



## Management of intra-articular fractures of distal humerus with two column fixation with orthogonal plate construct

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### ABSTRACT

Accurate reconstruction of articular surface of distal humerus by closed manipulation is not possible. The recent trend for displaced intra-articular fractures of the distal humerus is open reduction and stable osteosynthesis with early rehabilitation. We hypothesized that the best exposure of both columns and articular surface of the distal humerus is achieved through trans-olecranon approach and fixation of two columns of intra-articular fracture of distal humerus with orthogonal plate construct would allow excellent stability and good healing to restore early elbow joint function. 40 cases of intra-articular fractures of distal humerus were treated by open reduction and internal fixation (ORIF) with orthogonal plate construct via transolecranon approach. Chevron type olecranon osteotomy was performed and fixed with tension band wiring in all cases. Periodical radiological evaluation and regular clinical examination were done as per Mayo elbow Performance score. All fractures united within average duration of 3 months. More than 100° of range of motion is attained in 70% of cases with mean motion of arc of 115°. The mean Mayo Elbow Performance Score was 90.25 indicating excellent results with mild impairment. The critical factors for a successful outcome of intra-articular fractures of the distal humerus depends upon meticulous surgical technique, stable internal fixation, surgical experimentation and early controlled postoperative mobilization. ORIF with orthogonal plate construct securing both humeral columns via transolecranon approach results in excellent healing by maintaining functional arc of motion.

Level of Evidence: Therapeutic level IV

**Key words:** distal ,humerus , two-column, fixation

### INTRODUCTION

Incidence of distal humeral fractures is increasing. Distal humerus fractures comprise 2-6% of all fractures. Distal humerus fractures remain one of the most difficult injuries to manage. They are commonly multifragmental, occur in osteopenic bone, and have complex anatomy with limited options for internal fixation. Treatment outcomes are often associated with elbow stiffness, weakness and pain. A painless, stable and mobile elbow joint is desired as it allows the hand to conduct the activities of daily living, most notably personal hygiene and feeding. Therefore, starting with a highly traumatized distal humerus and finishing with a stable, mobile and pain free joint is challenging and requires meticulous planning, systematic approach, obtaining an anatomic intraarticular reduction, and creating a fixation construct that is rigid enough to tolerate early mobilisation<sup>[1]</sup>.

In 1913, Albin Lambotte challenged the leading opinions of conservative management for distal humerus fractures and advocated an aggressive approach of open reduction and internal fixation. He described the principles of osteosynthesis and believed restoration of anatomy correlated with a better return to function. Evans in 1953, advised 'bag of bones' treatment and believed that although it may be appropriate for the elderly patient, it was not ideal for the young active patient<sup>[2]</sup>. Traditionally, these fractures had been managed in an operative fashion with various extensor mechanism-disrupting surgical approaches<sup>[3-10]</sup>. These approaches are often associated with delayed union or nonunion of the olecranon, triceps weakness, and osteotomy-related prominent implants<sup>[11-13]</sup>. To avoid these problems, various extensor mechanism-sparing approaches that provide bicolumnar exposure of the distal part of the humerus have been described, including triceps-splitting and reflecting techniques<sup>[5,8-10]</sup>. In the last

quarter of century improved outcomes have been reported with surgery for distal humerus fractures. The principles set out by the Arbeitsgemeinschaft für Osteosynthesefragen (Association for the Study of Internal Fixation, AO-ASIF) group, including anatomic articular reduction and rigid internal fixation, allow for rapid healing and early postoperative range of motion. The last decade has seen advances in the understanding of elbow anatomy, improvements in surgical approaches, new innovative fixation devices and an evolution of post-operative rehabilitation protocols. Precontoured locking plates for posterior column, medial column and for fixation of olecranon osteotomy by AO group is new and effective method of fixation in distal humeral fractures and more effective in osteoporotic bone<sup>[1]</sup> So, in younger patients, open reduction and internal fixation of distal humerus fractures using modern fixation principles should be considered. Hence, the present study is undertaken to evaluate the management and outcome of two column fixation of intra-articular fracture of distal humerus in adults by orthogonal plate construct via trans olecranon approach.

## MATERIALS AND METHODS

This was a retrospective interventional study which included 40 consecutively admitted cases of intra-articular fractures of distal humerus carried out in Department of Orthopaedics, Govt. Medical College, Patiala from July 2011 to July 2014 after getting the approval from ethical committee and complete informed written consent from all patients participated in our study.

Fractures were classified as per AO fracture classification system. Inclusion criteria were AO Type C fractures (Fig. 1-A and 1-B) in adults (15-70 years). Most of the fractures were of C1 type in 26 cases, C2 in 10 and C3 in 4 cases. All the patients underwent ORIF of distal humeral fractures with orthogonal plate construct via trans olecranon approach after general anesthesia or regional block as per the anesthetist recommendation. Trans olecranon posterior approach was used as it gives visualization of the articular surface for reduction and fixation. Disadvantages are non-union and hardware prominence related to osteotomy and linked visualization of anterior articular surfaces<sup>[14]</sup>. In our study we used 3.5 mm reconstruction plates of appropriate size mostly which will be contoured according to the need and appropriate size, cortical screws along with Kirschner wires and stainless steel wires for tension band wiring of osteotomised olecranon.

### *Surgical Technique*

Patient was placed in a lateral decubitus on a bean bag. A midline posterior incision was made over the distal humerus. The Ulnar Nerve was identified and protected. An olecranon chevron osteotomy was used for adequate exposure of the joint surface with the osteotomy being placed at the lowest point of the trochlear notch. Later on osteotomy was fixed with tension band wiring in all cases. The Anconeus Muscle was elevated as a flap to preserve its innervation in most of cases. The articular fragments were reduced and held with a partially threaded cancellous screw or cortical screws. They were then secured to the columns. In most cases two reconstructive plates (3.5mm) were contoured to the distal humerus. One plate was placed on medial column and one on the posterior aspect of the lateral column (90° to each other). Plates applied on distal humerus at right angle to each other (Fig. 2) create '*Girdler like effect*' which strengthens fixation construct. Plates should end at different levels on humeral shaft to minimize the '*stress riser*' effect. Each plate should have at least 3 bicortical screws proximal to metaphyseal comminution<sup>[2]</sup> (Table-1).

After fixation, ulnar nerve was secured by making its bed, wound closed in layers under unobstructed drain. Post-operatively light posterior plaster splint was given for 3 days which was replaced by hinge brace and gentle active or active-assisted exercises were carried out as soon as possible as pain permits. All patients were followed up at monthly intervals for 6 months then quarterly. During this period patient was motivated for physiotherapy and gradual normal use of the affected limb, fracture union was assessed clinically and radiologically (Fig. 3-A and 3B) and elbow function on the operated side was evaluated and compared with the normal side as per Mayo elbow score<sup>[15]</sup> by the same observer.

Mayo Elbow Performance Score<sup>[15]</sup> (Table 2) which is based on 100-point scale with maximum of 45 points for Pain, 25 points for Function, 20 points for Range of Motion and 10 points for stability:

## RESULTS

Among the patients, 15 were females and 25 were males. The mean patient age was 45.8 years. The left side was involved in 26 cases. 35 fractures were closed and 3 were Gustilo Type I and 2 were Gustilo Type II. Gustilo-Anderson Grade III fractures were excluded from the study. The mechanism of injury was road side accidents (27 cases) in most of cases followed by falls (8 cases). 8 associated with other injuries like ulna fracture of ipsilateral

side in 2 and both bone leg fractures in 4 and Nerve injury in 2 cases. Co-morbid conditions were also encountered in 4 cases like Diabetes mellitus and Hypertension. Most of the patients were operated within 24 hours of injury.

The mean duration of follow up was 28 months, ranging from 6 to 60 months. The duration of fracture healing was 3 months, ranging from 2 to 4 months. The flexion at the elbow joint ranged from  $60^{\circ}$  to  $140^{\circ}$  with an average of  $120.2^{\circ}$  (Fig. 5-B). 32 patients had a flexion beyond  $110^{\circ}$ . And average loss of extension ranged from  $0^{\circ}$  to  $30^{\circ}$  with an average of  $14.2^{\circ}$  (Fig. 5-A). More than  $100^{\circ}$  of range of movement is obtained in 70% of cases. The mean motion of arc was  $115^{\circ}$ . An average pronation-supination arc was  $40^{\circ}$  to  $90^{\circ}$  (Fig. 4-A and 4-B). In most the cases functional arc of motion ( $30^{\circ}$  to  $110^{\circ}$ ) is preserved (Fig. 6). Scoring of range of motion is done as per Mayo Elbow Performance Score<sup>[15]</sup> which was calculated as 90.25 (Table-3). The final functional outcome was excellent in 24(60%), good in 12(30%), 2 fair (5%) and 2 poor (5%) results (Table-4). Most of the fixations were stable. 2 patients suffered transient Ulnar N Neuropraxia in the early post-operative period. No patient suffered from iatrogenic vascular injury. Hardware failure in 1, painful hardware in 3, superficial infection in 3, non-union of olecranon osteotomy in 1, elbow stiffness in 4 and 2 had mild cubitus varus deformity.

## DISCUSSION

It is important to realize that final outcome of painless, functional range of motion at elbow causing no disability is more important than a sound radiographic and anatomic union. At the average follow up of 28 months, the average flexion achieved was 120.2 degrees and the average loss of extension was 14.2 degrees. The mean Mayo Elbow Performance score was 90.25 comparable with other studies and signifies excellent results by maintaining functional arc of motion ( $30^{\circ}$  to  $110^{\circ}$ )<sup>[3,23,24,25]</sup>.

Within the last seven years, a two-column theory of the distal humerus anatomy has been advocated whereby the coronal plane of the distal humerus is in the shape of a triangle, with the coronoid fossa and olecranon fossa accounting for the majority of the central area, and the medial and lateral condyles forming two strong columns by proximal extension<sup>[9,16]</sup>. Fixation of the distal humerus must not only restore the capitellum-trochlea joint, but also the integrity of the medial and lateral columns. The articular segment functions architecturally as a tie arch<sup>[2]</sup>. There are several options for fixation between the condyle and humeral metaphysis. These include the use of Y-shaped plates, single plates, double K-wire, and K-wire together with tension band wiring<sup>[17,18]</sup>. The aim is to facilitate biomechanical reconstruction of the aforementioned two column structure. We found that plates applied in orthogonal fashion gives the girder like effect by overcoming the bending forces and securing the two columns<sup>[3,26]</sup>. Nowadays, the market offers anatomical plates designed especially for medial and lateral columns but these are expensive. We used reconstructive plates which are economical and gives the stable and strong construct if applied in orthogonal fashion. Rigid fixation and early rehabilitation are the most important goals in treatment of type C elbow fracture. In our study, posterior approach with olecranon osteotomy was used in distal humerus fracture. This approach gives the better exposure of articular surface<sup>3,19,20</sup> and both columns as well as it provides easy access to neural structures (ulnar nerve) and negates the risk of triceps injury without compromising extensor mechanism. Articular restoration is the most essential step followed by stabilization of the largest columnar fragment. Good exposure is mandatory for the fixation of Type C3 fractures and to provide good fixation. We found the operative field to be extensive, fracture reduction satisfactory and the implementation of early functional exercises easily possible. The most important step in these fractures is the early rehabilitation<sup>26</sup>. We started gentle active or active-assisted exercises in the first week and active exercise around the third week. At the end of the sixth week we encouraged the patients to discontinue the cast. In each case, fracture reduction was satisfactory, fixation was strong and durable, fracture site stable and early post-surgical functional exercise was possible.

In our series, at the time of injury 1 patient had ulnar nerve palsy and 1 patient had radial nerve which completely recovered over a period 10 months. Post-operatively, 2 patients had transient ulnar nerve Neuropraxia (which was completely recovered after 3 months), 3 patients had superficial infection which got better with antibiotics and dressings. Some degree of loss of extension is seen in most of the cases, more than 20 degree of stiffness is seen in 3 patients. Other complications encountered in our series were mild varus deformity in 2 patients, hardware failure in 1, non-union of olecranon osteotomy in 1 patient, 15 patients had mild pain and 24 patients had no pain at all. There was no case of heterotopic ossification. This may relate to complete intraoperative haemostasis, unobstructed postoperative drainage, and early postoperative functional exercise. Henley (1987)<sup>[21]</sup> in their series of 33 patients observed fixation failure in 5 patients, infection in 2 patients, one superficial and one deep and heterotopic ossification in 2 patients. Sodegard et al (1992)<sup>[22]</sup> in his series of 96 patients encountered 6 post-operative infections. 12 neural injuries and 16 fixation failures. Thus the complications in our study was comparable to other studies.

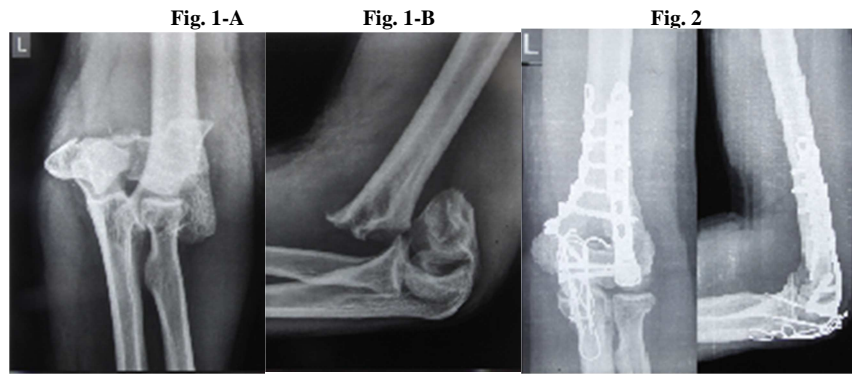


Fig. 1-A Initial injury anteroposterior radiograph of a 30-year-old man with displaced AO Type C2 distal humerus fracture  
 Fig. 1-B Initial injury lateral radiograph of a 30-year-old man with displaced AO Type C2 distal humerus fracture

Fig. 2 Anteroposterior and Lateral radiographs of a 21-year-old man with AO Type C2 distal humerus fracture, made six months after the fracture fixation

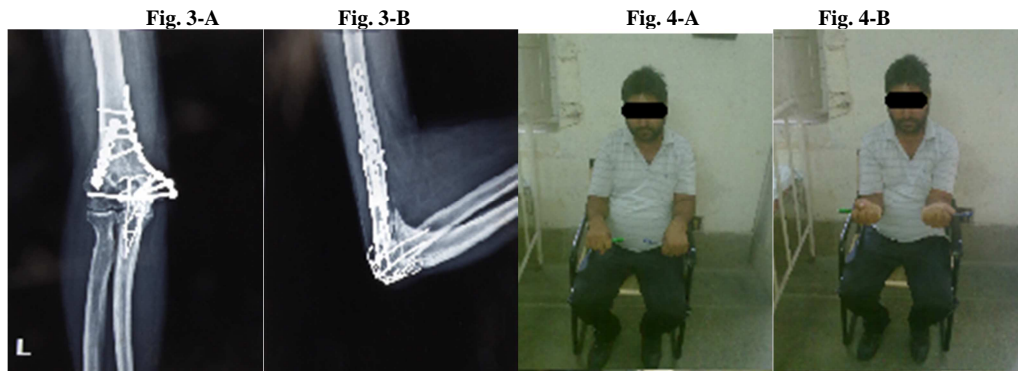


Fig. 3-A Anteroposterior radiograph made fifteen months after fixation of fracture shown in Figs. 1-A and 1-B  
 Fig. 3-B Lateral radiograph made fifteen months after fixation of fracture shown in Figs. 1-A and 1-B  
 Fig. 4-A Clinical picture with full supination fifteen months after fixation of fracture shown in Figs. 1-A and 1-B  
 Fig. 4-B Clinical picture with full pronation fifteen months after fixation of fracture shown in Figs. 1-A and 1-B



Fig. 5-A Clinical picture with full extension twenty-four months after fixation of fracture shown in Figs. 2  
 Fig. 5-B Clinical picture with full flexion twenty-four months after fixation of fracture shown in Figs. 2  
 Fig. 6 Clinical picture with good functional arc of motion after twenty-four months of fixation of AO type C3 fracture of distal humerus of 60-year-old female

Table 1-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.
<i>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<sup>2</sup>.</i>

Table 2- Mayo Elbow Performance Score				
FUNCTION				MEAN SCORE (Points)
PAIN (Maximum 45 points)				
None(45)	Mild(30)	Moderate(15)	Severe(0)	
ROM (Maximum 20 points)				
>100 <sup>o</sup> (20)	50 <sup>o</sup> to 100 <sup>o</sup> (15)	<50 <sup>o</sup> (5)		
STABILITY (Maximum 10 points)				
Stable(10)	Moderately Stable (5)	Unstable(0)		
FUNCTION (Maximum 25 points)				
Comb(5)	Feed(5)	Personal(5)	Shirt(5)	Shoes(5)
<b>Mean Total</b> (maximum 100 points)				

Interpreting the Mayo Elbow Performance Score:	
	Score
Excellent	90
Good	75-89
Fair	60-74
Poor	Below 60

Table 3-Mayo Elbow Performance Score				
FUNCTION		NO. OF PATIENTS	Percentage (%)	MEAN SCORE (Points)
<b>PAIN</b> (Maximum 45 points)	None (45)	24	60	38.62
	Mild (30)	15	37.5	
	Moderate (15)	1	2.5	
	Severe (0)			
<b>ROM</b> (Maximum 20 points)	>100 (20)	28	70	18
	50 TO 100 (15)	10	25	
	<50 (5)	2	5	
<b>Stability</b> (Maximum 10 points)	Stable (10)	38	95	9.75
	Moderately (5)	2	5	
	Unstable (0)			
<b>Function</b> (Maximum 25 points)	Comb (5)	35	87.5	23.88
	Feed (5)	40	100	
	Personal (5)	40	100	
	Shirt (5)	40	100	
	Shoes (5)	36	90	
<b>Mean Total</b> (max. 100 points)				<b>90.25</b>

Table 4-Final Functional Outcome		
Grading	No. Of patients	Percentage
Excellent	24	60
Good	12	30
Fair	2	5
Poor	2	5

General limitations observed in our study were our patient numbers were small overall and across fracture types, inadequate follow-up in some cases and there is limited literature regarding objective extensor mechanism strength assessment in our study.

In summary, we found that use of a trans-olecranon approach (with Chevron osteotomy) gives best view to intra-articular distal humeral fractures and direct manipulation of fracture fragments. It is imperative to maintain the width of distal humerus and the two columns for the treatment of type C distal humerus fractures with orthogonal plates, so that the fixation is stable enough for early post-operative rehabilitation. Complications were minimal and healing satisfactory. We advocate the use of this approach for repair of type C distal humerus fractures.

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