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Original Research Article

A Comparative Study of Functional Outcomes of Distal Humerus Fractures with Intra-Articular Extension Managed by Bicolumnar Fixation with or Without Olecranon Osteotomy

Darshan K S[1], Arjun Chakrapani[2], Rahul Ragate[3], Abhilash C S[4], Ramesh G[5]

[1]Clinical Fellow, Dept of Orthopaedics, Yashoda Hospital, Somajiguda, Hyderabad, Telangana
[2]Senior Resident, Dept of Orthopaedics, Rajiv Gandhi Institute of Medical Sciences, Adilabad, Telangana
[3]Clinical Assistant, Dept of Orthopaedics, Sir H N Reliance Hospital, Mumbai, Maharashtra
[4]Clinical Fellow, Dept of Orthopaedics, Medicover Hospital, Hyderabad, Telangana
[5]Professor and Unit Chief, Dept of Orthopaedics and Traumatology, Osmania Medical College, Hyderabad

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Corresponding Author: Dr. Arjun Chakrapani
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Abstract:

Background: The standard of care for intra articular distal humerus fractures is ORIF with bicolumnar fixation. The most commonly used approach is that of Olecranon Osteotomy, though non osteotomy approaches have also been described and are in use. We sought to compare the functional outcomes of patients treated with osteotomy and non-osteotomy approaches.

Methods: 24 consecutive patients with distal humerus fractures with intra articular extension were treated by Open Reduction and Internal Fixation with 2 parallel fixed angle anatomical locking plates. 16 patients were operated by Chevron Osteotomy and 8 patients by triceps sparing approach. Clinical follow-up with the Mayo Elbow Performance score and plain radiographic evaluation were performed for an average of 13 months postoperatively. Patients with vascular injuries, grade 3 compound open fractures and severely un reconstructable communited fractures were excluded.

Results: Radiographic union was achieved at the fracture site in 100% patients. 1 patient had non-union at the osteotomy site. The average time from surgery to radiographic union was 12.81 weeks (12.87 for without osteotomy, 12.75 for osteotomy). The net complication rate was 41% with higher rate of complications such as infection, neurologic sequelae and stiffness in the non-osteotomy group. Range of movement measurements obtained from the most recent clinical follow up was a mean flexion extension arc of 107 degrees. The mean MEPS score was 80.7 (73.625 for non-osteotomy and 84.062 for olecranon osteotomy).

Conclusion: Both olecranon osteotomy and non-osteotomy are effective approaches for the treatment of intra articular distal humerus fractures in terms of union (100% in both groups) but olecranon osteotomy provided better functional outcomes in our study.

Keywords: Distal Humerus Fractures, Intra Articular, Triceps Sparing Approach, Olecranon Osteotomy.

Introduction

Distal humerus fractures in adults are relatively uncommon injuries amounting to 2 to 6 % of all fractures in the body and 30 % of all elbow fractures [1]. In young adults, most distal humerus fractures occur from high-energy trauma like sideswipe injuries, road traffic accidents(RTA). In elderly persons these injuries occur even from trivial falls. [2]

Due to the complex shape of the elbow joint, the adjacent neurovascular structures and the thinly distributed soft tissue envelope combine to make these fractures difficult to treat. Composite problems in distal humerus fracture management include frequent articular involvement, metaphyseal comminution, bone loss and osteopenia. Accurate reduction and stable fixation immediately at the time of the injury is usually the best treatment and malunion is an infrequent complication when current surgical techniques of rigid internal fixation are used. [3,4]

Attempt to achieve painless, stable yet mobile elbow requires a systematic approach in for open reduction and internal fixation. [5,6,7,8,9,10] On the basis of the results reported in the more recent series, fixation with two plates at 90 degrees angle with one another or parallel plate arrangement has become the standard against which all other treatments are measured. [3,4,5,11,12,13]This requires exposure of the fracture, usually by

moving the triceps out of the way at the same time protecting the ulnar nerve.

The most commonly used approach, especially for AO/OTA type C fractures appears to be the olecranon osteotomy, another approach less investigated or less commonly used approach for this fracture is the triceps split or triceps sparing approach [14,15,16]. An olecranon osteotomy provides a wide exposure, particularly of the dorsal two thirds of the distal humerus which is sufficient for most of the intra-articular fractures. The osteotomy however adds another fracture that needs fixation and is a potential source of non-union and hardware problems, something that has been demonstrated in several publications [15,17,18]

This study tries to bring out a comparison between the approaches to distal humerus with or without osteotomy.

Materials and Methods

Between May 2019 and October 2021, 24 patients between the ages of 20 to 65 years who were admitted at the Osmania General Hospital, Hyderabad with recent distal intra articular humerus fractures were enrolled into the study after taking clearance from the Hospital Ethical Committee and informed consent from the patients. 8 patients were randomly selected for treatment by non-osteotomy approach (either triceps splitting Campbell [19,20] approach or tricep reflecting Bryan Moorey approach [21])(Table 2) and 16 patients served as the control group undergoing treatment by the conventional olecranon osteotomy approach (Table 1). Both groups underwent ORIF with parallel anatomical locking plates (Figure 1) with identical implants being used in both groups so as not to confound the results. Patients with severely comminuted unreconstructable fractures and Gustilo Anderson grade 3 fractures were excluded.

3 patients had AO type C3 fractures, 7 had C2, 9 had C1, 4 had A3 and 1 patient had A2 type. Intraarticular fractures 79.16% of cases and Extraarticular Metaphyseal fractures constituted the remaining 20.82%. The average age of the patients was 37.9 years (range 20 to 65 years) with 18 male and 6 female patients. All the patients received their initial treatments at the Osmania General Government Hospital and were operated by the treating consultant. The mode of injury was road traffic accident in 17 patients, fall from height in 3 patients and 2 patients each due to simple falls or assault.

All the patients elbows were mobilised from the third post operative day. Indomethacin prophylaxis for heterotopic ossification was given for the first postoperative month (75 mg/day in three divided doses) to all patients. Follow ups were conducted by the primary author at the 2nd, 4th, 6th, 8th weeks and also 6 months. Further follow ups were done At each follow up, patients were evaluated clinically and radiologically for union, and the outcomes were measured in terms of Mayo elbow performance score (MEPS). Subjective degrees of patient satisfaction and pain were obtained through Visual Analogue Scale scoring at each routine visit.

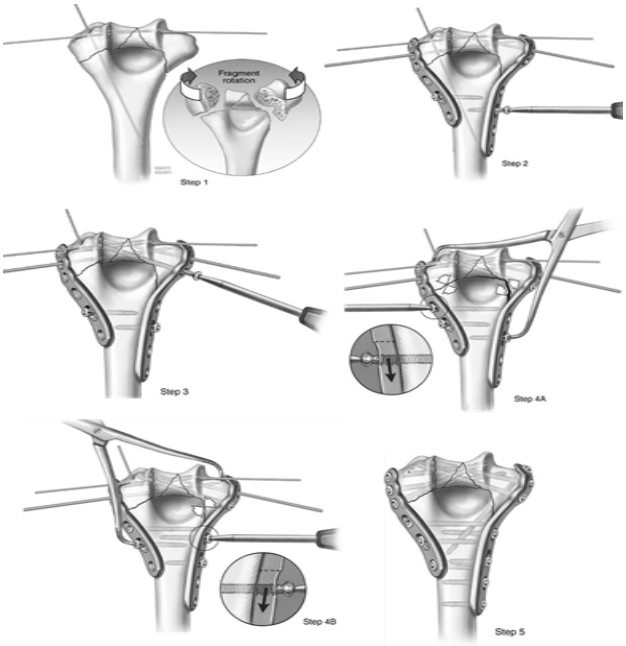


Figure 1: Illustrative technique of parallel plating

Figure 2: Radiographic case examples of 2 patients

Table 1 . Demographic data on Patients who underwent ORIF by Olecranon Osteotomy approach

No	IP No.	Age	Sex	Side	Mode of injury	AO type	Grade	Treatment	Approach	Associated injuries
1	48465	23	M	R	RTA	C1	Closed	ORF with parallel plating	Olecranon osteotomy	
2	77855	45	M	L	RTA	A3	Closed	ORIF with parallel plating	Olecranon osteotomy	
3	48673	32	M	R	RTA	C1	Closed	ORIF with parallel plating	Olecranon osteotomy	
4	47635	45	F	R	RTA	C3	Closed	ORIF with parallel plating	Olecranon osteotomy	
5	63881	24	M	L	RTA	C1	Closed	ORIF with parallel plating	Olecranon osteotomy	Preoperative ulnar N palsy
										Head injury

6	15215	35	M	R	Fall from height	C2	Grade II	ORF with parallel plating	Olecranon osteotomy	Right superior and inferior pubic rami #
7	14598	20	M	L	RTA	C2	Closed	ORIF with parallel plating	Olecranon osteotomy	
8	26928	54	M	R	Assault	C2	closed	ORIF with parallel plating	Olecranon osteotomy	Uina fracture on the opposite side
9	63021	53	M	L	RTA	C3	closed	ORIF with parallel plating	Olecranon osteotomy	
10	63426	45	M	R	RTA	C2	Closed	ORIF with parallel plating	Olecranon osteotomy	
11	57519	23	M	R	RTA	C2	closed	ORIF with parallel plating	Olecranon osteotomy	
12	43548	29	M	L	Fall from height	C1	closed	ORIF with parallel plating	Olecranon osteotomy	
13	41213	38	F	R	RTA	C2	closed	ORIF with parallel plating	Olecranon osteotomy	Distal radius #R
14	92561	24	M	R	RTA	C1	closed	ORIF with parallel plating	Olecranon osteotomy	
15	68642	32	M	L	RTA	A3	Grade I	ORIF with parallel plating	Olecranon osteotomy	Metatarsal # R foot
16	66478	52	F	R	RTA	C1	closed	ORIF with parallel plating	Olecranon osteotomy	Shaft of femur #R

Table 2 . Post operative outcomes and surgical data on Patients who underwent ORIF by Olecranon Osteotomy approach

No	Extension in degrees	Flexion in degrees	ROM in degrees	VAS score	MEPI rating	MEPS	Complications	Duration of surgery in mins	Length of incision in cm	Blood loss in ml	Implant removal	Time of follow up in months	Time of union in weeks
1	10	135	10-135	2	Excellent	95	Hardware prominence	150	10	150	Yes	16	10
2	10	125	10-125	3	Good	85	Parasthesia of ulnar N sensory area	120	12	200	No	7	10
3	10	130	10-130	0	Excellent	95	None	150	12	180	No	8	12
4	10	110	10-	2	Good	85	None	18	12	200	No	6	14

			110					0					
5	30	95	30-95	3	Fair	70	1. Decreased elbow ROM due to Hetero-topic ossification	150	10	120	No	6	15
							2.Only partial recovery of ulnar nerve after 1 year						
6	10	110	10-110	0	Good	80	None	180	10	150	No	6	10
7	20	130	20-130	0	Excellent	95	None	180	12	120	No	10	18
8	10	120	10-120	0	Good	90	None	200	10	150	No	8	17
9	20	100	20-100	3	fair	70	latrogenic Radial N neuropraxia which recovered in 3 months	180	12	150	No	6	16
10	10	120	10-120	1	good	85	Hardware prominence	150	10	100	Yes	10	12
11	20	90	20-90	6	Fair	65	Stiffness the elbow	200	12	120	No	12	14
12	10	140	10-140	0	Excellent	90	None	180	10	100	No	6	10
13	20	130	20-130	3	Good	90	None	150	10	150	No	8	14
14	10	120	10-120	2	Good	85	None	120	10	100	No	6	10
15	10	110	10-110	2	good	80	None	180	10	150	No	8	12
16	10	130	10-130	2	Good	85	None	150	10	80	No	12	10

Table 3. Demographic data on Patients who underwent ORIF by triceps sparing approach

No	Age	Sex	Side	Mode of injury	AO type	Grade	Treatment	Approach	Associated injuries
17	26	M	R	RTA	A3	Closed	ORIF with parallel plating	Triceps sparing	None
18	23	M	L	RTA	A2	Grade I	ORIF with parallel plating	Triceps sparing	None
19	22	M	I	Fall from height	A2	Grade II	ORIF with parallel plating & Bone grafting	Triceps sparing	None
20	41	M	L	RTA	C1	Grade I	ORE with parallel plating	Triceps sparing	None
21	36	M	R	RTA	C2	Grade II	Primary ORIF with parallel plating SSG for soft tissue defect after debridement	Triceps sparing	None
22	65	F	R	Self Fall	C3	Closed	ORIF with parallel plating	Triceps sparing	Left Femur IT #
23	55	F	L	Self Fall	C1	closed	ORIF with parallel plating	Triceps sparing	None
24	46	F	R	Assault	C1	closed	ORF with parallel plating	triceps sparing	None

Table 4 . Post operative outcomes and surgical data on Patients who underwent ORIF by triceps sparing approach

No	Extension in degrees	Flexion in degrees	ROM in degrees	VAS score	MEPI rating	MEPS	Complication	Surgery time in mins	Length of incision in cm	Blood loss in ml	Implant removal	Time of follow up in months	Time of union in weeks
17	20	90	20-90	3	good	84		120	8	150	No	13	12
18	0	120	0-120	0	Excellent	80	Superficial infection settled with antibiotics for 3 weeks	180	8	100	Yes	8	14
19	10	135	10-135	2	Excellent	75	Superficial infection settled with antibiotics for 3 weeks	120	8	100	No	9	13

20	20	120	20-120	0	Good	80		150	8	180	No	6	13
21	30	90	30-90	5	poor	55	Compound injury with laceration over distal arm. Wound necrosis for which abdominal flap cover is done. Delayed union and elbow stiffness	180	10	120	Yes	7	15
22	20	100	20-100	2	fair	75	Superficial infection settled after debridement and SSG for raw area	120	10	120	No	10	12
23	20	90	20-90	5	fair	70	Stiffness at elbow	150	8	100	Yes	14	11
24	20	140	20-140	2	Excellent	70	Parasthesia in Ulnar sensory area	150	8	120	No	9	

Results

Radiographic union was achieved at the fracture' site in 100% patients in both groups. There was one case of non union at the osteotomy site which was managed by revision osteosynthesis with tension band wiring and which finally attained union. The average follow up was 13 months (range 6-18 months). The average time from surgery to radiographic union was 12.81 weeks (12.87 weeks for non osteotomy, 12.75 weeks for olecranon osteotomy, range 10-18 weeks). Average operating time was 151.16 minutes (153.75 mins for without osteotomy and 163.75 mins for olecranon osteotomy). Range of movement measurements obtained from the most recent clinical follow up was a mean flexion extension arc of 107 degrees. The mean MEPS score was 80.7 (73.625 for non osteotomy and 84.062 for olecranon osteotomy). The functional outcomes were excellent (MEPS>90) for 6 elbows(6 out of 16 for olecranon osteotomy and 0 of 8 for non osteotomy), good (MEPS 75-89) for 12 elbows (7 of 16 patients for olecranon osteotomy and 5 of 8 patients without osteotomy), fair (MEPS> 60-74) for 5 patients (3 of 16 olecranon osteotomy patients and 2 of 8 triceps non osteotomy patients) and poor (MEPS<60) for 1 patient in the non Osteotomy group.

Results regarding Mean Flexion deformity, Visual Analogue Score for pain, MEPS score, duration of surgery, length of incision and time to union are elaborated in the following tables. The length of incision and time to union analyses yielded p values > 0.05 and not statistically significant. All other analyses were statistically significant.

Stiffness was noted in 2 of 8 patients undergoing non osteotomy approach and 1 of 16 patients from the osteotomy group. Heterotopic ossification with reduced elbow range of movements was noted in 1 patient from the osteotomy group who had concomitant head injury. 3 of 8 patients treated by non osteotomy approach developed infection in the post operative period while none of the 16 patients treated by olecranon osteotomy developed infection. 2 patients in the osteotomy group developed transient iatrogenic neurological sequelae with ulnar nerve neuropraxia and associated parasthesias and sensory deficits over the sensory distribution of the nerve. 1 patient in the non osteotomy group developed ulnar and radial nerve neuropraxia with the radial nerve showing spontaneous recovery but the ulnar nerve requiring anterior transposition after 12 weeks and the patient ultimately having permanent neurologic

sequelae with only partial recovery after 8 months. 2 of the 16 patients treated by the osteotomy approach complained and had hardware prominence related to the osteotomy fixation.

3 of 8 patients treated by non osteotomy approach developed superficial infection in the post operative period while none of the 16 patients treated by olecranon osteotomy developed infection. 2 of these 3 patients were treated conservatively with antibiotics for three weeks and this proved curative. For the remaining patient debridement was performed and a split skin graft performed for the subsequent raw area. One patient who had an initially compound injury developed wound necrosis which warranted wound debridement and final closure

with an abdominal flap cover. This patient suffered from delayed union, stiffness and an ultimately poor outcome.

Table 5: t Test 2 sample assuming equal variances for Flexion Deformity

	Olecranon Osteotomy	Triceps Sparing Approach
Mean	13.75 degrees	17.5 degrees
Variance	38.33333333	78.57142857
Observations	16	8
Pooled Variance	51.13636364	
Hypothesized Mean Difference	0	
df	22	
t Stat	-1.211060142	
P(T<=t) one-tail	0.119360887	
t Critical one-tail	1.717144374	
P(T<=t) two-tail	0.0238721773	
t Critical two-tail	2.073873068	

Table 6: t Test 2 sample assuming equal variances for VAS Score

	Olecranon Osteotomy	Triceps Sparing Approach
Mean	1.8125	2.375
Variance	2.695833333	3.696428571
Observations	16	8
Pooled Variance	3.014204545	
Hypothesized Mean Difference	0	
df	22	
t Stat	-0.748230712	
P(T<=t) one-tail	0.231122749	
t Critical one-tail	1.717144374	
P(T<=t) two-tail	0.0462245497	
t Critical two-tail	2.073873068	

Table 7: t Test 2 sample assuming equal variances for Mayo Elbow Performance Score

	Olecranon Osteotomy	Triceps Sparing
Mean	84.0625	73.625
Variance	84.0625	80.8392857
Observations	16	8
Pooled Variance	83.0369318	
Hypothesized Mean Difference	0	
df	22	
t Stat	2.6452103	
P(T<=t) one-tail	0.0073917	
t Critical one-tail	1.71714437	
P(T<=t) two-tail	0.0147834	
t Critical two-tail	2.07387307	

Table 8: t Test 2 sample assuming equal variances for duration of surgery

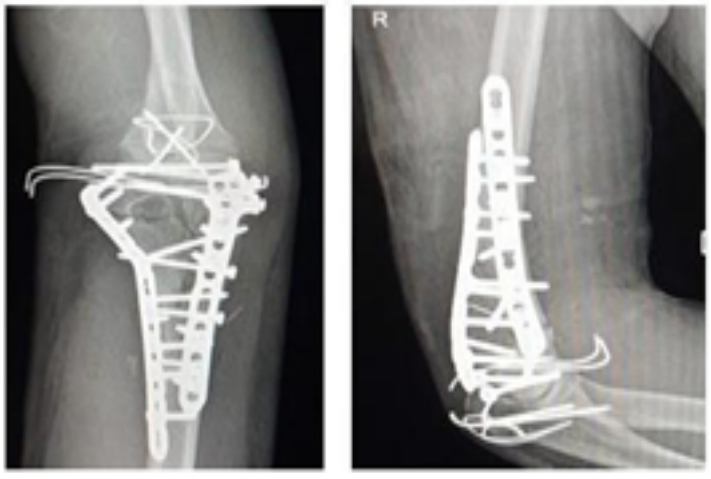
	Olecranon Osteotomy	Triceps Sparing
Mean	163.75 minutes	153.75 minutes
Variance	611.666667	1655.35714
Observations	16	8
Pooled Variance	943.75	
Hypothesized Mean Difference	0	
df	22	
t Stat	0.75174558	
P(T<=t) one-tail	0.23008571	
t Critical one-tail	1.71714437	
P(T<=t) two-tail	0.046017141	
t Critical two-tail	2.07387307	

Table 9: t Test 2 sample assuming equal variances for length of incision

	Olecranon Osteotomy	Triceps Sparing
Mean	10.75	8.5
Variance	1	0.85714286
Observations	16	8
Pooled Variance	0.95454545	
Hypothesized Mean Difference	0	
df	22	
t Stat	5.31843156	
P(T<=t) one-tail	1.2227E-05	
t Critical one-tail	1.71714437	
P(T<=t) two-tail	2.4453E-05	
t Critical two-tail	2.07387307	

Table 10: t Test 2 sample assuming equal variances for time to union

	Olecranon Osteotomy	Triceps Sparing
Mean	12.75	12.875
Variance	7.53333333	1.55357143
Observations	16	8
Pooled Variance	5.63068182	
Hypothesized Mean Difference	0	
df	22	
t Stat	-0.1216547	
P(T<=t) one-tail	0.45213843	
t Critical one-tail	1.71714437	
P(T<=t) two-tail	0.90427687	
t Critical two-tail	2.07387307	



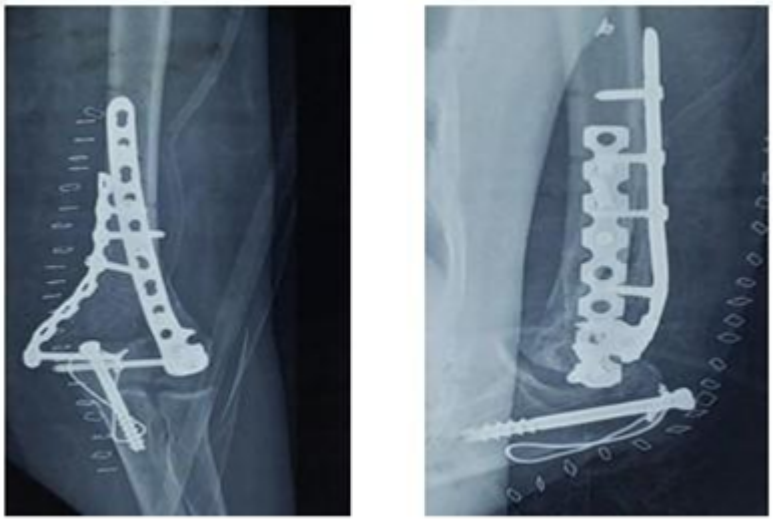


Figure 3. Post Operative radiographs of the case examples demonstrated in figure 2.

Discussion

Fractures of the distal humerus may directly affect the functional movement of elbow especially intercondylar (intra-articular) fracture. The relationship of the radio-humeral joint and ulnohumeral joints must be perfect for a good functional outcome.

Fracture configuration according to the OTA type had a significant bearing on the outcome in distal humerus patients treated surgically. Group C had a poorer outcome than group A patients. This has again stressed the importance and prognostic significance of the OTA classification. Study by Sanchez-Sotelo et al [22] revealed that the commonest fracture type was OTA class A and C which our study concurs it is also important to stress on the fact that incidence of type C fractures is more than the type A fractures suggesting that the incidence of high velocity injuries is on the rise.

The restoration of elbow function is dependent on three salient features: exposure, fixation and the post-operative rehabilitation, with later two are of primary consideration. Adequate exposure is necessary for visualization fixation of the fracture fragments. The optimal exposure is provided by the posterior approach with oste otomy of the olecranon.

Olecranon osteotomy was done in 16 of our cases. ten of them were fixed with modified TBW with K wires and 6 of our cases were fixed with cancellous screws with TBW. This allowed us complete examination of the articular surfaces of trochlea, capitellum, olecranon and radial head. It also gives access to the medial and lateral supracondylar ridges. Full evaluation of the fragments of the fracture and reduction can then be performed. Although non- union of the osteotomy may be regarded as a potential complication of this exposure, TBW of the osteotomy has provided sufficient stability of the olecranon for immediate use of the elbow through a secure range of motion. Only one case in our 16 osteotomized elbows showed a non-union which united with revision osteosynthesis with modified TBW.

24 cases in our study were operated with parallel and orthogonal plating. The former provided stable fixation and stability for early mobilisation .The lateral plate placement directly on the lateral column allows for lengthy screw placement which is limited in traditional orthogonal plating due the fear anterior capitellar breach in the same. Since we use the 3.5mm reconstruction plates, it allows for easy contourability for both column fixation. The previous concept of using the more malleable 1/3 tubular plate for the medial column which

requires heavy contouring is now in question and several authors recommend at least a stronger 3.5mm plates or precontoured plates for both columns to achieve a more stable rigid construct to allow for early mobilization.In our study we have not met any implant failures or non-union at the fracture site which is on par with the fact that parallel plating offers a inherently stable construct in a given clinical situation and in concurrence with studies done on parallel plating by Sanchez-Sotelo et al 22 and Atalar et al [23].

Sanchez-Sotelo et al [22] describes complication rates of 43% which included wound-healing complications (6%), deep infection (3%), nonunion (3%),heterotopic ossification (16%),Osteonecrosis 1 (3%),Posttraumatic arthritis 2 (6%) Permanent ulnar neuropathy (6%). Gofton et al reported a complication rate of 48%, which included heterotopic ossification(17%), olecranon

nonunion(9%), and infection (9%). Atalar et al 24 showed a complication rate of 48% in their study group of 21 patients.The other previously referenced studies reported complication rates of 11% to 29% [24, 25]. In the recently published retrospective series of Athwal et al.25 assessing the Mayo Elbow parallel plate technique, they noted a complication rate of 53 percent, with complications arising in 17 of 32 patients. Our study showed a similar complication rate of 41 % which is concurrent with the international literature which included infection (12.5%), heterotopic ossification (8.3%), Nonunion at osteotomy (4%),permanent ulnar neuropathy(4%),stiffness with pain excluding myositis and infection(8.3%),hard ware prominence(4%).

Iatrogenic nerve complications were noted in 4 patients(16.6%) in our study. Post-operative ulnar nerve paraesthesia was observed in 3 patients. These paraesthesia were transient and all of them recovered without any particular treatment within 2 months post op. Medial plates or ulnar nerve handling may be a reason for this. One patient had both sensorimotor involvement of the ulnar nerve and radial nerve with neuropraxia postoperatively. Initially the patient was treated conservatively when he showed recovery of only the radial nerve symptoms. Anterior transposition of the ulnar nerve was done at the end of three months. He showed a partial recovery of the ulnar nerve function at the last follow up. Ulnar neuropathy can occur during the initial injury or iatrogenically during surgical fixation. The rate of ulnar neuropathy following ORIF of distal humerus fractures has been reported as being between zero and 12% in the previously described studies [13,25]

McKee et al reported on 20 patients with ulnar neuropathy following failed elbow reconstruction; they found mostly good to excellent recovery from ulnar neuropathy when they performed neurolysis and transposition of the nerve. Bony union took an average of 13.4 weeks in our study which is comparable to 12 weeks obtained by Sanchez-Sotelo et al [46]. All patients had bony union at end of the study period, except for the one patient with deep infection had a delayed union.

Atalar et al [47] had a mayo elbow score of 86 with 85% good to excellent results in his series (flexion –extension 120°). Sanchez-Sotelo et al [50] showed an average MEPI score of 85 (flexion –extension 99 deg) with 83% good to excellent results in his series. Athwal et al 48 in his recently published retrospective review of AO/OTA type C fractures treated with the Precontoured parallel plates. In their series of 32 patients, the mean elbow arc of motion was 97 degrees. The mean Mayo Elbow Performance score was 82 points. Our study group had an average Mayo elbow score of 80.6(flexion extension arc of 107 deg) which was comparable to the previous studies and shows that parallel plating can produce consistently good to excellent functional outcomes in management of these complex injuries.

A systematic review and meta-analysis conducted by Chen et al compared various surgical approaches on elbow functional outcomes for patients with distal humerus fractures [53]. They concluded olecranon osteotomy was superior than triceps sparing approach in restoring joint function (OR: 2.38; P = 0.009). Our analysis suggested the incidence of excellent/good elbow function might increase for patients treated with olecranon osteotomy. Also, potential harmful effects of olecranon osteotomy on operation time, blood loss, and complications have to be evaluated. The shortcomings of our study include the relatively small sample size and lack of longer term follow up.

Overall fractures of the distal humerus can be devastating injuries posing a significant challenge even to the most experienced treating orthopedist. Advances in physical rehabilitation and implants in the future along with a more vigorous team based approach may help to reduce the incidence of complications in the future.

Table 4: Comparison with similar studies in the literature

	Our study	***Sanchez-Sotelo et al[22]***	***Atalar et al [24]***
Number of elbows	24	32	21
Mean Age	38 yrs	58 yrs	47 yrs
M:F ratio	3:1	1.4:1	2:1
Mean Follow up	12 months	24 months	28 months
Fracture types AO	A2=1, A3 = 4, C1 =9, C2 = 7, C3= 3	A3 = 3, C2 = 4, C3 = 25	C1 = 3, C2 = 6, C3 = 12
Open injuries	7(29%)	13(41%)	8(38%)
Major mode of violence	RTA	Fall	Not specified
Bony union	12.7 weeks	12 weeks	Not specified
Complication rate	41%	43%	48%

Resurgeries	Wound debridement /coverage (2), Revision osteosynthesis at Osteotomy (1),Anterior transposition of ulnar Nerve (1)	Wound débridement or coverage (4), bone-grafting (1), HO removal (4), distraction. arthroplasty (1), triceps reconstruction (1)	Wound débridement (1), HO removal (2), Stiffness (2), Osteotomy site Implant removal (5)
Ulnar Neuropath	4(16.6%)	6(18.75%)	Nil
Mean Arc of motion	107°	99°	90.2±31.1°
MEPS	81	85	86.1±12.6°

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