

Comparission Of Functional Results Between Parallel And Orthogonal Plating In The Management Of Distal Humerus Fracture (Ao Type –C)

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Abstract: Study Design: Prospective study.

Purpose: The objective of our study was to compare functional results between parallel and orthogonal plating in the management of distal humerus fracture (AO Type –C)

Methods: 40 patients with distal humerus fracture were included in the study out of which 19 patients were treated with parallel plating (group I) and 21 patients were treated with orthogonal plating (group II) between September 2012 to May 2014 at S.S Hospital, IMS, BHU. Clinical and radiological evaluations were performed regularly at 2 weeks, 1 month, 3 months, 6 months, 1 year, and then at 6-month intervals. Standard anteroposterior and lateral radiographs were obtained. The Mayo Elbow Performance Score (MEPS) was used to determine functional results of the elbow 1 year after the operation.

Results: In group I, The mean elbow flexion was 117.37 ± 5.81 (range, 110° – 130°) and the mean elbow extension was 13.37 ± 2.40 (range, 0° – 18°). The mean MEPS was 89.89 ± 4.34 points (range, 72–98 points). Twelve cases were rated excellent, five cases were rated good, and two cases were rated fair. The rate of excellent and good results was 89.47% (17/19).

In group II, The mean elbow flexion was 112.67 ± 9.43 (range, 90° – 135°) and mean elbow extension was 12.10 ± 2.04 (range, 0° – 30°). and the mean MEPS was 88.00 ± 7.04 points (range, 70–98 points). Thirteen cases had results rated as excellent, five cases were rated as good, and three cases were rated as fair. The rate of excellent and good results was 85.7% (18/21).

Conclusions: Parallel plating method scored better than orthogonal plating method with respect to bone union time, mean flexion arc, mean extension arc, MEPS score although the differences are not statistically significant. In parallel plating method the operative time and blood loss having greater values with respect to orthogonal plating method (values are statistically significant).

Keywords: Distal humerus fractures, AO Type- C, Parallel, Orthogonal, MEPS

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I. Introduction:

Fracture distal humours accounts for 2 -6 % of all the fractures and its incidence in the adults of 5.7 per 100,00 per year¹.with bimodal age group of distribution; early peak in the young male and second peak in the osteoporotic bones mostly elderly females with trivial trauma as compared to the adult group in whom high energy trauma is needed².Articular surface having typical shape, limited bone stock for instrumentation and adjacent neurovascular bundle make it really challenging situation for the surgeons. Rigid fixation of the displaced bony fragments, maintaining congruent articular reduction and early mobilisation is necessary to achieve better outcomes as elbow is intolerant to immobilisation. Complex three dimensional anatomy, limited bone stock and osteoporotic bone quality in elderly make it complicated for fixation. Open reduction and internal fixation with plates with good articular reconstruction have demonstrated satisfactory clinical outcomes. Firm stabilisation can achieved through various methods of fixation of plates^{3, 4, 5}. The double plate construct being more stable than the other methods as suggested by other mechanical models^{6, 7}.

The distal humerus is composed of medial and lateral columns with a central area of weaker bone. This central area which includes the coronoid and olecranon fossa facilitates elbow flexion and extension by allowing space for coronoid and olecranon tip articulation and providing bony stability⁸. Restoration of

diaphyseal -metaphyseal contact and reconstruction of olecranon fossa is essential to provide more stability and allowing best healing. Various plate designs have been developed for the fixation of these fractures, some are like Y-plates, recon plates, precontoured anatomical plates.

However controversy still exists concerning the plate positions in terms of providing optimal stability for distal humerus fractures. The most widely used plate fixation method is placing plates perpendicular to each other one over medial supracondylar ridge and other one over the flat posterior surface of lateral column called as orthogonal plating. Stoffel et al demonstrated on mechanical studies two plates placed parallel to each other, one over each supracondylar ridges, providing better stability in compression and external rotation than to perpendicular plating system in cadaveric models⁹.

In the present study, we have compared clinical outcomes and complications for two different plating methods in patients with comminuted intraarticular distal humerus fractures AO type C. The objective of our study was to compare clinical outcomes (anatomical reduction, rigid fixation , union , range of motion) and complications for parallel and orthogonal dual plating methods.

II. Material And Methods:

Between September 2012 to May 2014, total 40 patients were taken with distal humerus fracture who were treated with parallel or orthogonal dual plating at S.S. Hospital, I.M.S, BHU.

Inclusion Criteria

- Single distal humeral fracture
- According to AO classification, types C1, C2, C3 distal humeral fractures
- Supposed to be functionally normal before the injury

Exclusion Criteria

- Open fracture.
- Pt with previous elbow surgery
- Pathological fracture
- Complicated by nervous and vascular injury
- Presence of ulnar and radial fractures.

Study Subjects

In our study total 40 patients were included Pre-operative anteroposterior and lateral radiographs were the basic investigation to evaluate the fracture pattern. Computerised tomography (CT) with three dimensional reconstruction was used for some complex fracture types but not routinely advised in all cases.

Among the forty patients 19 patients were treated with parallel plating and included in group I. There were 12 males and 7 females with an average age of 41.16 years (range 32 – 60). Mechanism of injury was road traffic accidents in 10 patients; sports injury in 5 patients; fall from height in 4 patients. Among these 21 patients 11 patients had their dominant elbow involved and 8 have non-dominant elbow. According to AO classification there were 5 in Type C1, 6 in Type C2 and 8 in Type C3 fractures.

Among the 40 patients 21 patients were treated with perpendicular plating and included in group II. There were 12 males and 9 females with an average age of 39.52 years (range 28 – 61). Mechanism of injury was road traffic accidents in 11 patients; sports injury in 6 patients; fall from height in 4 patients. Among these 21 patients 12 patients had their dominant elbow involved and 9 had non-dominant elbow. According to AO classification there were 6 in Type C1, 7 in Type C2 and 8 in Type C3 fractures.

There was no statistically significant difference between the two groups in terms of age (p-value - 0.549), sex distribution (p-value- 0.698) and fracture types (p-value – 0.966). (p values are >0.05).

Surgical Procedures

Under adequate effect of general anaesthesia or regional anaesthesia (brachial plexus block) patients were held in lateral decubitus position with affected arm supported with side rest with tourniquet , forearm hanging free allowing movement at elbow. A longitudinal incision was made on the posterior aspect of the elbow with extend of incision proximally starting 5-7 cm above the tip of olecranon process curved laterally at the level of tip then extending the incision distally along the subcutaneous margin of ulna.

The triceps-retracing approach was used in 3 patients with Type C1 and 1 patient with Type C2 fractures in group II. The triceps were stripped from the lateral and medial inter-muscular septum, and the distal end of the humerus was exposed¹⁰. A medial incision was made between the groove of the ulnar nerve and olecranon. A lateral incision was made between the olecranon and the lateral humeral condyle. The olecranon, olecranon fossa, and the posterior part of the capitulum humeri and trochlea could then be exposed

A posterior approach with an olecranon osteotomy was used for all patients with Type C3 and 6 patients with Type C2 fracture and 3 patients with type C1 fracture in Group II and all patients in Group I. Both in parallel and perpendicular fixation methods technique of olecranon osteotomy was same^{11,12}.Thorough

dissection of ulnar nerve over the medial condyle made and was made free The interval between the triceps and anconeus muscles was incised to expose the joint. A V-shaped osteotomy was made approximately 2 cm from the tip of olecranon process after making multiple drill holes and connecting through sharp osteotomes from each side. The apex of the V was directed distally. Holding the bone block with trowel clip, it was lifted up proximally with dissection of triceps from the back of humerus with periosteal elevator. The exposed triceps muscle was covered up with wet gauzes. There was complete visualisation of articular surface and the posterior aspect of distal humerus.

The displaced articular fragments were reduced and fixed provisionally with multiple thin k-wires and then reduced to the shaft of the humerus^{13, 14}. If the articular fracture was complex, and either the medial or lateral condyle had a good key to reduction with the shaft, the condyle to the shaft was reduced, and then the articular surface was reconstructed, followed by reduction and fixation of the opposite condyle. The procedure was helpful to determine the intercondylar length and width. When satisfactory reduction was achieved, definitive fixation was completed using perpendicular or parallel dual-plating methods either with precontoured plates or recon plates^{15, 16, 17}.

In the parallel configuration (group I), two plates were placed along the medial and lateral supracondylar ridges separately and at approximately 180° to each other. In the perpendicular configuration (group II), one plate was applied along the medial epicondyle and the other was applied in the posterior aspect of the lateral column. Each screw in the distal fragments needed to pass through the plate so that it contributed to stability at the supracondylar level and engaged as many articular fragments as possible. Care was taken not to narrow the trochlea with a lag screw when there was bone loss.

In 32 patients fixation of the olecranon osteotomy was done with two 2.0-mm K-wires and tension band wiring was done and in 4 patients withan 6.5-mm cancellous bone screw was used in place of k-wires in which prior drilling was done . Every screw was examined to ensure that it did not cross the articular surface. Ant transposition of ulnar nerve was not routinely performed. The wound was closed over suction drain in layers after maintaining haemostasis.

Mean gap between date of injury and date of surgery in group I 4.0 ± 0.66 days (3-5 days) and in group II the gap is 4.19 ± 0.814 (3-6 days). There is no statistical significance between the gap between the date of injury and surgery (p value – 0.426)

Post-Operative Care

Monitoring of general condition and vital signs was done postoperatively. The suction drainage tube was pulled out on 2nd post operative day. After first dressing change, passive assisted flexion-extension exercises were done in the pain free zone. Elbow flexion was evoked by gravity force and then active extension was completed under the protection of the uninjured side. In the interval between exercises, an above elbow posterior slab was placed with the elbow in 90° of flexion for three weeks. Active movements were allowed after three weeks.



Parallel plating (Group – I)

A, B: Pre- operative x-rays (AP /LAT views)

C, D: Early post operative x-rays (AP /LAT views)

E, F: At six months post operative x-rays (AP /LAT views)

G, H: At six months postoperative clinical photos (extension & flexion)



Orthogonal plating (group – II)

- A, B: Pre- operative x-rays (AP /LAT views)
- C, D: Early post operative x-rays (AP /LAT views)
- E, F: At six months post operative x-rays (AP /LAT views)
- G, H: At six months postoperative clinical photos (flexion & extension)

Evaluation Of Outcome

The surgical time, blood loss, bone union time, and the recovery of function were indices of outcome. Clinical and radiological evaluations were performed regularly at 2 weeks, 1 month, 3 months, 6 months, 1 year, and then at 6-month intervals. Standard anteroposterior and lateral radiographs were obtained to assess the fixation conditions and to determine the incidence of nonunion, metal failure, and the presence heterotropic ossification. The Mayo Elbow Performance Score (MEPS) was used to determine functional results of the elbow 1 year after the operation.

III. Observation:

The mean surgical time in group I was (159.68±9.00) minutes (range, 142–168 minutes) and in group II was (154.29±7.9) minutes (range, 144–170 minutes) (p-value =0.051) .The mean blood loss in group I was (334.21±24.79)ml (range, 300 - 370 ml) and in group II was (329.33±33.65) ml (range, 280–380 ml) (p-value =0.608).Although average surgical time taken and blood loss in is more in parallel plating method than in orthogonal plating method , the differences between the two groups is not statistically significant. These values may indicate the longer operative time and more exposure and soft tissue dissection in parallel plating than in orthogonal plating method.

Table 1. Patient demography

	Parallel (n=19)	Orthogonal (n=21)	p-value
Age	41.16±7.28	39.52±9.52	0.549
Sex (Male/Female)	12/7	12/9	0.698

Table 2.Type of fracture

	Parallel (n=19)		Orthogonal (n=21)	
	No.	%	No.	%
C1	5	26.31	6	28.57
C2	6	31.59	7	33.34
C3	8	42.10	8	38.09
Total	19	100.00	21	100.00

$\chi^2=0.068$; $p=0.966$

Table 3. Injury mechanism

	Parallel (n=19)		Orthogonal (n=21)	
	No.	%	No.	%
Road Traffic Accidente	10	52.63	11	52.38
Sports injury	5	26.32	6	28.57
Fall from height	4	21.05	4	19.05
Total	19	100.00	21	100.00

$\chi^2=0.038$; $p=0.980$

Table 4. Gap between date of injury and date of surgery

	Gap (mean±SD)	t-value	p-value
Parallel(n=19)	4.00±0.66	.805	0.426
Orthogonal (n=21)	4.19±0.81		

Table 5. Operative time

	Operative Time (min) (mean±SD)	t-value	p-value
Parallel (n=19)	159.68±9.0	2.017	0.051
Orthogonal (n=21)	154.29±7.9		

Table 6. Blood Loss

	Blood loss (ml) (mean±SD)	t-value	p-value
Parallel (n=19)	334.21±24.79	0.517	0.608
Orthogonal (n=21)	329.33±33.65		

All patients were followed up. Patients in group II were followed up from 12 to 18 months, with an average of (14.5±1.5) months. Patients in group I were followed up from 12 to 28 months, with an average of (14.0±2.0) months. Radiographically, all fractures were fixed without a step-off at the articular margin of greater than 2 mm or an angular deformity of greater than 10° at final follow-up evaluations. Bony union was achieved at a mean of (6.24±0.43) months (range, 5.4–6.8 months) in group I and at (6.30±0.32) months (range, 5.8–6.8 months) in group II with three patients in group II going in non-union. There was no significant difference in the bone union time between the two groups (0.66) but the percentage of non-union is more in orthogonal plating.

Table 7. Bone union time

	Bone union time (month)(mean±SD)	t-value	p-value
Parallel (n=19)	6.24±0.43	0.443	0.660
Orthogonal (n=21)	6.30±0.32		

There were 1patient in group I (5.26%) and 2 patients in group II (9.5%) had superficial wound infections. One patient in group I(5.26%) and three patients in group II(14.28%) suffered from heterotropic ossification. Transient ulnar nerve neuropraxia developed in 2 patients (10.52%) in group I and 4 patients (19.0%) in group II. Nerve symptoms recovered completely within 3 months. Three patients in group II had non union while no patient in group I had non union. Two patients in group I and Four patients in group II had arthrofibrosis. Four patients in group I and one patient in group II had implant impingement.

Table 8. Postop complications

Complications	Parallel (n=19)		Orthogonal(n=21)		P-value
	No.	%	No.	%	
Transient ulnar nerve neuropraxia	2	10.52	4	19.04	0.451
Non union	0	00.00	3	14.28	0.086
Implant impingement	4	21.05	1	04.76	0.309
Heterotropic ossification	1	05.26	3	14.28	0.342
Superficial wound infection	1	05.26	2	09.52	0.609
Arthrofibrosis	2	10.52	4	19.04	0.451

In group I, The mean elbow flexion was 117.37±5.81 (range, 110°–130°) and the mean elbow extension was 13.37±2.40 (range, 0°–18°).. The mean MEPS was 89.89±4.34 points (range, 72-98 points). Twelve cases were rated excellent, five cases were rated good, and two cases were rated fair. The rate of excellent and good results was 89.47% (17/19).

In group II, The mean elbow flexion was 112.67±9.43 (range, 90°–135°) and mean elbow extension was 12.10±2.04 (range, 0°–30°).and the mean MEPS was 88.00±7.04 points (range, 70–98 points). Thirteen

cases had results rated as excellent, five cases were rated as good, and three cases were rated as fair. The rate of excellent and good results was 85.7% (18/21). The differences in MEPS, the flexion-extension arc, and the total range of flexion and extension between the two groups were not significant.

IV. Discussion:

Complex three dimensional anatomy and comminuted displaced fractures makes it really difficult for the management of distal humerus fractures. In our present study, we have compared the functional results between parallel versus orthogonal plating in the management of these fractures. Although several mechanical studies are in view of advantage of putting plates parallel to each other is more mechanically stable, but in clinical scenario no significant difference observed^{18,19}. Between the two types of plating systems there was no statistically significant difference in terms of the arc of flexion, function, union time and other clinical status. Although the incidence of non union is not clinically significant, but there is more non unions in the perpendicular plating. In orthogonal system through posterolateral plate only small screws are used holding only the lateral column distal fragments without any direct link to the medial column fragments, and this is taken care of in parallel plating system which creates link between both the columns with the crisscrossed configuration of the screws. So distal part of lateral column act like weak zone in orthogonal method if it is not fixed properly through the intercondylar screw.

In parallel plating system optimal rigidity is provided by interdigitation of screws without additional screws for articular fixation for comminuted fractures. Where as in perpendicular system inadequate purchase of small screws into the distal part of lateral column may produce a weaker zone in the construct thus failure of the fixation or creating nonunion.

Postoperative complications are not uncommon for type C distal humerus fractures. In the present study, the most common complication was transient ulnar nerve palsy, followed by arthrofibrosis and heterotopic ossification. Ulnar nerve was not routinely anteriorly transposed. However, despite the high rate of transient ulnar nerve palsies observed in the present study, all recovered during a period of 3 to 5 months no patient suffered permanent nerve dysfunction. The reported prevalence of heterotopic ossification after the surgical treatment of distal humerus fractures ranges from 5.26% to 14.28%, although no functional deficit was involved in most cases. In my study there 4 out of 40 have heterotopic ossification encountered regardless of plate position²⁰. In our study there was no routine use of indomethacin and prophylactic radiotherapy.

Implant impingement is another complication which is also common; in my study population percentage of patients with metal impingement is more in parallel plating (group I). These patients were usually women; it may be due to thin body built and orientation of plate over two extreme surfaces.

Soft tissue dissection, blood loss is comparatively more in parallel plating group although the difference is statistically insignificant. Operative time is also greater in case of the parallel plating group as we observed that it is easier to apply the plate over the broad posterior surface of lateral column than to apply on the lateral supracondylar ridge.

Overall, parallel plating and perpendicular AO plating techniques both appear to provide acceptable outcomes in the treatment of these complex fractures, although plate configuration is controversial. In the present study, no significant differences in MEPS, the total range of flexion and extension between the two groups. Shin et al²³ also found no significant differences between clinical outcomes of the two plating methods¹⁷. But mean MEPS, mean flexion and extension arc is greater in parallel than orthogonal plating.

Parallel and Perpendicular plating methods require different surgical techniques each having its own advantages and disadvantages. Perpendicular plating is based on the anatomical characteristic of the distal humerus. The posterior aspect of the lateral column is an ideal plating position because it is spacious and flat without an articular surface. Perpendicular plating seems more surgeons friendly as per easier exposure and easier plate position over the posterior aspect of lateral column.

Interdigitation of the screws in the distal articular fragment is the principle upon which the parallel plate configuration based on. In the parallel-plate technique, each screw should be as long as possible, and an adequate number of screws should be placed in the distal fragments. This architectural stability on which the comminuted and/or osteoporotic bone of the distal fragments is assembled gives it its intrinsic stability in most of the times intercondylar stay screw was not put in parallel plating.

V. Conclusion:

In our study, parallel plating method scored better than orthogonal plating method with respect to bone union time, mean flexion arc, mean extension arc, MEPS score although the differences are not statistically significant. In parallel plating method the operative time and blood loss having greater values with respect to orthogonal plating method (values are statistically significant).

In summary, the goal is to get functional elbow which can be achieved by stable fixation, anatomical reduction articular surface and early rehabilitation programs. These goals can be achieved through application of

appropriate surgical techniques and fixation either by parallel or perpendicular methods depending upon the fracture configuration and surgeons experience and implementation of proper postoperative rehabilitation protocol.

Lastly the appropriate conclusion about benefits and drawbacks of the two different plating methods can be derived by longer duration of prospective study and longer follow up of the patients with respect to their functional status.

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