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Dr. Ravikant Jain
MBBS, MS Orthopaedics, Professor and Head, Department of Orthopaedics, SAMC and PGI, Indore, Madhya Pradesh, India

Dr. Utkarsh Agrawal
MBBS, MS Orthopaedics, Senior Resident, Department of Orthopaedics, Samc and PGI, Indore, Madhya Pradesh, India

Dr. Vishal Singh Champawat
MBBS, MS Orthopaedics, Resident, Department of Orthopaedics, SAMC and PGI, Indore, Madhya Pradesh, India

Dr. Daksh Sharma
MBBS, MS Orthopaedics, Resident, Department of Orthopaedics, SAMC and PGI, Indore, Madhya Pradesh, India

Correspondence
Dr. Vishal Singh Champawat
MBBS, MS Orthopaedics, Resident, Department of Orthopaedics, SAMC and PGI, Indore, Madhya Pradesh, India

Pre-contoured locking plates vs. conventional reconstruction plates in AO type C distal humerus fractures: A prospective randomized study

Dr. Ravikant Jain, Dr. Utkarsh Agrawal, Dr. Vishal Singh Champawat and Dr. Daksh Sharma

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Abstract
Background: Reconstruction plates have been used from a long time for fixation of distal humerus fractures. Locking plates are increasingly used now-a-days. The aim of this study is to compare the radiological and functional outcome of AO Type C distal humerus fracture treated with pre-contoured locking plates and conventional reconstruction plates.
Material and Methods: A total of 25 patients of AO type C distal humerus fracture were enrolled for the study during 2016- 2018. Out of 25 patients, 14 were treated using locking plates and 11 were treated using reconstruction plates.
Patients were followed up at 2 weeks, 6 weeks, 3 months, 6 months and 12 months post operatively. Radiological assessment was done by follow-up X-rays at 3, 6 and 12 months. Mayo Elbow Performance Score was used for assessment of functional outcome at 3, 6 and 12 months post-operatively.
Results: The mean duration of surgery and hospital stay was similar in both the groups. The mean Range of motion and MEPS score was significantly higher in locking plate group as compared to conventional reconstruction plates at 3 months post operatively. However both of them were similar at 6 months and 12 months post operatively. 93% union rate in locking plate group and 9% union rate in reconstruction plate group were seen at the end of 12 months follow-up. Excellent and/or good results were obtained in 93% in locking plate group which is significantly higher than reconstruction plate group in which only 82% patients had excellent and/ or good results.
Conclusion: Locking plates has advantage over reconstruction plates in early mobility and greater functional outcome.

Keywords: Distal humerus fracture, AO type C, locking plates, reconstruction plates, meps score

Introduction
Fractures of distal humerus are relatively uncommon injuries and very challenging to manage. Approximately 7% of the adult fractures involve the elbow of which about 1/3rd involve the distal humerus [1, 2]. The proximity of neurovascular structures, the frequent occurrence of metaphyseal bone loss and significant comminution, and the unforgiving tendency of the elbow toward capsular stiffness and heterotopic ossification make these fractures often difficult to treat [3, 4].
The most common mechanism of injury are simple fall from standing height or Road traffic accident and the peak incidence is seen in the age group of 30-50 years. The overall incidence of distal humerus fracture is increasing, mimicking the increasing incidence of hip, proximal humerus and wrist fractures [5]. Historically, these injuries were treated by means of closed reduction and slinging (the so called "bag of bones" technique) because the results of open reduction and internal fixation were poor [6].
Given advances in the techniques of open reduction and internal fixation with the goal of anatomic restoration and early mobilization, the standard of care has shifted to open treatment of these injuries. The ultimate surgical goals are stable Facture fixation and mobile elbow [7]. Depending upon the severity of communition and displacement, open reduction and internal fixation with pre-contoured locking plates, reconstruction plates, cannulated cancellous screws (C.C. screws), kirschner wire and tension band wmng can be done.

The introduction of locking plate technology approximately a decade ago ushered in the latest advances for the management of distal humerus Factures, offering enhanced biomechanical properties and more robust fixation. One might suggest that standard non-locking screws, well-placed to maximize subchondral buttressing, might perform as well or better than locking screws placed through the factory preset trajectories which are often distant from and not parallel to the articulation of the distal humerus. Ultimately, the clinical benefits of locking plate fixation for distal humerus fractures are not known [8]. So the purpose of this study was to determine whether is there any *appreciable difference in fixation of intra-articular distal humerus fractures with non-locking and locking plates with regard to functional and radiographic outcomes*.

The aim of this study was to compare and evaluate the results of pre-contoured locking plates and conventional reconstruction plates in management of AO type C distal humerus fractures in adults with regard to Functional outcome usmg Mayo Elbow Performance Score (MEPS) and Radiological outcome in terms of rate of union.

Materials and Methods

This randomised prospective study was a comparative study of patients with intra-articular distal humerus fractures AO type C treated using either pre-contoured locking plates or conventional reconstruction plates. Fractures were classified using the AO/OTA classification system on the basis of preoperative X-rays, CT scans and intra-operative findings. A total of 25 patients (18 men and 7 women) were included in this study during a period of 30 months with a follow-up of 12 months. The patients were allocated randomly to either group. The baseline characteristics of the patients were compared and has been mentioned as in Table 1. The fracture excluded from this study were: a) open fractures, b) pathological fractures, c) fractures with neuro-vascular injury, d) associated fracture of ipsilateral upper limb.

All the fractures were treated with definitive open reduction and internal fixation (ORlF) within 3 days. For the surgical procedure, the patients were placed in the lateral position with the involved arm supported and forearm hanging allowing at least 90° flexion and an intravenous antibiotic was applied. In all patients, posterior approach was performed. Visualization of the fracture was done through Chevron osteotomy of the olecranon. The ulnar nerve was explored routinely; however, transposition was only performed in those patients where mechanical irritation at the ulnar plate was a concern. After temporary reduction and fixation with K-wires, osteosynthesis using either the pre-contoured locking compression plates or 3.5mm reconstruction plates were performed. Locking plates were used in 14 patients and reconstruction plates were used in 11 patients. For osteosynthesis of olecranon osteotomy, cannulated cancellous screws or K-wires were used along with Stainless Steel (SS) wire. The elbow was splinted in 90° flexion post-operatively and X-rays were done (Figure 1 and 2). Patients were instructed to keep the limb elevated and move their fingers. Intravenous antibiotics were continued till post-operative day 2. Suction drain was removed after 48 hours and wound inspection was done at 2nd and 5th post-operative day. Antibiotics and analgesics were given to the patient till the time of suture removal.

Sutures/staples were removed on the 12th postoperative day. Active elbow and shoulder range of motion exercises were started as per patient pain tolerance at the end of 2 weeks in case of rigid fixation. Mobilization was delayed as long as 4 weeks in case of less rigid fixation. At that time POP slab was removed and patient was given arm pouch. Patients were instructed to carry out physiotherapy in the form of active elbow flexion-extension and pronation-supination. Patients were advised not to lift heavy weight or exert the affected upper limb.

Patients were advised to report for follow up after 6 weeks, 3 months, 6 months and 12 months post-operatively and assessment was done. At follow up, a detailed clinical examination was done and patients were assessed subjectively for the symptoms like pain, swelling and restriction of joint motion. The range of motion was assessed with patient in seated position. Unaffected elbow was taken as control. Range of motion was assessed using goniometer.

The functional assessment of the patient was done according to MEPS and radiological assessment on the basis of union time from x-rays of the elbow joint, anteroposterior and lateral views. The results were statistically analysed using Mann Whitney U test and a level of $p < 0.05$ was considered significant.

Table 1: Patient baseline characteristics

Parameters	Locking plate group (n=14)	Reconstruction plate group (n=l1)	p-value
Age	38.07±18.73	31.81±10.65	0.3337
Gender Ratio (M:F)	8:6	10: 1	0.090
Side ofInjury R:L)	8:6	8:3	0.6766
AO type (CI:C2:C3)	5:7:2	4:5:2	0.9581
Mean Duration of Surgery	139.64± 12.16	137.27 ± 14.55	0.661
Mean Duration of Hospital stay	8.50 ± 2.74	9.09±3.18	0.622

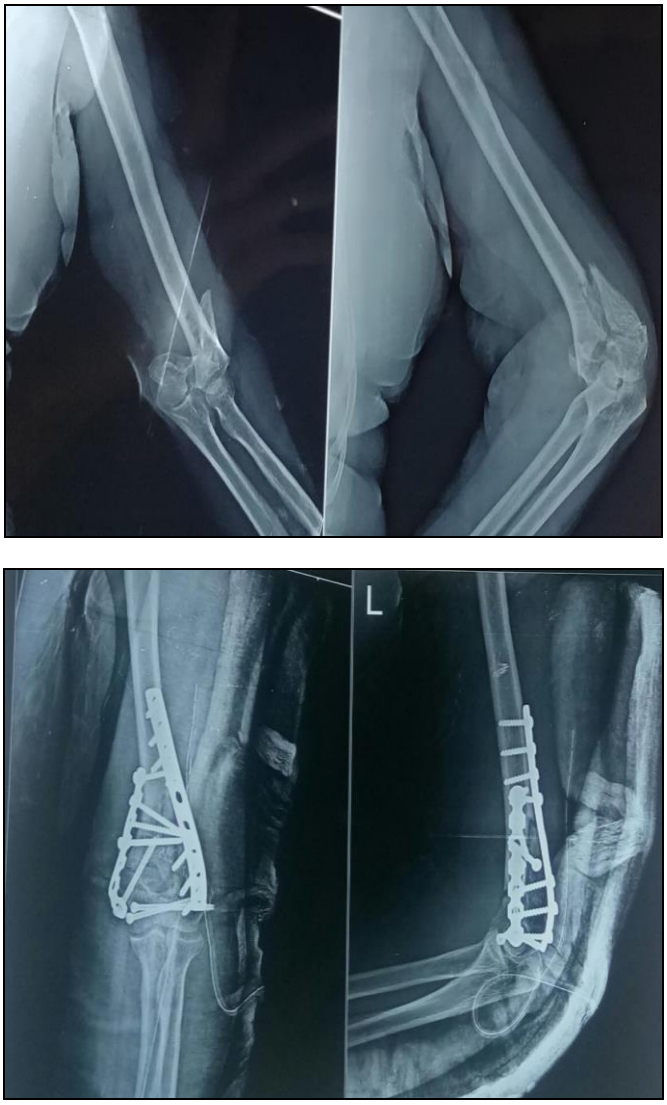

Fig 1: Pre-operative (A), Immediate Post-Operative (B) photograph of patient treated with reconstruction plates.

Fig 2: Intra-operative photograph of patient treated with locking plates

Results

The mean age of patients was 35 years (range, 18-75 years). The dominant arm was involved in 16 fractures (16/25). AO type Cl simple intra-articular fracture was found in 9 patients (9/25), AO type C2 simple articular fractures with metaphyseal comminution were seen in 12 cases (12/25) and 4 fractures (4/25) were classified as AO type C3 multifragmentary intra-articular fractures.

Out of 25 patients; 14 were operated usmg locking plates and II were operated using reconstruction plates. Mean duration of surgery and mean duration of hospital stay were statistically similar in both the groups (p value=0.661 and 0.622 respectively).

Median range of motion was statistically higher in locking plate group as compared to reconstruction plates groups at 3 months follow-up (p<0.0001) while the difference was statistically insignificant at 6 and 12 months follow-up (p=0.085 and 0.166). On comparing the mean MEPS score between the two groups at different time intervals, the difference was found to be statistically higher in locking plate group at 3 months (p-value=0.029) but at 6 and 12 months the difference was statistically insignificant (p-value=0.066 and 0.107 respectively).

About 93% patients in locking plate group and 82% patients in reconstruction plate group achieved excellent and/or good results on the basis of MEPS score. We achieved 93% union rate in locking plate and 91% union rate in reconstruction plate group at the end of 12 months follow-up suggesting that radiologically no significant difference exists between the two groups. Results of both groups are mentioned in Table 2.

We found only 2 cases of superficial infection, one each in locking and reconstruction plate group which were treated with Intra-venous/oral antibiotics. 3 cases of post-operative stiffness were reported, 1in locking plate group and 2 in reconstruction plate group which were managed with physiotherapy and Manipulation under anaesthesia. At final follow-up, all 3 patients achieved reasonably good to fair range of motion. One case of ulnar nerve neuropathy was reported in locking plate group which required anterior transposition of ulnar nerve at 4 months post-operatively and consequently completely recovered at final follow-up. One case of non-union was observed each in locking plate group and reconstruction plate group which further required revision surgery as management of complication with plate replacement and bone grafting. Interestingly, no case of failure of osteosynthesis of olecranon osteotomy was observed in our series. Summary of complications mentioned In Table 3.

Table 2: Functional and radiological outcome of the two groups

Parameters	Locking plate group (n=14)	Reconstruction plate group (n=l1)	p-value
ROM* at 3 months	43.2l±8.22	33.18±6.80	<.0001
ROM* at 6 months	76.42±14.06	71.36±15.98	0.085
ROM* at 12 months	1 11.35± 17.7	102.72±20.90	0.166
MEPS# at 3 months	53.92±11.l2	42.27±13.84	0.029
MEPS# at 6 months	66.42±10.45	59.69±14.96	0.095
MEPS# at 12 months	82.85±9.94	76.36±13.24	0.107
Union rate	93%	91%	0.089

* Range of motion
# Mayo Elbow Performance Score

Table 3: Summary of complications

Parameters	Locking plate group (n=14)	Reconstruction plate group (n=l1)
Superficial infection	01	01
Post-operative stiffness	01	02
Ulnar nerve neuropathy	01	00
Non-union	01	01

Discussion

Treatment of distal humerus fractures still remains one of the most demanding challenges in elbow surgery. Type C fractures of distal humerus are difficult to manage in spite of the advancement in fixation technique.

In recent years, the techniques used to reduce distal humerus fractures have evolved significantly: from conservative treatment to open reduction using different fixation methods and systems.

The locking plate technology in the management of distal humerus fractures has various biomechanical and theoretical advantages. Despite of these stated advantages, there are scant clinical data directly companng its efficacy to non-locking plate fixation for the management of intra-articular distal humerus fractures.

This study was aimed to determine whether locking plates offered any advantages over non-locking plates in term of functional and radiological outcomes. Our study showed that though at initial 3 months follow-up, the results were statistically higher in locking plate group with regard to mean range of motion and mean MEPS score, there exists no statistically significant difference between the two groups in term of functional and radiological outcome at final follow-up. The data demonstrate that while non-locking constructs allowed for more ideal screw positioning, the rate of union was equivalent between both groups. The difference between the two groups at initial 3 months follow-up might be due to less rigid fixation provided by reconstruction plates in comparison to locking plates leading to delay in range of motion exercises.

As limited studies have been performed directly comparing the functional and radiological outcome between locking and non-locking construct, there are minimal data for comparison.

One such study performed by Berkes *et al*, in which they retrospectively analysed 96 patients with intra-articular distal humerus fractures and compared the locking and non-locking construct on the basis of clinical and radiological outcome, fixation failure, complications and cost-effectiveness. They observed that though locking constructs cost on average 348% more than the non-locking constructs, there exists no statistically significant advantage that locking plates provide with regard to adequacy of fixation, clinical and radiographic outcomes and cornplications [8].

A comparison of non-locking and locking plate constructs in biomechanical study has been done by Komer *et al*. In which they found that the stiffness of the construct was no different if arranged in the same configuration [9]. Another study by the same group compared orthogonal constructs using conventional reconstruction plates, locking cornpression plates, and precontoured distal humerus locking plates in cadaveric specimens of varymg bone mineral densities and they concluded that fixation with either locking or non-locking plates is acceptable in patients with good bone mineral density, but locking plates could prove to be more effective 111 patients with lower bone mineral density [10].

Since there were no large data available cornpanng the locking and non-locking constructs for AO type C distal humerus fractures, we therefore analysed other studies comparing the two constructs for fractures other than the distal humerus. This includes comparisons involving treatment of the distal radius, proximal humerus, and proximal tibia fractures in which all have shown equivocal rates of non-union, functional outcome, and complication rates [11, 12, 13].

The results of this study verify what has been shown 111 the studies of distal radius, proximal humerus and tibial plateau comparing two types of fixation: there has been no statistically significant advantage that locking plates provide with regard to adequacy of fixation, clinical outcomes and complications. Though non-locking plates allow for ideal screw placement, the impact of this is unknown. The results of this study does not provide enough data to make any recommendations at present but it definitely serves as a critical analysis of locking and non-locking plates fixation that might stimulate future research on this topic.

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