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Functional outcome of orthogonal plating in treatment of distal humerus fracture

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Abstract
Background: The study was conducted to evaluate the outcome of orthogonal plating system in distal humerus intraarticular fracture.
Material and Methods: 15 patients of age between 18 to 60 yrs with fracture distal end of humerus with intraarticular extension were evaluated, with the mean age group of 37 to find the functional outcome of Orthogonal plating using olecranon osteotomy approach.
Results: The mean union time was 9.53 weeks. The arc of flexion was 99.66º. Average mayo elbow performance score (MEPS) was 83. There were 2 case of infection. One case of implant failure noted secondary to infection leading to implant removal.
Discussion and Conclusion: The following results were assessed: operating time, arc of flexion and extension, time to fracture union, functional recovery, and complications. By using proper principles of stable fracture fixation and appropriate exposure in intraarticular fracture (with transolecrenon approach) a good reduction can be achieved which leads to good union, which helps in early mobilization and restoring elbow functions with early intensive physiotherapy.

Keywords: Functional outcome, plating, treatment, humerus fracture

Introduction
Distal Humerus fracture are relatively uncommon and comprise approximately 2-6 % of all fractures [2, 3, 21]. While relatively uncommon injuries, intraarticular fractures of the distal humerus continue to provide operative challenges to the surgeons attempting to address this problem as it is complicated by the anatomy of the elbow, its small area for fixation and otherwise compounded by comminution and osteopenia of articulating surfaces [8, 3, 4].
Historically, fractures seen in the distal humerus have been recognized as complex articular injuries that are difficult to address and have poor outcomes with permanent disability to the involved extremity. The main goal is to achieve a stable, accurate articular and bony reconstruction that allows early range of motion for rehabilitation and eventually a successful functional outcome [1]. In management of such fractures surgeons are required to observe several factors when considering plate fixation. These factors include, fractures patterns, quality of the bone, location of the implant, and the biomechanical properties of the implants.
Complex fractures of the distal humerus are not amenable to single column plating systems, which are proven to be less stable to loads compared to double column plating methods. Based on clinical and biomechanical studies, fixation with double plating is currently recommended.
With the continuing improvements in implants for distal humerus fractures, it is expected that newer types of plates, which are anatomically precontoured, thinner and less irritating to soft tissue, would have comparable outcomes when used in a clinical study [1]. The purpose of this study was to evaluate the clinical and radiographic outcomes in patients with distal humerus fractures who were treated with orthogonal plating methods using precontoured distal humerus plates [5, 8].
Orthogonal constructs (medial plate on medial column and posterior plate on lateral column) have been proposed for fixation of these fractures [1, 2, 8].
This fixation strategy focuses on maximizing stability between the distal fragments and the shaft of the humerus at the metaphyseal level. According to O'Driscoll [6, 8, 34] this can be achieved by following a set of eight technical objectives:

1. Every screw should pass through a plate.
2. Each screw should engage a fragment on the opposite side that is also fixed to a plate.
3. As many screws as possible should be placed in the distal fragments.
4. Each screw should be as long as possible.
5. Each screw should engage as many articular fragments as possible.
6. The screws should lock together by interdigitation within the distal fragment, thereby creating a fixed-angle architecture that provides stability to the entire distal humerus.
7. Plates should be applied such that compression is achieved at the supracondylar level for both columns.
8. Plates used must be strong enough and stiff enough to resist breaking or bending before union occurs at the supracondylar level.

Initially these fractures were classified based on the concept that the distal end of the humerus was made up of condyles. The term supracondylar, condylar, transcondylar and bicondylar fractures were utilized. Currently, fracture of the distal humerus are more commonly described based on the columnar structure of the distal humerus. This include describing fractures as single columnar, bicolumnar, and transcolumnar fractures [3].

AO/OTA used classification is the most widely used.

Extra-articular (AO type A)

Partial articular (AO type B)

Complete articular (AO type C)

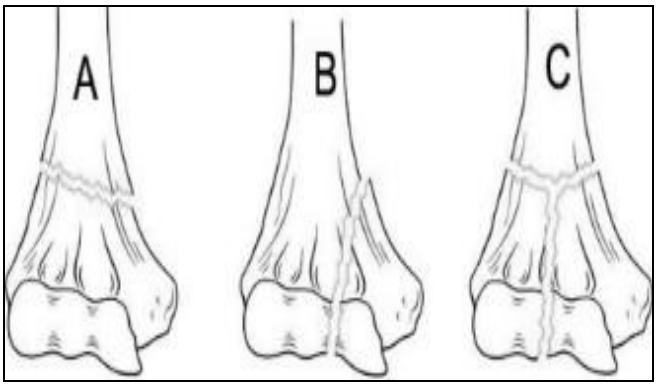


Fig 1: AO Classification of Fracture Distal Humerus

A TYPE: fracture is non articular

B TYPE: Partially articular, A part of the articulating segment remains in the continuity with the shaft

C TYPE: Fractures are articular, but have no articular fragments remaining in the continuity with the shaft.

C1- T or Y fractures

C2- articular fractures is simple, but the non-articular supracondylar area is segmental or comminuted.

C3- articular segment is segmental or comminuted.

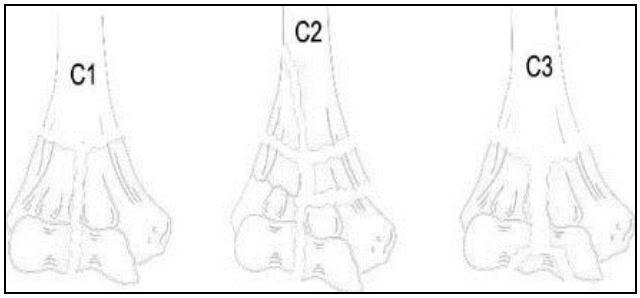


Fig 2: Type C Intraarticular Fracture Distal End Humerus

We prospectively studied 15 patients with fracture distal end of humerus with intraarticular extension that presented to the hospital emergency room between August 2015 and August 2017. The patients were treated at Department of Orthopaedics and Traumatology, M.G.M. Medical College and M.Y. Hospital, Indore.

All patients reported to the emergency room with history of trauma, swelling in the elbow and severe pain and inability to move the joint. Primary and secondary survey was done with recording of the vitals and limb assessed for neurovascular compromise. After the necessary interventions like fluids and analgesics, standard anteroposterior and lateral radiographs were ordered. Appropriate splints were given, admitted and advised limb elevation and ice fermentation in the wards. The patients who completed the following criteria were included in the study

- Age: 18-60 years
- All patients who have type C intra-articular distal humerus fractures(according to AO classification)
- Fractures requiring internal fixation
- informed consent obtained

The following were excluded from our study

- Ages <18, >60
- Extra-articular fractures
- Pathological fractures,
- Skeletally immature patients
- Grade 2 and Grade 3 compound fractures
- Fractures with Neurovascular compromise
- Refusal of inclusion by the patient

The selected patients who satisfied the above inclusion criteria were then registered, all history and clinical details were recorded in the history sheet as per the proforma (Annexure I)

Patient with severe swelling were delayed till it subsided,

All patients were planned for Orthogonal or parallel plating as even or odd number

Surgical Technique

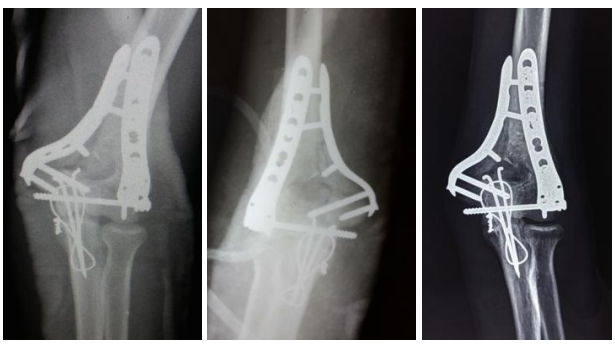
The patient is placed in the lateral decubitus position. Under tourniquet control, midline posterior skin incision is utilized with or without a slight curvature medial or lateral to the olecranon to avoid incising directly over it. Ulnar nerve identified and mobilized to avoid damage to this structure. Proximally the intermuscular septum and Arcade of Struthers are resected. The ulnar nerve is then transposed anteriorly, with the intention to later perform a formal anterior subcutaneous transposition. Once the ulnar nerve is mobilized the distal humerus is approached through a triceps sparing approach, a triceps splitting approach or an olecranon osteotomy. The triceps splitting and triceps sparing approaches allow visualization of the posterior portion of the trochlea, but only the olecranon osteotomy permits access to the anterior portions of the trochlea and capitellum. The olecranon osteotomy is thought to provide optimal exposure to the intra-articular surface of the distal humerus. In addition, by performing the osteotomy, complications involving the triceps can be avoided. These include disrupting the elbow extensor mechanism, fibrosis of the triceps, and intramuscular nerve injuries. The olecranon osteotomy is started with the use drilling kirschner wire but it is not completed. An osteotome is utilized to complete the osteotomy. If the distal humeral fracture does not have significant articular segment

comminution, a triceps splting approach to the distal humerus can be performed. This is done by reflecting equal portions of the medial and lateral triceps aponeurosis and detaching them off of the olecranon. Lastly, a triceps sparing approach can be utilized with extra-articular fractures or simple intraarticular fractures by working medial and lateral to the triceps. Once the fracture fragments are identified and reduced, provisional fixation is performed with Kirschner wires. Care must be taken here to pay attention to neurovascular structures around the elbow as the provisional Kirschner wires can injure these structures if left too long or too sharp. The orthogonal plates are then applied to the bone with the medial one being placed along the medial column of the distal humerus and the second plate being placed along the posterolateral aspect of the lateral column. The fixation should ideally have at least three screws proximal and three screws distal to the fracture site through each plate and thus through each column. When reconstruction plates are utilized, insufficient stability may be present and require placing a third reconstruction plate along the lateral aspect of the lateral column. Once the plates are secured to the distal humerus, the elbow range of motion is assessed to ensure adequate stability is present without a mechanical block. Utilizing a tension band technique, fixation of the olecranon osteotomy done.

Post-Operative Treatment

Postoperatively, a well-padded extension splint is applied and patients are encouraged to keep the arm elevated in order to minimize swelling. After removal of the drain, motion exercises are initiated within the first week after surgery including active assisted and gentle passive motion for elbow flexion/extension and pronation / supination. Patients were followed up at intervals of 4 weeks in the first 3 months and 3 monthly thereafter.

Fig 3: Fracture supracondylar Humerus with intraarticular extension in a 18 year old male patient



2 weeks, one month and three month follow up AP and lateral radiographs of the same patient with Orthogonal plating. Significant union can be seen on the 3 month follow up. This patient scored 100 points by the Mayo Elbow Performance Score System which suggests an 'excellent' outcome.

Post-Operative Assessment

Post operatively the patients were assessed radiographically and clinically. Radiographic and clinical assessment was done by the Mayo Elbow Performance Score.

The clinical outcome was assessed according to the Mayo Elbow Performance Score. The Overall clinical outcome was graded as follows.

- Excellent : >90
- Good(satisfactory) : 75-89
- Fair : 60-74
- Poor : <60

Complications

- These include non-union, ulnar neuropathy, failure of fixation, nonunion, malunion, infection, elbow stiffness and complex regional pain syndrome.

The study was conducted on fifteen distal humerus fractures in patients who presented to the emergency room of Maharaja Yashwantrao Hospital, Indore from September 2015 to August 2017 and were treated by orthogonal plating by the Department of Orthopaedics and Traumatology. The details of the various variables and data is presented as follows.

1. Age Distribution

The study involved 15(n) skeletally mature patients from 18 to 60 years. The youngest in the study was an 18 year old male while the eldest was a male aged 60 years. The mean age of the sample size was 35 years. Most patients were in the age group of 18-23 years.

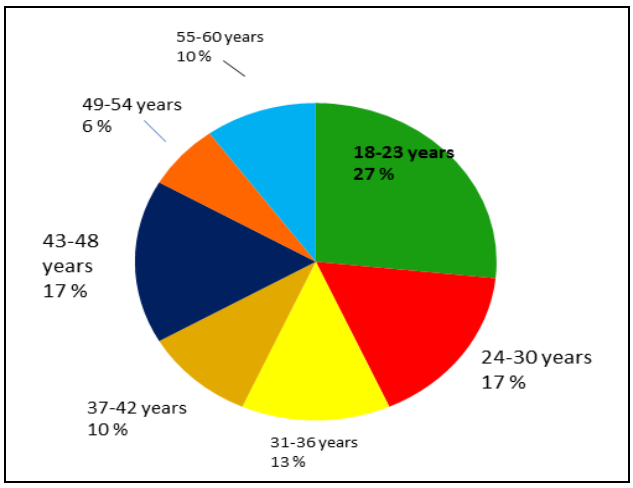


Fig 4: Age distribution (18-60 years) mean age: 37 years

Age Group	No. of Patients
18-23 years	4
24-30 years	2
31-36 years	2
37- 42 years	3
43-48 years	2
49 – 54 years	1
55 – 60 years	1

2. Sex Distribution

There was a male predominance in the subjects of study with 80% being males and compared to females which were 20 % of the sample size.

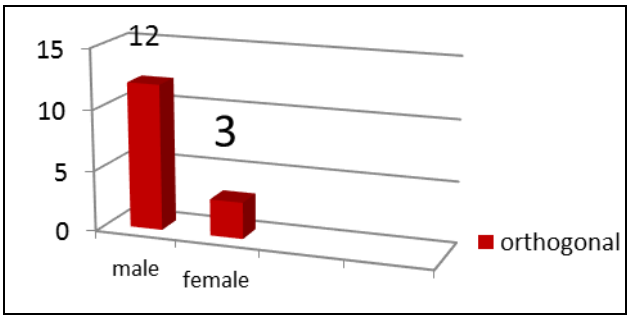


Fig 5: orthogonal

Group	Male	Female	Total
Orthogonal Plating	**12**	**3**	**15**

3. Laterality

Most patients who presented had fractured their left Humerus, with the left to right ratio being 2:1

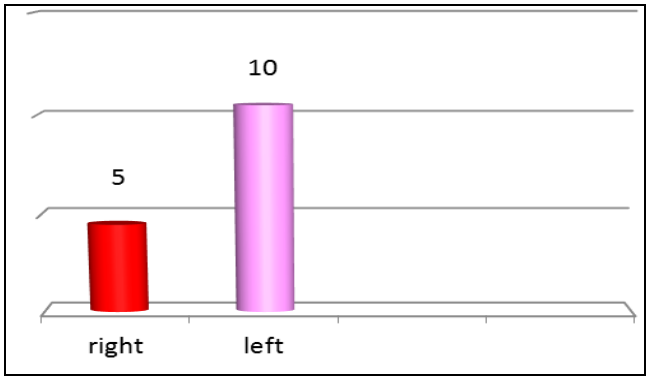


Fig 6

4. Mode of Injury

With rising motor vehicles on the roads and the lack of driving sense with very few people following traffic rules, road traffic accidents were the major mode of injury sustained by our patients with respect to fall and assault.

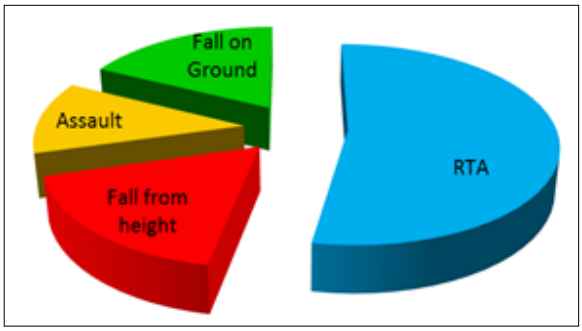


Fig 7: Patients No.

Mode of Injury	No of Patients
Road Traffic Accident	09
Fall from Height	03
Fall on Ground	02
Assault	01

5. Fracture Union

Fracture union was assessed clinically and radiologically. Clinical assessment was done mainly by Absence of pain. pain/tenderness on palpation/examination, No motion at fracture site on examination, Full range of motion at adjacent joint, Ability to perform activities of daily living with no pain. Radiological union was callus formation on 3 cortices in two views. Most upper limb fracture repair completely in 6-8 weeks. Nonunion was failure of the fracture to progress towards healing for at least two months at a minimum of six months post-operative. The mean union time for was 9.53 weeks. There were 2 cases of non union.

Operating Time

Mean operating time for Orthogonal plating was 120.33 minutes.

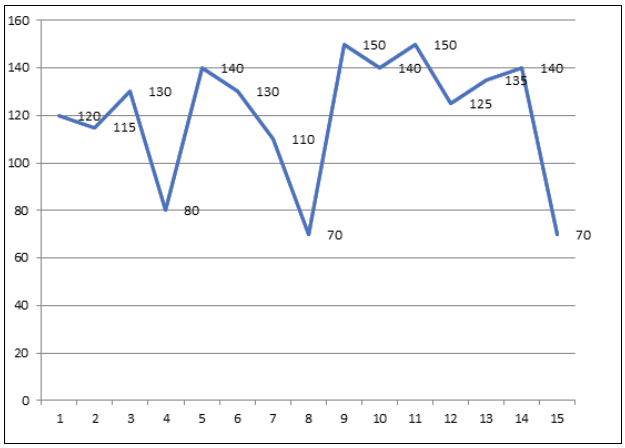


Fig 8: Mean operating time for orthogonal plating – 120.33

6. Range of Motion

In orthogonal plating group one patient had flexion upto 0-20°, one had 0-45^0, three had 0-90^0 and rest were more than 0-110^0. The mean range of motion in orthogonal plating was 99.66$^{0.}$ there was one patient with significant restriction of the range of motion.

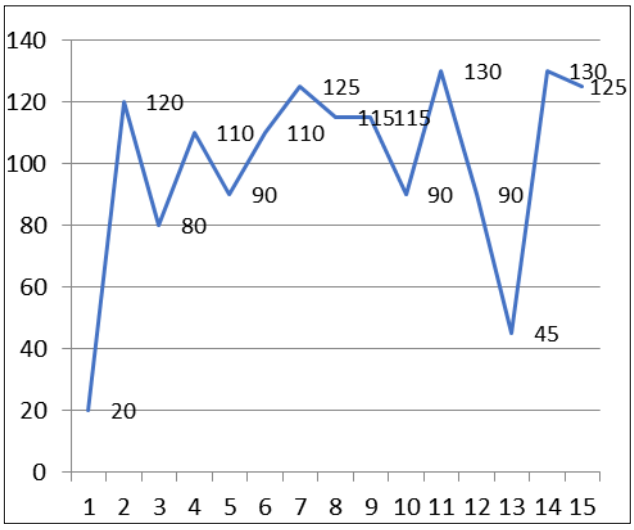
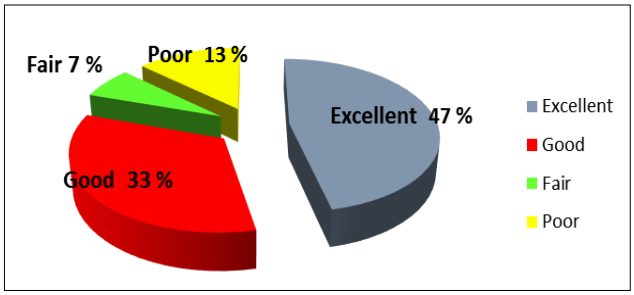


Fig 9: Range of motion for orthogonal plating mean- 99.66

7. Overall Mayo Elbow Performance Score Outcome

According to Mayo Elbow Performance Score in Orthogonal Plating the functional outcome was excellent in 7 cases, good in 5 cases, fair in 1 and poor in 2 cases.



Mayo elbow performance score in orthogonal plating

Results

Over the last 2 years we evaluated 15 patients with intraarticular fracture lower end of Humerus treated with orthogonal plating using olecrenon osteotomy approach. Open reduction and internal fixation with double plating is the gold standard treatment for distal humerus fractures. Controversy between lateral column plate placement methods, direct lateral or posterolateral continues. The AO (Association for the Study of Internal Fixation) group recommended orthogonal plating in distal humerus fractures. However, achieving this structure is not possible in all fractures, particularly in fractures with posterolateral bone defects. The placement of the lateral plate may be difficult because of the muscles and ligaments that adhere to the lateral column. Posterolateral plate placement is much easier.

This techniques has yielded excellent outcomes after ORIF, however, has significant complications associated with it. Orthogonal plating can be done in cases of an anterior shear fracture where the fixation from posterior to anterior will provide additional stability to the intra-articular fractures.. The key to successful treatment of these fractures is obtaining anatomic reduction with stable fixation to allow early range of motion. Performing anatomic reductions while minimizing soft tissue trauma will lead to improved patient outcomes while minimizing the complication rates.

We studied 15 fresh intraarticular fracture lower end of Humerus, with a mean age of 37 years (18-60 years), 57% being in the age group of 18 to 36 years. More than 80 % of our patients were males; left Sided fractured with a 2:1 ratio to right, with maximum injuries caused by road traffic accidents.

Out of fifteen patients, 7 had the follow up of more than 6 months needed to assess the union. Rest 8 patients had follow up between 3 months to 6 months. The mean follow up was 6.23 months.

The mean Operating time in our study for this plating technique was 120.33 minutes.

There was one case of infection in orthogonal plating group out of total 15 patients in this study. In study done by Sanchez-Sotelo [6], 2007 there were two cases of infection in a series of 34 patients. Gofton *et al.* [40], 2003 reported two cases of infection in their study of 23 patients.

In our study the mean union time was 9.53 weeks. Kulkarni *et al.* [4] reported the mean union time of 3.25 months. There were 2 cases of non union as defined by our criteria of failure of the fracture to progress towards healing for at least two months at a minimum of six months post-operative. The t-value is -0.79784. The p-value is 216096. The result is not significant at $p < .05$

Mean operating time for Orthogonal plating was 120.33 minutes.

Functional outcome was excellent in 7 cases, good in 5 cases, fair in 1 and poor in 2 cases. The average Mayo Elbow Performance Score was 83 which was good to excellent. According to Gofton *et al.* [40], the average mayo elbow performance score was 93 in the group of patients (n= 23) treated with orthogonal plating technique.

Conclusion

The mean age of presentation was 37 years and operating time was 120.33 minutes. Two patients had poor follow up resulting in elbow stiffness. Two patients were incidentally infected. We recommend further study with a larger sample size so that such features (drawbacks) as mentioned above do not hamper the significance in the results of the study.

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