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Open reduction and internal fixation using suture anchors for an isolated lesser tuberosity fracture: description of technique and a case report

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Isolated fractures of the lesser tuberosity (LT) of the humerus are uncommon injuries that can pose significant challenges in diagnosis and treatment. Although infrequent, these fractures have the potential to cause substantial functional deficits if not managed appropriately.[16,20] The LT and the attached subscapularis play a crucial role in the biomechanical function and stability of the shoulder joint, underscoring the importance of accurate diagnosis and effective treatment to preserve shoulder function and prevent long-term complications.

Accurate diagnosis of isolated LT fractures can be particularly challenging since small or minimally displaced fracture fragments may go unnoticed on routine anteroposterior and scapular radiographs.[15-17] The subtle nature of these fractures can lead to missed or delayed diagnoses, potentially leading to postponed treatment and an increased risk of complications. To overcome these challenges, additional imaging modalities such as axillary radiographs, computerized tomography (CT) scans, magnetic resonance imaging, and sonography have proven to be helpful tools in visualizing the fracture fragment and assessing possible displacement.[10] It is important to note, however, that larger avulsion fractures can be displaced inferiorly to a subglenoid position, mimicking other pathologies such as bony Bankart fragments or calcified tendonitis of the subscapularis tendon.[8] These diagnostic challenges contribute to the potential underreporting of isolated LT fractures, emphasizing the importance of raising awareness and improving diagnostic strategies in the field.

Given their rarity, with an estimated annual incidence of 0.46 per 100,000 population,[16] there remains a lack of consensus regarding the optimal treatment approach for these injuries, resulting in varying recommendations in the literature. While nonoperative management with immobilization has demonstrated favorable outcomes for non-displaced or minimally displaced fractures,[7,15,23] misaligned or displaced fractures can lead to complications such as malunion, rotator cuff dysfunction, and subcoracoid impingement, indicating surgical intervention.

The gold standard in surgical intervention for LT fractures has been the use of open reduction and internal fixation with cancellous screws. This approach has a long-standing history of providing excellent outcomes, with studies reporting successful stabilization and functional recovery in patients.[2,9,11,13,17] Cancellous screws offer reliable stability, promoting the healing of the fractured LT. However, despite its historical success, this technique is not without its challenges.

Arthroscopic-assisted reduction and fixation has emerged as a promising alternative, offering a less invasive approach to fragment reduction and fixation.[1,3,14,19] Our article presents a departure from traditional methods, opting for suture anchors as an alternative to the commonly used screw fixation. Suture anchors offer potential advantages, including improved postoperative imaging, reduced risk of bone damage, minimal need for intraoperative fluoroscopy, and the biodegradability of the anchors. The decision to explore alternative fixation methods reflects the

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ongoing debate within the medical community regarding the optimal approach to managing these rare but challenging fractures. This technique, utilizing suture anchors, presents a useful addition to the spectrum of surgical options for the treatment of isolated LT fractures, providing surgeons with an additional option in their repertoire.

Case report

An otherwise healthy 27-year-old female presented with left shoulder pain, weakness, and limited range of motion (ROM). She had experienced a skiing accident 3 months prior to her visit to our clinic, and another orthopedist had diagnosed her with a closed left humeral head fracture on the day of the accident. Initially, the patient's fracture was managed nonoperatively using a sling for immobilization, pain medication, and pendulum exercises. About a month later, the patient returned with complaints of limited ROM and persistent pain. The decision was made to discontinue the sling, initiate gentle exercises, and reevaluate in 3 weeks. Three weeks later, the patient reported intermittent pain, occasional numbness, and tingling in the elbow. Physical examination indicated profound loss of movement, audible clicking, and popping in the joint. The patient was referred to our care with a recommendation for shoulder surgery.

The patient's physical examination upon initial presentation to our clinic was notable for tenderness to palpation at the anterior humerus, limitation in internal rotation, as well as weakness, including an abnormal belly press, bearhug test, and liftoff test. The CT scan (Fig. 1) revealed an isolated LT fracture, with the major fragment measuring approximately 16 × 7 × 22 mm. Additionally, the fragment was found to be displaced inferiorly by about 7 mm and rotated 90 degrees vertically. Our team conducted follow-up radiographs (Fig. 2), which further demonstrated evidence of a displaced and angulated LT fracture.

Due to the displacement and angulation of the fracture fragment, as well as the relatively lengthy period between the initial injury and the patient's presentation, we decided to proceed with an open surgical approach to treat the fracture. The fracture pattern permitted the use of suture anchors instead of screws for internal fixation of the fragment.

Surgical technique

On the day of the surgery, the patient underwent a regional anesthesia nerve block and was taken to the operating room. She was then transferred to the operating table and received general anesthesia administered by the anesthesia team. The patient was positioned semi-upright in a modified beach chair position, and the operative site was prepared and draped following standard sterile procedures.

A deltopectoral incision was made, and dissection was performed through the deltopectoral interval. The cephalic vein was identified, protected, and mobilized laterally to provide access to the fracture site. The biceps tendon was located within the bicipital groove, and the fracture fragment was observed to be displaced medially and rotated approximately 90 degrees vertically. Additionally, the fracture had partially healed in a malunion. A curved osteotome was utilized to mobilize the fracture fragment, and a curette and rongeur were employed to prepare the fracture bed and fragment for reduction (Fig. 3).

After performing a trial reduction of the fragment, the medial row of suture anchors was prepared. Two double-loaded 4.5-mm fully threaded anchors (Arthrex, Naples, FL, USA) were inserted into the medial border of the exposed footprint of the fracture site using an anchor screwdriver following preparation with an awl and bone tap (Fig. 4). The 8 suture limbs from the anchors were then passed in a mattress fashion through the subscapularis tendon medial to the fracture fragment using a medium-free needle. The suture limbs were then pulled laterally to reduce the fracture and bring the LT into anatomical position (Fig. 5). Subsequently, each suture limb was sequentially tied using secure knots, and preparation for lateral row fixation was undertaken next.

Figure 1 Axial CT scan taken 3 months after initial injury showing dominant fracture fragment displaced medially and angulated. *CT*, computerized tomography.

The lateral row anchor sites were prepared with an awl at the lateral margin of the fracture bed but medial to the bicipital groove. A suture limb from each know was passed through the eyelet of a 4.75-mm fully threaded, knotless suture anchor (Arthrex, Naples, FL, USA). Each suture limb was individually tensioned over the fracture fragment, and the first lateral row anchor was inserted to achieve secure fixation lateral to the fracture site. The remaining suture limbs were passed through a second lateral row 4.75-mm knotless anchor, which was then inserted into the humeral head just inferior to the first lateral row anchor (Fig. 6) to further secure the fragment.

Intraoperatively, the movement of the glenohumeral joint was tested, demonstrating stable fixation of the LT fracture fragment (Fig. 7). Importantly, fluoroscopy was not utilized during the procedure which limited the patient's exposure to radiation.

Postoperative management and rehabilitation

In the postoperative period, the patient's left shoulder was immobilized with a sling for 6 weeks. The left upper extremity was to be non-weight-bearing for 6 weeks; avoiding heavy lifting or strenuous activity. Follow-up appointments at 2-, 6-, and 12-week postsurgery, with radiographs taken at each visit, were scheduled. Physical therapy (PT) played a pivotal role, initiated six weeks after surgery, strategically timed after the initial immobilization period. The PT regimen included a gradual introduction of active ROM (AROM) exercises tailored to the patient's tolerance and surgical

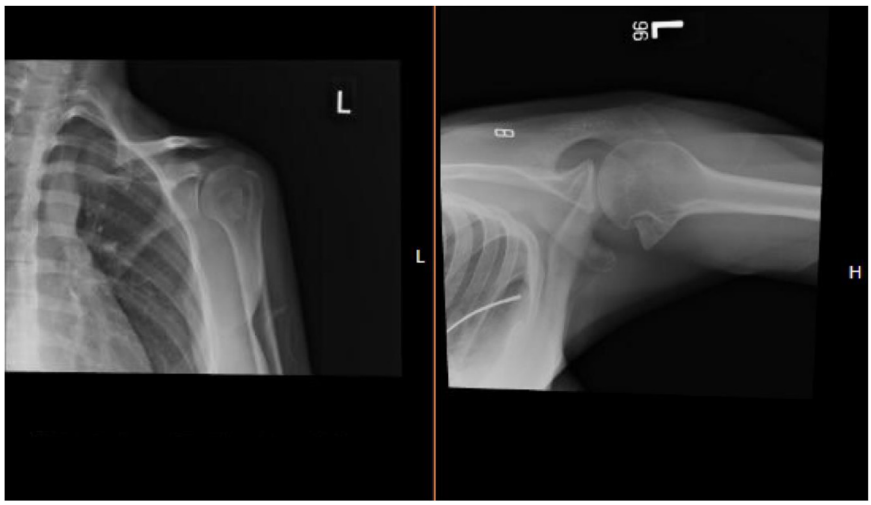

Figure 2 Preoperative anteroposterior and axillary radiographs taken 3 months after initial injury showing displacement of major fracture fragment.

Figure 3 The mobilized lesser tuberosity fracture fragment can be visualized on the medial edge of the humeral head.

Figure 4 Medial row suture anchors inserted with the free suture limbs positioned medially.

requirements. Beyond AROM exercises, the program encompassed strengthening exercises progressing in intensity as the healing process advanced.

Postoperative progress

Postoperative ROM progress was as follows:

- 2 weeks: passive ROM 80/40.
- 4 weeks: physical therapy referral for passive ROM and active ROM to achieve 140/40.
- 6 weeks: AROM 130/50/L1.
- 12 weeks: AROM 145/55/L1.
- 6 months: AROM 165/5/T12.
- 9 months: AROM 175/65/T10.

Strength assessments at the 6-month postoperative visit demonstrated 5/5 strength on flexion, extension, external rotation, and internal rotation, along with successful bear hug and belly press tests. These outcomes affirm the successful recovery and functional restoration of the patient's shoulder.

At a 9-month postoperative visit, photos were taken indicating substantial improvement in ROM including abduction (Fig. 8), external rotation (Fig. 9), internal rotation (Fig. 10), and flexion (Fig. 11).

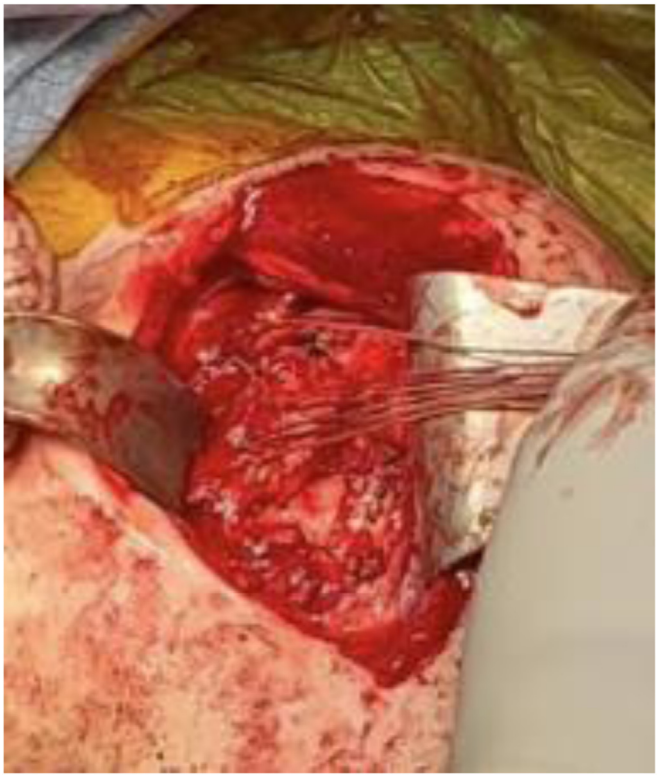

Figure 5 Anatomic reduction of the fracture fragment with the suture limbs being pulled laterally.

Figure 6 Insertion of the lateral row of suture anchors.

At this same visit, the patient's postoperative Single Assessment Numeric Evaluation score was 75%, indicating a significant improvement in overall shoulder function and stability when compared to her presenting state. Additionally, a 9-month postoperative radiograph (Fig. 12) was included to provide further insights into the healing process and the stability of the fixation.

Figure 7 Sturdy fixation of the major fracture fragment achieved in anatomic position.

Discussion

Isolated fractures of the LT of the humerus pose a diagnostic challenge due to their elusive nature, often escaping detection on standard radiographs.[15-17] To overcome this, reliance on alternative imaging modalities such as axillary radiographs, CT scans, magnetic resonance imaging, and sonography is crucial for enhanced diagnostic accuracy.[10]

The ongoing debate regarding operative versus nonoperative management reflects the rarity of LT fractures, leading to a lack of consensus. Surgical intervention is recommended for fractures exceeding 5 mm displacement, 45 degrees of angulation, impaired motion, failed nonoperative management, or severe disability.[5] The optimal timing for surgical intervention remains contentious,[19,23] emphasizing the need for further exploration in this area.

Studies such as Robinson et al 2009 underscore the rarity of isolated LT fractures, reporting a low estimated annual incidence of 0.46 per 100,000 population.[16] The scarcity of standardized guidelines accentuates the challenges in diagnosis and treatment, urging the necessity for more extensive research. Large-scale studies could illuminate the epidemiology and outcomes of LT fractures, paving the way for more robust guidelines.

Figure 8 Nine-month postoperative range of motion demonstrating abduction of the previously injured shoulder.

Figure 9 Nine-month postoperative range of motion demonstrating external rotation of the previously injured shoulder (left) with comparison from the uninjured shoulder (right).

While traditional open reduction and internal fixation with cancellous screws have been the gold standard,[4,5,8,10,11,15,21] emerging techniques such as arthroscopic-assisted reduction and fixation are challenging this paradigm.[1,6,19,22] Lin et al 2021 demonstrated significant improvement in 15 patients who underwent repair with suture anchors using an arthroscopic-assisted approach. Each patient showcased full range of shoulder motion and bilateral symmetric strength on physical examination with the bear-hug test, liftoff test, and internal rotation resistance 90-degree test. However, our case study emphasizes its infeasibility in delayed presentations, underlining the importance of considering fracture timing in treatment selection.

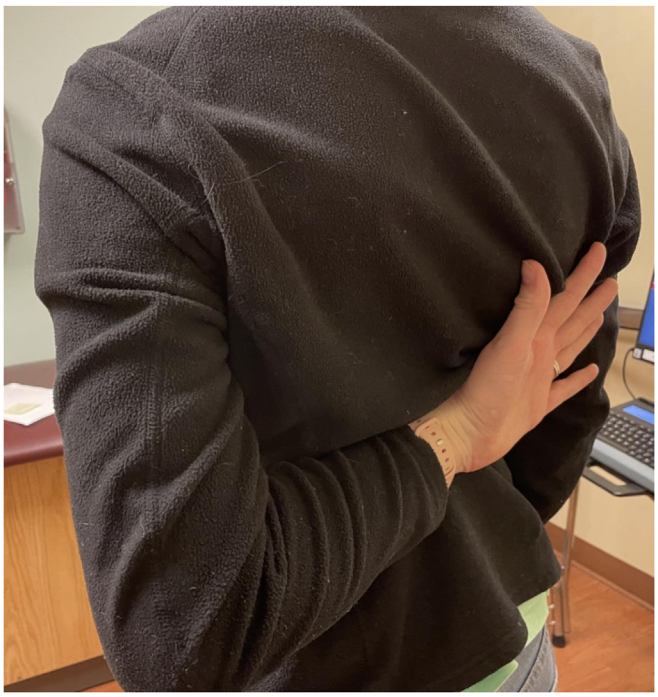

Figure 10 Nine-month postoperative range of motion demonstrating internal rotation of the previously injured shoulder.

Suture anchor fixation offers several advantages over traditional screw fixation, including improved postoperative imaging and reduced risk of collateral bone damage. It is important to note that a significant portion of the existing evidence supporting suture anchors in LT fracture fixation pertains to pediatric patients and shoulder arthroplasty. Despite this predominant focus, we believe that the results gleaned from these settings can be cautiously generalized to adult trauma patients, although further dedicated research in the adult trauma population is warranted. Suture anchors are biodegradable, eliminating concerns related to hardware removal, and they do not require intraoperative fluoroscopy, decreasing radiation exposure. However, technical expertise and potential cost implications should be considered. This study contributes to the growing evidence[4,12,18] supporting suture anchors in LT fracture fixation, offering secure fixation, promoting healing, and minimizing complications compared to screw fixation.

On the other hand, screw fixation has been a long-standing gold standard, providing stable fixation. Inserting screws carries a risk of collateral bone damage, potentially leading to complications. Traditional screws may necessitate a second surgery for hardware removal.

In the context of shoulder arthroplasty, biomechanical studies focusing on LT osteotomies have provided important insights. Specifically, research indicates that LT osteotomy repaired with suture anchors offers superior strength compared to subscapularis tenotomy, as evidenced by higher load-to-failure values at “time-zero”.[18] Additionally, long-term assessments reveal statistically significant improvements in subscapularis muscle strength at 24 months postoperatively for cases where LT osteotomy was fixed with suture anchors, as compared to baseline measurements in patients undergoing shoulder replacement.[12] These findings from arthroplasty-related studies contribute to the growing body of evidence supporting the

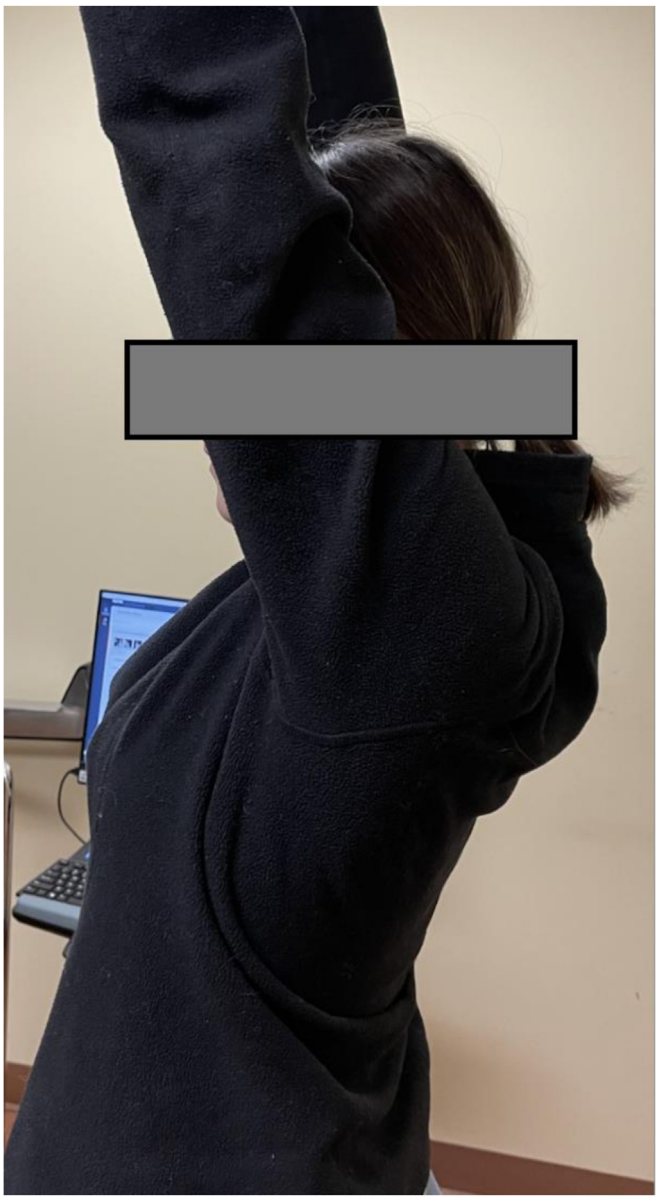

Figure 11 Nine-month postoperative range of motion demonstrating flexion of the previously injured shoulder.

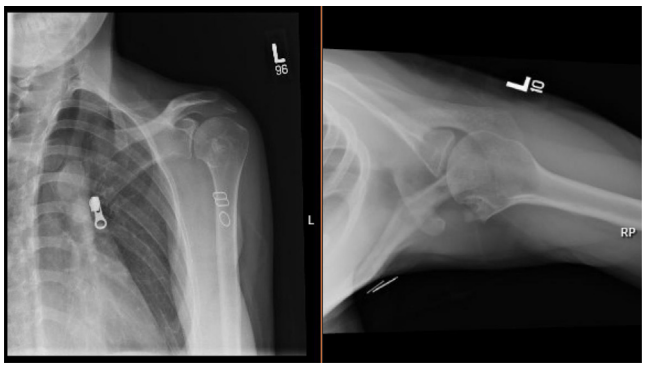

Figure 12 Nine-month postoperative anteroposterior and axillary radiographs demonstrating normal anatomic positioning.

efficacy and durability of suture anchor fixation in the management of LT fractures.

In addition to the case presented here, the authors have additional data for another patient where the same technique was used with similar follow-up and results. Our cases align with larger studies such as Robinson et al 2009, highlighting excellent outcomes after open reduction and internal fixation.

Isolated fractures of the lesser tuberosity present diagnostic challenges and require careful consideration for appropriate treatment. Our case series highlights the effectiveness of open reduction and internal fixation using suture anchors as an alternative to screw fixation.

Conclusion

Isolated LT fractures are rare injuries that can be easily overlooked and require careful consideration for appropriate management. Accurate identification and early treatment of displaced LT fractures are crucial to prevent malunion and functional loss in the shoulder joint. This study elucidates the effectiveness of open reduction and internal fixation using suture anchors, a technique more commonly associated with greater tuberosity fractures.

While the application of double-row anchor fixation is well-established in the context of greater tuberosity fractures, its adaptation for isolated LT fractures remains a relatively unexplored territory in the literature. Our case study contributes insights into the nuanced use of this technique in the unique anatomical and biomechanical context of LT fractures. The detailed surgical technique and outcomes presented here aim to shed light on the potential benefits and considerations in employing double-row anchor fixation specifically for isolated LT fractures.

This study not only addresses the diagnostic intricacies and treatment challenges associated with isolated LT fractures but also underscores the distinct contribution of utilizing double-row anchor fixation in this clinical scenario. The choice of treatment should be individualized, considering patient factors, fracture characteristics, and timing. By sharing our experiences and contributing to the existing body of knowledge, we aspire to advance the understanding and management of these unusual fractures and, ultimately, enhance patient outcomes.

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