragment to the footprint especially in neglected or failed cases decides whether it can be done arthroscopically or by open surgery. Comminution caused by failure of the previous fixation warrants the cuff attached to all fragments, should be pulled in a direction so as to reduce the chunk of the GT. Double-row anchors work very well in comminuted fragments as they bypass the bony fragments and indirectly reduce the GT.

Most of the pain could be attributed to the prominent screws; however, the weakness in the cuff muscles could be due to the insufficiency of the cuff. A large displacement of the GT with weakness of the cuff muscles was an indication to fix the GT back.

This technique provides an effective minimally invasive alternative to open techniques in revision GT fracture fixation and is the only reported case of an arthroscopic revision surgery in a previously done open

fixation of the GT. The advantages and disadvantages as well as pearls and pitfalls of the technique are enumerated in Tables 1 and 2.

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