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Outcome of Extra-Articular Distal Humerus Fractures Fixed by Single Column Extra-Articular Distal Humerus Locking Compression Plate Using Triceps Sparing Postero-Lateral Approach

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ABSTRACT

Objective: To determine the time to radiological union and final functional outcome of fixation of extra-articular distal humeral fractures with extra-artricular distal humerus locking plate.
Methods: This prospective study was conducted from March 2014 to February 2018 and included extra-articular distal humeral fractures managed by operative fixation using extra-articular distal humerus locking plate. All the fractures were approached using lateral para-tricepetal approach of Gervin, and stabilized with extra-articular distal humerus locking plate with or without lag screws. Time to radiological union was assessed in the follow up and at the final follow up functional outcome was evaluated using Mayo Performance Elbow Score (MEPS). Complications and need for any additional procedures was also recorded.
Results: A total of 20 patients with mean age of 36.5 years and an average follow up of 17 months were included. The mean time to radiological union was 17.4 weeks (12 to 36 weeks) which included one delayed union that required bone grafting. The mean flexion at elbow was 127^o with only one patient having flexion extension arc movement of less than 100^o at the final follow up. The average MEPS at final follow up was 94.7±8 with 19 patients having excellent and good results.
Conclusion: Use of extra-articular distal humeral locking plate using lateral para-tricepetal approach in extra-articular distal humeral fractures allows stable fixation of the fracture to allow early return to function with minimal soft tissue dissection and excellent final functional results and minimum complications.

Keywords: Humerus; Fracture; Elbow; Locking plate; Extra-articular.

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Introduction

Fractures of shaft of humerus have successfully been managed conservatively by bracing as well as surgically by plate fixation or intra-medullary nail [1, 2]. However, management of extra-articular distal humeral fractures (EADHF) has always been difficult and challenging [3]. Non-surgical management with hanging cast and bracing is not always a feasible option as the distal fragment is small and difficult to control with a tendency to go into adduction [4].Associatedmetaphyseal comminution further adds to difficulty of non-surgical treatment [5]. Prolonged bracing or casting may result in delay in return to work and stiffness of the elbow joint [6]. Surgical management with conventional plates is mechanically unstable because of inappropriate number of screws in the short distal fragment with additional risk of impingement of the plate on olecranon fossa [7]. Dual platting increases the stability at the risk of soft tissue stripping of the bone [4]. Oblique plates used by Moron increases purchase in the distal fragment but compromises fixation of the proximal fragment [8]. Availability of the extra-articular distal humeral locking plate (EADHLP), having an angular offset distally has resolved the shortcomings of conventional posterior plating and Moron's oblique platting system in management of extra-articular distal humeral fractures. Here we study the outcome of EADHF managed by EADHLP by triceps sparing postero-lateral approach.

Materials and Methods

Study Population

Twenty-four patients with EADHF were managed by EADHLCP through postero-lateral triceps reflecting approach between March 2014 and February 2018. Patients aged less than 16 years, compound fractures of GustiloAderson grade II and III, associated vascular injury, compartment syndrome, pathological fractures, surgical intervention after three weeks of injury, associated ipsilateral upper extremity fractures, and patients with final follow up of less than 9 months were excluded from the study. Based on the exclusion criteria four patients were excluded with one patient being operated at five weeks after injury, two patients lost in follow up before completion of 9 months and one patient had not completed 9 months follow up. Thus out of 24 operated patients only 20 qualified to be included in this study. Patient demographics, mode of injury, side involved, soft tissue status, pre-operative radial nerve status, AO type of the fracture, associated injuries, time interval between injury and surgical intervention were recorded.

Surgical Technique

Surgery was performed under general anesthesia or nerve blocks (supra-clavicular or inter-scalene nerve blocks) in lateral position with involved arm resting on a well-padded bar, allowing flexion of at least 120^{o} at the elbow. The humerus was approached through a mid-line skin incision that curves distally lateral to olecranon over lateral column of the humerus. The triceps was separated and reflected from the lateral septum, lateral supracondylar ridge and posterior surface of humeral diaphysis, as described by Gerwin*et al*., [9]. While reflecting the triceps, radial nerve was carefully identified, dissected and secured. Care was taken not to strip comminuted fragments of soft tissue attachments. Fracture was reduced anatomically and temporarily stabilized with clamps and or k wires. If required separate fragments, long oblique and spiral fractures were stabilized with lag screws. Numbers of the lag screws used were recorded. Finally, the fracture was internally fixed and stabilized with EADHLCP composed of stainless steel, with its proximal part resting on the center of the shaft and anterior to the radial nerve and distal angular offset resting on posterior surface of lateral column of distal humerus (Figures 1 and 2). The wound was closed over suction drain and soft well-padded dressing applied and extremity immobilized in an arm pouch.

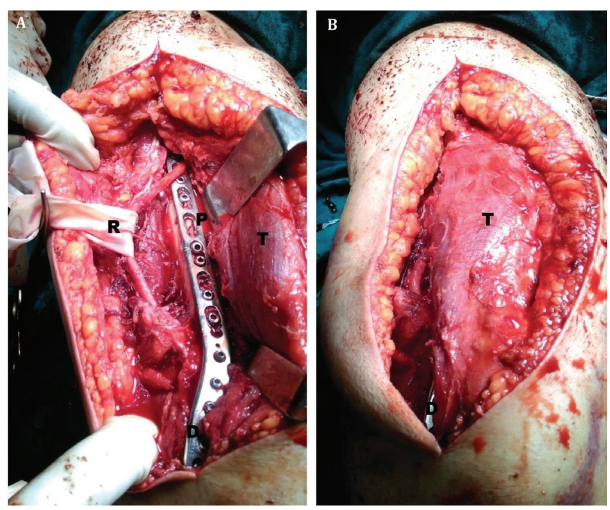

Fig. 1. Intra-operative pictures. A) Fracture fixed with EADHLCP with radial nerve (R) running over the plate, triceps muscle (T) dissected from lateral septum and posterior aspect of humerus and reflected medially. The proximal part (P) of the plate rests on center of the shaft of humerus and distal part (D) rests on posterior part of lateral column of distal humerus. B) Triceps muscle repositioned covering the plate.

Surgical Implant

EADHLCP is a specially designed 4.5 mm narrow fixed angle locking plate having elongated combi holes in proximal part that accepts 3.5 mm screws and distal part is tapered with an angular offset to rest on the posterior aspect of lateral column with increased hole density to accommodate five 3.5 mm locking screws. The plate is available in six lengths with 4 (122 mm) to 14 (302 mm) combi holes with different plates for right and left side (Figure 3).

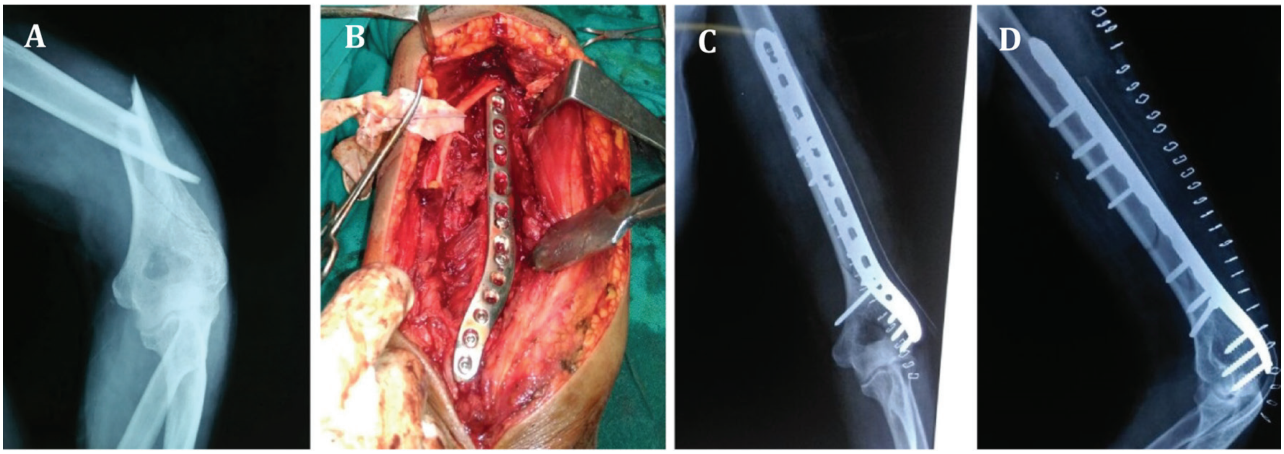

Fig. 2. Pre-operative radiograph showing EADHF with a butterfly fragment (A). Intra-operative image after stabilization with a lag screw and EADHLCP (B). Post-operative radiographs showing the butterfly fragment fixed and stabilized to distal fragment with a lag screw and the main fracture reduced and fixed using EADHLCP (C and D).

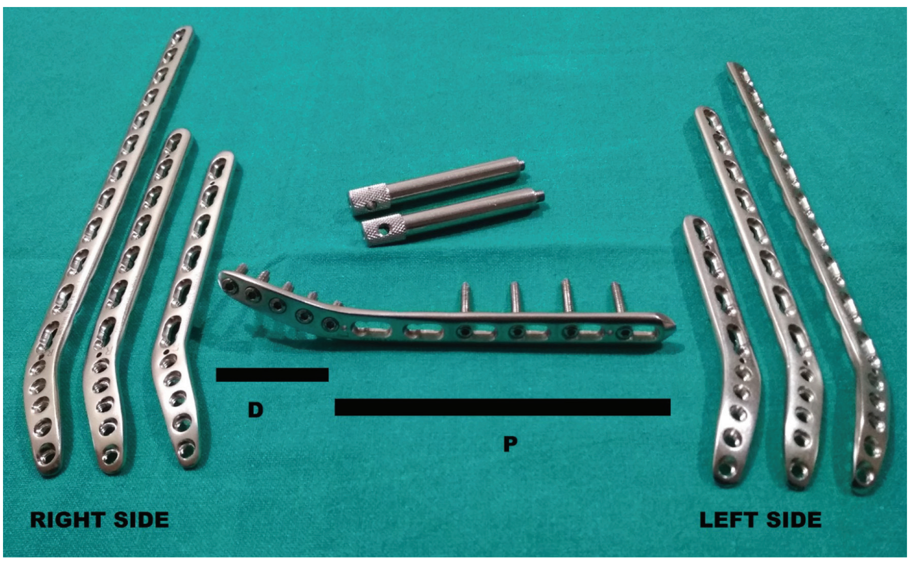

Fig. 3. Stainless steel EADHLCP having a distal (D) angular offset that rests on lateral column of distal humerus and proximal part (P) with combi holes that rests on the center of the shaft, with different plates for right (R) and left (L) side.

Postoperative Protocol

Intermittent range of motion exercises were started as tolerated. Postoperatively distal neurological and vascular status was evaluated and recorded. Any signs of surgical site infection were looked for. In case of radial nerve palsy, a cock up splint was given. Stitches were removed at two weeks. The patients were followed at every four weeks' interval post-operatively and were evaluated clinically and radiologically for alignment, union and complications. The fracture was said to be clinically united when local tenderness disappeared and radiological union when there was bridging of at least three out of four cortices on two orthogonal radiographic views (Figure 4). In case of radial nerve palsy recovery of the function of the nerve was evaluated. At final follow up range of motion arc at elbow, elbow function using Mayo Elbow Performance Score (MEPS), any complication and any additional procedure required were evaluated. The function of elbow was graded as excellent (≥90 points), good (75 -89 points), Fair (60–74 points) and poor (<60 points) on the basis of MEPS [10].

Statistical Analysis

All the data are analyzed using statistical package for social sciences (SPSS Inc., Chicago, Illinois, USA). Data are presented as mean±SD and proportions as appropriate. All the data are summarized in tables.

Results

A total of 20 patients were included in this prospective study. At the time of surgery, the average age of the patients was 36.5±14.1 years (range 17 to 61 years), with 13 males and 7 female patients. Road traffic accident was the most common mode of trauma seen in 60 % of the patients followed by fall in 35 % of the patients. Right extremity was involved in 11 patients and left in nine. 30 % patients had other associated injuries. Three (15%) patients had associated radial nerve palsy at the time of presentation. AO type

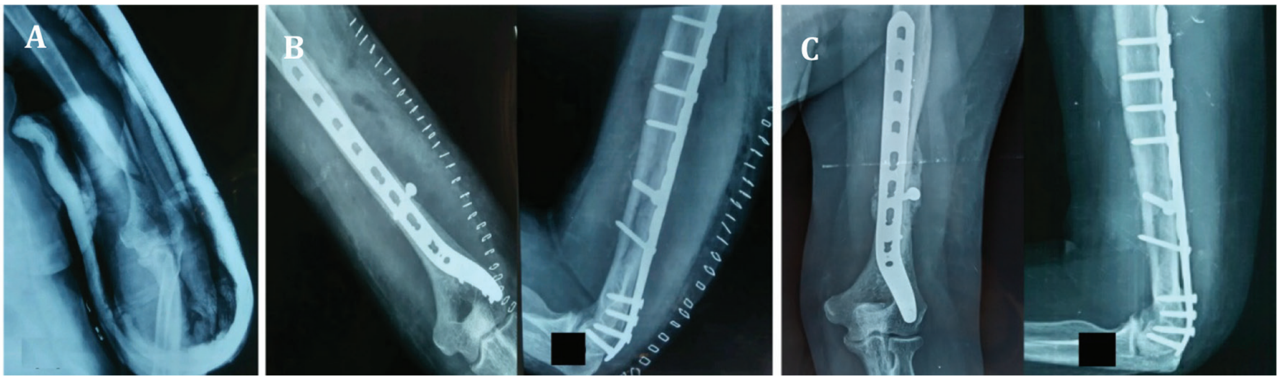

Fig. 4. Case No. 2. Pre-operative radiograph (AO type 12-A2) **(A)**. Post-operative radiograph showing anatomical reduction **(B)**. Final follow up radiograph showing radiological union **(C)**.

12B2 was the most common fracture pattern, seen in 25 % followed by 12A2 (20 %), 12A1 (15 %), and 12B1 (15 %). Surgical procedure was performed with a mean delay of 9.9±4.7 days (range 3 to 20 days) from the time of injury (Table 1).

The average follow-up ranged from 9 to 28 months (mean of 17±5.1 months). Lag screws had been used for fixation in 17 patients with an average of 1.6 screws per patient. Radiological union of the fracture ranged from 12 to 36 weeks (average of 17.4±5.8 weeks). This also included one patient that developed delayed union and was managed by bone grafting at 26 weeks and radiological union was achieved at 36 weeks. Three patients who had radial nerve palsy at the time of presentation had complete anatomical continuity of the nerve noted at the time of surgical procedure and all of them recovered completely. In two patients it recovered at 3 months and at 5 months in other patient. Besides this, one patient developed radial nerve palsy post-operatively and it recovered completely within 8 weeks' period. One patient developed superficial surgical site infection that was managed by lavage and debridement. Three patients complained of hardware impingement at the distal end of the plate, however, plate was not removed in any patient till date.

At the final follow up, mean flexion at elbow was 127±12.07^o (range of 95 to 145^o). Four patients had extension lag of 5^o and one had 15^o lag. One patient had hyperextension of 5^o at the elbow. All the patients had flexion extension arc movement of more than 100^o at the elbow joint at final follow up except one patient who had arc motion of only 80^o. MEPS of the patients ranged from 70 to 100 at final follow up with an average score of 94.7±8. On the basis of MEPS 16 patients had excellent, 3 had good and one patient had fair results (Table 1).

Table 1. Demographic parameters, clinical details, final functional outcome and the complications.

Variable	Value
Age (years)	36.5±14.1 (Range 17 to 61)
Gender	
Men (%)	13 (65%)
Women (%)	7 (35%)
Mode of trauma	
Road side accidents (%)	12 (60%)
Fall (%)	7 (35%)
Sports injury (%)	1 (5%)
Side involved	
Right (%)	11 (55%)
Left (%)	9 (45%)
Preoperative radial nerve palsy (%)	3 (15%)
Associated injuries (%)	6 (30%)
Injury to surgery interval (days)	9.9±4.7 (Range 3 to 20)
Follow up (months)	17±5.1 (Range 9 to 28)
Lag screw use (%)	17 (85%)
Average number of lag screws used	1.6 per patient
Radiological union (weeks)	17.4±5.8 (Range 12 to 36)
Range of motion at elbow (degrees)	127±12.1 (Range 95 to 145)
Final MEP Score	94.7±8 (Range 70 to 100)
Final functional results	
Excellent (%)	16 (80%)
Good (%)	3 (15%)
Fair (%)	1 (5%)
Poor (%)	0 (0%)
Complications	6 (30%)
Hardware symptoms (%)	3 (15%)
Infection (%)	1 (5%)
Radial nerve palsy (%)	1 (5%)
Delayed union	1 (5%)
Additional surgical procedures	2 (10%)
Debridement (%)	1 (5%)
Bone grafting (%)	1 (5%)

Discussion

Treatment of extra-articular fractures of the distal humerus is debatable, with advocates of non-surgical management in brace as well as surgical fixation using plates [11, 12]. But comparative data is limited. Sarmiento A *et al.*, [11] in their series on functional bracing of comminuted EADHF had radiological union of the fracture in 96% patients with good functional results. Radiological misalignment, especially Varus deformities followed by apex posterior angulations was the most common deformity, though not clinically evident. Surgical fixation carries advantage of restoration and maintenance of alignment of the fracture fragments and quick return of function [13]. However surgical fixation is plagued with complications like non-union, radial nerve palsy, infection and hardware symptoms [14].

Different techniques have been used for plate osteosynthesis of EADHF. Conventional 4.5 mm plates do not allow appropriate number of screw placement in the short distal fragment with added disadvantage of impingement on the olecranon fossa [7]. Presence of strong torsional strain in this region puts conventional plates at the risk of failure [5, 15]. Dual plating improves stability and gives rigid fixation but requires excessive soft tissue stripping with risk of non-union and infection [4]. El Mahboub N *et al*. in their series of 30 patients of EADHF managed with dual plating, had delayed union in two patients that required bone grafting, while as one patient in our series had delayed union. One patient developed deep SSI and two had superficial SSI. In our series only one patient had superficial SSI. The range of motion arc at elbow was more than 100^{o} in only 46.7% of their patients while as 95% of our patients had motion arc of more than 100^{o}. The mean MEPS in our series was 94.7 while as it was only 79.7 in series of dual plating [16]. To solve the problem of conventional plating in EADHF, Moron MC used oblique posterior platting at an angle of 5^{o} to 8^{o} to long central axis of humerus in his small series of 8 patients [8]. Based on the same principle Yang Q *et al*., [17] fixed these fractures in 19 patients with oblique metaphyseal locking compression plating. All the fractures united, with excellent results in 84 %. Due to obliquity of the plate the proximal end of the plate tends to go off the bone medially, making fixation of proximal fragment insecure in long oblique and spiral fractures which extend proximally towards diaphysis.Saragaglia*et al*., [18] developed an inverted Y or Lambda plate to achieve bi-columnar fixation, but lacked locking holes making it vulnerable to failure in comminution and osteoporosis.

With the advent of anatomically pre-contoured locking plates, which are fixed angle stable constructs, the fixation of peri-articular fractures has improved and dual plating is rarely required [19]. Scolaro JA *et al*., [15] in their experimental biomechanical model showed pre-contoured EADHLCP had significantly greater bending and tortional strength than 3.5 mm locking compression plate. However, bi-columnar plating is superior in very low type EADHF. Levy JC *et al*., [7] in their series of 15 patients used lateral tibial head buttress plate with some modifications, that had an angular offset of 22^{o} to rest on lateralcolumn of distal humerus distally and on the center of shaft proximally, had excellent results without any case of non-union or hardware failure. EADHLCP is a fixed angle locking plate which has resolved the short comings of conventional plates, dual plating and oblique metaphyseal platting for EADHF. It's distal angular offset and increased screw hole density in distal part which accommodate five locking screws with distal two screws directed towards trochlea and capitulum, increases stability especially of the small distal fragment.

EADHF differ from mid diaphyseal fractures of humerus in associated comminution, usually in the form of butterfly fragment. Chowdary RL *et al*., [20] in their series of 24 patients of EADHF had comminution with a long butterfly fragment in 60% patients. Similarly, in our series, 60% EADHF were wedge or complex type. Kharbanda Y et al and Jain D et al respectively had 75% and 84.6% of patients in their series having a wedge fragment or complex type of fracture pattern [4, 21]. Incidence of distal humeral fractures is on rise due to high velocity road traffic accidents and the elderly women with osteoporosis is the most vulnerable group [21, 22]. Preoperative radial nerve palsy in different studies ranged from 4.3 % to 23.3 % with 15% incidence in our series [4, 5,16, 20, 21, 23].In all, the radial nerve was intact at the time of surgical intervention and recovered with time. Postoperative radial nerve neuropraxia occurred in 5% of our cases with range of 0% to 8.3% in different series [4, 5, 20, 21, 23]. Exposure of ulnar nerve is seldom required for EADHLCP. Bi-columnar plate fixation carries risk of ulnar nerve injury at the time of dissection and even neuropathy, in case the nerve constantly rubs against the plate [16, 24]. There is a relative safety to radial nerve with use of EADHLCP using lateral para-tricepetal approach [25].

The average time to radiological union in different series using EADHLCP ranged from 12 weeks to 7.3 months with an average of 17.4 weeks in our series [4, 5, 20, 21, 23, 26]. This gross variability may be explained on the basis of different incidence of complex fractures and of open fractures, if included, as well as inter-observer variability in assessing radiological union because of no or minimal callus formation. Incidence of non-union is reported from 0% to 7.7% with the use of EADHLCP [4, 5, 21, 23, 25]. There was one case of delayed union in our series that was managed by bone grafting. Jain D et al in their series had failure of proximal screws in 4 patients (15.4%), which had been attributed to lack of proper spacing of screws in the proximal fragment that increased stress concentration on the proximal screws especially in fractures with metaphyseal comminution. So they advised a longer plate with uniform screw distribution to prevent this proximal screw failure [21]. We did not have any implant or screw failure in our series. Mean elbow flexion at elbow ranged from 122.9° to 141.2° in studies using EADHLCP and in our study the mean flexion arc at elbow was 127° [4, 5, 21]. The approach (triceps splitting or lateral para tricepetal) did not have any bearing on the final motion arc [4, 5, 21, 23]. Illical EM *et al*., [27] in their study on EADHF found both triceps splitting as well as triceps sparing approach resulted in reliable union and comparable functional outcomes. However, triceps sparing approach had a better elbow range of motion and triceps strength. Mean MEPS at final follow up was comparable with other studies that utilized same scoring system for functional evaluation. Trikha V*et al*., [5] and Jain D *et al*., [21] in their series had a mean MEPS of 90.8 and 96.15 respectively at their final follow up.

Our study is in support of using EADHLCP in treatment of extra-articular distal humeral fractures with advantage of minimal soft tissue dissection of fracture fragments and stable fixation allowing early return to function. It yields excellent functional results with least complications as compared to conventional implant and techniques. Small sample size, lack of case control comparing different implants and different techniques are the limitations of this study. A randomized control trail is warranted comparing different implants and techniques for EADHF.

Conflicts of Interest: None declared.

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