

Early functional outcome of intercondylar humerus fractures fixed with precontoured dual plating in inverted Y-Fashion

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Abstract

Objective: In this study we report the functional outcome of patients with intercondylar distal humerus fractures treated by precontoured angular stable anatomical locking plates in inverted Y fashion, using a standard approach. **Materials and Methods:** A total number of 24 patients with AO type C closed intercondylar distal humerus fractures were operated with open reduction through an olecranon osteotomy approach and internal fixation using two plates in inverted-Y fashion. Patients were followed at 4 weeks, 6 weeks, 12 weeks and thereafter every 6 months. They were evaluated using the Mayo Elbow performance index and Riseborough and Radin Score. **Results:** There were 9 (37.5%) men and 15 (62.5%) women with mean age of 46.72 years. 79.17% of the cases were following fall and rest following Motor vehicle accident. AO type C2 fractures accounted for 45.83% of cases; type C3 fractures accounted for 33.33% of cases and type C1 accounted for 20.84%. According the Riseborough and Radin criteria, the results were Good in 14(58.33%) of patients, Fair in 9(37.50%) and Poor in 1(4.17%). According to MEPI, we had Excellent results in 5(20.83%), Good in 12(50%), Fair in 6(25%) and Poor in 1(4.17%) patients. The mean MEPI was 82±18. Thus according to MEPI, we achieved excellent to good results in ~70% of patients with 100% union rate and complications less than 13%. **Conclusion:** Intercondylar fractures of humerus treated by Dual plating in inverted Y-fashion offers a reliable and stable fixation permitting early mobilization and comparable functional outcome with good union rates.

Keywords: Intercondylar fractures; distal humerus fractures; Distal humerus; Dual plate; precontoured anatomical locking plates

Introduction

Fractures of the distal humerus are uncommon injuries, accounting for only 0.5–2% of all adult fractures and continue to provide operative challenges to the surgeon [1-3]. Distal humerus fractures commonly occur through a fall or more significant force onto a flexed elbow, transmitting forces through the thin-walled olecranon/coronoid fossae, occasionally splitting down through the articular margin. Historically, nonoperative management (i.e., “bag of bones”) was advocated as the best form of treatment because of a lack of adequate surgical techniques and implant-related issues. During the past several decades, operative management became widely accepted as the best treatment for these injuries,

despite the complications associated with operative treatment. Distal humerus fractures are broadly categorized into those with intra-articular extension and those without. Intra-articular fractures are generally more challenging, at times requiring an olecranon osteotomy and extensive dissection.

Difficulties exist when managing distal humeral fractures because of challenges in obtaining an anatomic reduction, related ulnar nerve issues, heterotopic ossification, comminution, osteopenia, nonunion, and the complex decision-making regarding whether to treat operatively with total elbow replacement or open reduction and internal fixation (ORIF). Success frequently depends on various factors, including quality of reduction, fracture type and severity, and patient

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compliance with physical therapy and lifting restrictions. Distal humerus fractures occur infrequently, but they represent 30% of all elbow fractures [1]. Most fractures of the distal humerus (50–70%) are intra-articular and generally related to a simple fall and osteoporosis [3,4]. Distal humeral fractures occur in a bimodal distribution, but women over the age of 65 are most commonly affected.

Younger patients who sustain intra-articular fractures generally are involved in high-energy trauma [5]. Recent research indicates that the overall incidence of distal humeral fractures is 5–30/100,000 and is increasing because of a more active older population with a longer lifespan [4,6,7]. Compared with hip fractures associated with osteoporosis, distal humerus fractures generally occur to a more active patient who

has a high-level of autonomy, frequently living independently [3]. Because of its increasing frequency, distal humeral fracture management is also increasing. The goals for the orthopedic surgeon treating these injuries should be to maintain function, decrease pain, and provide a stable ulnohumeral and radiocapitellar joint. Complications associated with distal humerus are nonunion, malunion, decreased motion, and instability.

Aims and Objectives

The purpose of the present study was to evaluate the early clinical outcome of inverted Y-shaped double-plating in 24 patients with intercondylar fractures of the distal humerus using the post-operative evaluation criteria by Riseborough and Radin⁸ and the Mayo Elbow Performance Index (MEPI) [9].

Materials and Methods

Place of study: The study included 24 patients admitted to the tertiary care hospital with intercondylar distal humerus fracture.

Type of study: The study was prospective type of study.

Sampling methods: The simple random sampling method was used in this study.

Sample collection: The sample collection period was from June 2015 to May 2017.

Inclusion Criteria: patients above 18 years of age with closed intra-articular distal humerus fractures

Exclusion Criteria

- patients less than 18 years of age
- fracture in a paralytic limb
- open fractures
- patients medically unfit for surgery
- inflammatory arthritis or other arthritis of the injured elbow
- Old neglected fractures

Primary & Pre-operative Management: Upon arrival in the department of casualty, thorough clinical examination of patients was done including neurovascular examination. Radiography in form of x-rays, traction x-rays and CT scans with 3D reconstruction were done to know the exact geometry of fracture. Written informed consent was obtained from every patient regarding the surgery and inclusion in the study. The patients were evaluated using a standardized pre-anaesthetic work-up, and other associated injuries were treated using the appropriate treatment for that particular disease.

Surgical Management: Surgery was performed either under general anaesthesia or under brachial block with or without tourniquet control. The patients were treated with primary open reduction and internal fixation using precontoured anatomical dual plating in inverted Y-fashion. Posterior approach (standard midline) with olecranon osteotomy was used in lateral decubitus position with arm supported and forearm hanging in all patients. Before osteotomy, ulnar nerve was identified and dissected and olecranon was drilled with 6.5 mm CC screw drill bit. Osteotomy was done with oscillating saw and final osteotomy was done with osteotome.

The intercondylar articular surface was visualized and the articular surface was reconstructed anatomically (provisionally stabilized with 'K' wires). The intra-articular reduction was stabilized with help of a 4.5 mm partially threaded CC screw passed over a guide wire. On attainment of a satisfactory articular reduction, the supracondylar ridges were examined and the shaft was reduced to the condyles and maintaining the medial and lateral ridges. The reduction was held with help of

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bone holding forceps and an interfragmentary screw was used to attain reduction if required. Precontoured distal humerus 3.5 mm + 2.7 mm locking plates were applied over the lateral and medial ridges in inverted Y-fashion. Length of both plates was kept unequal and less comminuted column was fixed first. Before definitive plate fixation, the elbow was placed through a range of motion to ensure there is no hardware impingement. Ulnar nerve was embedded in the soft tissue and a fat pad harvested locally was placed between the nerve and the medial plate if required. The olecranon osteotomy was stabilized with tension band wiring principle over long 6.5 CC screw.



Pre-operative Radiograph

Post-operative Radiograph

Postoperative regime: Post-operatively, patients were instructed to move their fingers actively and limb elevation was maintained. Clean dressing was done on every third day post-operatively. On every dressing elbow was put to full range of motion once as per tolerability of the patients. Intravenous antibiotics were given for 6 days, later converted to oral until suture removal. Sutures were removed on the 14-16th postoperative day and check x-ray in antero-posterior and lateral views were obtained. Patients were later discharged with the above elbow posterior POP slab and advised to perform active shoulder and finger movements. Patients were advised not to lift heavy weight or exert the affected upper limb.

Data collection, Follow-up & Evaluation: At the end of 4 weeks, the plaster slab was then removed, an arm pouch was given and the patient was advised to do an active range of elbow movements as the pain permits. Patients were asked to return at 6 weeks, 12 weeks and thereafter every 6 months. The results were assessed at 3 months, 6 months and 1 year. At follow up, a detailed clinical examination was done and patients were assessed subjectively for the symptoms like pain, swelling and restriction of joint motion. Patients were instructed to perform physiotherapy in the form of active flexion-extension and pronation-supination without loading.

The functional assessment of the patient was done according to the Riseborough and Radin grading system and the Mayo Elbow Performance Index.

Stastical Method: All the statistical analysis was performed using Microsoft Excel Software. Data were presented as mean \pm SD and proportions as appropriate. Nonparametric data was compared using chi-square test while independent t-test was used to compare the parametric variables. A 2-sided p-value of less than 0.05 was considered statistically significant.

Results

The average age of the patients in our study was 46.72 years with a range of 18-72 years. 9 male patients and 15 female patients participated in the study; the female-to-male ratio was 1.67. The side involvement was almost equal with 11 fractures on the left side and 13 on the right. Majority of the patients 19 sustained injury due fall while 5 patients sustained injury due to road traffic accidents.

The fractures of the distal humerus were classified according to the AO classification. In our study maximum number (11 patients) had C2 type of fracture of the distal humerus followed by C3 type (8 patients). C1 type fracture was seen in 5 patients. We observed that complexity of fracture increased with increasing age. Patients with road traffic accidents had relatively complex fractures as compared to fall.

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Maximum numbers of patients were operated within first week of injury. Delay in Surgery was either due to delayed presentation to the institution or due to management of comorbid conditions. One patient presented after one month of trauma. Mean duration between injury and surgery was 6.78 ± 3.48 days and mean duration of hospital stay was 8.84 ± 3.37 days. The average follow-up was 15.3 months with a range of 12-22 months.

Out of the 24 patients, 4 had hypertension, 2 had diabetes and 1 had both hypertension and diabetes which were treated pre-operatively according to physician's advice. 1 patient had distal radius fractures which were treated with percutaneous pinning and casting at the same time as the surgery for distal humerus. One patient had associated distal third femur fracture treated with Anatomical plating in the same sitting.

14 patients had range of motion of more than 100 degrees. 9 patients had range of motion between 80-100 degrees. Only 1 patient had range of motion less than 80 degrees. Mean range of motion was 117.083 degrees.

Table-1: Demographic distribution of patients.

| Variable | Numbers | % (n=24) |
|----------------------|---------|----------|
| Sex | | |
| male | 9 | 37.5 |
| female | 15 | 62.5 |
| Side Involved | | |
| Right | 13 | 54.16 |
| Left | 11 | 45.84 |
| AO types | | |
| C1 | 5 | 20.83 |
| C2 | 11 | 45.84 |
| C3 | 8 | 33.33 |
| Age (years) | | |
| 18-30 | 5 | 20.83 |
| 31-40 | 4 | 16.67 |
| 41-50 | 5 | 20.83 |
| 51-60 | 6 | 25 |
| 61-70 | 4 | 16.67 |
| total | 24 | 100 |

The final results were classified according to the Riseborough and Radin criteria and the Mayo Elbow Performance Index (MEPI). In our study, according to the Riseborough and Radin criteria, the results were Good in 14 patients, Fair in 9 patients and Poor in 1 patient. According to MEPI, we had Excellent results in 5 patients, Good in 12 patients, Fair in 6 patients and Poor in 1 patient. The mean MEPI was 82 ± 18 . Thus according to MEPI, we achieved excellent to good results in ~70% of patients. Most of the good results were seen in type C1 and C2 fractures while the poor result was seen in type C3 fracture.

The most common complication in our study was post-operative stiffness of the elbow, seen in 2 patients. The second complication was superficial infection seen in 1 patient. Three patients had complains of itching at local site seen 4-5 months after surgery. None of our patient had deep infection or implant failure. None of our patient had Non-union either at distal humerus or at olecranon osteotomy site.

Stiffness was treated with physiotherapy in the form of CPM and ROM exercises, but for some stiffness persisted and led to poor results according to the final score. The superficial infections were treated by IV antibiotics according to culture & sensitivity and patients recovered without any long term complications.

No statistical significant relationship was found while comparing various fracture subtypes with parameters like interval between injury and surgery, duration of hospital stay and post-operative complications. Statistically no difference was found between younger and older patients in form of range of motion, mayo elbow performance score or pain at final follow up. Prolonged immobilization for a period of (4-6 weeks) had relatively poorer outcome in terms of range of motion and mayo elbow performance score at final follow up.

Table-2: Results.

| Results | | | | |
|-------------------------|------|------|------|-------|
| RR criteria → MEPI ↓ | Good | Fair | Poor | Total |
| Excellent | 5 | 0 | 0 | 5 |
| Good | 9 | 3 | 0 | 12 |
| Fair | 0 | 6 | 0 | 6 |
| Poor | 0 | 0 | 1 | 1 |
| | 14 | 9 | 1 | 24 |

Discussion

Orientation of plates: It is well known fact and published studies proved that Open reduction plus dual plating remains ‘Gold Standard’ for management of intercondylar distal humerus fractures. There is much debate going on and controversy still prevails regarding orientation of plates for treatment of these fractures.

Currently 3 techniques available for placement of dual platings:

- 1 perpendicular 90-90 plating recommended by AO group
- 2 Parallel plating recommended by O’driscoll [10]
- 3 Placement of plates in inverted Y-fashion

As far as perpendicular plating is concerned it was promoted early on by the AO group the biomechanical study of Helf et and Hotch kiss added credibility to this technique. A number of subsequent clinical studies revealed nearly 75–85% good to excellent results with 90–90 plating [11].

Along term follow-up study at a mean of 19 years after injury by Doornberg concluded that the long term results of open reduction and internal fixation of 19 Type C fractures of the distalpart of the humerus treated with perpendicular orientation aresimilar to those reported in the short term [13]. They suggested that the results are durable over time. The clinical experience with parallel plating has not been as extensive or with longer follow up, however current reports reveal no evidence of failure of the fixation and comparable clinical results as with 90-90 plating.

Biomechanical evidence: Which technique is more stable? Several biomechanical studies compared parallel plating with perpendicular 90–90 orientation, concluding that parallel plating with additional use of bolts was favorable to perpendicular plating. Their observations were supported by Armander who concluded that, parallel plating was superior to the

perpendicular orientation although they expressed concern that placing aplate lateral can be technically difficult [14,15]. Kimball found that the risk of delayed union or nonunion increased by the extensive subperiosteal elevation with parallel plating orientation [16].

Jacobson concluded that perpendicular plate orientation was strongest in the sagittal plane while Korner stated that perpendicular plating had increased stiffness to torsional and anteroposterior bending forces [15,17]. Korner showed that locking plates have a substantial advantage in poor bone quality or if significant metaphysical comminution is present [17]. Otherwise they concluded that there was no difference in plate type and that plate position is critical. Schwartz found similar stabilization among both plate orientations. Wong tested both fixation methods and concluded that both methods may be above the threshold necessary for early motion and predictable fracture healing, rendering the marginal strength of parallel plating clinically unimportant [18-19].

R. K. Guptaet.al., concluded that Dorsal application of both the plates provides steady enough configuration, requiring less extensive dissection and ulnar nerve retraction thereby resulting in a low incidence of complications [20-21].

Our Observation: Although parallel plating much discussed and used more frequently being a new procedure, we still used dual plates in inverted Y-fashion. Only reason was to avoid much dissection on both columns in sagittal plane which may compromise origin of common flexors and extensors of forearm from both epicondyles. It may increases chances of myositis ossificans post operatively. Furthermore the flat surface of plate is less likely to irritate the ulnar nerve as compared to the edge of the plate when placed medially over the supracondylar crest. We found

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posterior placement of both plates was having sufficient strength to hold fragments together and being anatomical they maintain normal anatomical flexion of distal humerus.

According to our clinical experience, placement of 3.5 mm locking screws in distal fragment (as used previously and still today) are too large to be placed for cancellous bone in distal humerus. Although 3.5 mm screws are must required for fixation of proximal fragment, 2.7 mm locking screws are better for distal fragment for two reasons: one for better purchase in small fragment and second was ease of placement in different direction (variable angle locking) in presence of 4.0 mm CC screw (which we used in all patients for intercondylar compression). It is proven and well known fact that one must never over compress 4.0 mm CC screw while achieving intercondylar compression to prevent trochlear stenosis. We followed the principle very well.

Regarding post-operative x-ray, it does not always coincide with the functional result. Those with Excellent function of the elbow may demonstrate a distorted radiographic appearance, and vice versa. On final x-ray, there may be nearly perfect anatomical restoration but poor functional capacity, usually due to joint stiffness [8]. Hence the surgeon may have to compromise appearance (both clinically and radiographically) in function point of view [12].

Clinical Observations: The average age of patients in our study was 46.72 year with maximum population in the 5th decade. This was comparable to study by Subramanian V et.al. where mean age was 40.83 years [22]. In our study, there were 9 males patients and 15 female patients contrary to studies by R. K. Gupta et.al, Subramanian V et.al, Amite Pankaj et.al, and Swagat Mahapatra et. al, where there was male dominant population almost reverse of our scenario [20-24]. This difference in sex distribution may be due higher incidence of house-hold accidents among female sin our region. Observations regarding fracture classification and side involvement were similar and comparable to studies by R. K. Guptaetal., Subramanian Vetal., Amite Pankaj et al., and Swagat Mahapatra et al [20-24].

The different mechanism of injury in our study was due to major female population in our study having history of fall by house-hold accidents. All the fractures in our study achieved bony union by six months. There was no delayed union or nonunion. Most authors including Lee SK et al., Leigey DF etal., and many others have similar observation in their studies [25-29]. The mean Mayo

Elbow performance score was 82±18. This was comparable to dual Y-plate study by Swagat Mahapatra et al [24]. Two studies by Rebuzziet al., (mean MEPS-94.17) and Sanjiv Kumar et al., (mean MEPS-96.32) where they used parallel plating had MEPS of greater than 90 following operative fixation [30-31]. This may be attributed to the lower averageage group of the study population in these studies. A further functional evaluation was also done using the Riseborough and Radin criteria [8]. The results were Good in 14 patients, Fair in 9 patients and Poor in 1patient. According to the original study, they obtained Good results in 10 (35.7%), Fair in 10(35.7%) and Poor in 8(28.5%) patients. Our results were likely more favorable due to advances in fixation and operative techniques.

The post-operative complication rates vary from 6 to 44 percent in various studies. Our study hadminimal complications. The application of both plates on the dorsal aspect instead of on the ridges results in a stable fixation requiring lesser soft tissue dissection, minimal periosteal stripping and minimal ulnar nerve retraction with decreased operative time and lesser complications like deep infection. Gupta et al., derived asimilar conclusion from their study [20,21].

Due to minimal soft tissue and periosteal stripping it was difficult to maintain reduction using reduction clamps. So it is advisable to provisional fix the fracture fragments with K wires for maintaining reduction and ease of plate application. Our study is not free of limitations which include smaller sample size, shorter follow-up and lack of comparison group. Long term follow-up for dorsal plating and clinical trials are needed to compare different plate orientation.

Conclusion

In conclusion, locking plate is a versatile implant providing stable-enough fixation and helping restoration of normal anatomy for good result and early rehabilitation. The results of our study do indicate that precontoured anatomical Dual plates in inverted Y-fashion is a useful option in distal humerus fractures even type C injuries with communitated small distal fragments which permits early mobilization and has a good functional outcome with minimal complications. This may in future become the preferred method of fixation by most surgeons.

What this study add to existing knowledge: Apart from parallel and perpendicular plating dual plating, posterior plating is equally effective and excellent method for treating distal humerus fracture.

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Contribution by Authors: Niravkumar Moradiya contributed to the study design, implementation of the research, verification of the analytical methods, supervised the findings of this work and to the writing of the manuscript. Niravkumar Moradiya and Neel Shah operated all the patients. Parth Joshi, Pujan Joshi and Neel Shah assessed follow up of patients and their functional outcome. Parth Joshi and Pujan Joshi collected data and analysed it. All authors discussed the results and contributed to the final manuscript.

Abbreviations: CC screw- Cannulated Cancellous screw; MEPI - Mayo Elbow Performance Index; CPM – Continuous passive motion; ROM – range of motion.

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