



## Simultaneous repair of chronic full-thickness rotator cuff tears during fixation of proximal humerus fractures and clinical results

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**Objectives:** We investigated the incidence of chronic rotator cuff tears encountered during fixation of proximal humerus fractures with locking plate-screw systems, and evaluated the functional results of simultaneous surgical repair of these injuries.

**Methods:** A total of 111 patients underwent surgical treatment for proximal humerus fractures. Of these, nine patients (8 females, 1 male; mean age 73 years; range 56 to 84 years) who had concomitant chronic full-thickness rotator cuff tears were included in the study. According to the AO classification, the fractures were type 11A1 (12C1 also present) in one patient, 11A2 (12C2 also present) in one patient, 11B1 in two patients, 11B2 in three patients, and 11C2 in two patients. None of the patients underwent preoperative magnetic resonance imaging. Fracture fixation was made with the PHILOS plate in five patients, and with the S3 Proximal Humerus Plate in four patients. All full-thickness rotator cuff tears were detected during the operation. Following open reduction and internal fixation after a deltoid splitting incision, rotator cuff tears were repaired by primary suture in two patients, and with a suture anchor in seven patients. All the patients used a padded shoulder-arm sling for six weeks and received a standard rehabilitation program. All the patients were evaluated radiographically and functionally using the Constant-Murley shoulder score at postoperative 6 weeks, 6 months, and 12 months. The mean follow-up period was 17.3 months (range 8 to 30 months).

**Results:** The incidence of full-thickness rotator cuff tears was 8.1%. All the patients had supraspinatus tears, which were accompanied by infraspinatus tears in three patients. The sizes of the tears were classified as large (between 3-5 cm) in three patients, intermediate (between 1-3 cm) in five patients, and small (<1 cm) in one patient. One patient had L-shaped, two patients had U-shaped, and six patients had C-shaped tears. None of the patients had healing problems or avascular necrosis. The mean Constant-Murley shoulder score was 85.4 (range 67 to 100). All the patients were satisfied with the results of surgical treatment.

**Conclusion:** The integrity of the rotator cuff must be checked after reduction and fixation of proximal humerus fractures and, when present, the tears should be repaired simultaneously either primarily or with suture anchors. Simultaneous repair of rotator cuff tears does not negatively affect functional outcomes.

**Key words:** Humeral fractures/surgery; rotator cuff/injuries; shoulder fractures/surgery; shoulder joint/pathology; tendon injuries.

Fractures of the proximal humerus occur as a result of high-energy trauma in young patients or low-energy trauma in elderly and osteoporotic patients.

Nondisplaced fractures of the proximal humerus can be treated conservatively, while displaced fractures require surgical treatment. Associated soft tissue in-

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injuries (neurovascular, rotator cuff), previous shoulder pathologies, patient-related factors, surgical technique, and the rehabilitation protocol are the factors affecting the functional results.<sup>[1]</sup>

The incidence of nontraumatic rotator cuff tears have been investigated by ultrasonography, magnetic resonance imaging (MRI), and cadaver studies and the incidence of full-thickness tears have been reported to be between 10.3% and 40.8%.<sup>[2]</sup> These injuries cause milder symptoms if the integrity of the rotator cuff is preserved and the anterior supraspinatus tendon is less severely affected. While partial tears are either asymptomatic or less symptomatic, full-thickness tears are often symptomatic.<sup>[2]</sup> The frequency of rotator cuff tears increases with age.<sup>[2]</sup> Although proximal humeral fractures are more frequently seen at advanced ages, the presence of associated chronic rotator cuff injuries have not been adequately studied. Studies have demonstrated that rotator cuff tears accompany displaced tubercle fractures.<sup>[3-8]</sup> The incidence of rotator cuff tears increases in parallel with the severity of fracture type and comminution. Although it is known that the integrity of the rotator cuff is important for the surgical outcomes of proximal humeral fractures,<sup>[1,3-6]</sup> it is observed that, in most cases, rotator cuff tears are not separately considered in the treatment strategies and evaluation of the results. The integrity of the rotator cuff is significantly related to functional success in patients with proximal humerus fractures.<sup>[1,3,4]</sup>

As the primary focus of surgical treatment is usually on displacement of fragments and fixation, associated soft tissue injuries may be overlooked or neglected. A survey of the studies on these injuries shows that only radiologic and functional results have been investigated in the follow-up of patients. Although the importance of an intact rotator cuff has been emphasized for a good clinical outcome since the studies by Neer, the effect of rotator cuff repairs on the results have not been adequately investigated.<sup>[4]</sup>

It has been stated that complex proximal humerus fractures with displaced tubercles are associated with tears especially in the rotator interval between the supraspinatus and subscapularis tendons. A tendinous gap will form leading to trophic changes in the rotator cuff if these injuries are full-thickness and are not closed.<sup>[4]</sup> A literature review showed no studies

concerned with the results of simultaneous repair of nontraumatic rotator cuff injuries together with the fixation of humerus fractures.

When a fracture occurs near a joint without dislocation or subluxation, usually only the bony structures are injured. However, MRI studies on peri-articular fractures near the knee, elbow, or ankle have shown a considerable incidence of soft tissue injuries related to bone injury.<sup>[1]</sup> There are only two studies evaluating the integrity of the rotator cuff after proximal humerus fractures.<sup>[4,5]</sup> However, both studies have problems regarding the recruitment of patients, in that either the patients in these studies were not operated on or had pain after bone healing. There are no studies that investigated the results of simultaneous repair of the rotator cuff with fracture treatment.

In this study, we investigated the incidence of nontraumatic rotator cuff injuries encountered during fixation of proximal humerus fractures with locking plate-screw systems, and evaluated the functional results of simultaneous surgical repair of these injuries.

## Patients and methods

Between September 2005 and December 2009, a total of 111 patients underwent surgical treatment for proximal humerus fractures. Of these, nine patients (8 females, 1 male; mean age 73 years; range 56 to 84 years) who had concomitant chronic full-thickness rotator cuff tears were included in the study. The mechanism of injury was fall in one patient and motor vehicle accident in eight patients. According to the AO classification, the fractures were type 11A1 (12C1 also present) in one patient, 11A2 (12C2 also present) in one patient, 11B1 in two patients, 11B2 in three patients, and 11C2 in two patients. All the patients were operated on by the same surgeon in the beach chair position and using a deltoid splitting incision. None of the patients underwent preoperative MRI examination. Fracture fixation was made with the PHILOS plate (Proximal Humerus Internal Locking System Plate, Synthes, Stratec Medical, Switzerland) in five patients, and with the S3 Proximal Humerus Plate (DePuy, Kirkel-Limbach, Germany) in four patients. The most important feature of the fixation method was the application of locking screw fixation that allowed early motion.

Full-thickness tears of the rotator cuff were noticed during surgery. Following open reduction and internal fixation after a deltoid splitting incision, rotator cuff injuries of two patients were repaired primarily with number 5 Ethibond sutures (Ethicon, Johnson & Johnson, Scotland) passing through the bone and plate (Fig. 1), and with Mitek suture anchors (DePuy, Johnson & Johnson, Boston, USA) in seven patients (Fig. 2).

Subacromial bursectomy was performed in all the patients. None of the patients underwent acromioplasty. All the patients used a padded shoulder arm sling for six weeks and received a standard fracture rehabilitation program. Passive exercises were initiated in the first week. Active-assisted and active motion exercises were allowed after the sixth week. All the patients were evaluated radiographically and functionally using the Constant-Murley shoulder score at postoperative 6 weeks, 6 months, and 12 months. After 12 months, the patients were questioned via telephone interviews. The mean follow-up period was 17.3 months (range 8 to 30 months).

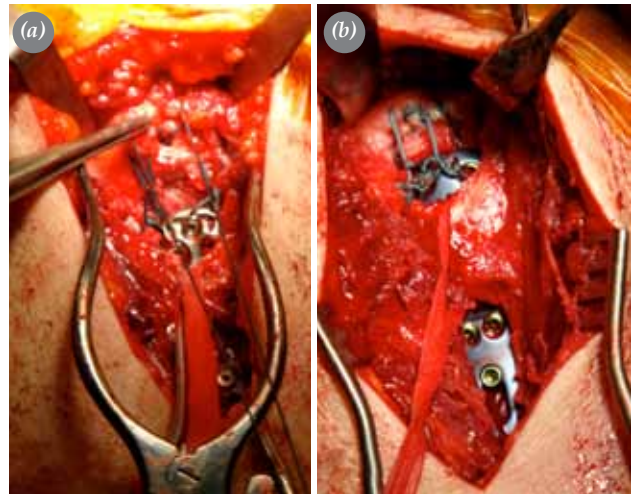
## Results

In our study, the incidence of full-thickness rotator cuff tears was 8.1%. All the patients had supraspinatus tears, which were accompanied by infraspinatus tears in three patients. The sizes of the tears were classified as follows: large (between 3-5 cm) in three patients, intermediate (between 1-3 cm) in five patients, and small (<1 cm) in one patient. One patient had L-shaped, two patients had U-shaped, and six patients had C-shaped tears. Two patients with B2 and C2 fractures also had a rotator interval defect smaller than 5 mm.

The mean Constant-Murley shoulder score was 85.4 (range 67 to 100). None of the patients had healing problems or avascular necrosis. All the patients were satisfied with the results of surgical treatment.

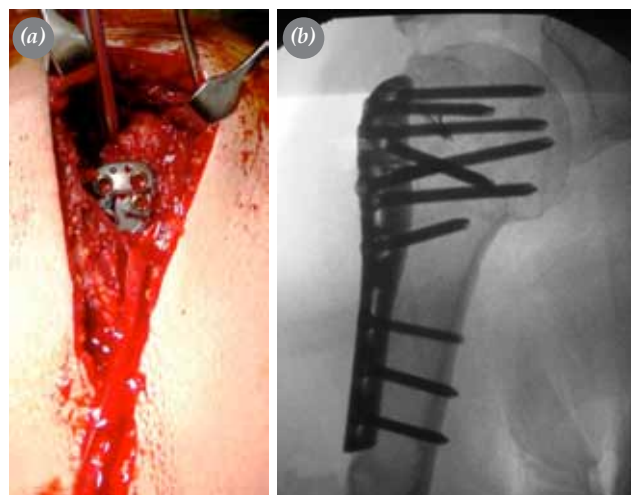
## Discussion

It has been shown in previous studies that rotator cuff injuries may accompany proximal humerus fractures.<sup>[2-9]</sup> Using plain radiographies, Gallo et al.<sup>[5]</sup> classified 30 patients with proximal humerus fractures according to the AO and Neer classifications, and investigated the presence of rotator cuff injuries on MRI scans. All the patients had major tubercle

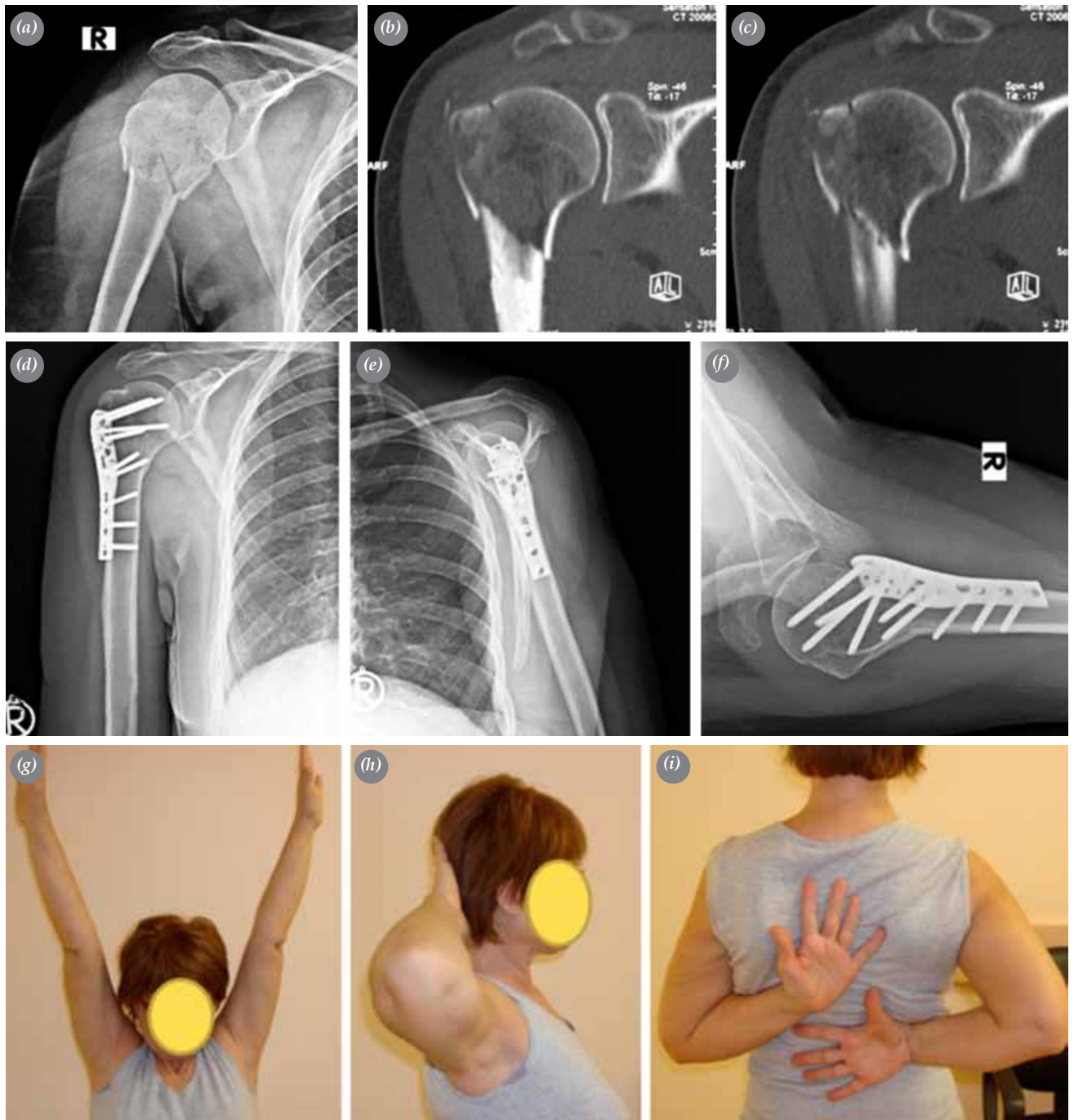


**Fig. 1.** Fixation with (a) the S3 humerus plate and (b) PHILOS plate following a deltoid splitting incision and preservation of the axillary nerve. Rotator cuff tear is primarily repaired with an Ethibond suture passing through the rotator cuff, bone, and plate holes.

fractures, of which 10 were nondisplaced, six were minimally displaced (<5 mm), and 14 were moderately-severely displaced ( $\geq 5$  mm). Twelve patients (40%) had full-thickness rotator cuff tears, and the incidence of full-thickness rotator cuff tears was found to be notably higher in fractures of the major tubercle having a displacement of  $\geq 5$  mm. It was reported that full-thickness tears of the rotator cuff were more frequent in type 11B and 11C fractures according to the AO classification, and in fractures with a displacement of  $\geq 5$  mm and/or in 3- or 4-part comminuted



**Fig. 2.** (a) Repair of the rotator cuff with a suture anchor and (b) intraoperative view of the suture anchor under fluoroscopy.



**Fig. 3.** (a) Plain radiograph and (b, c) computed tomography scans of a 56-year-old female patient with an 11B1 fracture according to the AO classification. (d-f) Radiographs obtained following fixation with the PHILOS plate and repair of the rotator cuff tear with a number 5 Ethibond suture. (g-i) Abduction, abduction-external rotation and internal rotation are seen in the second postoperative month. Her Constant-Murley shoulder score was 100.

fractures according to the Neer classification. With increased severity of the fractures in the AO or Neer classification systems, the probability of rotator cuff tears increased. The weak aspect of the cited study is the lack of a standard treatment of fractures (17 patients were treated surgically, and 13 were treated

conservatively). Even the surgical treatment was not standard, which included open reduction and internal fixation in 13 patients, closed reduction and percutaneous pinning in two patients, and hemiarthroplasty in two patients. In addition, the functional results of the patients were not evaluated.<sup>[5]</sup>

Injury to the rotator cuff is rare in cases where the tubercles are intact and displacement of the greater tubercle is less than 5 mm, and therefore, functional results are better in these fractures. The frequency of injury to the rotator cuff is higher in 2-, 3- and 4-part comminuted fractures where the major tubercle is displaced more than 5 mm, and the functional results are adversely affected.<sup>[6]</sup>

Some authors have stated that repair of injuries may be neglected during reduction and fixation of fractures.<sup>[4]</sup> The relationship between the integrity of the rotator cuff and functional results was investigated in a study involving 37 patients with proximal humerus fractures treated conservatively or surgically. All the patients underwent ultrasonography, which showed a rotator interval defect in 26 patients in whom the integrity of the rotator cuff was impaired.<sup>[4]</sup> Transverse degenerative tears are rare in fractures of the humeral head, and when present, they are often present before the trauma, related to a chronic process, and unrelated to the fracture mechanism.<sup>[4]</sup> Complex humeral head fractures may be accompanied by rotator interval defects. In proximal humerus fractures, the type of the tear that results from trauma is a longitudinal tear of the rotator cuff. This tear is caused by the fracture and is seen with displaced tubercle fractures.<sup>[4]</sup> Tears of the rotator cuff result in changes in rotator cuff biomechanics. The major tubercle is generally displaced superiorly and posteriorly, while the minor tubercle is frequently displaced inferiorly and medially. If the tubercle is not properly reduced, a gap in the tendon will form, resulting in incomplete coverage of the humeral head, which in turn will lead to trophic changes in the rotator cuff. Atrophy of the rotator cuff and scar formation have been observed during revision surgery for malunited fractures. These changes may be related to proprioception, low tension, unrepaired tissue contact, or missing tissue contact due to tubercle displacement.<sup>[3,4,10]</sup> In this study, two patients with type B2 and C2 displaced tubercle fractures had defects in the rotator cuff which measured less than 5 mm. In our cases, we used the deltoid split incision, enabling a 270° view of the proximal aspect of the humerus. We observed that the defects were closed by sutures that passed through the rotator cuff, bone, and plate. In our study, avulsion injuries accompanying bone fragments were not accepted as rotator cuff tears.

In the diagnosis and surgical treatment of proximal humerus fractures, the fracture and its treatment

may be the primary focus, and the loss of integrity of the rotator cuff may be overlooked depending on the choice of incision. The deltoid split approach provides a wide exposure of 270°, which allows a thorough observation of the attachment site of the rotator cuff from anterior to posterior. In the deltopectoral incision, however, only the posterior aspect of the major tubercle is seen because the arm is internally rotated. As a result, the tear may be missed.<sup>[10-13]</sup> It is known that, especially in tears that are greater than 2 cm and involve the insertion site of the supra- and infraspinatus tendons rather than relaxation or elongation of the rotator cuff, the biomechanics of the rotator cuff and the balance between the power components of the shoulder are disrupted.<sup>[3,4,14]</sup> The repair of the rotator cuff will increase the perfusion of especially the tubercular fragments.<sup>[4]</sup> Sutures that are passed through the rotator cuff and inserted to the plate, which are recommended in osteoporotic elderly patients to facilitate and preserve reduction of proximal humerus fractures, may also be used for rotator cuff repairs, as we did in all our cases (Fig. 1). If the morphology and structure of the tear do not allow passage of these sutures, a suture anchor may be used to attach the tendon to the bone. Another advantage of this method is prevention of functional loss that may occur as a result of rotator cuff injury after fracture treatment. We believe that, due to the presence of metal implants, postoperative MRI studies will not be very helpful in explaining functional losses.

Proximal humerus fractures are common in osteoporotic elderly individuals, and there may be concomitant fractures. Among our cases, there was a 78-year-old woman with an accompanying distal radius fracture and a previous history of vertebroplasty procedure for osteoporotic vertebral fractures. Another osteoporotic elderly patient was treated with the S3 humerus plate for a type 11B2 fracture with addition of a spongy bone allograft and the rotator cuff injury was repaired with a suture anchor. One month after the operation, collapse of the head occurred due to inadequate fixation of the head, resulting in peg penetration (Fig. 4).

A study in patients with united proximal humerus fractures treated conservatively showed that patients with and without full-thickness tears of the rotator cuff did not differ significantly with respect to function results assessed at 3 and 6 months.<sup>[9]</sup>





**Fig. 4.** (a) Plain radiograph of an 11B2 fracture in a 69-year-old female patient who was a heavy smoker and had osteoporosis and diabetes. (b) The fracture was fixed with the S3 humerus plate with addition of a spongy bone allograft and the rotator cuff injury was repaired with a suture anchor. (c) One month after the operation, collapse of the head occurred due to inadequate fixation of the head with pegs, resulting in peg penetration. (d) Active abduction and elevation in the postoperative fifth month. Her Constant-Murley score was 67.

In patients with full-thickness tears, the presence and degree of fatty degeneration is directly related to the postoperative success.<sup>[15-19]</sup> Since the patients in our series had presented with traumatic injuries, we did not apply routine MRI and computed tomography. Therefore, detection of the presence of fatty degeneration was not possible. The tears in our patients did not have a traumatic origin, and the incidence was lower than those reported in previous radiologic and cadaver studies. Actual tear of the rotator cuff, not of the rotator interval, was seen in nine patients (8.1%) out of 111 cases. A defect in the rotator cuff interval was seen in two patients (2/111, 1.8%) and was secondary to trauma. The strength of our study lies in the use of locking plate-screw fixation systems which represent the modern methods of fracture treatment and early initiation of functional rehabilitation.

The repair of the rotator cuff in proximal humerus fractures not only ensures accurate positioning of the tubercle, but also restores the normal position of the

nutrient vessels supplying both tubercles. Suturing the rotator cuff has a positive effect on the perfusion of the humeral head, and decreases the risk for humeral head necrosis.<sup>[4]</sup> In our study, patients treated in this way did not develop any postoperative complications related to the procedure or joint stiffness, and had a mean Constant-Murley score of 85.4.

In conclusion, the integrity of the rotator cuff must be checked after reduction and fixation of proximal humerus fractures and, when present, the tears should be repaired simultaneously either primarily or with suture anchors. This simultaneous repair of rotator cuff tears does not negatively affect functional outcomes.

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