Fixation of extra-articular distal humeral fractures with a lateral approach and a locked plate: an alternative method

Atilla Sancar PARMAKSIZOĞLU¹, Ufuk ÖZKAYA¹, Fuat BİLGİLİ², Harun MUTLU¹, Ümit ÇETİN¹

¹Gaziosmanpaşa Taksim Training and Research Hospital, Department of Orthopaedics and Traumatology, İstanbul, Turkey
²Istanbul University Istanbul Faculty of Medicine, Department of Orthopaedics and Traumatology, İstanbul, Turkey

Objective: The purpose of this study was to evaluate the efficacy of lateral approach and anterolateral anatomical locked plate fixation on clinical and radiological healing of extra-articular distal humeral fractures.

Methods: Twenty-three (17 male, 6 female) consecutive patients who underwent surgical management for closed extra-articular comminuted distal humeral fractures between 2006 and 2013 were included in this study. Anterolateral fixation with an anatomical locked plate using a lateral approach was preferred. Mean age was 34 years (range: 17–56 years). AO Foundation/American Orthopaedic Trauma Association (AO/OTA) classification was used; all patients had AO/OTA 12-B1.3 type fractures. Inclusion criteria were patients with polytrauma, late-onset radial nerve injury, and unsatisfactory closed reduction. Patients were followed up at postoperative weeks 6, 12, and 24, and in 3-month intervals thereafter. Mean follow-up period was 16 months (range: 14–18 months). Functional results were evaluated using the Disabilities of the Arm, Shoulder and Hand (DASH) score, visual analog scale (VAS) score, and Mayo elbow performance score.

Results: Mean flexion was 135° (range: 128–140°) at 24 weeks postoperatively; there was no loss of pronation and supination of the forearm. All fractures healed uneventfully in an average of 19.3 weeks (range: 16–24 weeks). Mean Mayo elbow performance score and DASH score at 24 weeks improved from 66.6 (range: 50–85) to 100 and from 53.6 (range: 25.75–80.75) to 12.7 (range: 5–26.5), respectively. VAS score at 24 weeks improved from 4 (range: 3–5) to 0.5 (range: 0–1). Postoperative radial nerve paralysis and infection were not observed.

Conclusion: We recommend anterolateral anatomical locked plate fixation using a lateral approach as an alternative method in the management of distal humeral extra-articular fractures. This enables rigid fixation of the distal fragment without interfering and impinging on the olecranon fossa, allows early active range of elbow motion, and avoids iatrogenic triceps muscle injury and radial nerve exposure, which prevents surgical radial nerve injury.

Keywords: Distal humerus; extra-articular; fracture; locking plate; shaft.

Level of Evidence: Level IV, Therapeuthic study.
The main objective in the treatment of extra-articular comminuted distal humeral fractures is to enable early elbow motion by achieving correct alignment and stable fixation.\textsuperscript{[1,2]} It has been reported that surgical risks can be avoided and good outcomes can be obtained by using functional bracing with conservative methods.\textsuperscript{[3]} Nonetheless, it has also been stated that bracing can be unsuccessful in achieving anatomic alignment and early elbow motion in distal humerus, where rotational strength is critical.\textsuperscript{[3–5]}

In the surgical treatment of extra-articular distal humeral fractures, a posterior approach with dynamic compression plates has been proposed.\textsuperscript{[6,7]} However, in posterior approach, it is difficult to fix both columns by inserting a sufficient number of screws in the small distal fragment without causing any impingement on the olecranon fossa\textsuperscript{[3,7]} (Figure 1). In order to insert more screws to the distal fragment, double plating with a posterior approach\textsuperscript{[2,4]} and posterolateral plating for the reconstruction of the lateral column have been described.\textsuperscript{[8]} However, it has been proven for the posterior approach that an iatrogenic triceps injury may occur and a high incidence of radial nerve injury may be seen during separation of the triceps muscle.\textsuperscript{[9]}

The purpose of our study was to evaluate the efficacy of lateral approach and anterolateral anatomic locked plate fixation on clinical and radiological healing of extra-articular distal humeral fractures. To the best of our knowledge, lateral approach to distal humeral metaphyseal-diaphyseal fractures with the osteosynthesis method with anterior single locked plate has not previously been reported in the literature.

**Patients and methods**

Twenty-three (17 male, 6 female) consecutive patients who underwent surgical management for extra-articular comminuted distal humeral fractures between 2006 and 2013 were included in this study. Inclusion criteria were patients with polytrauma\textsuperscript{(n=2)}, late-onset radial nerve injury \textsuperscript{(n=2)}, and unsatisfactory closed reduction\textsuperscript{(n=19)}. Angulation <20\textdegree{} in the sagittal plane and <30\textdegree{} in the frontal plane, and less than 2 to 3 cm of shortening were determined to be acceptable reduction limits. Pathological fractures, intra-articular fractures, open fractures, and patients under the age of 16 were not included in the study. The etiology comprised of traffic accidents \textsuperscript{(n=11)}, sports injuries \textsuperscript{(n=8)}, and falls \textsuperscript{(n=4)}. Mean age of the patients was 34 years (range: 17–56 years). AO/OTA classification was used; all patients had AO/OTA 12-B1.3 type fractures. Mean duration until surgery after fracture was 3 days (range: 2–5 days).

For surgical method, lateral incision was preferred, and fixation was extended to the distal and anterolateral humerus with an anatomically compatible distal tibial locked titanium cobra head plate (LCP medial distal tibia plate 2.7/3.5 mm, Synthes-DePuy, Oberdorf, Switzerland). As the distal humerus and distal tibial possess a similar anatomic curvature, this plate was preferred in the present study, allowing the insertion of 8 locked/unlocked screws to the distal fragment if required (Figure 2).

The patient was placed in a beach chair position, and a lateral incision was performed to the distal humerus (Figure 3a). No tourniquet was used. The subcutaneous tissue and fascia were opened along the incision. Exploration of the radial nerve was performed from the interval between the brachialis and brachioradialis muscles; however, attempts were made to protect the vascularity of the radial nerve by not suspending it (Figure 3b). The anterior section of the humerus, where the distal part of the plate was to be placed, was prepared by incising, the extensor carpi radialis longus muscle subperiosteally from its point of attachment (Figure 3c). The triceps muscle was detached upwards from the posterior portion of the fracture site to perform the reduction. Radial nerve is observed but not detached entirely from the soft tissues. The interval between the brachialis and brachioradialis muscles was identified to prepare the

![Fig. 1. Posterior plating with a hybrid plate on distal humerus model.][1]

[1] Color figures can be viewed in the online issue, which is available at www.aott.org.tr
bony surface which the plate will be placed (Figure 3d). If longer plates were needed in fractures with proximal extension, a third window was prepared by opening the interval between the deltoid and brachialis muscles without damaging the attachment of the deltoid muscle (Figure 3e). After ensuring fracture reduction, the cobra head distal tibial plate, anatomically compatible to the distal humerus, was fixed through the proximal and distal ports with 1.6-mm K-wires. The butterfly fragment was fixed with interfragmentary screws over the unat-
attached portion and/or plate. Taking into consideration the character of the fracture, bone quality, and age of the patient, fixation was performed with approximately 4 screws (3.5-mm locking screws) to the proximal and approximately 6 screws (2.7-mm cortical and/or 3.5-mm locking screws) to the distal fragments. Due to the screw configuration feature of the plate, there was no screw impinging on the olecranon fossa. While preventing damage to the deltoid muscle in the proximal portion and iatrogenic injury to the brachialis and brachioradialis muscles in the mid-diaphyseal section with this surgical approach, only the extensor carpi radialis longus muscle was partially and subperiosteally detached for the distal placement of the plate in the distal fragment (Figure 3f).

Casting or bracing was not performed on any patient in the postoperative period. However, shoulder-arm sling was used for 5–10 days according to patient requirements in order to resolve soft tissue trauma due to iatrogenic surgery and postoperative pain. After postoperative day 3, twenty minutes of active and passive shoulder and elbow exercises were encouraged under the supervision of a physical therapist working in our clinic. Patients were followed up at postoperative week 6, 12, and 24, and every 3 months thereafter. Mean follow-up period was 16 months (range: 14–18 months). Radial nerve injury was not seen in any of the patients postoperatively (Figure 4). In the evaluation of functional results, DASH (Disabilities of Arm, Shoulder and Hand), VAS (visual analog scale), and Mayo elbow performance scoring were used.[10–12]

Results

Mean elbow flexion of the patients was $107^\circ$ (range: 90–120°), $124^\circ$ (range: 110–130°), and $135^\circ$ (range: 128–140°) at postoperative week 6, 12, and 24, respectively. Mean extension loss at week 6 was $3^\circ$ (range: 0–5°). Any degree of limitation of pronation or supination was not observed in any of the patients in this study. It was observed that the iatrogenic partial injury to the extensor carpi radialis muscle did not cause restriction in elbow movements.

Mean union period was 19.3 weeks (range: 16–24 weeks), with no patient experiencing any problems in union. Mean Mayo elbow performance and DASH scores improved from 66.6 to 100 (range: 50–85) and to 12.7 (range: 5–26.5) from 53.6 (range: 25.75–80.75), respectively, at postoperative week 24. Mean VAS score improved from 4 (range: 3–5) to 0.5 (range: 0–1) at week 24 (Table 1). Two patients with preoperative radial paralysis following closed reduction attempt of the fracture, was intraoperatively observed to have intact but stretched radial nerves, and had spontaneous recovery in the second postoperative month. Infection, implant failure and soft tissue problems were not observed in this study.

Fig. 4. Clinical and radiological images of a 32-year-old male patient with AO/OTA type 12-B1.3 fracture. [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]
Table 1. Functional outcomes at postoperative weeks 6, 12, and 24.

<table>
<thead>
<tr>
<th>Score</th>
<th>6. week</th>
<th>12. week</th>
<th>24. week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disabilities of the Arm, Shoulder and Hand</td>
<td>53.6 (25.75–80.75)</td>
<td>23.2 (12.5–54)</td>
<td>12.7 (5.5–26.5)</td>
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<tr>
<td>Mayo</td>
<td>66 (50–85)</td>
<td>96 (75–100)</td>
<td>100</td>
</tr>
<tr>
<td>Visual analog scale</td>
<td>4 (3–5)</td>
<td>2 (1–3)</td>
<td>0.5 (0–1)</td>
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</tbody>
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Discussion

The general consensus in the treatment of extra-articular distal humeral comminuted fractures is to first attempt conservative methods. However, although functional bracing does not appear to cause problems with elbow movements, skin problems and rotational and angular deformities may develop in the fracture, and thus, shoulder functions can be impaired. The most frequent factor for surgical intervention has been indicated as failure to obtain acceptable reduction or sustain it during conservative treatment. In a study by Jawa et al., comparing the outcomes of functional bracing and plate-screw use, it was stated that better fracture alignment and better functional results could be achieved with surgical treatment. The authors have also suggested including the patient in the decision-making process after having informed her or him regarding the advantages and disadvantages of both treatment methods.

The metaphyseal-diaphyseal portion of the distal humerus is an area where deformative rotational forces are extensive. When compared to other areas of the humerus, it possesses a relatively weak bone structure. In order to diminish the possibility of late union or non-union in the surgical treatment of fractures in this area, rigid fixation and early elbow motion are mandatory. However, in metaphyseal-diaphyseal fractures of the distal humerus, the distal fragment is generally short, making it difficult to perform a rigid fixation. Levy et al. described the difficulty in using plates of an adequate length without causing impingement on the olecranon fossa in the surgical treatment of fractures in the transition area of the diaphyseal-metaphyseal area. As a means to fix the distal fragment with more screws, they utilized the locking plate used in the treatment of proximal tibial plateau fractures with a posterior incision in 15 patients with metaphyseal-diaphyseal fractures of the distal humerus, and thus, they stated that they could fix the distal fragment with 4 locking screws. They emphasized that implant failure and infection did not develop in their study. Prasarn and colleagues have similarly reported difficulty in rigid fixation without causing impingement on the olecranon fossa. In a study consisting of 15 patients, they suggested the application of double plates to fix both columns with a posterior midline incision and reported that only with this method can a biomechanically strong fixation be achieved. The authors used demineralized bone matrix in 10 of the 15 patients, and all fractures achieved union; however, deep infection developed in 1 patient. Posterolateral plates for the reconstruction of the lateral column has also been suggested. In fractures of the proximal humerus and mid diaphysis, utilizing the helical plate—which extends to the lateral in the proximal and to the anterior in the distal—has been suggested, which is made compatible to the anatomy of the proximal humerus by bending it intraoperatively. Although they reported having achieved successful outcomes with this method, the authors also warned that bending the plate intraoperatively may decrease plate resistance. The distal tibia locked titanium cobra head plate used in our study is custom-manufactured to match the premeasured inclination to fully fit the anatomy of the distal humerus. There is a possibility to insert 7 to 8 screws to fix both columns from the distal fragment and metaphyseal-diaphyseal area without causing impingement on the olecranon fossa. In our study, implant failure, reduction loss, and nonunion were not seen in any patients.

Anterolateral approach in humerus one-third proximal diaphysis fractures, lateral approach in one-third mid diaphysis fractures, and posterior approach in distal one-third diaphysis fractures are recommended. Iatrogenic injury, scar, adhesion, and muscle denervation may develop in the triceps muscle with a posterior approach. Therefore, lateral paratricipital approach, entering between the lateral head of the triceps and lateral intermuscular septum, has been suggested. Although the presence of radial nerve damage at first evaluation does not necessitate surgical indication, the development of radial nerve damage in the course of reduction attempts or follow-up is another accepted indication for surgery. In the study by Levy et al., who suggest using posterior incision, it was reported that the mean elbow range of motion at final follow-up was 11–112° and emphasized that spontaneous healing was seen in 2 of their patients with preoperative radial nerve damage. In another study, where posterior incision was used, Prasarn et al. emphasized that while spontaneous healing was detected in 1 of 3 of their patients and preoperative ra-
dial nerve injury and partial recovery in another, the remaining patient did not show any sign of healing. In the lateral approach, while the interval between the brachialis and brachioradialis muscles is used for the exploration of radial nerve injury and the interval between the deltoide and brachialis muscles is used for the proximal placement of the plate, the extensor carpi radialis muscle is partially and subperiosteally scraped for the anterior placement of the plate, and thus, the triceps muscle remains undamaged and only the extensor carpi radialis muscle is minimally damaged. In our study, mean elbow flexion of the patients was 107° (range: 90–120°), 124° (range: 110–130°), and 135° (range: 128–140°) at postoperative Weeks 6, 12, and 24, respectively. Supination and pronation loss due to surgical loosening of the extensor carpi radialis muscle was not seen in any patient. Except for the polytrauma patients, closed reduction was performed in all patients in this study. Two patients who were observed to have sustained radial nerve injury during reduction maneuver were operated on. In the intraoperative evaluation, it was seen that the nerve was tightened between the fragments of the fracture but remained intact. Spontaneous clinical healing was observed in the postoperative second month.

Another disadvantage of the posterior incision is that only 55% of the distal humerus can be removed without mobilizing the radial nerve.[25] Gerwin et al. reported that an iatrogenic radial nerve injury rate of up to 76% may develop during detachment of the triceps muscle in the posterior approach.[9] Owing to the proximity of the radial nerve to the distal diaphysis area of the humerus, other authors have also emphasized the risk of causing iatrogenic injury in this area.[7,25,27,28] A path of entry that will easily reveal and protect the radial nerve is preferable. In our study, the radial nerve in all patients was exposed for clarity to avoid injury between the brachialis and brachioradialis muscles with a lateral incision. The radial nerve was not suspended and separated from the surrounding soft tissue in any of the patients. Iatrogenic radial nerve injury was not seen in any patients postoperatively.

The relatively small number of patients included in this study and the absence of a control group treated with posterior incision are the weaknesses of our study. The strength of the study is in suggesting a new method to provide more rigid fixation to the distal fragment, which had not previously been described in the current literature.

In conclusion, we recommend the application of the anatomically compatible locking plate to the distal humerus with a lateral approach as an alternative method in the surgical treatment of extra-articular comminuted distal humerus fractures, as it enables rigid fixation by inserting a large number of screws in the distal fracture segment, allows for early elbow motion, does not cause triceps injury, makes radial nerve exploration easy, and reduces the risk of developing iatrogenic nerve injury.

Conflicts of Interest: No conflicts declared.

References


17. Available at: http://www.aotrauma.org/.


