Research Square

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Comparison of the Outcomes With Suture Anchors Versus Anatomical Locking Plates for Humeral Greater Tuberosity Fractures: a Case Control Study.

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Research Article

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Abstract

Background: Humeral greater tuberosity fractures account for approximately one-fifth of the fractures of the proximal humerus. There are a variety of internal fixation devices used in the treatment of fractures. Suture anchors and anatomical locking plates are the two commonly used internal fixation devices. However, there are no systematic studies on which device is more advantageous for the treatment of greater tuberosity fractures.

Materials and methods: We retrospectively analyzed the medical records and radiological results of patients with humeral greater tuberosity fractures who underwent surgical treatment and were followed up for at least one year from June 2017 to March 2020. A total of 31 patients were included in the study, including 13 males and 18 females, with an average age of 51.4 years old (18 to 75 years old). According to the different fixation methods, the patients were divided into the suture anchor treatment group (13 cases) and the anatomical plate treatment group (18 cases). The clinical and radiological results of these two internal fixation devices were evaluated by various criteria.

Results: All 31 patients were followed up successfully, with a mean follow-up time of 27.74 months. There were no differences in patient demographic and characteristic information between the two groups. The blood loss in the suture anchor treatment group was less than that in the anatomical plate treatment group. In contrast, the average operation time of the anatomical plate treatment group was shorter than that of the suture anchor treatment group, but the results were not significantly different. The postoperative Visual analog scale score, Constant-Murley shoulder joint function score and range of motion of the two groups were not significantly different. In addition, there was no significant difference in the postoperative complication rate between the two groups.

Conclusion: Both suture anchors and anatomical plates can achieve satisfactory clinical results in the treatment of humeral greater tuberosity fractures, and there is no significant difference in the long-term functional results between the two groups. These two fixation devices can be flexibly selected according to the surgeon's experience and fracture characteristics.

Introduction

Proximal humeral fractures are one of the most common types of upper limb fractures. They are the third most frequent fractures in elderly patients after hip and distal radius fractures. They are mostly caused by low-energy trauma and are common in elderly women with osteoporosis3. Greater tuberosity fractures account for one-fifth of proximal humeral fractures. They usually occur in young male patients with better bone quality, and the energy of the injury is usually higher. The main mechanisms of injury for greater tuberosity fractures are falls from a height over an outstretched hand with the elbow to the ground in external rotation associated with shoulder abduction or direct trauma on the lateral side of the shoulder10. Three classification systems are commonly used to describe greater tuberosity fractures: the AO, Neer, and morphological classifications13. Approximately 5%-57% of greater tuberosity fractures of

the humerus are combined with shoulder dislocation. Inappropriate treatment can lead to acromion impingement, shoulder joint pain, and limited mobility, which affect the daily life and work of patients17. Fortunately, most of these fractures are stable and nondisplaced or minimally displaced and treated conservatively. A recent study indicated that 85%-95% of greater tuberosity fractures do not require surgical treatment, and only 5%-15% of displacements greater than 5 mm require surgical intervention2. A variety of surgical devices have been used in the past, including lag screws, trans-osseous suture fixation, tension band wiring, proximal humeral internal locking system (PHILOS), suture anchors, and arthroscopic techniques. However, the optimal treatment of displaced fractures is still controversial18. The choice of methods for treating isolated displaced fractures of the greater tuberosity mainly depends on the fracture type, the bone quality, the fracture fragment size, and the preference of the surgeon. Bony healing of the displaced greater tuberosity critically depends on anatomical reduction and rigid fixation, and mechanical stability further allows early rehabilitation of the shoulder to achieve satisfactory clinical outcomes16. Anatomical locking plates and suture anchors are currently two commonly used fixation methods for the treatment of these fractures. However, there is no systematic study on the long-term clinical results between the two devices. Some scholars believe that arthroscopic-assisted suture anchor fixation can achieve satisfactory clinical results. However, arthroscopy has higher requirements for technology and equipment, and a long learning curve is required. In addition, a study found that there were few important differences between arthroscopic suture anchor fixation and ORIF for isolated displaced greater tuberosity fractures7. This limits its clinical popularity. The anatomical locking plate is also widely used for fractures of the greater tuberosity, and most studies have confirmed that it can also achieve satisfactory long-term results. However, there is no report on the differences between suture anchors and anatomical locking plates. Therefore, we retrospectively analyzed the clinical results for these two fixation devices in the treatment of greater tuberosity fractures. The hypothesis of this study was that the clinical results obtained with suture anchors and anatomical locking plates for humeral greater tuberosity fractures would reveal equal functional and radiographic outcomes.

Materials And Methods

1. General information

The study design was approved by the Guyuan People's Hospital Clinical Research Ethics Committee and performed in accordance with the Declaration of Helsinki. Informed consent was obtained from the parents/guardians of the patients included in the study. In this study, 31 patients with humeral greater tuberosity fractures from March 2015 to June 2019 were taken as the research objects, including 12 males and 19 females, with an average age of 51.4 years old (18 to 75 years). The causes of injury included falling from heights, traffic accidents, and falling while walking or standing. All patients received shoulder X-rays and CT before surgery, and 14 patients (45.16%) underwent shoulder MRI scans to better determine rotator cuff injury. According to the AO classification, these fractures were type A extra-articular unifocal fractures (unifocally displaced greater tuberosity fracture A1.2). Among them, 19 cases were comminuted fractures, 20 cases were combined with rotator cuff injury, and 9 cases were combined with shoulder joint dislocation (Table 1. Demographics of patients). Spontaneous relocation of the shoulder

joint might have occurred prior to clinical assessment. Cases might have been falsely assigned to the group of patients without shoulder dislocation. Therefore, a detailed medical history should be requested after hospitalization to avoid omissions. According to different surgical methods, the patients were divided into a suture anchor treatment group (11 cases) and an anatomical locking plate treatment group (20 cases). The postoperative follow-up was at least one year. All operations were performed by the same team of surgeons. During the operation, we also carefully checked to confirm whether cases were combined with damage to the rotator cuff and other accessory structures and treated them as needed.

Table 1
Comparison of the key patient demographics between groups

	SAF (n = 13)	ALPF (n = 18)
Age(year)	53.44 ± 5.12	49.76 ± 4.33
Gender		
Male	5	8
Female	7	11
Fracture status		
Non-comminuted fractures	7	9
Comminuted fractures	6	9
Combined rotator cuff injury	9	11
Side		
Right	7	8
Left	6	10
Shoulder joint dislocation	3	6
Interval from injury to surgery (days)	2.35 ± 1.74	2.87 ± 1.43
Follow-up (months)	26.88 ± 4.22	28.36 ± 3.45
(SAF, suture anchor fixation; ALPF, anatomical locking plate fixation. Age, interval from injury to surgery, and follow-up are expressed as the means ± standard deviation.)		

2. Inclusion and exclusion criteria

All patients were chosen by the following criteria.

The inclusion criteria were as follows: (1) patients with a closed fracture with normal shoulder joint function before injury; (2) clinical symptoms, signs and radiological imaging findings diagnosed as

humeral greater tuberosity fracture; (3) fracture fragment displacement > 5 mm; and (4) follow-up for one year or more after the operation.

Exclusion criteria: (1) Patients with previous shoulder joint trauma or shoulder joint insufficiency; (2) Open fractures and pathological fractures; (3) Brachial plexus injury; (4) Cervical spondylosis, hemiplegia; 5) Accompanied by severe liver and kidney insufficiency, abnormal cardiopulmonary function, blood system disease; (6) Those who have a history of mental illness.

3. surgical procedure

1. Suture anchor group

The patient was under brachial plexus or general anesthesia. After anesthesia was satisfied, patients were placed in a beach chair position, and the surgical area was routinely disinfected. The incision extends from the anterolateral edge of the acromion to the distal end with a length of 5-6 cm. The gap between the anterior and middle deltoids is carefully separated, exposing the displaced greater tuberosity fracture fragment and the rotator cuff attached to it. When the distal end of the incision is separated, attention should be given to protecting the axillary nerve after clearance of hematoma and scar tissue. The displaced fracture fragment was reduced and temporarily fixed with Kirschner wires. The rotator cuff is passed, and two suture anchors are inserted (Smith & Nephew Endoscopy, Andover, MA, USA) obliquely into the humeral head on the edge of the articular cartilage. When combined with a rotator cuff injury, the suture on the suture anchor can be used for supplemental fixation. Then, a small hole is drilled in the humeral shaft 1-2 cm below the distal fracture line, and the anchor thread is passed through the small hole and tied. Alternatively, the end of the suture is squeezed with the distal row of anchors. After C-arm fluoroscopy to determine the reduction of the fracture and the position of the screw was satisfactory, the shoulder joint is passively moved to check the stability of the fracture, and the incision is sutured layer by layer (Figure 1).

2. Anatomical locking plate group

The posture and incision were the same as those in the suture anchor treatment group. The displaced greater tuberosity fracture fragment and the attached rotator cuff are exposed. After the fracture is reduced, Kirschner wire is used to temporarily fix it. Subsequently, the anatomical locking plate (Double Medical Technology Inc, Xiamen, China.) is placed below the tip of the greater tubercle and 0.8 cm outside the biceps groove, screwed in with the appropriate length screw, sutured to the surrounding rotator cuff and tied to the plate through the suture eyelets for supplemental fixation. After C-arm fluoroscopy to determine that the reduction of the fracture and the position of the screw is satisfactory, the shoulder joint is passively moved to check the stability of the fracture, and the incision is washed and sutured layer by layer (Figure 2).

4. Postoperative Management

Symptomatic treatments such as oral analgesics were given after the operation. An intravenous drip of antibiotics was given 0.5-1 hour before the operation, and another intravenous drip of antibiotics was given 12 hours after the operation to prevent infection. The postoperative rehabilitation protocols were similar for patients in the two groups. The shoulder and elbow bands were externally fixed for two weeks after the operation. After two weeks, the external fixation was removed, and the shoulder joint was passively moved. Part of the flexion and extension activities were started four weeks after the operation. Internal and external rotation and abduction were performed six weeks after the operation. The surrounding bones were reviewed after three months. After the scab formed, strength training gradually started, and some antagonistic training began approximately half a year after the operation (Figure 3). All of these activities and training methods were completed under the guidance of professional rehabilitation therapists.

5. Data Collection

Surgical times were recorded during the perioperative period. Surgical time was defined as the time from initiation of the incision to the time when suture of the incision was finished. Radiographs were obtained immediately after surgery to evaluate the adequacy of fracture reduction, which was determined by measuring the degree of residual displacement. Our follow-up doctors followed up patients in the outpatient clinic or by telephone at two weeks, one month, two months, three months, six months, and twelve months after surgery. Observe or take pictures of the relevant angle, range of motion, local skin, and patient satisfaction. The carrying angle and the range of motion were measured using a full-circle goniometer and compared with that of the contralateral arm. X-ray examination was required at each follow-up to determine the healing of the fracture. A detailed clinical and radiological examination was performed on all patients and documented. The images were blindly reviewed by a senior resident surgeon. The charts were reviewed by another resident surgeon.

6. Statistical Analysis

The data were analyzed using the Statistical Package for Social Sciences (SPSS version 13.0). The *t-test* was used to compare the postoperative clinical results, including ROM and functional scores. Statistical significance was set at a probability less than 0.05. The results are expressed as the means ± standard deviation (SD), and $p<0.05$ indicates a statistically significant difference.

Results

A total of 31 eligible patients were included in this retrospective study. No significant differences were found between the two groups according to demographics (Table 1), suggesting the comparability of the two groups. All 31 patients were followed up after surgery. All patients had achieved primary incision healing in both groups at the last follow-up. The blood loss in the suture anchor treatment group was less than that in the anatomical plate treatment group (Table 2). In contrast, the average operation time of the anatomical plate treatment group was shorter than that of the suture anchor treatment group, but the results were not significantly different. The postoperative VAS score and Constant-Murley shoulder

function score were better in the suture anchor treatment group than in the locking plate treatment group, but the difference was not statistically significant. There was no significant difference in hospitalization time between the two groups. In terms of complications, the complication rate was 7.69% in the suture anchor treatment group and 11.11% in the locking plate treatment group. One patient in the plate treatment group had acromion impingement. One patient in each group had fracture displacement after surgery, but the displacement was less than 3 mm. After conservative treatment, the joint function recovered satisfactorily. For ROM, all indices, including forward flexion, abduction, external rotation and internal rotation, were also non-significant (Table 3).

Table 2
Comparison of clinical outcomes and functional scores between the two groups

	SAF (n = 13)	ALPF (n = 18)	*p* value
Blood loss(ml)	100 ± 12.649	106.50 ± 16.944	0.145
Operative duration (min)	46.82 ± 7.922	49.60 ± 9.081	0.235
VAS score	1.55 ± 0.688	1.75 ± 0.716	0.083
Hospitalization (day)	6.27 ± 1.489	6.05 ± 1.234	0.533
Constant-Murley score	87.73 ± 5.042	89.75 ± 5.149	0.438
(SAF, suture anchor fixation; ALPF, anatomical locking plate fixation; VAS, visual analog scale. All data were expressed as means ± standard deviation.)			

Table 3
Comparison of ROM between the two groups

ROM(º)	SAF (n = 13)	ALPF (n = 18)	*p* value
Forward flexion	153.7 ± 11.2	151.2 ± 9.5	0.288
Abduction	136.7 ± 14.7	141.3 ± 10.0	0.083
External rotation	40.2 ± 5.2	39.8 ± 6.4	0.547
Internal rotation	L1	L1	-
(SAF, suture anchor fixation; ALPF, anatomical locking plate fixation; ROM, range of motion. All data were expressed as means ± standard deviation.)			

Discussion

Proximal humerus fractures are the third most frequent fractures in elderly patients after hip and Colles fractures. Greater tuberosity fractures account for one-fifth of proximal humeral fractures. They usually occur in young male patients with better bone quality, and the energy of the injury is usually higher1. In our series of cases, there were more female patients than male patients. Regarding the age of the patient,

our results are consistent with those previously reported. Our study found that these fractures were more common in 58.06% of females vs 41.94% of males, and the more affected group had an age < 65 years (83.87%) vs > 65 years (16.13%). The causes of injury included falling from heights, traffic accidents, and falling while walking or standing. The greater tuberosity of the humerus is one of the important attachment points of the rotator cuff. The supraspinatus and infraspinatus can induce superior displacement of the greater tuberosity. The proximal displacement of this part after fracture can lead to subacromial impingement and limitation of abduction and external rotation5. In addition, simple fractures of the greater tuberosity of the humerus are not common and are often associated with shoulder dislocation and rotator cuff tears. A study found that secondary interventions are required more frequently after shoulder dislocation. Surgery is most likely required for associated soft tissue lesions rather than for secondary displacements14. In our cases, 20 were combined with rotator cuff injury, accounting for 64.52%, and 9 cases were combined with shoulder joint dislocation, accounting for 29.03%.

The diagnosis and classification of isolated greater tuberosity fractures are mainly based on standard plain radiographs. However, these fractures may be challenging to identify because of osseous overlap9. Surgeons feel slightly more confident about their treatment recommendation when assessing CT images with radiographs compared with radiographs alone4. In our study, all patients underwent CT examination before surgery. There are still many controversies regarding detailed surgical indications. Most scholars believe that conservative treatment can obtain satisfactory clinical and imaging results for fractures with a displacement of less than 5 mm, while surgical intervention is required for a greater tubercle fracture of the humerus with a fracture displacement of more than 5 mm, even 3 mm for a population with high demands on shoulder function12. Malunion is one of the most common complications following surgical treatment of proximal humeral fractures. The deltoid force required for abduction is significantly higher when the greater tuberosity is displaced more than 5mm11. Due to the limited dimension of the subacromial space, even small residual superior displacement may cause clinical impairment. Therefore, we deem that the surgical indication for greater tuberosity should comprehensively consider the displacement of the fragment, the width of the subacromial space, and the patient's rotator cuff injury.

Patients who sustain an isolated greater tuberosity fracture are younger and more active than those who sustain other proximal humerus fractures. Therefore, in the treatment of GT fractures, there is increased emphasis on returning to high activity and function6. Mechanical stability is essential to allow early functional rehabilitation to achieve satisfying clinical results. There are multiple fixation methods, including screws, locking plates, suture anchors, and tension bands, to treat this type of injury. However, no established technique is considered the gold standard for the treatment of displaced greater tuberosity fractures. When screw fixation is selected, small or thin bones are likely to cause fracture fragments to split, resulting in fixation failure. The anatomical locking plate can better fix the fracture fragment and can repair the injured rotator cuff during the operation. Since its application, satisfactory clinical treatment results have been achieved. In one study, the authors used a self-adjusted calcaneus titanium plate (Litos) that was cut into a 6 or more holed small plate. Excellent postoperative outcomes were obtained with no complications and no secondary loss of reduction in ten patients15. The results of a

recent study show that a novel plate (Kaisidis plate, Fa. Königsee) has good biological properties in the treatment of displaced greater tuberosity fractures. However, the most critical points of the Kaisidis system are the screws that are connected to the bone, which may be limited in patients with osteoporosis6. In our cases, the functional results of the plate we used in the treatment of greater tuberosity fractures were encouraging. However, it seems to be difficult to fix fractures that are smaller and closer to the articular surface.

The suture anchor is the other tool generally described for fixation of greater tuberosity fractures in both open and arthroscopic surgeries. A biomechanical study suggested that suture anchor constructs would be stronger than fixation constructs using screws for humeral greater tuberosity fractures8. The suture anchoring technique assisted by arthroscopy has achieved satisfactory results since its application. Despite the benefit of reduced soft tissue damage and skin incision, there are higher requirements for doctors' arthroscopic techniques and a longer learning curve, so the development in primary hospitals is partially restricted. In addition, some studies believe that the arthroscopic technique has no advantage over open reduction in the treatment of simple humeral greater tuberosity avulsion fractures due to the longer operation time7. Using a small incision through the deltoid approach with suture anchors to treat this type of injury can effectively avoid the above problems. In addition, a biomechanical study concluded that there is no significant difference between double-row suture anchor fixation and the suture-bridge technique in the treatment of greater tuberosity fractures8. Therefore, we consider that a familiar fixation method can be selected according to the experience of the surgeon.

It is not clear whether the suture anchors or anatomical locking plates have better functional results. For this reason, we compared the clinical treatment results of the small incision suture anchoring technique through the deltoid muscle and the locking plate for the treatment of humeral greater tuberosity fractures. In our study, the blood loss in the suture anchor treatment group was less than that in the anatomical plate treatment group. In contrast, the average operation time of the anatomical plate treatment group was shorter than that of the suture anchor treatment group. There was no significant difference in operation time, postoperative VAS score, hospital stay or postoperative function score. The complication rate was 7.69% in the suture anchor treatment group and 11.11% in the locking plate treatment group. Considering the small sample size and differences in the study, the results should be interpreted cautiously. One patient in each group had fracture displacement after surgery, but the displacement was less than 3 mm. After conservative treatment, the joint function recovered satisfactorily. Although the two have similar functional results, we found that suture anchors have advantages in cases where the fracture is smaller and closer to the articular surface, and plate fixation could provide rigid fixation and cover a larger fracture area. One of the benefits of suture fixation is that it depends on the strength of the rotator cuff tendons themselves and not only on the bone quality. In older patients with osteopenic bone suture anchors, healing and stability could be helpful. In addition, the suture anchors do not require a second operation to remove them. Therefore, we consider that satisfactory functional results can be achieved with both fixing methods. However, suture anchors seem to be more advantageous in cases where the fracture is smaller and closer to the articular surface, while the anatomical locking plate is more secure in cases where the fracture is larger. Our study compared the functional results of the two

fixed methods, but the study also has certain limitations. First, this is a nonrandom retrospective study, and its results may be biased. Second, the small number of cases in the study may also have a certain impact on the results.

Conclusion

Both suture anchors and anatomical plates can achieve satisfactory clinical results in the treatment of humeral greater tubercle fractures, and there is no significant difference in the long-term functional results between the two groups. These two fixation devices can be flexibly selected according to the surgeon's experience and fracture characteristics.

Declarations

Ethics approval and consent to participate: This study was approved by the medical ethics review board of Guyuan People's Hospital. Written informed consent was obtained from the parents/guardians of the patients.

Consent for publication: Not applicable.

Availability of data and materials: All data generated or analysed during this study are included in this published article.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: YHS, TQJ and SBW performed the surgeries. GRZ and YHY designed this study. TQJ, SBW and LLH prepared the manuscript, tables and figures. All authors read and approved the final manuscript.

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References

1. Bahrs C, Lingenfelter E, Fischer F, Walters EM, Schnabel M. Mechanism of injury and morphology of the greater tuberosity fracture. J Shoulder Elbow Surg. 2006;15(2):140-7.10.1016/j.jse.2005.07.004
2. DeBottis D, Anavian J, Green A. Surgical management of isolated greater tuberosity fractures of the proximal humerus. Orthop Clin North Am. 2014;45(2):207-18.10.1016/j.ocl.2013.12.007
3. Huntley SR, Lehtonen EJ, Robin JX, Arguello AM, Rouleau DM, Brabston EW, et al. Outcomes of surgical fixation of greater tuberosity fractures: A systematic review. Orthop Traumatol Surg Res. 2020;106(6):1119-26.10.1016/j.otsr.2020.05.005

4. Janssen SJ, Hermanussen HH, Guitton TG, van den Bekerom MP, van Deurzen DF, Ring D. Greater Tuberosity Fractures: Does Fracture Assessment and Treatment Recommendation Vary Based on Imaging Modality? Clin Orthop Relat Res. 2016;474(5):1257-65.10.1007/s11999-016-4706-6
5. Janssen SJ, Jayakumar P, Ter Meulen DP, van Deurzen DFP, Ring D. Quantitative 3-dimensional Computerized Tomography Modeling of Isolated Greater Tuberosity Fractures with and without Shoulder Dislocation. Arch Bone Jt Surg. 2019;7(1):24-32
6. Kaisidis A, Pantos PG, Bochlos D, Lindner H. Biomechanical Analysis of the Fixation Strength of a Novel Plate for Greater Tuberosity Fractures. Open Orthop J. 2018;12:218-28.10.2174/1874325001812010218
7. Liao W, Zhang H, Li Z, Li J. Is Arthroscopic Technique Superior to Open Reduction Internal Fixation in the Treatment of Isolated Displaced Greater Tuberosity Fractures? Clin Orthop Relat Res. 2016;474(5):1269-79.10.1007/s11999-015-4663-5
8. Lin CL, Hong CK, Jou IM, Lin CJ, Su FC, Su WR. Suture anchor versus screw fixation for greater tuberosity fractures of the humerus--a biomechanical study. J Orthop Res. 2012;30(3):423-8.10.1002/jor.21530
9. Mattyasovszky SG, Burkhart KJ, Ahlers C, Proschek D, Dietz SO, Becker I, et al. Isolated fractures of the greater tuberosity of the proximal humerus: a long-term retrospective study of 30 patients. Acta Orthop. 2011;82(6):714-20.10.3109/17453674.2011.618912
10. Muhm M, Arend S, Winkler H, Ruffing T. [Associated injuries with greater tuberosity fractures : Mechanism of injury, diagnostics, treatment]. Unfallchirurg. 2017;120(10):854-64.10.1007/s00113-016-0235-8
11. Nyffeler RW, Seidel A, Werlen S, Bergmann M. Radiological and biomechanical assessment of displaced greater tuberosity fractures. Int Orthop. 2019;43(6):1479-86.10.1007/s00264-018-4170-x
12. Razaeian S, Hawi N, Zhang D, Liodakis E, Krettek C. Conservative treatment of displaced isolated proximal humerus greater tuberosity fractures: preliminary results of a prospective, CT-based registry study. Eur J Trauma Emerg Surg. 2020.10.1007/s00068-020-01453-7
13. Rouleau DM, Mutch J, Laflamme GY. Surgical Treatment of Displaced Greater Tuberosity Fractures of the Humerus. J Am Acad Orthop Surg. 2016;24(1):46-56.10.5435/jaaos-d-14-00289
14. Schliemann B, Heilmann LF, Raschke MJ, Lill H, Katthagen JC, Ellwein A. Isolated fractures of the greater tuberosity: When are they treated conservatively?: A baseline study. Obere Extrem. 2018;13(2):106-11.10.1007/s11678-018-0459-z
15. Schöffl V, Popp D, Strecker W. A simple and effective implant for displaced fractures of the greater tuberosity: the "Bamberg" plate. Arch Orthop Trauma Surg. 2011;131(4):509-12.10.1007/s00402-010-1175-3
16. Sun Q, Ge W, Li G, Wu JZ, Lu G, Li R, et al. Plate Fixation versus Arthroscopic-Assisted Plate Fixation for Isolated Medium-Sized Fractures of the Greater Tuberosity: A Retrospective Study. Orthop Surg. 2020;12(5):1456-63.10.1111/os.12773

17. White EA, Skalski MR, Patel DB, Gross JS, Tomasian A, Heckmann N, et al. Isolated greater tuberosity fractures of the proximal humerus: anatomy, injury patterns, multimodality imaging, and approach to management. Emerg Radiol. 2018;25(3):235-46.10.1007/s10140-018-1589-8
18. Zeng LQ, Chen YF, Jiang YW, Zeng LL, Miao XG, Liang WG. A new low-profile anatomic locking plate for fixation of comminuted, displaced greater tuberosity fractures of the proximal humerus. J Shoulder Elbow Surg. 2020.10.1016/j.jse.2020.08.036

Figures

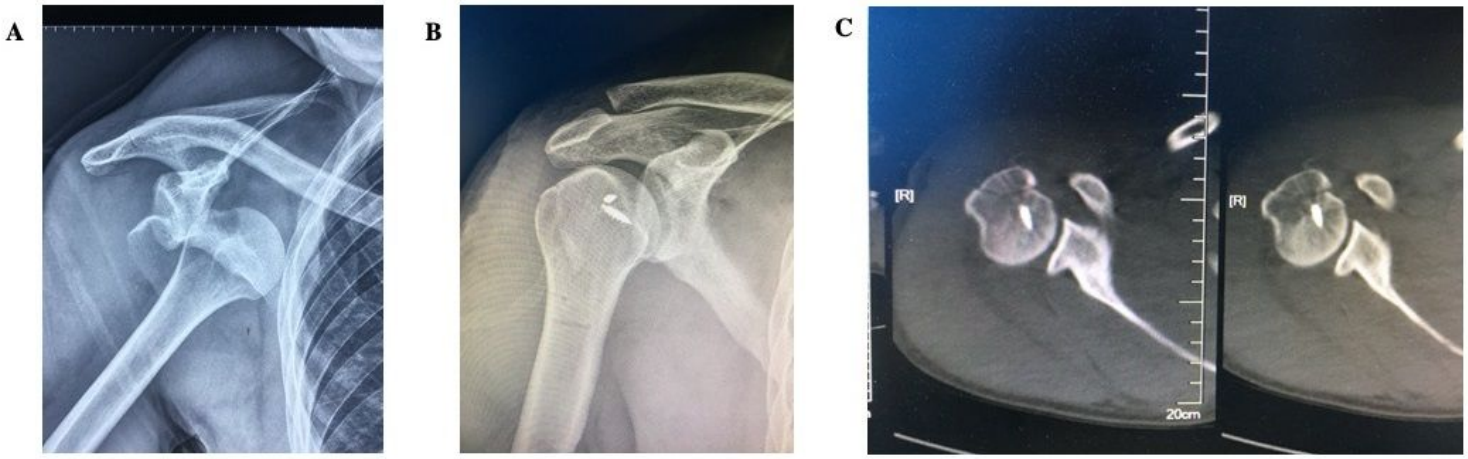

Figure 1

(A) A 38-year-old male patient had a fracture of the greater tuberosity of the humerus combined with shoulder joint dislocation. (B) X-ray examination after fixation with suture anchor. (C) Postoperative CT examination.

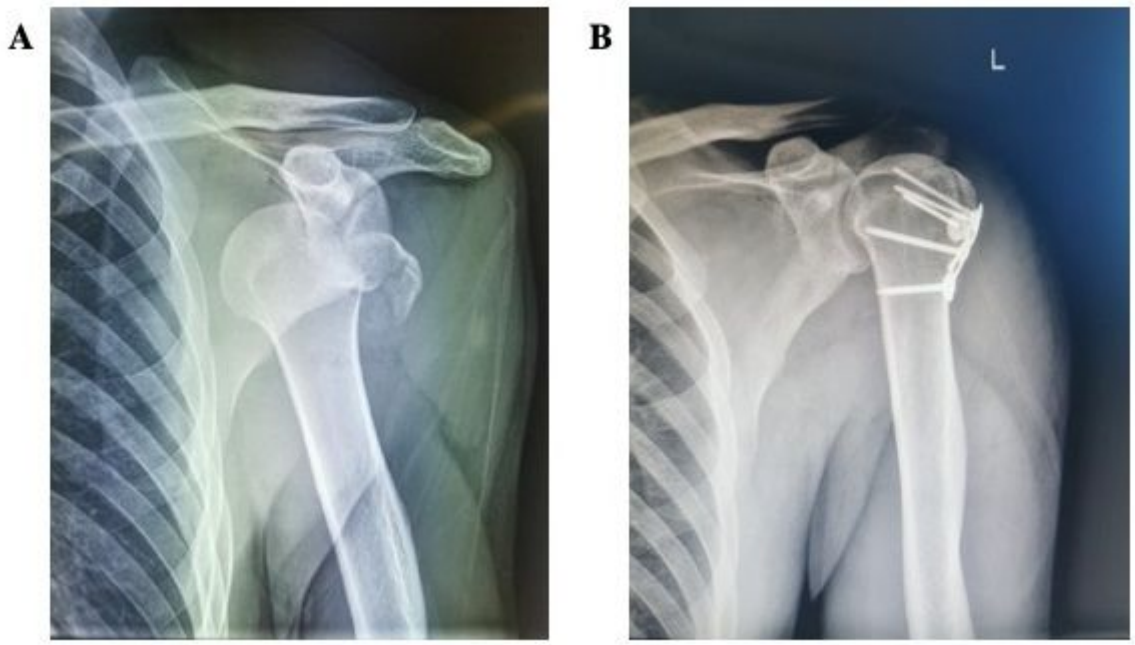

Figure 2

(A) A 58-year-old male patient had a fracture of the greater tuberosity of the humerus combined with shoulder joint dislocation. (B) X-ray examination after fixation with anatomical locking plate.

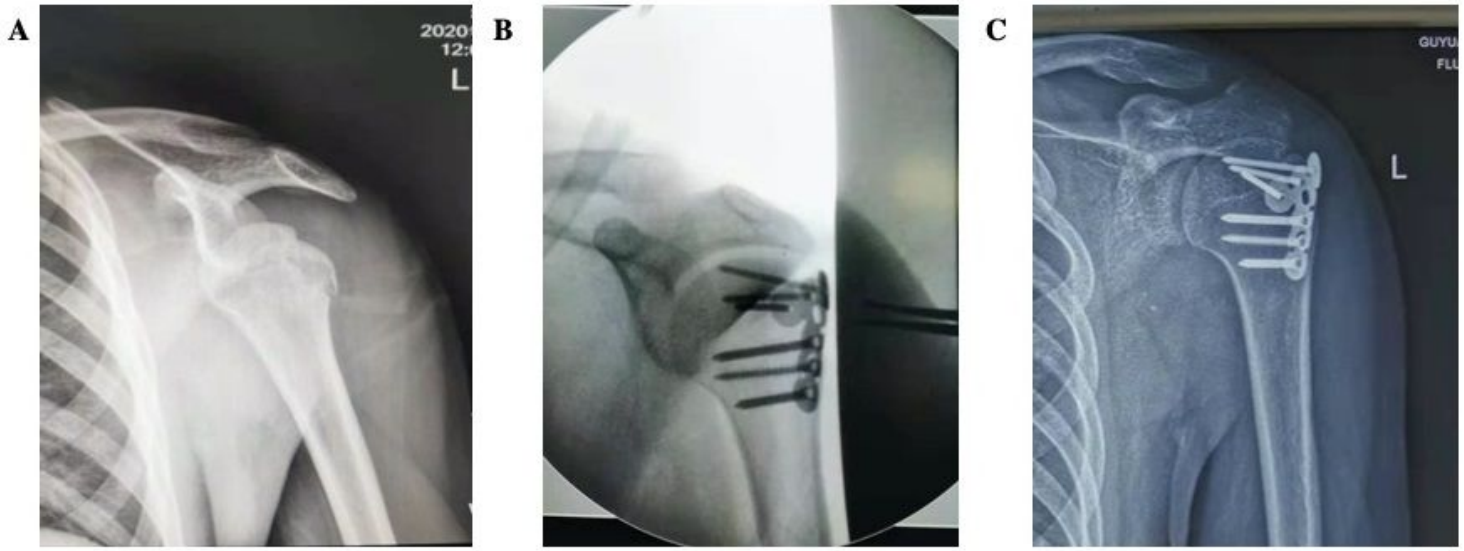

Figure 3

(A) A 18-year-old male patient had a fracture of the greater tuberosity of the humerus combined with shoulder joint dislocation. (B) After fixation with anatomical locking plate, intraoperative fluoroscopy was performed. (C) The X-ray examination showed that the fracture had healed six months after the operation.