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The functional and radiological outcome of open reduction and internal fixation of comminuted intra-articular distal humerus fracture with bi-columnar plating technique in adults

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Abstract

Recent studies have emphasised the importance of surgical approach, anatomical reconstruction, rigid fixation and early rehabilitation for good outcome. Hence the present study was planned to evaluate the outcome of surgical treatment of comminuted intra-articular distal humerus fractures fixed with bi-columnar plating technique. All the fractures were fixed using the AO bi-columnar plating techniques with distal humerus locking plates or reconstruction plates, fifteen cases via olecranon osteotomy approach and seven fractures fixed by triceps reflecting anconeus pedicle (TRAP) approach. Physiotherapy was started from 1st post-op day with unprotected ROM exercises were allowed by 3rd week. Patients were followed up at 6 weeks, 3 months, 6 months interval. Clinical outcome was assessed using MEPI (Mayo Elbow Performance Index) score and radiologically assessed for reduction, alignment, fracture union, post traumatic arthritis, and heterotopic ossification. The mean MEPI score was 90.45 points (range, 0 to 100 points), indicating mild impairment. Radiological union was achieved in 18.18% of patients at one and half month intervals whereas 81.82% of patients had radiological union during third month with average time for union being 10.9 weeks. We conclude that open reduction internal fixation of comminuted intra-articular fractures of the distal humerus with bi-columnar plating technique is an effective procedure with an excellent outcome in 54.5%, good outcome in 27.3% and fair outcome in 18.2% of patients in most age groups according to MEPI scoring. Patients have a high level of satisfaction and the majority return to their previous level of activity.

Keywords: comminuted intra-articular distal humerus fracture; olecranon osteotomy; triceps reflecting anconeus pedicle approach

Introduction

Comminuted intra-articular distal humerus fractures comprise 0.5% to 7% of all fractures and 30% of elbow fractures [1]. Distal humeral fractures occur in the younger age-groups secondary to high-energy trauma and in elderly women as a result of relatively low-energy trauma [1]. Fractures of the distal humerus are often the result of a fall (low-energy injury) or a direct blow onto the back of the upper arm when the elbow is held in a flexed position (high-energy injury). Fractures due to falls are most common in the elderly while those resulting from trauma are more common in the younger population.

Comminuted intra-articular distal humerus fractures can be among the most challenging injuries treated by orthopaedic surgeons. The goals of surgical treatment are anatomical restoration of the articular surface and stable fixation of the fracture fragments to allow for early motion. However, the bone stock of the distal humerus is limited, and stable fixation may be difficult to achieve in the case of a low fracture pattern, comminution, or osteoporosis [2].

The management of intra-articular distal humerus fractures has evolved over the last few years. The worldwide application of the AO principles of fixation during the late 1980s and early 1990s remained a major breakthrough for quite some time [3]. Recent major advancements in the management of these injuries include the widespread availability of computed tomography (CT) scans with three-dimensional reconstruction, recognition of the more complex articular shear fractures [4], understanding the benefits of the parallel-plate technique [5], the availability of pre-contoured peri-articular plates, and the selective use of total elbow arthroplasty [6].

In comminuted intra-articular distal humerus fractures, the primary goal is to achieve a stable and mobile elbow. Fractures managed by closed reduction and cast application usually give poor results. The chances of functional impairment and deformity are very high following conservative treatment of such comminuted fractures of distal humerus. Fractures managed by traction give better results but are not acceptable. Unfortunately, insufficient internal fixation with Kirschner wires continues to be performed by some surgeons which greatly compromises patient outcome.

Standard surgical techniques are used for fixation of both columns, using a combination of reconstruction plates, dynamic compression plates, locking anatomical plates. Good anatomical alignment, stabilization, and early mobilization can provide satisfactory results. Severe comminution, bone loss, and osteopenia predispose to unsatisfactory results because of inadequate fixation of the fracture [8, 10]. Over 25% of such fractures develop significant complications during treatment and a few of them may need further surgery [9].

There is a lot of opportunity for improvement, as reflected by the interest in elbow arthroplasty for the treatment of these injuries and the controversy regarding the ideal management of the ulnar nerve as a part of this surgery and how to best manage structural bone loss. Till present day as new techniques are being designed, a clear cut protocol is yet to be established. Many controversies exist and many questions remain un-answered.

Recommendations vary from conservative management to full reconstruction of the joint. Hence the present study was planned to evaluate the functional and radiological outcome of open reduction and internal fixation of comminuted intra-articular distal humerus fractures fixed with bi-columnar plating technique in adults.

Objectives

To assess the anatomical reduction of distal humeral articular surface and union of fracture post internal fixation by radiological examination and to study the role of surgical management of comminuted intra-articular distal humerus fractures by the functional assessment using Mayo Elbow Performance Index over a period of 6 months. During the study the complications that occurs after the injury and treatment were assessed and discussed.

Material and Methods

Twenty two consecutive patients with comminuted intra-articular distal end humerus fracture were treated from October 2018 to May 2019 at our tertiary care centre. All the fractures were fixed using the AO bi-columnar plating techniques with distal humerus locking plates or reconstruction plates, fifteen cases via olecranon osteotomy approach and seven fractures fixed by triceps reflecting anconeus pedicle (TRAP) approach. Physiotherapy was started from 1st post-op day with unprotected ROM exercises were allowed by 3rd week. Patients were followed up at 6 weeks, 3 months, 6 months interval. Clinical outcome was assessed using MEPI (Mayo Elbow Performance Index) score and radiologically assessed for reduction, alignment, fracture union, post traumatic arthritis, and heterotopic ossification.

Methodology

On admission, each patient was assessed, with particular attention to general health, co-morbid conditions, associated injuries, other systemic injuries and their social status. A

thorough local and general examination was performed. Routine investigation and radiological examination of elbow and the limb was carried out. After thorough work up patients were taken up for surgery as early as possible, once they are fit for surgery under general anaesthesia. Pre-operatively all patients were immobilized with above elbow POP slab and were advised limb elevation. Associated injuries were dealt simultaneously or at a later date depending upon convenience. But every effort was made to operate as early as possible as these fractures are intra-articular. All the patients were explained about the consequences and the results of intra-articular fractures and a valid consent was taken, before any operative internal fixation is undertaken.

All the patients were evaluated for associated medical problems and were referred to respective department and treated accordingly. Associated injuries were evaluated and treated simultaneously. The patients were operated on selective basis after overcoming the avoidable anaesthetic risks.

All cases were operated on a single standard table under general anesthesia in lateral position using olecranon osteotomy approach or TRAP approach with standard operative techniques. C-Arm was used in all cases.

Pre-operative regimen

The patient was resuscitated in the emergency room and a complete examination of the patient, for other associated injuries as well, was performed. Neurological and vascular assessment of the involved limbs was done. Wound lavage, dressing as needed and above elbow splint was given as per the initial assessment and injury to the patient. Analgesics, antibiotics, intra-venous fluids were administered as per trauma protocol and tetanus prophylaxis as per requirement was administered.

The patient was taken for surgery after stabilization of vital parameters and after getting pre- anaesthetic check-up and clearance. Pre-operative roentgenograms and CT scan was assessed to determine the fracture configuration and to plan the operative procedure.

Post operative protocol

The central goal of post-operative rehabilitation is early range of motion. In the immediate post-operative state, the arm is placed into a bulky cotton padding and POP splint and elevated to minimize swelling. The elbow was splinted in 90 degrees flexion. Post-operative X-ray were done to document proper reduction and fixation of fracture fragments. Antibiotics (Intravenous/Oral) were continued till the wound condition necessitated. Starting on the first post-operative day the splint is removed and gravity-assisted range of motion exercises are begun. Extension is achieved by allowing gravity to extend the elbow while the patient stands. Flexion is achieved by having the patient lie supine and holding the arm vertical. The contra- lateral arm is used to control the rate and degree of motion. Motion against resistance is not begun until radiographic evidence of healing, typically after 6 to 8 weeks. The presence of an olecranon osteotomy is not a contraindication to early motion. In cases with tenuous fixation, range of motion exercises can be delayed for 2 weeks. Delaying beyond 3 weeks significantly increases the risk for developing post-traumatic elbow stiffness. Suture removal was done on 15th Post-operative day.

Period of follow-up

We have assessed patients clinically and radiologically at regular follow up of the patient in OPD with radiographs (Elbow AP and LATERAL-views) for a period of 6 months at regular intervals, i.e. at immediate post-operative, 6 weeks, 3 months and 6 months after surgery. On follow up, Mayo Elbow Performance Index was calculated for post-operative patients. The final result was based on the functional and radiological outcome at 6 months.

This is the standard follow-up protocol of all post-operative cases of open reduction internal fixation of comminuted intra-articular distal humerus fractures. The patients will not bear any extra expenses for the purpose of our study.

Results

In our study out of 22 fractures, 3 fractures (13.6%) are open fractures and remaining 19 fractures are closed fractures (86.4%)

Table 1: Distribution of subjects according to type of fracture (n=22)

		Type of fracture		Total	P value	Significance
		Closed	Open			
Results	Fair	2(10.53)	2(66.67)	4(18.18)	0.039	Significant
	Good	5(26.32)	1(33.33)	6(27.27)		
	Excellent	12(63.16)	0(0)	12(54.55)		
Total		19(100)	3(100)	22(100)		

The average period from day of injury to surgery was 3.64 days with a range between 3 to 5 days.

Table 2: Injury-operation interval days (n=22)

		Injury-operation interval days			Total	P Value	Significance
		3	4	5			
Results	Fair	0(0)	1(25)	3(60)	4(18.18)	0.006	Significant
	Good	3(23.08)	1(25)	2(40)	6(27.27)		
	Excellent	10(76.92)	2(50)	0(0)	12(54.55)		
Total		13(100)	4(100)	5(100)	22(100)		

In our study out of 22 patients, olecranon osteotomy approach was used in 15 cases (68.2%) and TRAP approach was used in 7 cases (31.8%). In cases where olecranon osteotomy was done to approach and fix the distal humerus

fractures with bi-columnar plating technique, olecranon was fixed with tension band wiring technique. Union occurred in all 15 (100%) patients at olecranon osteotomy site with an average time of union of 6.6 weeks. (Range; 6-8weeks)

Table 3: Distribution of subjects according to approach used for plating

Approach for plating	Frequency	Percent
Olecranon osteotomy	15	68.2
Trap	7	31.8
Total	22	100.0

In our study out of 22 patients, early mobilisation of affected elbow joint was done after 3 weeks post-surgery in

12 patients (54.5%) and 4 weeks post-surgery in 10 patients (45.5%).

Table 4: Mobilisation (n=22)

		Mobilization		Total	P value	Significance
		After 3 weeks	After 4 weeks			
Results	Fair	0(0)	4(40)	4(18.18)	0.007	Significant
	Good	2(16.67)	4(40)	6(27.27)		
	Excellent	10(83.33)	2(20)	12(54.55)		
Total		12(100)	10(100)	22(100)		

F-E ARC: The average flexion-extension arc at 6 months follow up was 104.32±13.3 degree. The reason for F-E arc below 100° in 7 patients was due to poor adherence to

physiotherapy and late weight bearing and in 2 patients due to infection which causes stiffness.

Table 5: F-E ARC (n=22)

F-E ARC	Frequency	Percent
85	2	9.1
90	3	13.6
95	4	18.2
100	2	9.1
105	1	4.5
110	4	18.2

120	4	18.2
125	2	9.1
Total	22	100.0

The average extension loss at 6 months follow-up was 14.77±7.15 degree. The reason for extension loss in 20 patients was due to poor adherence to physiotherapy and

late weight bearing and in 2 patients due to infection which causes stiffness.

Table 6: Extension loss (n=22)

EXT loss	Frequency	Percent
5	3	13.6
10	7	31.8
15	5	22.7
20	3	13.6
25	3	13.6
30	1	4.5
Total	22	100.0

In our study of 22 patients, we observed 3 patients (13.6%) with hardware pain, 2 patients (9.1%) with infection and 2 patients (9.1%) with transient ulnar nerve palsy (neuropraxia) at 3 months. In final follow up at 6 months only, one patient out of 3 is improved in range of motion with reduced hardware pain, remaining 2 patients had

hardware pain. Patients with infection in 2 cases are the same without improvement on regular treatment and also having less range of motion due to inflammation and pain. Another important finding was infection or elbow stiffness was more common in open type fractures.

Table 7: Distribution of subjects according to complications

		Complications				Total	P value	Significance
		Hardware pain	Infection	Neuropraxia	None			
Results	Fair	1 (33.33)	2 (100)	1 (50)	0 (0)	4 (18.18)	<0.001	Significant
	Good	2 (66.67)	0 (0)	1 (50)	3 (20)	6 (27.27)		
	Excellent	0 (0)	0 (0)	0 (0)	12 (80)	12 (54.55)		
Total		3(100)	2(100)	2(100)	15(100)	22(100)		

In this study the radiological union was achieved in 4 (18.18%) patients at one and half month intervals whereas 18 (81.82%) patients had radiological union during third month with average time for union being 10.9 weeks.

Table 8: Radiological Union

Intervals	Distribution (n=22)	
	Number	Percentage
6weeks	4	18.18
3 months	18	81.82

In this study of 22 patients, pain during activity was graded as moderate in 1 patient (4.5%), mild in 3 patients (13.6%), and none in 18 patients (81.8%) at the end of 6months.

Table 9: Distribution of patients according to pain during activity at 6 months follow-up

Pain	Frequency	Percent
None	18	81.8
Mild	3	13.6
Moderate	1	4.5
Total	22	100.0

In our study of 22 patients, average MEPI score was 90.45±11.33% at 6 months. Higher MEPI score suggestive of higher level of functional outcome with lower level of symptoms. In present study, functional outcome was found to be excellent in 54.5%, good in 27.3%, fair in 18.2% of subjects.

Table 10: Results

Results		Age	F-e arc	Ext loss	Pronation	Supination	Mepi score
Fair	Mean	53.00	87.50	22.50	62.50	68.75	70.00
	Median	53.50	87.50	25.00	65.00	70.00	70.00
	Std. Deviation	17.83	2.89	8.66	8.66	6.29	4.08
Good	Mean	37.17	95.00	13.33	71.67	76.67	87.50
	Median	37.50	95.00	15.00	70.00	75.00	87.50
	Std. Deviation	10.68	3.16	5.16	2.58	5.16	2.74
Excellent	Mean	33.33	114.58	12.92	75.83	80.00	98.75
	Median	32.50	115.00	10.00	77.50	80.00	100.00
	Std. Deviation	8.72	8.11	6.20	6.34	6.03	2.26
P value		0.045	<0.001	0.128	0.015	0.026	<0.001
Significance		Significant	Significant	Not significant	Significant	Significant	Significant

Plating technique

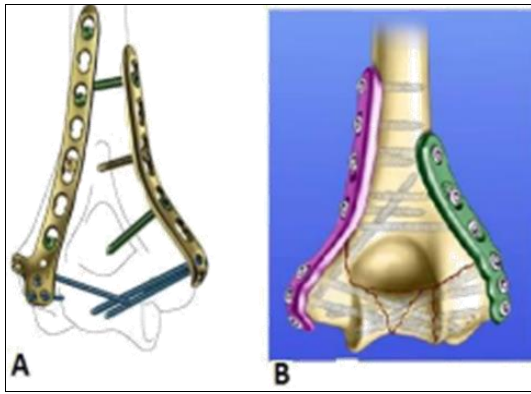


Fig 1(A): Orthogonal plating technique, **(B)** - Parallel plating technique showing anatomically pre-contoured locking plate

Discussion

The average period from day of injury to surgery was 3.64 days with a range between 3 to 5 days. The timing of surgery depended on the soft-tissue conditions. In our study of 22 fractures, all have undergone open reduction internal fixation within 1 weeks of injury.

In a study conducted by Kundel K *et al.* in 1996^[11], follow up examination of 77 cases showed that early operations within 24 hours of injury resulted in significantly less heterotopic bone formation and better overall function that did delayed treatment.

In a study conducted by Bauer AS *et al.* in 2012^[12], in 786 elbow fractures treated surgically, risk factors for the development of heterotopic ossification were days to surgery, with subjects waiting 8 or more days having 12 times the odds of heterotopic ossification than subjects having surgery within a day of injury, and time to postoperative mobilization, with subjects who had at least 15 days to mobilization having greater odds of heterotopic ossification than those who had less than 7 days to mobilization.

Final result in our study recorded that, there was no immediate postoperative wound complication in any patients after 3 and half day of injury-operation interval. We have found out that swelling and soft tissue tension reduced after 3 and half day from injury.

In our study out of 22 patients, early mobilisation was done in all cases. Vigorous physiotherapy of affected elbow joint was done after 3 weeks post-surgery in 12 patients (54.5%) and 4 weeks post-surgery in 10 patients (45.5%). Patients were discharged with advice of active, assisted active range of motion exercises. The above elbow posterior slab was continued for 3weeks for it allows good wound healing without any soft tissue contractures

In a study conducted by Bauer AS *et al.* in 2012^[12], in 786 elbow fractures treated surgically, risk factors for the development of heterotopic ossification were days to surgery, with subjects waiting 8 or more days having 12 times the odds of heterotopic ossification than subjects having surgery with in a day of injury, and time to post-operative mobilization, with subjects who had atleast 15 days to mobilization having greater odds of heterotopic ossification than those who had less than 7 days to mobilization.

In a study conducted by M Dhawan *et al.* in 2000^[13], 108 closed intra articular fractures of distal humerus were

treated by operative fixation and showed that most of the elbow function was seen to be acquired at three months after the surgery and no improvement was seen after six months in spite of standard physiotherapy.

On analysis of final result of our study, we have found that early mobilization of elbow post-surgery resulted in better functional outcome.

In our study out of 22 patients, olecranon osteotomy approach was used in 15 cases (68.2%) and TRAP approach was used in 7 cases (31.8%) but its not making any significant effect on functional out come and radiological outcomes. In cases where olecranon osteotomy was done to approach and fix the distal humerus fractures with bi-columnar plating technique, olecranon was fixed with tension band wiring technique. Union occurred in all 15 (100%) patients at olecranon osteotomy site with an average time of union of 6.6 weeks. (Range; 6-8weeks). With all posterior approaches, the ulnar nerve was carefully dissected without excessive stripping and transposed anterior to the medial epicondyle at the end of the procedure.

In a study conducted by Jacko P *et al.* in 2019^[14], which included 40 patients with distal humerus intra-articular fractures, 18 patients have been operated on, who met the inclusion criteria of the study on type C distal humerus fracture without the use of olecranon osteotomy. This group of patients was subsequently compared with a control group of patients in whom the olecranon osteotomy was performed and concluded that there is no significant difference in functional outcomes was found between the examined approaches.

In our study of 22 patients, we observed 3 patients (13.6%) with hardware pain, 2 patients (9.1%) with infection and 2 patients (9.1%) with transient ulnar nerve palsy (neuropraxia) at 3 months. In final follow up at 6 months only one patient out of 3 is improved in range of motion with reduced hardware pain, remaining 2 patients had hardware pain. Prominence of k-wires on the ulna was the common cause of pain. These patients underwent secondary procedures for the k- wire removal after achieving union at the osteotomy site. There were no cases with permanent nerve palsies except for 2 cases which had transient ulnar nerve palsy. They were managed conservatively and they completely recovered. Patients with infection in 2 cases are on regular treatment for which we did thorough lavage and treated the patient with high end antibiotics and are also having less range of motion due to inflammation and pain. At 6 months follow-up in both cases, amount of discharge from wound was less which was slowly getting better. Another important finding was infection or elbow stiffness was more common in open type fractures.

Macko D *et al.* in 1985^[15] reported elbow symptoms due to prominent k-wires in 75% of their 20 cases and skin breakdown in 20% of the cases.

Wang KC *et al.* in 1994^[16] in their study of 20 patients reported, 4 complications *viz.* 1 nonunion, 1 malunion, 1 deep infection, and 1 brachial artery laceration.

Singh R *et al.* in 2019^[17] in their study of 24 patients, reported post-operative transient ulnar nerve palsy in two cases, heterotopic ossification (HO) in one case, infection in two cases, implant prominence in five and elbow stiffness in three cases.

Thus the low incidence of infection in our study and described study can be attributed to the wound management

protocol in conjunction with skillful handling of soft tissue and use of peri-operative broad spectrum antibiotics.

In this study the radiological union was achieved in 4 (18.18%) patients at one and half month intervals whereas 18 (81.82%) patients had radiological union during third month with average time for union being 10.9 weeks.

Singh R *et al.* in 2019 ^[17] in their study of 24 patients reported that all fractures united by the end of 3 months.

In a study conducted by Keykhosro Mardanpour *et al.* In 2013 ^[18] reported that mean duration of fracture healing was 2.3 months (range 2–4months).

Conclusion

Thus, we conclude that open reduction internal fixation of comminuted intra-articular fractures of the distal humerus with bi-columnar plating technique is an effective procedure with an excellent outcome in 54.5%, good outcome in 27.3% and fair outcome in 18.2% of patients in most age groups according to MEPI scoring. Patients have a high level of satisfaction and the majority return to their previous level of activity.

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