Research Article
Orthopaedics

COMPARATIVE STUDY BETWEEN RESULTS OF ORTHOGONAL VS PARALLEL PLATING IN TREATMENT OF DISTAL HUMERUS FRACTURE

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Abstract:

Background: The study was conducted to evaluate the outcome of the parallel plating system and orthogonal plating system in distal humerus intraarticular fracture

Material and Methods: 30 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 35 for both the plating system to know which plating syatem is better using olecrenon osteotomy approach.

Results: The mean union time for orthogonal plating was 9.53 weeks and for parallel plating was 8.93 weeks. The arc of flexion in parallel plating was 119.33 o while that for the orthogonal plating group was 99.66o. Average mayo elbow performance score (MEPS) for the parallel plating was 96.33 and for orthogonal plating was 83. There were 2 case of infection in orthogonal plating group. One case of implant failure noted secondary to infection leading to implant removal in orthogonal plating group.

Discussion and Conclusion: The following results were assessed: operating time, arc of flexion and extension, time to fracture union, functional recovery, and complications. In our study Parallel plating group was superior to the orthogonal plating group, in post operative recovery time, early union, and early mobilization, better range of motion and with less complication

Key words: *Orthogonal plating, parallel plating, distal humerus fracture*

Introduction

Distal Humerus fracture are relatively uncommon and comprise approximately 2-6% of all fractures[2,3,21,61].

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, 60].

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[60].

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[60].

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, 61]. The purpose of this study was to compare the clinical and radiographic outcomes in patients with distal humerus fractures who were treated with orthogonal and parallel plating methods using precontoured distal humerus plates[5, 8].

Orthogonal constructs (medial plate on medial column and posterior plate on lateral column) and parallel constructs (medial plate on medial column and lateral plate on lateral column) have been proposed for fixation of these fractures[1,2,8,60].

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 columner 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)

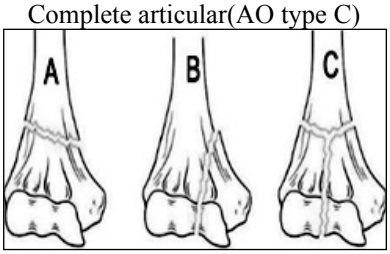


Figure 1: AO Classification of Fracture Distal Humerus

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.

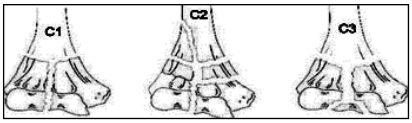


Figure 2: Type C Intraarticular Fracture Distal End Humerus

We prospectively studied 31 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

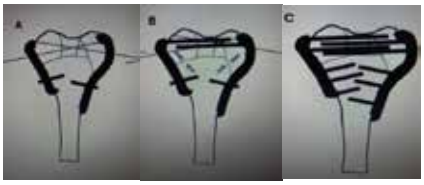
Surgical Technique

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 wirebut 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

Parallel Plating

In parallel plating, initial exposure of the humerus is similar to that with orthogonal plating except more exposure of the lateral column for lateral column plating. This technique is best described by O'Driscoll and Sanchez-Sotelo et al.

The patient is positioned 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 olecrenon osteotomy. Attention is initially directed at the articular surface of the distal humerus to ensure an adequate reduction. Once the articular surface is anatomically reduced, the plates are placed along the medial and lateral columns of the distal humerus. With selection of the appropriate size and length of the medial and lateral plates, they are provisionally held in place by Kirschner wires, which are driven into the lateral and medial epicondyles through holes in the plates. These pins are left only to be removed later and replaced by screws. Once plate adjustment and appropriate anatomic reduction of the fragments at the supracondylar area to the humeral shaft is achieved, one cortical screw is introduced loosely into the proximal hole of each plate. A large bone clamp is then used to compress the intraarticular fragments together with the plates followed by introduction of 2 distal screws, one each for the medial and lateral plates. These screws should be as long as possible, pass through as many fragments as possible, and engage through the opposite column. Once the two distal screws are purchased and the distal fragments are secured to the plates, focus on the supracondylar region follows. Once the proximal screw on one side is backed out and a large bone tenaculum is placed eccentrically to provide interfragmentary compression across the fracture at the supracondylar level, a second proximal screw is then inserted in compression mode and the initial proximal slotted screw is re-tightened. One-third tubular plates are not strong enough for fixation of these fractures and therefore, the precountered distal humerus plates are currently favored. The plates should be long enough to allow for at least three screws to be placed in the proximal part of the humeral shaft proximal to the metaphyseal component of the fracture. Additionally, the plates should end at different levels to avoid creating a stress-riser. Once the plates are affixed to the humerus, the elbow is taken through a range of motion of flexion-extension as well as pronation-supination to ensure no mechanical blocks are present. One deep and one subcutaneous drain are placed and the wounds are closed. The arm is then placed in a bulky noncompressive dressing with an anterior plaster splint to maintain full extension. The dressing is removed approximately three to five days post-operatively and physical therapy including active and passive motion is begun.



Surgical techniques of parallel plating. (A) Plate placement and insertion of initial loose proximal screws. (B) Long distal screw placement and compression across the fractures at the supracondylar level. (C) All screws passing through plates lock together

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.

Fracture supracondylar Humerus with intraarticular extension in a 54 year old male patient

2 weeks, one month and three month follow up AP and lateral radiographs of the same patient. 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

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

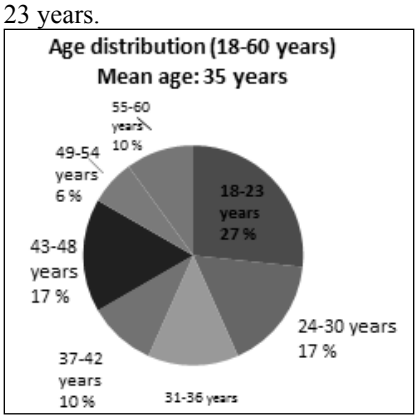
Complications

- Complications arise whether utilizing the orthogonal plating technique or the parallel plating technique. These include non union, ulnar neuropathy, failure of fixation, nonunion, malunion, infection, elbow stiffness and complex regional pain syndrome.

The study was conducted on thirty distal humerus fractures in 30 patients who presented to the emergency room of Maharaja Yashwant rao Hospital, Indore from September 2015 to August 2017 and were treated by orthogonal and parallel plating by the department of Orthopaedics and traumatology. The details of the various variables and data is presented as follows.

1. Age Distribution

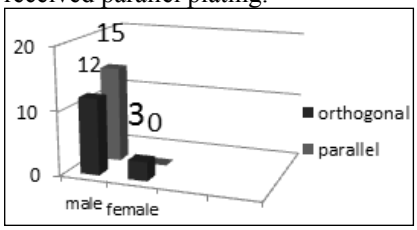
The study involved 30(n) skeletally mature patients from 18 to 60 years. The youngest in the study was an 18 year old male while the eldest was a male aged 60 years. The mean age of the sample size was 35 years. Most patients were in the age group of 18-23 years.



Age Group	No. Of Patients
18-23 years	8
24-30 years	5
31-36 years	4
37- 42 years	3
43-48 years	5
49 – 54 years	2
55 – 60 years	3

2. Sex Distribution

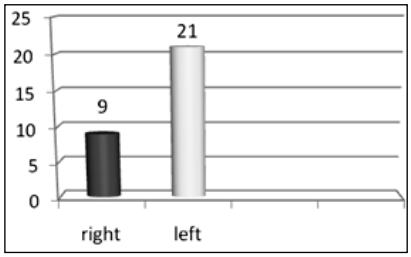
There was a male predominance in the subjects of study with 90% being males and compared to females which were 10% of the sample size. 100% of the female received orthogonal plating and 55% of the male population received parallel plating.



Group	Male	Female	Total
Orthogonal Plating	12	3	15
Parallel Plating	15	0	15
Total	27	3	30

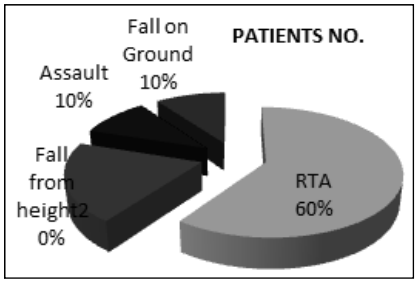
3. Laterality

Most patients who presented had fractured their left Humerus, with the left to right ratio being 2.33:1



4. Mode Of Injury

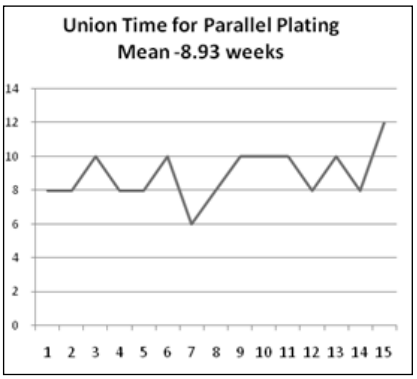
With rising motor vehicles on the roads and the lack of driving sense with very few people following traffic rules, road traffic accidents were the major mode of injury sustained by our patients with respect to fall and assault.

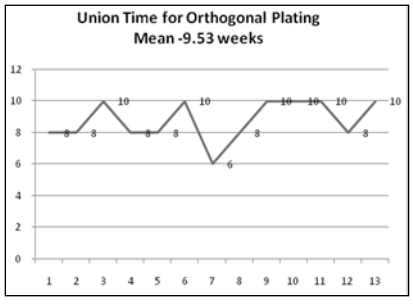


Mode Of Injury	No Of Patients
Road Traffic Accident	18
Fall From Height	06
Fall on Ground	03
Assault	03

5. Fracture Union

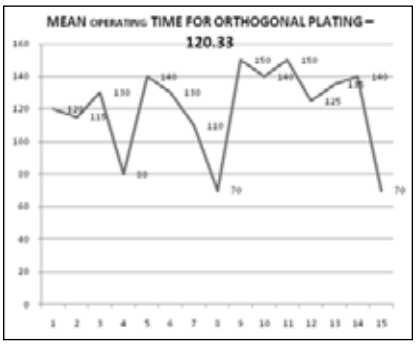
Fracture union was assessed clinically and radiologically. Clinical assessment was done mainly by Absence of pain. pain/tenderness on palpation/examination, No motion at fracture site on examination, Full range of motion at adjacent joint, Ability to perform activities of daily living with no pain. Radiological 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 Orthogonal plating was 9.53 weeks, which was higher than for that of the parallel plating which was 8.93 weeks. There were 2 cases of non union in orthogonal plating.

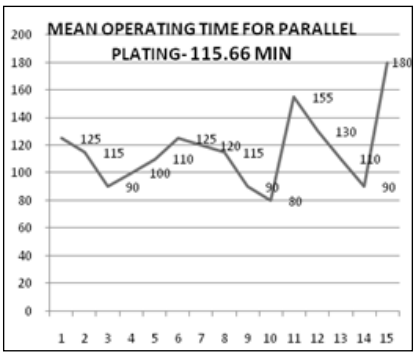




Operating Time

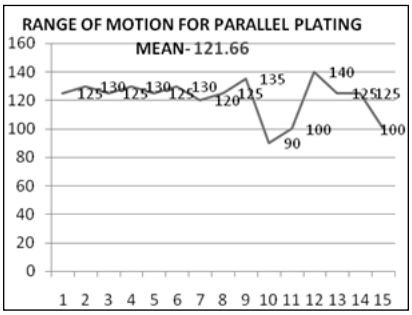
Mean operating time for parallel plating was 115.66 minutes while the same for Orthogonal plating was 120.33 minutes. There was no significant difference in the mean operating time for both the plating systems.



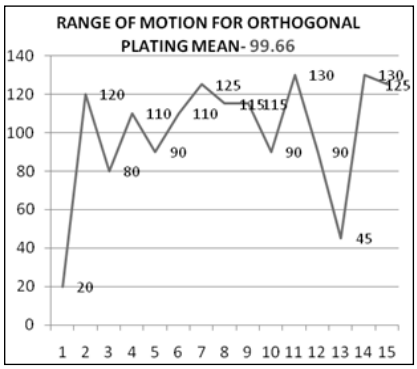


6. Range Of Motion

In parallel plating group only one patient had flexion upto 0-90° , two had 0-100 and rest were more than 0-1200. The mean range of motion in parallel plating was 121.660. There was no patient with significant restriction of elbow extension or flexion.



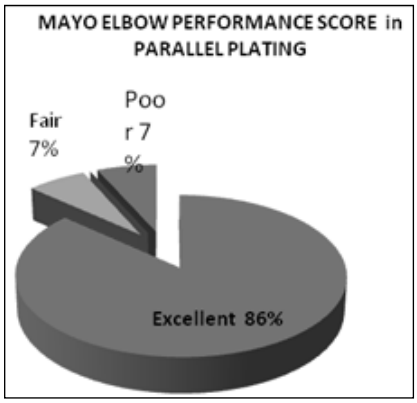
In orthogonal plating group one patient had flexion upto 0-20°, one had 0-45°, three had 0-90° and rest were more than 0-110°. The mean range of motion in orthogonal plating was 99.66°. there was one patient with significant restriction of the range of motion.

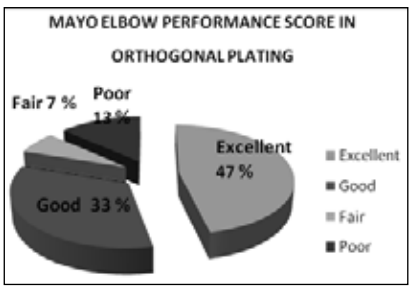


7. Overall Mayo Elbow Performance Score Outcome

According to Mayo Elbow Performance Score, for Parallel Plating group the functional outcome was excellent in 13 cases, good in 1 case, fair in 0 and poor in 1 cases.

For Orthogonal Plating group the functional outcome was excellent in 7 cases, good in 5 cases, fair in 1 and poor in 2 cases.





Results: Over the last 2 years we evaluated 30 patients with intraarticular

fracture lower end of Humerus treated with parallel plating and 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, whereas **O'Driscoll et al[6, 8, 34].** recommended osteosynthesis with parallel plates. The latter noted that orthogonal plating could not resist varus loads and sustain compression between the shaft and the metaphysis. O'Driscoll maintained that compression at the supracondylar region could be achieved with the parallel plating system. In this system, the medial and lateral columns are linked with interdigitation of the distal screws, similar to the keystone of an arch. 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 study has described two techniques that can be utilized to tackle these difficult fractures. Both of these techniques have yielded excellent outcomes after ORIF, however, both techniques have significant complications associated with them. Use of parallel plating or orthogonal plating will be depending on surgeon preference and the fracture pattern present. Orthogonal plating may be preferred in cases of an anterior shear fracture where the fixation from posterior to anterior will provide additional stability to the intra-articular fractures.

In Our study we found that Parallel plating may be the preferred technique utilized for very distal fracture patterns since more stability can be obtained by providing additional screws in the distal fragment. 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 30 fresh intraarticular fracture lower end of Humerus, with a mean age of 35 years (18-60 years), 57% being in the age group of 18 to 36 years. More than 75 % of our patients were males; left Sided fractured with a 2.3:1 ratio to right, with maximum injuries caused by road traffic accidents.

Out of thirty patients, 14 had the follow up of more than 6 months needed to assess the union. Rest 16 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 parallel plating technique was 115.66 minutes and for the orthogonal plating technique was 120.33 minutes, the difference of the two is not statistically significant.

There was two case of infection in orthogonal plating group out of total 30 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 for Orthogonal plating was 9.53 weeks, which was higher than for that of the parallel plating (8.93 weeks). **Kulkarni et al [4] reported** the mean union time of 3.25 months. There were 2 cases of non union in orthogonal plating 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 $p< .05$

In parallel plating group only one patient had flexion up to 0-90°, three had 0-100 and rest were more than $0\text{-}120^0$. The mean range of motion in parallel plating was $119.33^{0.}$ There was no patient with significant restriction of elbow extension or flexion. In orthogonal plating group one patient had flexion up to 0-20°, one had $0\text{-}45^0$, four had $0\text{-}90^0$ and rest were more than $0\text{-}110^0$. The mean range of motion in orthogonal plating was $99.66^{0.}$ There was one patient with significant restriction of the range of motion. The results of range of motion of our study was differed from **Kulkarni et al [4],** they reported the mean arc of extension- flexion of 111 degree in orthogonal plating and 99 degree in parallel plating technique, And was similar to **Shin et al.** who reported that the mean range of motion in parallel plating was better(112 degree) then the orthogonal plating technique (106^0). **Sanjeev Kumar et al [2].** found the mean range of motion of 116 degree in parallel plating technique.

The t value is 2.15335. The p value is .020025. The results is significant at $p<.05$

Mean operating time for parallel plating was 115.66 minutes while the same for Orthogonal plating was 120.33 minutes. There was no significant difference in the mean operating time for both the plating systems. The t-value is -0.4808. The p-value is .317338. The result is not

significant at p<.05

Functional outcome was assessed using the Mayo Elbow Performance Score, it was excellent in 12 cases, good in 3 case, with no fair and poor cases, for parallel plating group. For Orthogonal Plating group the 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 for parallel plating group was 96.33 which was excellent and for orthogonal group was 83 which was good to excellent. Our results of the parallel plating technique was very similar to **Sanjeev Kumar et al.** [2]study, who also found MEPS of 96.32 % in a series of 19 patients. 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.

The difference in the MEPS of the two plating technique was **statistically significant** in our study, (p-value is .017004). The parallel plating technique in our study was better as compared to the orthogonal plating technique, this could be explained by the following facts:

1. Two patients in the orthogonal plating group infected incidentally.
2. There were two patients with poor follow up in the orthogonal plating group resulting in elbow stiffness.
3. Most of the patients in the orthogonal plating group (n=11) suffered non dominating hand injury compared to the parallel plating group (n=8).
4. The mean operating time in orthogonal plating technique was 120.33 minutes which was more than that of the parallel plating technique (115.66 minutes).
5. The mean age group who were operated with orthogonal plating technique was 37 years compared to other group (33 years).

We further concluded that these 5 reasons are also the drawback of my study. So 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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