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## Observational study of outcome of open reduction and internal fixation of supracondylar with inter condylar humeral fracture in patient above 18years at tertiary care center of south Gujarat

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### Abstract

**Aim:** To analyse functional outcome of surgical management of supracondylar with inter condylar humeral fracture.

**Materials and Method:** We hereby report the outcome of a series of Intracondylar fractures of the humerus treated by open reduction and internal fixation and discuss the controversies in light of published literature. Total 50 patients included in this retrospective study which include 36 male and 14 female. 39 patients were treated using Orthogonic plating and 11 patients were treated using parallel plating via posterior approach within 15 days of injury. Functional outcome was assessed via DASH (Disability of the Arm, Shoulder and Hand), MEPS(Mayo Elbow Performance Score) at 6 months.

**Results:** At the end of 6 months flexion arc was  $115 \pm 6.79$  in the orthogonal group while that in the parallel plating group was  $112 \pm 7.72$ . MEPS and DASH scores were  $87.23 \pm 7.75$  and  $24.23 \pm 6.02$  for the orthogonal group and  $89 \pm 8.07$  and  $23.18 \pm 11.33$  for the parallel plating group, respectively. In our practice, no significant differences were found between the orthogonal and parallel plating methods in terms of clinical outcomes or complication rates.

**Conclusion:** The high rate of union can be achieved in complex intra-articular fractures of distal humerus if the proper principles of stable fracture fixation are followed, and dual fixation of both columns and restoration of the continuity of articular surface. The stability achieved by this technique permits institution of early intensive physiotherapy to restore elbow function.

**Keywords:** Observational, internal fixation, condylar humeral fracture

### Introduction

Intra-articular fractures of the distal humerus constitute 0.5%–7% of all fractures and 30% of elbow fractures. Distal humeral fracture occurs in the younger age-groups secondary to high-energy trauma and in elderly women as a result of relatively low-energy trauma.<sup>16</sup>

The chances of functional impairment and deformity are very high following conservative treatment of such distal intra-articular fractures of the humerus, and stable internal fixation may be difficult to achieve due to the complexity of the fracture and associated osteoporosis.<sup>9</sup> Good anatomical alignment, stabilization, and early mobilization can provide satisfactory results.

However, in the management of intra-articular distal humerus fractures in adults controversy still exists regarding the surgical approach, type of olecranon osteotomy, method of stabilization of osteotomy, type of fracture stabilization, use of orthogonal or parallel plate fixation, need for transposition of ulnar nerve, place for primary TEA, and type of rehabilitation schedule after surgical fracture treatment.

In this article we report the outcome of a series of intracondylar fractures of the humerus treated by open reduction and internal fixation (ORIF) and discuss the controversies in light of available evidence in literature.

### Classification

AO Classification

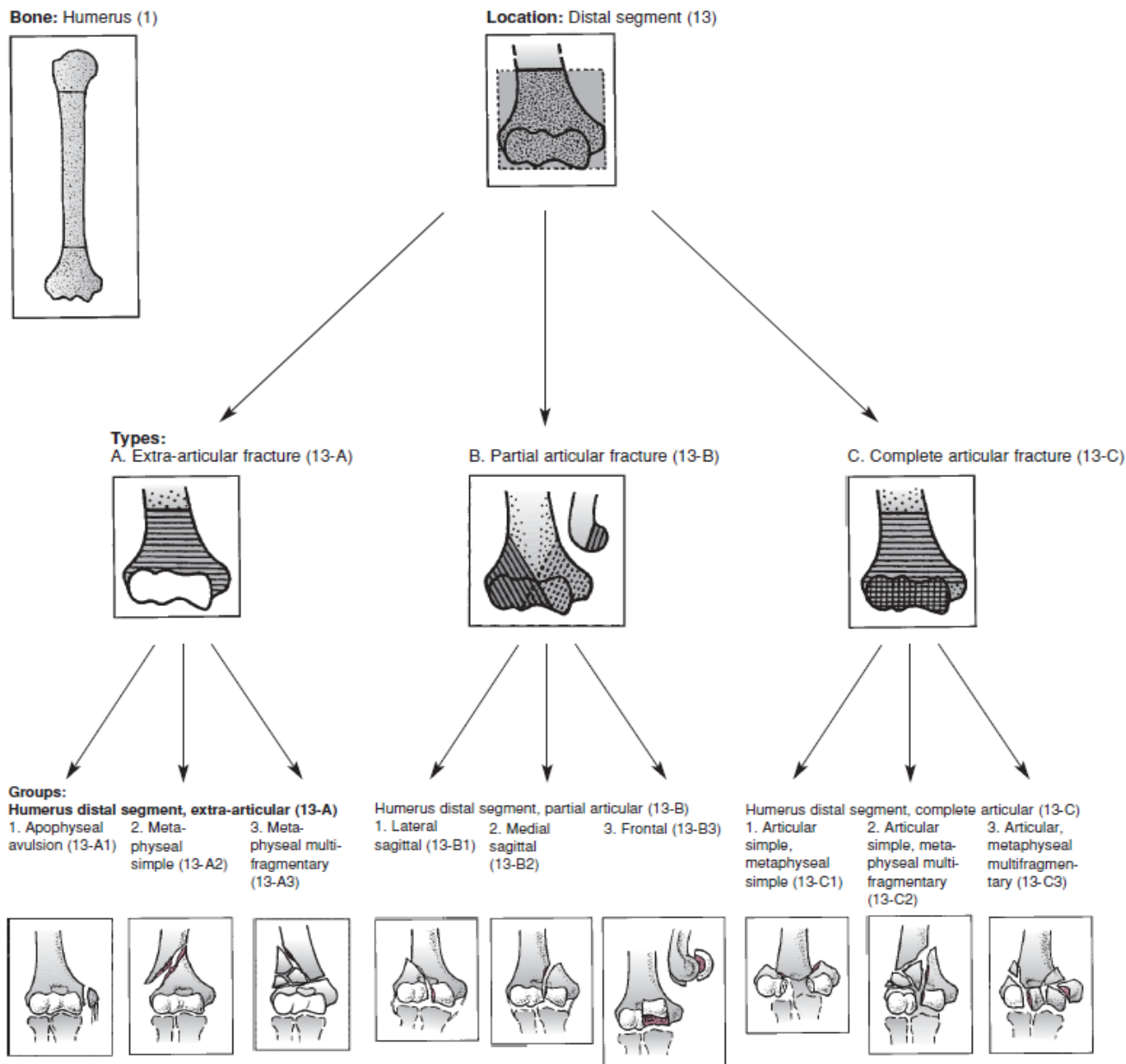


Fig 1: AO classification

**Aims & Objectives**

To Analyse functional outcome of surgical management of supracondylar with inter condylar humeral fracture.

1. Assessment of functional out come of shoulder and elbow after surgical management of supracondylar with inter condylar humeral fracture.
2. Assessment of outcome of different operative techniques of supracondylar with inter condylar humeral fracture.
3. Correlation of pre operative and intra-operative findings with post operative outcomes supracondylar with inter condylar humeral fracture.

**Materials and Methods**

- This is a retrospective analysis of intra-articular fractures (50 patients) of distal humerus (C1, C2 and C3) treated by us over a period of 1 ½ year between February 2017 to August 2018. 50 patients were operated. All patients had recent injuries and reported within 1 to 15 days of injury.
- All patient with supracondylar with inter condylar extension of humeral fracture treated surgically at NCH, SURAT will be evaluated during the hospital stay and the clinical, radiological and functional outcomes will be

assessed

- All detail of patients obtain from hospital record from February 2017 to August 2018.
- Hematological investigation, Plain radiography, conducted before surgery for all patients
- After the explanation of the advantages and disadvantages of therapeutic methods, the patients will be placed in study on their own volition.
- The choice of surgical techniques determine by the Surgeon. All patients were operated by through either triceps sparing or triceps splitting approach or olacranon osteotomy approach. Both columns were stably fixed routinely by either orthogonal plate (90-90) or parallel plating. But most fracture stabilize using orthogonal plate.
- Following surgical stabilization using different operative techniques.. The posterior plaster slab will be retained for 5–7 days. Gentle elbow mobilization start thereafter and the patient will be discharged with advice to attend daily active and assisted physiotherapy. Patient will be reviewed every 3 weeks for the first 2 months, every month for next 4 months.

- At each follow up evolution, clinical examination, necessary hematological investigation and plain radiographic studies, DASH and Constant Shoulder Scores will be obtained to determine the fusion status, range of motion, and instrumentation failure.
- Standard antero-posterior & lateral radiography will be obtained at each visit to assess the healing process and any complications. Healed fractures define as bony callus formation across the fracture fragments.
- DASH is a self-reported questionnaire designed to measure physical function and symptoms in patients with any of several musculoskeletal disorders of the upper limb.
- Elbow function is measured by the Constant Elbow Score, which includes the pain score, functional assessment, range of motion and strength measures. Patient satisfaction according to strength, Elbow function and pain was also assessed.

**Humerus, distal complete, articular simple, metaphyseal simple (13-C1)**

1. With slight displacement (13-C1.1)

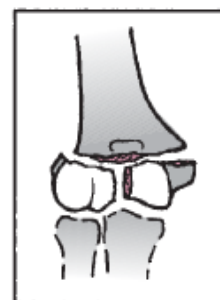
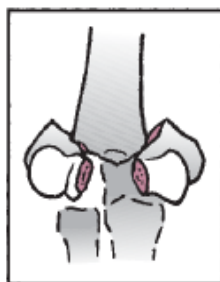
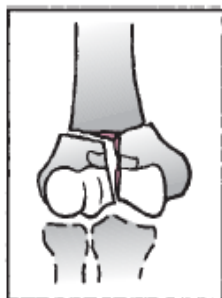
- (1) Y-shaped
- (2) T-shaped
- (3) V-shaped

2. With marked displacement (13-C1.2)

- (1) Y-shaped
- (2) T-shaped
- (3) V-shaped

3. T-shaped epiphyseal (13-C1.3)

C1



**Humerus, distal, complete articular simple metaphyseal multifragmentary (13-C2)**

1. With intact wedge (13-C2.1)

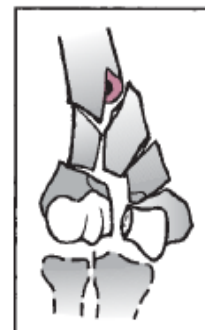
- (1) metaphyseal lateral
- (2) metaphyseal medial
- (3) metaphysio-diaphyseal lateral
- (4) metaphysio-diaphyseal medial

2. With a fragmented wedge (13-C2.2)

- (1) metaphyseal lateral
- (2) metaphyseal medial
- (3) metaphysio-diaphyseal lateral
- (4) metaphysio-diaphyseal medial

3. Complex (13-C2.3)

C2



**Humerus, distal, complete multifragmentary (13-C3)**

1. Metaphyseal simple (13-C3.1)

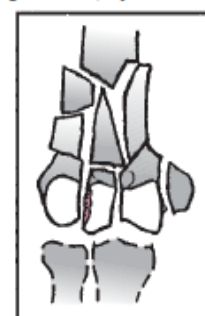
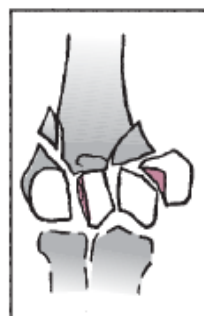
2. Metaphyseal wedge (13-C3.2)

- (1) intact
- (2) fragmented

3. Metaphyseal complex (13-C3.3)

- (1) localized
- (2) extending into diaphysis

C3



**Fig 2:** AO Classification

**Patients:** of total 50 patients included in study. Thus a total of 14 women and 36 men. The demography shown in table-1.

Three patient had open fracture, 2 were grade 1 and one was grade 2 according to Gustilo-Anderson classification.

**Table 1:** Total no. of Patients per age, sex, Fracture type, and side

Age-group (years)	No. of patients	Age, sex, side involved, type of fracture pattern						
		M	F	Fracture type			Side involved	
				C_1	C_2	C_3	R	L
18-30	10	7	3	3	5	2	6	4
31-40	21	15	6	9	8	4	14	7
41-50	14	10	4	4	6	4	8	6
51-60	3	2	1	0	2	1	2	1
61-70	2	2	0	1	0	1	1	1
TOTAL	50	36	14	17	21	12	31	19

**Table 2:** Summary of orthogonal versus parallel plating (NO. of Patients per type of fracture and mechanism of injury)

	Orthogonal plating	Parallel plating
Gender	3;1	3;6
Type of fracture		
C1	26	11
C2	7	4
C3	6	6
Mechanish of injury		
Slip	15	5
Fall down	14	4
Rta	10	2

**Diagnostic Studies**

- Standard anteroposterior and lateral radiographs of the elbow are usually sufficient for diagnosis, classification, and surgical templating.
- However, initial radiographs obtained in plaster or a splint may obscure the fracture pattern and should be repeated.
- In some cases where fracture shortening, rotation, and angulation distorts the images, gentle traction views with appropriate analgesia or conscious sedation may improve the yield of the radiographs.
- Computed tomography (CT) with three-dimensional

reconstructions substantially improves the identification and visualization of fracture patterns [52].

- While CT is not required for all cases, it is recommended for certain situations.
- CT scan can assist with decision-making and in identifying the locations of fracture fragments intraoperatively.
- Patients with highly comminuted fractures, or capitulum and trochlea fracture a CT scan may be useful in accurately identify comminution, the fracture pattern, or location of fragments.



**Fig 3:** X-ray



**Fig 4:** CT SCAN



### Specifics of the implant design

- The implants used were reconstruction plates, dynamic compression plates, locking compression plates, 1/3<sup>rd</sup> Tubular plates and screws (2.7mm and 3.5mm simple/locking corticle screws, 4mm cc screws, Herbert screws) and K-wires.
- The plate used in the LCDHP group was anatomically precontoured to properly fit the distal humeral metaphysis.
- This is a novel fixed-angle plating system consisting of 2 anatomically pre-shaped orthogonal plates. The anatomically precontoured medial distal humerus plate attaches at the ulnar and the radial columns, and then the anatomically precontoured posterolateral distal humerus plate with lateral support can be applied. These plates provide 3–14 holes of 3.5 mm each, for fixation on the humerus shaft (depending on plate length). Distally, 3 of the 2.7-mm threaded holes allow for insertion of fixed-angle locking or cortical screws.
- Moreover, this posterolateral plate is equipped with an additional support allowing the lateral placement of 2 additional 2.7-mm locking screws, which can potentially increase stability and allow early mobilization.

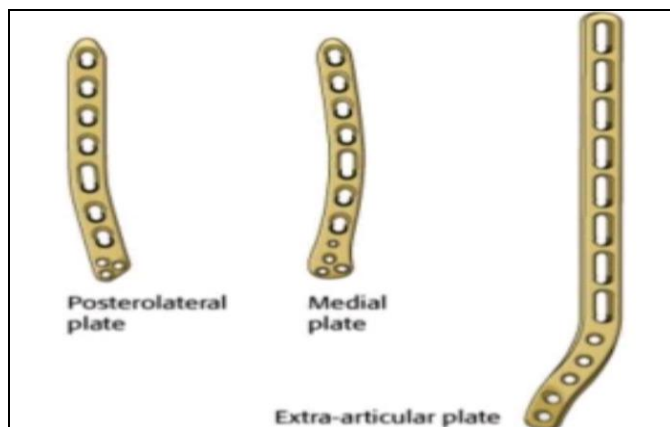


Fig 5: Distal humerus plate



Fig 6: Implant

### Surgical approach

Generally, intra-articular fractures of the distal humerus are accessed by the posterior approach, which gives excellent exposure of the articular fragments of the distal humerus [22, 24]. This approach requires reflection of the extensor mechanism, typically through either a triceps-splitting approach or an olecranon osteotomy.

The transolecranon exposure for distal humerus fractures is a very popular technique that is suggested for improving articular visualization and allowing accurate reduction. Significant osteotomy complications have prompted recommendations for alternative exposure techniques [24].

Distally, intra-articular exposure is dependent on triceps mobilization, and there are many modifications in the posterior elbow surgical approaches: e.g., triceps-splitting, triceps-reflecting, triceps-reflecting anconeus pedicle (TRAP), anconeus flap transolecranon (AFT), and paratricipital approaches.

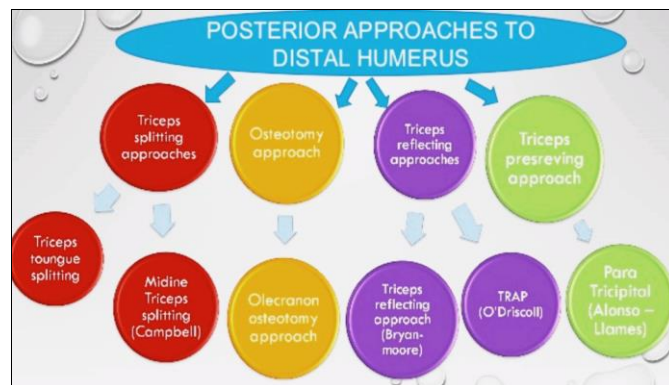


Fig 7: Posterior Approaches

### Technical Objectives For Distal Humerus Fracture Fixation

#### Technical Objectives for Fixation of Distal Humeral Fractures

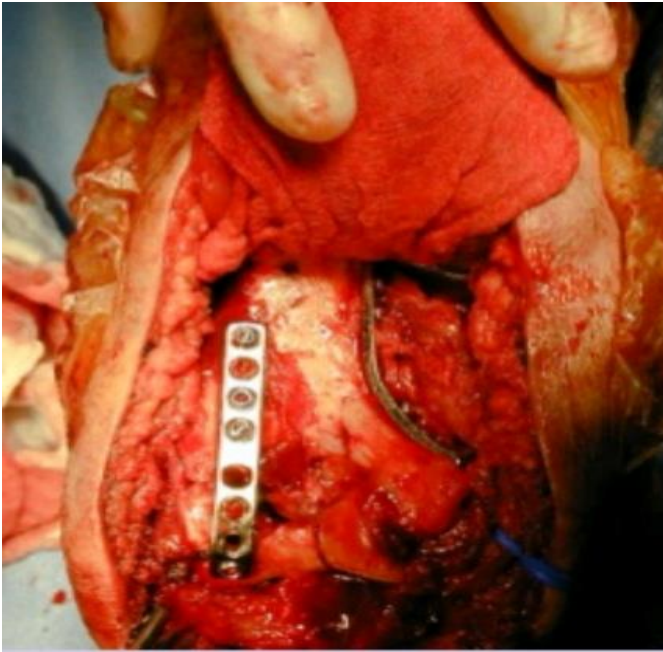
- Every screw should pass through a plate.
- Each screw should engage a fragment on the opposite side that is also fixed to a plate.
- As many screws as possible should be placed in the distal fragments.
- Each screw should be as long as possible.
- Each screw should engage as many articular fragments as possible.
- Plates should be applied such that compression is achieved at the supracondylar level for both columns.
- Plates used must be strong enough and stiff enough to resist breaking or bending before union occurs at the supracondylar level.

From Sanchez-Sotelo J, Torchia ME, O'Driscoll SW: Principle-based internal fixation of distal humerus fractures, Tech Hand Upper Extremity Surg 5:179, 2001.

There are two ways of fixation of fracture, according to the plan worked out with the help of the paper tracings.

#### a) Type A: 90-90 fixation – orthogonal

- Intercondylar fixation is carried out first using a lag screw, except in the case of a C3 type of fracture, which can be fixed simply by an intercondylar screw.
- The intercondylar fixation is done either by using a 4-mm cancellous screw or Herbert screw or with a malleolar or 6.5-mm cancellous screw, which converts T-Y fracture into a supracondylar fracture.
- Subsequently, column fixation is done using plates: the lateral column is fixed by a posterolateral reconstruction plate and, medially, another plate is fixed, either reconstruction or Dynamic compression plate. On both sides the plate requires precontouring.

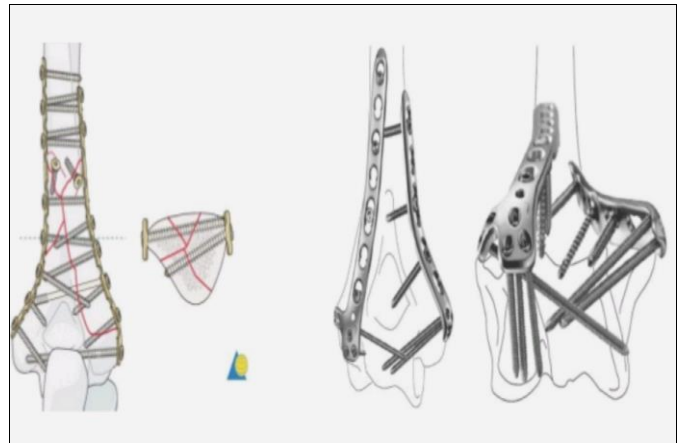


**Fig 8:** Orthogonal plating (intra-operative image)

#### b) Type B: Parallel plate

- Here the intercondylar lag screw is not used. Instead the fracture is fixed by two parallel plates (medially and laterally) with screws that interdigitate with each other from both sides giving the effect of a fixed-angle structure.
- Plate length is chosen according to the proximal extension of the fracture line and each plate is fixed with at least three bicortical screws at the diaphysis. The plates are fixed to the distal fragment with cortical screws that extend into the opposite condyle; the proximal fixation is initially done with a cortical screw.
- Then the fracture is compressed at the supracondylar level with the insertion of an eccentric screw through one of the proximal holes in both plates. An attempt is made to hold the distal fragments together using at least two screws extending to the opposite column. Proximal fragments are fixed according to the configuration of the fracture by at least three bicortical screws.
- The stability achieved by this fixation construct combines the features and stability of an arch, while locking the two columns of the distal part of the humerus together.
- The concept follows the architectural principles of an arch, in which two columns are anchored at their base to the shaft of the humerus and are linked together at the bottom (long screws from the plates on each side interdigitating within the articular segment).
- The medial plate is placed on the medial aspect of the medial column and the lateral plate is placed laterally, rather than posteriorly, on the lateral column. To avoid the stress riser effect, one of the plates should be longer proximally. Although the plates are referred to as being parallel, each plate is actually rotated posteriorly slightly out of the sagittal plane such that the angle between them is often in the range of 150°–160°. This orientation permits the insertion of at least four long screws completely through the distal fragments from one side to the other.
- These screws interdigitate, thereby creating a fixed-angle structure and greatly increasing the stability of the construct. Contact between screws is intended to enhance

the locking together of the two columns. The plates must be contoured to fit the geometry of the distal part of the humerus.



**Fig 9:** Parallel plating

- If precontoured plates are not available, locking plates may be used. Interfragmentary compression is obtained between articular fragments as well as at the metaphyseal level through the use of large bone clamps that provide compression during the insertion of the screws attaching the articular segment to the shaft. In the distal fragments, fully threaded screws inserted in this manner provide maximum thread purchase.
- The fracture fixation is tested on the table by manually moving the elbow joint and confirming the stability achieved by surgery. The absolute stability allows early range of motion, which is one of the more important advantages of stable rigid fixation. Finally the osteotomy is fixed either by tension band wires over two parallel K-wires or by cancellous screw or by olecranon plate.

#### Postoperative management and rehabilitation

- All patients followed the same postoperative management and rehabilitation protocol. A well-padded long-arm posterior plaster splint was applied postoperatively in all patients with the elbow at 90° flexion with the forearm in neutral rotation.
- On the second or third day after surgery, the drain was removed and the splint was changed to a removable splint to start ROM exercise. Active-assisted elbow motions, including pronation and supination, were initiated and continued under supervision.
- The patients were evaluated by the principal investigator and physiotherapist. Suture materials and the splint were removed together within 12–14 days, depending on the patient's healing capacity. After 3 weeks, active ROM exercise was allowed. Physiotherapy was usually terminated at 3 months, even though further functional improvement continued for a longer period.

#### Assessments of patients

- Patients were evaluated clinically and radiographically.
- Clinical and radiological evaluations were performed every 2 weeks postoperatively for first 2 months and callus formation or cortical continuity was observed radiographically, after which patients were evaluated every month for next 4 months.
- Preoperative evaluation included anteroposterior, lateral and oblique radiographs. After the operation, radiological

follow-up included standard anteroposterior and lateral radiographs that were evaluated by the principal investigator for reduction, fracture union, implant failure, and HO.

- A step or gap of  $\leq 1$  mm in the articular surface on the radiographs was considered satisfactory articular reduction [47]. Fracture union was judged to have occurred when a bridging callus was evident on the anteroposterior, lateral, and oblique radiographs of the elbow.
- Varus–valgus angulation was measured on the anteroposterior radiograph, with  $4^{\circ}$ – $8^{\circ}$  valgus angulation of the distal humerus joint surface considered within normal limits [48].
- Clinical follow-up included recording the incidences of complications; evaluating elbow ROM (flexion, extension, pronation, and supination); measuring pain according to a visual analog scale (VAS) score [49]; and obtaining the disabilities of the arm, shoulder, and hand (DASH) score [50], and the mayo elbow performance score (MEPS) [30].

**Radiological outcomes**

Postoperatively and at the last follow-up, no angular deformity, steps, or gaps were noted at the articular margin  $>1$  mm. Bony union was achieved.

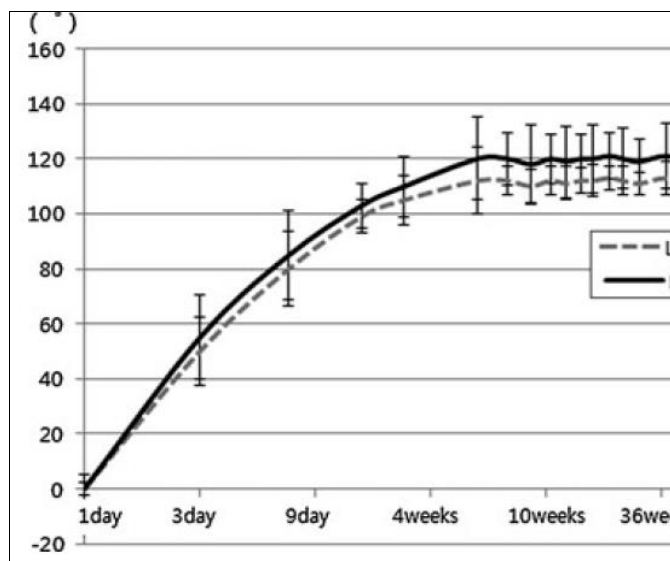
- At the end of the operation, 35 patients had fixation performed using tension-band wire. 1 patient treated with a tension-band wire at the olecranon osteotomy site had metal failure 1 week postoperatively.
- Two patients with screw loosening in the PAP group had a secondary procedure. One patient had 2 loosened screws at the plate hole, while the other had a single loosened screw at the independent inter fragmentary screw. The screws were removed at 3 and 2 months after the operation, respectively, because of skin irritation and prominence of the screws.
- One patient developed a peri-prosthetic fracture at the level of the humeral shaft in the PAP group 2 years postoperatively because of another accident (fall). This patient required revision surgery, where both plates were removed, and the peri-prosthetic fracture was fixed with an intra-medullary nail.
- One patients in the LCDHP group and one patients in the PAP group had HO during the follow-up..
- One patient in the LCDHP group had grade I HO at 2 weeks postoperatively, and the arc of elbow ROM was recorded 114°. However, the HO disappeared 6 weeks postoperatively,

**Clinical outcomes**

The final VAS score, DASH score, and MEPS results are shown in Table 2. There were no significant differences

between both groups.

DASH scores averaged  $24.23 \pm 6.02$  points (range 9–61) in the orthogonal plating group and  $23.18 \pm 11.33$  (range 5–54) in the parallel plating group. Among the 4 patients with higher DASH scores (range 45–61), 3 patients (orthogonal plating) had an ipsilateral forearm fracture, and 1 patient in the parallel plating group had a grade IIA HO, which led to limited daily activity and ROMs of the elbow,



**Fig 10:** The follow-up of the arc of motion in both groups

The mean MEPS was  $87.23 \pm 7.75$  points (range 70–100) in the orthogonal plating group, which corresponded to an excellent result in 25 elbows, a good result in 13, and a fair result in 1. The fair result was attributed to severe bone loss and osteoporosis, which led to a restricted elbow ROM (MEPS 70 points). The mean MEPS was  $89 \pm 8.07$  points (range 75–100) in the parallel plating group, which corresponded to an excellent result in 6 elbows, a good result in 3, and a fair result in 1.

**Table 3:** Summary of orthogonal plating versus parallel plating method

	Orthogonal plating group	Parallel plating group	p value
Operation time, minutes	110 +- 31	105+-27	
Mean follow-up years	6+- 0.5	6+-0.5	
Union time, months	5.5+-0.4	5.6+-0.3	
Last ROM			
Flexion	115 ± 6.79	112 ± 7.73	0.21
Extension	11±2.46	9±2.7	
Last DASH score	24.23 ± 6.02	23.18 ± 11.33	0.7
Last MEPS	87.23 ± 7.75	89 ± 8.07	0.51
HO	1	1	HO



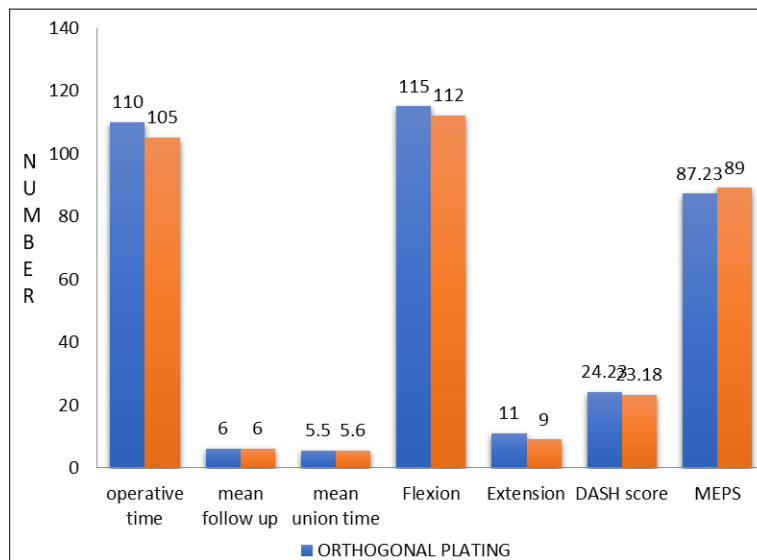


Fig 11: Summary of orthogonal plating versus parallel plating method

**Discussion**

- SCIC humerus fractures represent a challenge to the surgeon due to the distal location and predilection towards articular involvement. ORIF of the fracture allows the surgeon to restore anatomical alignment of the fracture fragments and permit early range of motion exercises which may aid in the return of a functional range of motion of the elbow postoperatively.
- Double plating method are popular, widely used surgical method for the fixation of the humerus fracture as indicated by many biomechanical studies.
- In this study, we report the outcome of surgical management of SCIC humerus fracture. We also report the outcome of different operative technique and discuss the controversies in light of available evidence in literature.
- Total 50 patients included in study which include 36 male and 14 female. 39 patients were treated using orthogonic plating and 11 patients were treated using parallel plating.
- The mean MEPS was 85.1 points (range 70–100) in the orthogonal plating group, which corresponded to an

excellent result in 25 elbows, a good result in 13, and a fair result in 1. The fair result was attributed to severe bone loss and osteoporosis, which led to a restricted elbow ROM (MEPS 70 points). The mean MEPS was 85.1 points (range 75–100) in the parallel plating group, which corresponded to an excellent result in 6 elbows, a good result in 3, and a fair result in 1.

- DASH scores averaged 25.2 points (range 9–61) in the orthogonal plating group and 22.9 (range 5–54) in the parallel plating group. Among the 4 patients with higher DASH scores (range 45–61), 3 patients (orthogonal plating) had an ipsilateral forearm fracture, and 1 patient in the parallel plating group had a grade IIA HO, which led to limited daily activity and ROMs of the elbow,
- As indicated in Fig. 10, nearly 95% of elbow ROM was obtained 4 weeks post-operatively, signifying the benefits of postoperative elbow ROM exercise. The recovery of nearly full elbow ROM is representative of the goal of stable anatomical reconstruction. Firm fixation is crucial in the realization of this goal. Applying an appropriate plating method based on fracture pattern leads to firm fixation and eventually to good clinical outcomes.

Table 4: Summary of comparison of my study with lee et. Study

CASE		Lee et al. 2014	MY Study
Flexion ARC	Orthogonal plating	98o ± 20o	115 ± 6.79
	Parallel plating	100o ± 23o	112 ± 7.73
DASH SCORE	Orthogonal plating	25.2 ± 9.8	24.23 ± 6.02
	Parallel plating	22.9 ± 8.7	23.18 ± 11.33
MEPS	Orthogonal plating	85.1 ± 28.2	87.23 ± 7.75
	Parallel plating	89.7 ± 30.1	89 ± 8.07

- LCDHP, which was used in orthogonal plating method, was used for achieving fixation through locking screw and plating methods. Locking compression plates were more effective for achieving firm fixation than the conventional reconstruction plates.
- However, in the posterolateral plate of the LCDHP, screw fixation in the distal lateral column is often limited to a short screw passing through the plate from the posterior to the anterior end.
- PAP, which was used in parallel plating methods, allows insertion of screws at various angles. The screws for distal fragments pass through the plate and contribute to

stability at the supracondylar level, while engaging as many articular fragments as possible. Because screws come from opposing sides of the condyles, the long screws can interdigitate in the distal fragments, creating an “arch” construct.

- The lack of a locking screw and the prominence of the lateral plate are viewed as shortcomings of this method. Therefore, the risk of a loosened screw cannot be ruled out in patients with severe osteoporosis. In the present study, 1 or 2 loosened screws were found among the screws inserted into lower portion of the distal humerus in 2 patients.



- However, fracture stability was not affected in these patients. Despite the different plating methods and characteristics of plates between the groups, there were no significant differences in clinical outcomes.
- No statistically significant differences were found in the mean operation time, union time, or elbow ROM.
- Elbow ROM (flexion and extension) was not significantly different between the groups.

### Limitation of Study

- Relatively small number of patients
- Short term follow up
- Long term effect of remodeling of this construct are not known.

### Case-1



### CASE-2



### Conclusion

- The ORIF remains the standard of care in the treatment of intra-articular distal humerus fractures in the physiologically active patient (36) The treatment of distal humeral fractures is labor-intensive and complex and, expectedly, there is a high incidence of complications.
- Severe comminution, bone loss, and osteopenia predispose distal humeral fractures to unsatisfactory results due to inadequate fixation.
- The surgical stabilization should be undertaken as planned surgery with careful preoperative planning. Using good traction films (anteroposterior and lateral views), tracings are made, carefully noting the fracture lines and outlining major fracture fragments; this should be compared to the tracings of the intact uninjured distal humerus of the opposite side.
- Dual plating in distal humerus fractures has been recommended for stable fixation with a new implant and better surgical exposures. Little difference in plating configuration, either orthogonal or parallel, was found in biomechanical analyses and no significant difference with regard to clinical outcomes.
- Both techniques have shown satisfactory outcomes and their own complications have been reported as well. When to use orthogonal or parallel plating is based on the surgeon's preference. But, decision may depend on fracture pattern and bone quality.
- Success in treating these fractures starts with preoperative understanding of the normal anatomy and the fracture pattern. Intraoperatively, obtaining an anatomic reduction of the articular surface with a stable hardware construct, which will allow early range of motion while minimizing complications, will surely result in favorable outcomes.

### References

1. Rockwood green's fracture in adults- 8th edition
2. Campbell's Operative orthopaedics-12th Edition
3. AO Principles of Fracture, 2000.
4. AO Surgery reference
5. Jupiter JB, Neff U, Holzach P, Allgower M. Intercondyla fractures of the humerus. An operative approach. J Bone Joint Surg Am. 1985;67:226-39.
6. O'Driscoll SW, Sanchez-Sotelo J, Torchia ME. Management of the smashed distal humerus. Orthop Clin North Am. 2002; 33:19-33.
7. Jupiter JB. The management of nonunion and malunion of the distal humerus- A 30 year experience. J Orthop Trauma. 2008; 22:742-50.
8. Mehne DK, Matta J. Bicolumn fractures of the adult humerus. Paper presented at the 53rd annual meeting of the American Academy of Orthopaedic Surgeons, New Orleans, 1986.
9. Sanchez-Sotelo J, Torchia ME, O'Driscoll SW. Complex distal humeral fractures: Internal fixation with a principle-based parallel-plate. Surgical technique. J Bone Joint Surg Am. 2008; 90:31-46.
10. Windolf M, Maza ER, Gueorguiev B, Braunstein V, Schwiager K. Treatment of distal humeral fractures using conventional implants. Biomechanical evaluation of a new implant configuration. BMC Musculoskelet Disord. 2010; 11:172.
11. Bryan RS, Morrey BF. Extensive posterior exposure of the elbow: A triceps-sparing approach. Clin Orthop. 1982; 166:188-92.
12. O'Driscoll SW. The triceps-reflecting anconeus pedicle

- (TRAP) approach for distal humeral fractures and nonunions. *Orthop Clin North Am.* 2000; 31:91-101.
13. Cassebaum WH. Open reduction of T and Y fractures of lower end of the humerus. *J Trauma.* 1969; 9:915-25.
  14. Morrey BF, Askew LJ, An KN, Chao EY. A biomechanical study of normal elbow motion. *J Bone Joint Surgery Am.* 1981;63:872-7.
  15. Muller ME, Allgower M, Schneider R, Willenegger H. *Manual of internal fixation. Techniques recommended by AO Group.* 2nd ed. New York: Springer, 1979.
  16. Galano GJ, Ahmad CS, Levine WN. Current treatment strategies for bicolunar distal humerus fractures. *J Am Acad Orthop Surg.* 2010; 18:20-30.
  17. Atalar AC, Demirhan M, Salduz A, Kilicoglu O, Seyahi A. Functional results of the parallel plating for complex distal humerus fractures. *Acta Orthop Traumatol Turc.* 2009; 43:21-7.
  18. Ackerman G, Jupiter JB. Non-union of fractures of the distal end of the humerus. *J Bone Joint Surg Am.* 1988; 70:75-83.
  19. Korner J, Diederichs G, Arzdorf M, Lill H, Josten C, Schneider E. Biomechanical evaluation of methods of distal humerus fracture fixation using locking compression plates versus conventional reconstruction plates. *J Orthop Trauma.* 2004; 18:286-93.
  20. Schemitsch EH, Tencer AF, Henley MB. Biomechanical evaluation of methods of internal fixation of the distal humerus. *J Orthop Trauma.* 1994; 8:468-75.
  21. Self J, Viegas SF, Buford WL Jr, Patterson RM. A comparison of double-plate fixation methods for complex distal humerus fractures. *J Shoulder Elbow Surg.* 1995; 4:10-6.
  22. Cheung EV, Steinmann, SP. Surgical approaches to the elbow Review article. *J Am Acad Orthop Surg.* 2009; 17:325-33.
  23. Marsh JL, Slongo TF, Agel J, Broderick JS, Creevey W, DeCoster TA *et al.* Fracture and dislocation classification compendium Orthopaedic Trauma Association classification, database and outcomes committee. *J Orthop Trauma.* 2007; 21:S1-S133.
  24. Wilkinson JM, Stanley D. Posterior surgical approaches to the elbow: A comparative anatomic study. *J Shoulder Elbow Surg.* 2001; 10:380-2.
  25. Stoffel K, Cunneen S, Morgan R, Nicholls R, Stachowiak G. Comparative stability of perpendicular versus parallel double-locking plating systems in osteoporotic comminuted distal humerus fractures. *J Orthop Res.* 2008; 26:778-784.
  26. McCann PA, Smith GC, Clark D, Amirfeyz R. The tricipital aponeurosis: a reliable soft tissue landmark for humeral plating. *Hand Surg.* 2015; 20(1):53-8.
  27. Frankle MA, Herscovici D Jr, Dipasquale TG, Vasey MB, Sanders RW. A comparison of open reduction and internal fixation and Primary total elbow arthroplasty in the treatment of intrarticular distal humerus fractures in women older than age 65. *J Orthop Trauma.* 2003; 17:47-9.
  28. Caja VL, Moroni A, Vendemia V, Sabato C, Zinghi G. Surgical treatment of bicondylar fractures of the distal humerus. *Injury.* 1994; 25:433-8.
  29. Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. *J Bone Joint Surg Am.* 1976; 58:453-458.
  30. Morrey BF, An KN. Functional evaluation of the elbow. In: Morrey BF (ed) *The elbow and its disorders*, 3rd edn. WB Saunders, Philadelphia, 2000, 82.
  31. Srinivasan K, Agarwal M, Matthews SJE *et al.* Fractures of the distal humerus in the elderly. *Clin Orthop Rel Res.* 2005; 434:222-30.
  32. London JT. Kinematics of the elbow. *J Bone Joint Surg.* 1981; 63:529-36.
  33. Korner J, Diederichs G, Arzdorf M, Lill H, Josten C, Schneider E. Biomechanical evaluation of methods of distal humerus fracture fixation using locking compression plates versus conventional reconstruction plates. *J Orthop Trauma.* 2004; 18:286-93.
  34. Waddell JP, Hatch J, Richards RR. Supracondylar fractures of the humerus: Results of surgical treatment. *J Trauma.* 1988; 28:1615-21.
  35. Schwartz A, Oka R, Odell T *et al.* Biomechanical comparison of two perpendicular plating systems for stabilization of complex distal humerus fractures. *J Clin Biomech.* 2006; 21:950-5.
  36. McKee MD, Jupiter JB. A contemporary approach to the management of complex fractures of the distal humerus and their sequelae. *Hand Clin.* 1994; 10:479-94.
  37. McKee MD, Jupiter JB. *Fractures of the distal humerus. Skeletal Trauma Basic Science, Management, and Reconstruction*, third edition. Saunders. Philadelphia, 2003, 1436-80.
  38. Leugmair M, Timofiev E, Chirpaz-Cerbat JM. Surgical treatment of AO type C distal humerus fractures: internal fixation with a Y-shaped reconstruction (Lambda) plate. *J Shoulder Elbow Surg.* 2008; 17:113-20.
  39. Grantham SA, Norris TR, Bush DC. Isolated fracture of the humeral capitellum. *Clin Orthop Relat Res.* 1981; (161):262-269.
  40. Goel DP, Pike JM, Athwal GS. Open reduction and internal fixation of distal humerus fractures. *Oper Tech Orthop.* 2010.
  41. Green A. Surgical treatment of bicolunar distal humeral fractures: relevant anatomy and classification. *Instr Course Lect.* 2009; 58:505-7.
  42. Lambotte A. *Chirurgie Operatoire des Fractures.* Paris: Masson et Cie, 1913.
  43. Eastwood WJ. The T-shaped fracture of the lower end of the humerus. *J Bone Joint Surg Am.* 1937; 19:364-369.
  44. Evans EM. Supracondylar-Y fractures of the humerus. *J Bone Joint Surg Br.* 1953; 35B(3):371-375.
  45. Alonso-Llames M. Bilateral tricipital approach to the elbow: Its application in the osteosynthesis of supracondylar fractures of the humerus in children. *Acta Orthop Scand.* 1972; 43:479-90.
  46. Athwal GS, Rispoli DM, Steinmann SP. The anconeus flap transolecranon approach to the distal humerus. *J Orthop Trauma.* 2006; 20:282-5.
  47. Reising K, Hauschild O, Strohm PC, Suedkamp NP. Stabilisation of articular fractures of the distal humerus: early experience with a novel perpendicular plate system. *Injury.* 2009; 40:611-617.
  48. Bucholz RW, Court-Brown CM, Heckman JD, Tornetta P. Distal humerus fractures. In: Athwal GS (ed) *Rockwood and Green's fractures in adults*, 7th edn. Lippincott Williams & Wilkins, Philadelphia, 2010, 945-998.
  49. Reips UD, Funke F. Interval-level measurement with visual analogue scales in Internet-based research: VAS Generator. *Behav Res Methods.* 2008; 40:699-704.
  50. Hudak PL, Amadio PC, Bombardier C. Development of

an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper Extremity Collaborative Group (UECG). *Am J Ind Med.* 1996; 29:602–608.

51. Winer BJ, Brown DR, Michels KM. *Statistical principles in experimental design*, 3rd edn. McGraw-Hill, New York, 1991.
52. Brouwer KM, Lindenhovius AL, Dyer GS et al. Diagnostic accuracy of 2- and 3-dimensional imaging and modeling of distal humerus fractures. *J Shoulder Elbow Surg.* 2012; 21(6):772–776.
53. Jacobson SR, Glisson RR, Urbaniak JR. Comparison of distal humerus fracture fixation: A biomechanical study. *J South Orthop Assoc.* 1997; 6:241-9.