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A prospective study to evaluate the functional outcome in intra-articular distal humerus fractures treated by dual plating

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Abstract
Introduction: In adults, distal humerus fractures are uncommon and intra-articular, often involve both the medial and lateral columns1. Distal humerus fractures account for one-third of all elbow injuries. The fractures are usually complex, involve intra-articular surface, in our study Double plate fixation is considered the correct treatment for a comminuted intra-articular fracture of the distal humerus. The objective of this study was to evaluate the clinical outcome in intra articular distal humerus fractures treated surgically with dual plates.
Material Methods: prospective study was conducted in our hospital SRMS IMS Bhojipura Bareilly for a period of 18 months between November 2019 to April 2021. We studied 12 patients with distal humerus intercondylar fracture, included in study as per inclusion criteria treated surgically with dual plating. All the patients aged between 18 to 60 years.
Results: Mean age of the patient was 41 +/- 13.39 years 7 cases were male and rest were female left sided involvement was more frequent in the present study 7 (58.3%) percent. 9 (75%) cases sustained fracture due to RTA followed by 3 cases due to fall from height According to AO classification, 13-C1, 13-C2 and 13-C3 fracture was reported among 41.7%, 41.7% and 16.7% of the subjects respectively. After 24 weeks of surgery, out of 5 subjects with 13-C1; good and excellent outcome was reported in 1 and 4 subjects respectively, while out of 5 subjects with 13-C2, good and excellent outcome was reported in 2 and 3 subjects respectively. All the subjects with 13-C3 fracture had fair outcome Out of total, 66.7% of subjects undergo open reduction and internal fixation of distal humerus with olecranon osteotomy whereas 33.3% subjects undergo surgery with para – tricepital approach After 24 weeks of surgery, out of 8 subjects with olecranon osteotomy; fair and excellent outcome was reported in 2 and 6 subjects respectively, while out of 4 subjects with para-tricepital approach; good and excellent outcome was found in 3 and 1 subjects respectively average duration of operative time was 117.35 +/- 4.93 minutes. Average duration of radiological union was 15 +\- 2.83 week, outcome was calculated using Mayo elbow performance score (MEPS) showed excellent in 58.3%(7) good in 16.7% (2) and in 25% (3) with no poor outcome.
Conclusion: Our study supports the use of dual locking plate fixation as an effective modality in treating intra-articular distal humeral fractures. It addresses the difficulties encountered while managing these fractures and provides a stable fixation with predictable and satisfactory results and an early return to function.

Keywords: Dual plating intraarticular fracture

Introduction
In adults, distal humerus fractures are uncommon and intra-articular, often involve both the medial and lateral columns [1]. Distal humerus fractures account for one-third of all elbow injuries. The fractures are usually complex, involve intra-articular surface. Non-operative management of these fractures may lead to either a pseudo-arthrosis with gross instability or a painful stiff elbow [2]. Distal humerus fractures in adults amount to 2 to 6% of all fractures and 30% of all elbow fractures. Distal humerus fractures occur in the younger age group secondarily to high energy trauma, and in elderly woman as a result of relatively low energy trauma [9]. There is a bimodal distribution with respect to the patients age and gender.

Peaks of incidence were described in males age 12 to 19 years and in females age 80 and older3. Low velocity injuries, are simple domestic falls in middle-aged and elderly females, in which the elbow is either struck directly or axially loaded, in a fall onto the outstretched hand. Road-traffic accidents (RTA), and sport injuries, are more common cause of high velocity injury, in younger males. These patients, often have open fractures and other injuries, (17% other orthopaedic injuries and 5%multisystem injuries). These, young population when injured, adds to the socio-economical burden upon the community. Several classification systems for intra-articular both column fractures of the distal humerus have been proposed. Divergent medial and lateral columns of bone support the distal humeral articular surface in an inverted-Y configuration. The traditional classification of distal humerus fractures has centered around the terminal ends, in the condyles of the humerus. The Orthopaedic Trauma Association's alpha-numeric system 3, assigned three main types: Type A (extra-articular), Type B (partial articular), and Type C (complete articular). The latest generation precontoured anatomical low compression locking distal humerus plate system allows angular stable and rigid fixation of intraarticular distal humerus fractures. These specially designed plating system for distal humerus provide better biomechanical properties and enhanced anchorage in these complex, unstable & more challenging injuries. Due to these advantages, early mobilization and aggressive functional rehabilitation is possible and functional outcome might be improved5. Double plate fixation is considered the correct treatment for a comminuted intra-articular fracture of the distal humerus. Articular fractures of the distal humerus in adults are difficult to treat because of their epiphyseal location. The objective of this study was to evaluate the clinical outcome in intra articular distal humerus fractures treated surgically with dual plates.

Material and Methods

Prospective observational study was conducted with 12 cases in Department of Orthopaedic surgery of SRMS-IMS, Bareilly for a period of 18 months from November 2019 to April 2021 among the patients having Intra-Articular Distal Humerus Fracture after obtaining approval from Hospital Ethics Committee. Written informed consent was taken from the patients before including them in the study.

Inclusion criteria

Patients having fracture distal humerus treated by dual plating:

1. Patients of age> 18 years to less than 60 years
2. Open fracture gustilo – Anderson grade 1
3. Closed fracture less than 12 days old
4. Intra articular distal humerus fracture

Exclusion Criteria

1. Age less than 18 years and more than 60 years
2. Open fracture gustilo anderson grade 2 and 3
3. Patients with pathological fractures (except osteoporosis)
4. Patients having extraarticular fractures.
5. Polytrauma patients
6. Fracture with distal neuro vascular compromise
7. Fracture with associated compartment syndrome
8. Patient not giving

Fractures are classified according to the AO classification and was operated within 24 hrs or 5-7 days till the swelling subsides. Preoperative evaluation includes assessment of general health and a thorough assessment of neurovascular status of the upper extremity. Radiographic evaluation includes antero-posterior and lateral views and CT scan if required) of the elbow. All these patients were reviewed at six weeks, 16 weeks, and 24 weeks. At each assessment we performed a clinical and radiological examination. Functional outcome was reviewed according to Mayo Elbow Performance Score (MEPS). Radiological union was assessed by visualizing callus formation Complications *viz*. superficial infections infection, delayed wound healing elbow stiffness, traisent ulnar verve neuropraxy, heterotrophic ossification hardware prominence, click sound during movement, screw loosening were recorded.

Statistical analysis: Under the supervision of a statistician, the data was tallied in an excel sheet. For statistical analysis, the means and standard deviations of the measurements per group were employed (SPSS 22.00 for windows; SPSS inc, Chicago, USA). Data were statistically examined using one way ANOVA for each assessment point. The chi square test was used to measure the difference between two groups, and the level of significance was chosen at p 0.05.

Surgical technique

In our study we used 2 kinds of surgical techniques were used that is olecranon osteotomy and para tricepital approach

Post op care: Patients are placed in well padded above elbow plaster and encouraged to keep the arm elevated to minimize swelling active hand range of motion started immediately drain is removed 3 days after surgery, elbow range of motion started between day 2 and day 7 post-op depending on incision generally active assisted and active range of motion are encouraged At 2 weeks the stitches were removed and the wound examined and any complication was reported and treated accordingly. The posterior plaster splint may be replaced with a removable splint and ranges of motion exercises are to be started

Case 1

Pre-op x-ray Post-op x-ray Radiological union

Radiographic evaluation

Case 2

Pre-op x-ray Post-op X-Ray

Radiological union

Case 3.

Flexion Extension

PT NO.- 21394667
Diagnosis- Intra –articular distal humerus fracture right side
Treatment – ORIF with Orthogonal Plating using olecranon osteotomy
Movement – At Right Elbow Joint

Extension Flexion

PT. No- 4205455
Diagnosis - Intra –articular distal humerus fracture right side
Treatment – ORIF with Orthogonal Plating using olecranon osteotomy
Movement – At Right Elbow Joint

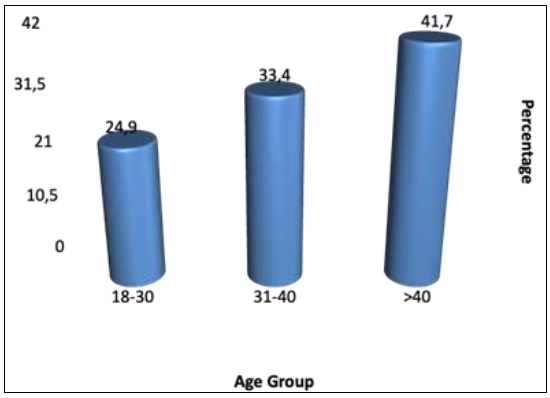
Results

The present study was conducted in the Department of Orthopaedics of SRMS-IMS, among 12 subjects suffering from Intra-Articular Distal Humerus Fracture after obtaining approval from Hospital Ethics Committee. Written informed consent was taken from the patients before including them in the study. The current study was conducted to evaluate the functional outcome in form of radiological union and post operative complications in intra articular distal humerus fractures treated by dual locking plate fixation.

Table 1: Age distribution among the study subjects

Age Group (in years)	N	Percent
18-30	3	24.9
31-40	4	33.4
>40	5	41.7
Mean±SD	41±13.39	

Table 1, graph 1 describes the age group wise distribution among the study subjects. The proportion of >40-years age group (41.7%) was maximum and 18–30-year age group (24.9%) was the least. The mean±SD age of the study subjects was 41±13.39 years.

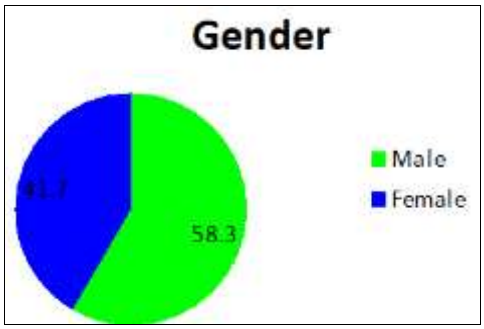


Graph 1: Age distribution among the study subjects

Table 2: Gender distribution among the study subjects

Gender	N	Percent
Male	7	58.3
Female	5	41.7
Total	12	100

Table 2, graph 2 describes the gender distribution among the study subjects. The proportion of male subjects (58.3%) was higher than female subjects (41.7%).

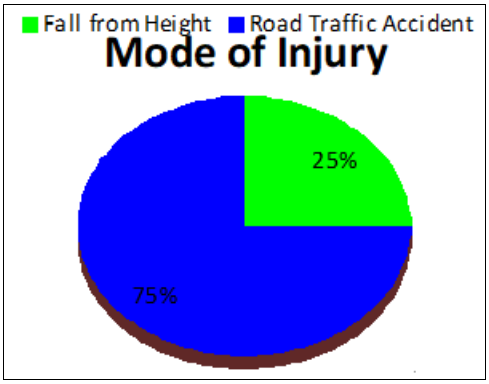


Graph 2: Gender distribution among the study subjects

Table 3: Mode of injury among the study groups

Mode of Injury	N	Percent
Fall from Height	3	25
Road Traffic Accident	9	75
Total	12	100

Table 3, graph 3 describes the mode of injury among the study subjects. 75% had a road traffic accident whereas rest of subjects had a fall from height.

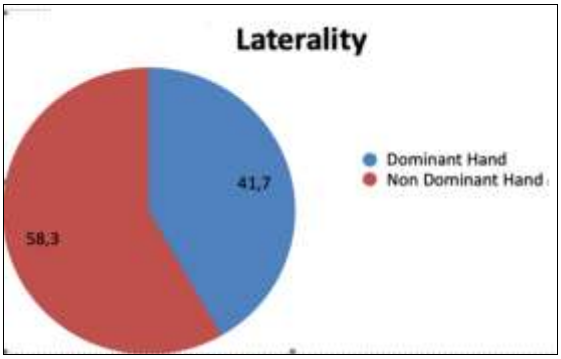


Graph 3: Mode of injury among the study groups

Table 4: Distribution of samples by laterality of fractures

Laterality	N	Percent
Dominant Hand	5	41.7
Non Dominant Hand	7	58.3
Total	12	100

Table 4, graph 4 describes the distribution of subjects according to laterality of fractures. Out of total, 58.3% had a fracture on non dominant hand whereas rest of subjects had fracture on the dominant side (41.7%).

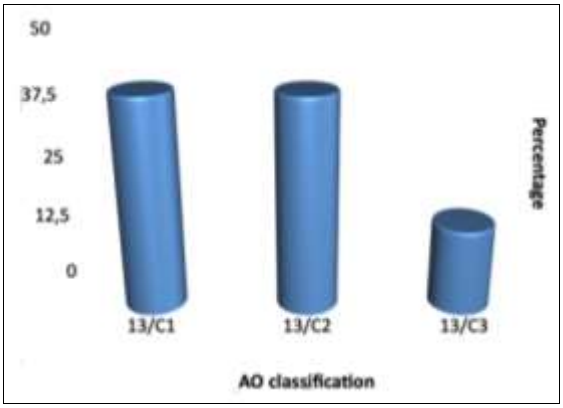


Graph 4: Distribution of samples by laterality of fractures

Table 5: Distribution of subjects according to AO classification

AO Classification	N	%	MEPS (24 Weeks)					
			Fair		Good		Excellent	
			N	%	N	%	N	%
13-C1	5	41.7	0	0	1	20	4	80
13-C2	5	41.7	0	0	2	40	3	60
13-C3	2	16.7	2	100	0	0	0	0
Total	12	100						
Chi Square			12.57					
p value			0.014*					

According to AO classification, 13-C1, 13-C2 and 13-C3 fracture was reported among 41.7%, 41.7% and 16.7% of the subjects respectively. After 24 weeks of surgery, out of 5 subjects with 13-C1; good and excellent outcome was reported in 1 and 4 subjects respectively, while out of 5 subjects with 13-C2, good and excellent outcome was reported in 2 and 3 subjects respectively. All the subjects with 13-C3 fracture had fair outcome.



Graph 5: Distribution of subjects according to AO classification

Table 6: Days since operation

Variables	Value
Minimum	3
Maximum	11
Mean	7.67
SD	3.03

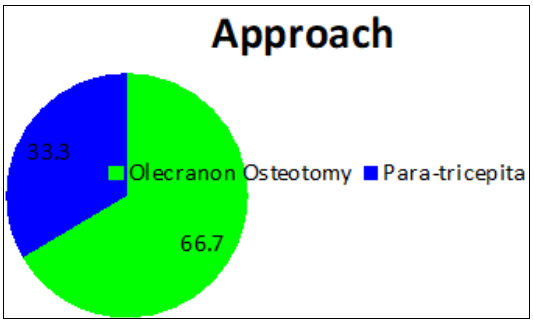
Mean days since operation was 7.67±3.03 days (table 6).

Table 7: Approach and their outcome

Approach	N	%	MEPS (24 Weeks)					
			Fair		Good		Excellent	
			N	%	N	%	N	%
Olecranon Osteotomy	8	66.7	2	25	0	0	6	75
Para-tricepital	4	33.3	0	0	3	75	1	24
Total	12	100						
Chi Square			8.14					
p value			0.02*					

*: statistically significant

Table 7, graph 6 describes the distribution of study subjects according to the surgical approach. Out of total, 66.7% of subjects undergo open reduction and internal fixation of distal humerus with olecranon osteotomy whereas 33.3% subjects undergo surgery with para-tricepital approach. After 24 weeks of surgery, out of 8 subjects with olecranon osteotomy; fair and excellent outcome was reported in 2 and 6 subjects respectively, while out of 4 subjects with para-tricepital approach; good and excellent outcome was found in 3 and 1 subjects respectively.



Graph 6: Approach

Table 8: Operative Time (in minutes) among the study subjects

Parameters	Mean	SD
Operative Time (in minutes)	117.35	4.93

Table 8, shows the mean±SD operative time (minutes) to carry out the surgery in study subjects was 117.35±4.93 minutes.

Table 9: Hospital Stay (in days) among the study subjects

Parameters	Mean	SD
Hospital Stay	8.92	1.44

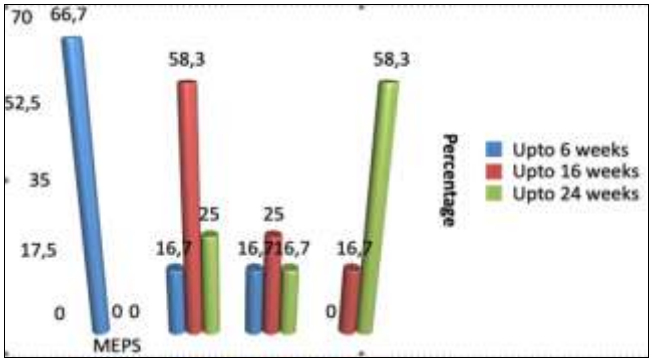
Table 9, shows the mean±SD hospital stay (days) was 8.92±1.44 days for study subjects.

Table 10: Functional outcome at different intervals using MEPS

MEPS	Upto 6 weeks		Upto 16 weeks		Upto 24 weeks		p value
	N	%	N	%	N	%	
Excellent	0	0	2	16.7	7	58.3	0.003*
Good	2	16.7	3	25	2	16.7	
Fair	2	16.7	7	58.3	3	25	
Poor	8	66.7	0	0	0	0	

*: statistically significant

Table 10, graph 7 describes the functional outcome at different time intervals using MEPS. It was observed that up to 6 weeks' time interval, MEPS grading was poor in 66.7% subjects, whereas up to 16 weeks' time interval MEPS grading was fair among 58.3% subjects and up to 24 weeks' time interval MEPS grading was excellent among 58.3% subjects. The variation of MEPS grading at various time interval was found to be statistically significant (p=0.003).



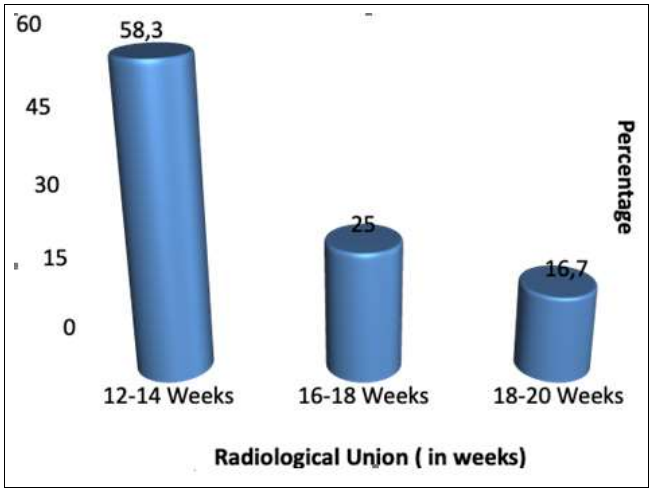
Graph 7: Functional outcome at different intervals using MEPS

Table 11: Radiological union among the study subjects

Radiological Union (in Weeks)	N	%	p value
12-14 Weeks	7	58.3	0.021*
16-18 Weeks	3	25	
18-20 Weeks	2	16.7	
Mean±SD	15±2.83		

*: statistically significant

Table 11, graph 8 shows the distribution of subjects according to time taken for radiological union. Out of total, in 58.3% of subjects radiographic union was seen at 12-14 weeks' time interval and in 16.7% of subjects radiographic union was seen at 18-20 weeks' time interval. The mean± SD time taken for radiological union among the subjects was 15±2.83 weeks.

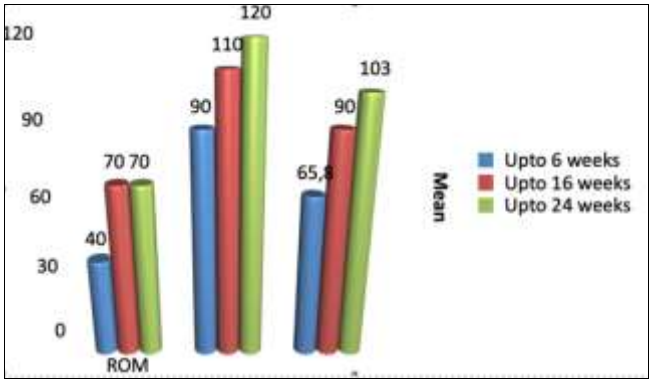


Graph 8: Radiological union among the study subjects

Table 12: Mean comparison of ROM at different intervals

Intervals	Minimum	Maximum	Mean	SD	Anova Test	p value
Upto 6 weeks	40.00	90.00	65.83	14.89	11.98	<0.01*
Upto 16 weeks	70.00	110.00	90.0	12.61		
Upto 24 weeks	70.00	120.00	102.50	15.88		

*: statistically significant The mean ROM upto 6 weeks, upto 16 weeks and upto 24 weeks was 65.83±14.89, 90±12.61 and 102.50±15.88 respectively with statistically significant difference as $p<0.01$ (table 12, graph 9).

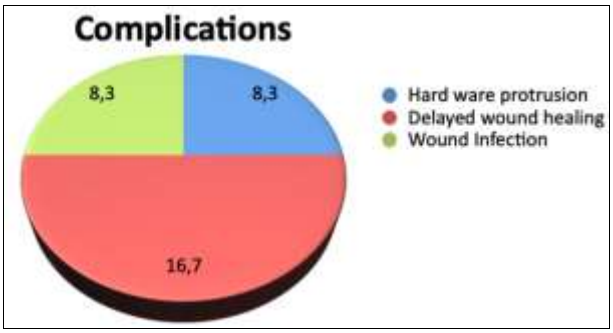


Graph 9: Mean comparison of ROM at different intervals

Table 13: Complications among the study subjects

Complications	N	%	p value
Hard ware protrusion	1	8.3	0.64
Delayed wound healing	2	16.7	
Wound Infection	1	8.3	

Table 13, graph 10 shows the post-operative complications among the study subjects. Out of total subjects, one subject had wound infection; one subject had hardware protrusion whereas 2 subjects reported delayed wound healing.



Graph 10: Complications among the study subjects delayed wound healing that was treated with regular dressings and continuous monitoring, with surgical debridement in one case.

In a study by Kulkarni V *et al.* [25], problems related with the use of dual plating to treat intercondylar fractures of the distal humerus included superficial infection, deep infection, implant failure, ulnar nerve neuropathy, radial nerve neuropathy, and myositis ossificans. Infection is one of the most common consequences associated with distal humeral fractures. In distal humerus fractures, the rate of surgical site infections has been found to range between 3% and 12%. According to Sanchez-Sotelo *et al.* [61], wound-healing complications (6 percent), deep infection (3 percent), non-union (3 percent), heterotopic ossification (16 percent), osteonecrosis 1 (3 percent), posttraumatic arthritis 2 (6 percent), and permanent ulnar neuropathy were the most common complications (6 percent). Gofton *et al.* [81] colleagues reported a 48 percent complication rate, with heterotopic ossification (17 percent), olecranon non-union (9 percent), and infection among the most common (9 percent). According to Atalar *et al.* [66], there was a 48 percent complication rate. Although good functional results for distal humeral intra-articular fractures were reported in our investigation, the study's limitations include the lack of a control or comparison group and a limited sample size. A randomised control research on a large number of patients comparing dual locking plate fixation to alternative fixation techniques will throw further light on this subject.

Summary

After receiving approval from the Hospital Ethics Committee, the current study was undertaken in the Department of Orthopaedics of SRMS-IMS, Bareilly for a period of 18 months from November 2019 to April 2021 among patients with intra-articulardistal humerus fracture. Before the patients were included in the trial, they gave their written informed consent. The purpose of this study was to assess the functional outcome in the form of radiological union and post-operative complications in intra-articular distal humerus fractures treated with dual locking plate fixation. The study's findings are summarised as follows:

The proportion of male subjects (58.3%) was higher than female subjects (41.7%).

1. The mean±SD age of the study subjects was 41±13.39 years.
2. 75% had a road traffic accident whereas rest of subjects had a fall from height.
3. Out of total, 58.3% had a fracture on non dominant hand whereas rest of subjects had fracture on the dominant side (41.7%).
4. According to AO classification, 13-C1, 13-C2 and 13-C3 fracture was reported among 41.7%, 41.7% and 16.7% of the subjects respectively.
5. Out of total, 66.7% of subjects undergo open reduction and internal fixation of distal humerus with olecranon osteotomy whereas 33.3% subjects undergo surgery with para-tricepital approach.
6. After 24 weeks of surgery, out of 8 subjects with olecranon osteotomy; fair and excellent outcome was reported in 2 and 6 subjects respectively, while out of 4 subjects with para-tricepital approach; good and excellent outcome was found in 3 and 1 subjects respectively.
7. Mean±SD operative time (minutes) to carry out the surgery in study subjects was 117.35±4.93 minutes.
8. Mean±SD hospital stay (days) was 8.92±1.44 days for study subjects.
9. The variation of MEPS grading at various time interval was found to be statistically significant (p=0.003).
10. The mean±SD time taken for radiological union among the subjects was 15±2.83 weeks.
11. The mean ROM upto 6 weeks, upto 16 weeks and upto 24 weeks was 65.83±14.89, 90±12.61 and 102.50±15.88 respectively with statistically significant difference as $p<0.01$.
12. In the current study; one subject had wound infection, one subject had hardware protrusion whereas 2 subjects reported delayed wound healing.

Conclusion

The treatment of distal humerus fractures has always piqued orthopaedic doctors' interest. Significant damage to the distal humerus, regardless of the manner of therapy, usually results in some limitation of motion, discomfort, weakness, and even instability. Even modest abnormalities on the elbow's joint surface generally result in some loss of function. Early, accurate open reduction with sufficiently rigid fixation to allow immediate mobility can typically reduce this. In our study, distal humerus fractures were treated by dual locking plate fixation and following conclusion were made:

1. The proportion of male was higher than female.
2. Most of the subjects had injury due to road traffic accident.
3. There was approximately equal distribution of fractures on dominant and nondominant hand.
4. olecranon osteotomy technique was found to be better as compared to para-tricepital approach as due to reduction of articular surface under direct visualization
5. MEPS score improved at each interval, pointing towards better mobilization of elbow due to excellent fixation by dual locking plate.
6. There was no non-union and malunion cases reported in our study. Hence radiological union was achieved in all the subjects.

As a result, our findings support the use of dual locking plate fixation as a viable treatment option for intra-articular distal humeral fractures. It solves the challenges of managing these fractures by providing a secure fixation with predictable and satisfactory results, as well as a quick return to function.

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