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Functional outcome following internal fixation of intraarticular fractures of the distal humerus

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Abstract
Introduction: To evaluate the functional outcome following internal fixation of intraarticular fractures of the distal humerus (AO Type C) with a minimum follow-up of twelve months.
Materials and Methods: This prospective study was carried out at the Orthopaedics Department Government Medical College, Srinagar Kashmir. A total of 170 consecutive patients with intraarticular fractures of the distal humerus were recruited from Emergency and outpatient departments and treated with open anatomical reduction and internal fixation with plating and lag screw. Functional evaluations of elbow joints were evaluated with Broberg and Morrey functional rating index. All patients were followed for twelve months.
Results: All fractures united in an average of 3.2 months (range 7-19 weeks). The results were excellent in 66.47% of patients and good in 22.35% of patients at final follow-up. Complications were found in 22.35% of patients who had insignificant delayed unions which were united next 3 weeks, 7.05% of insignificance malunion, 5.83% of ulnar nerve neurapraxia, and 5.83% of patients who developed elbow stiffness.
Conclusions: We conclude that internal fixation of intraarticular fractures of the distal humerus is an effective procedure with an excellent or good functional outcome in majority of the patients. Patients have a high level of satisfaction and the majority return to their previous level of activity.

Keywords: Intercondylar fracture, intra-articular, distal humerus, double plate fixation, olecranon osteotomy

Introduction
The incidence of intraarticular fracture of distal humerus is 0.5%-7% of all fractures and of elbow fractures [1]. These fractures are more common in young adults due to high-energy trauma and in elderly as a result of low-energy trauma [1]. Complications are very high following conservative treatment of these fractures and internal fixation is difficult due to osteoporosis and complexity of fractures [2]. Stable internal fixation and early mobilization can provide good results. Inadequate fixation due to osteoporosis, bone loss and severe comminution can provide unsatisfactory results [2, 3]. Incidence of complications is 30% with distal humerus fractures and needs further surgery [4]. Both column fractures of distal humerus are fixed with a combination of reconstruction plates, locking compression plates, dynamic compression plates, screws and k- wires. Intercondylar fixation is done with a lag screw or intercondylar screw [5-7]. This study aimed to evaluate the functional outcome following internal fixation of intraarticular fractures of the distal humerus (AO Type C) with a minimum follow-up of twelve months.

Materials and methods
This prospective study was carried out at Orthopaedics Department, Govt. Medical College, Srinagar. Written informed consent was obtained from all the patients. A total of 170 consecutive patients with intraarticular fractures of the distal humerus were recruited from emergency and outpatient departments.

Inclusion criteria

- Age between 17 to 62 years.
- Fresh Displaced Intraarticular distal humerus fracture, By using the classification system of AO/ASIF, C1, C2 and C3 type.
- We include closed intraarticular fracture, Gustilo grade 1 open intraarticular fracture treated within 12 hours of injury.

Exclusion criteria

- Extraarticular or partial articular fractures of distal humerus (AO/OTA classification types 13A and 13B).
- Intraarticular fracture of the distal humerus (type 13 C) that did not require surgical intervention.
- Gustilo grade 1 open fracture that had not had irrigation and debridement within 12 hours of occurrence.
- Gustilo grade II, IIIA, IIIB and IIIC open fractures.
- Associated vascular injury.
- Previous ipsilateral distal humeral fractures.
- Pathological fractures.
- Fractures with diaphyseal extension of 8 cm or more.
- Definitive surgery more than 21 days after injury.
- Pre-existing severe joint disease (e.g., rheumatoid arthritis).

There were 80% (136/170) males and 20% (34/170) females with an average age of 41.4 years (range, 17-62). There were 60.58% (103/170) left-sided and 39.41% (67/170) right-sided fractures. All patients were followed for twelve months. None was lost to follow-up. By using the classification system of AO/ASIF, 56.47% (96/170) fractures were type C1, 31.76% (54/170) were type C2 and 11.76% (20/170) were type C3. 18.82% (32/170) cases had grade 1 open fracture.60% (102/170) patients were injured due to road traffic accidents, 27.05% (46/170) from falls and 11.76% (20/170) patients from sports injuries. The patients were divided in three groups according to their age for simplicity. Young age group included those patients whose age was less than thirty years. In this group, there were 25.88% (44/170) patients. Middle age group included patients, who were between the ages of 30-50 years. This group included 37.05% (63/170) patients. Old age group included patients older than fifty years. This group consisted of 37.05% (63/170). (Table 1) One hundred and three fractures were treated early within 24 hours. Sixty-seven fractures (surgery was postponed until the swelling had subsided) had delayed treatment (>24 hrs). Out of 170 (100%) patients, 12.94% (22/170) patients had multiple fractures elsewhere in the body. 17.05% (29/170) patients had associated fractures in the forearm area. None was lost to follow-up. All the patients were treated with anatomical reduction and a cancellous lag screw fixation of the articular surface of both the condyle of the humerus. The next step was to anatomically reattach the condyles to the humeral shaft. All the fractures were treated with two plates, medially with a 1/3rd tubular plate, and laterally with a reconstruction plate. (Figure 1a, 1b, 2a, 2b, 3a and 3b) The time of operation ranges from the 1st day of injury to the 8th day of injury with the mean time of operation being 4.6 days.

A B

Fig 1: A (Preoperative anteroposterior and lateral radiograph of intraarticular fracture of lower end of humerus of 43 years old man), B (. Post-operative anteroposterior and lateral radiograph of intraarticular fracture of lower end of humerus treated medically with 1/3rd tubular plate and laterally with reconstruction plate and a lag screw inserted through the articular surface of lower end of humerus)

Fig 2: A (Preoperative anteroposterior and lateral radiograph of intraarticular fracture of lower end of humerus of 48 years old man), B (Post-operative anteroposterior and lateral radiograph of intraarticular fracture of lower end of humerus treated medically with 1/3rd tubular plate and laterally with reconstruction plate and a lag screw inserted through the articular surface of lower end of humerus)

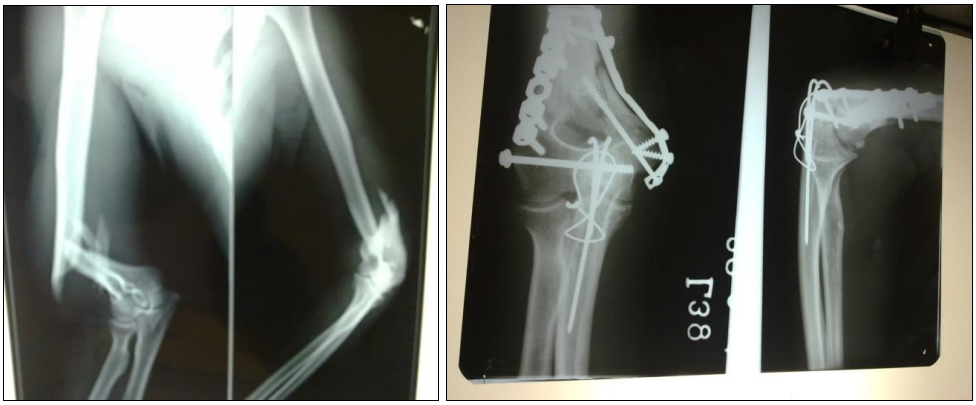

Fig 3: A (Preoperative AP and lateral radiograph of intraarticular fracture of lower end of humerus of 63 years old man), B (Post-operative anteroposterior and lateral radiograph of intraarticular fracture of lower end of humerus treated medically with 1/3rd tubular plate and laterally with a reconstruction plate and a lag screw inserted through the articular surface of lower end of the humerus)

Table 1: Age and sex variations in a study group (n=170)

Age	Male	Female	Total
Less than	36	8	44
30-50	49	14	63
More than 50	51	12	63
Total	136	34	170

Operative Techniques

All the patients were operated in lateral positions with the involved extremity flexed and hanging off the operating table. The pneumatic tourniquet was used. A straight posterior incision with radial deviation across the tip of the olecranon was made. The ulnar nerve was then identified and carefully protected. Intra-articular chevron osteotomy was performed approximately two centimeters from the tip of the olecranon with a high-speed micro-oscillating saw to cut up to the subchondral bone. The osteotomy was completed with an osteotome used as a lever to crack through the articular surface. The proximal part of the olecranon was elevated with the triceps, which provides excellent exposure as far as seven centimeters proximal to the joint line before the radial nerve is threatened. The elbow capsule was incised and the fracture fragments were identified by carefully dissecting soft tissue and muscular attachments, as necessary.

Post-operative care

Usually, by the second postoperative day, active or active-assisted range of elbow motion exercises as pain permitted was started in patients with good bone quality and rigid osteosynthesis. Longer immobilization (>3 weeks) was used when the bone quality was poor and the stability of the osteosynthesis was questionable. No continuous passive motion machines were used. After the postoperative 6th week, resisted exercises were started and normal daily activities resumed. Strenuous physical exercise was only allowed after radiological evidence of union.

Assessment of the patients

Assessment was done in a follow-up clinic for postoperative patients by a surgical team. The results were analyzed using clinical and radiographic evaluation at a final follow-up of 12 months. The clinic-radiological results of our study were based on the criteria of union, non-union delayed union, or malunion [8]. Fractures are considered to be united normally if a union was observed clinically as well as radiologically till 12 weeks of fixation. A delayed union was diagnosed if the fracture healed between 12 and 24 weeks; nonunion was considered to be present if the fracture was not clinically or radiologically united after 24 weeks post-injury or sooner if implant failure was associated with displacement of the fracture. The quality of reduction was graded (A to C), based on the postoperative radiographs. Grade A was an anatomical reduction, grade B a step or gap of the articular surface of less than 2 mm and grade C involved a step or gap of more than 2 mm. The quality of reduction was based on the immediate post-operative plain radiographs and operative findings. Functional evaluations of elbow joints were evaluated with Broberg and Morrey functional rating index. (Table 2) [9] The grading scale was weighted as follows: normal motion, 40 points; no pain, 35 points; normal strength, 20 points; and normal stability, 5 points.

Table 2: Broberg and Morrey functional rating index

Variable	Points value
Motion	
Degree of flexion (0.2 3 arc)	27
Degree of pronation (0.1 3 arc)	6
Degree of supination (0.1 3 arc)	7
Strength	
Normal	20
Mild loss (appreciated but not limiting, 80% of opposite side)	13
Moderate loss (limits some activity, 50% of opposite side)	5
Severe loss (limits everyday tasks, disabling)	0
Stability	
Normal	5
Mild loss (perceived by patient, no limitation)	4
Moderate loss (limits some activity)	2
Severe loss (limits everyday tasks)	0
Pain	
None	35
Mild (with activity, no medication)	28
Moderate (with or after activity)	15
Severe (at rest, constant medication, disabling)	0
Excellent	95-100
Good	80-94
Fair	60-79
Poor	0-59

Results

The clinical-radiological results of our study were based on the criteria of union, nonunion [8], delayed union, or malunion. (Table 3) The patients were followed according to their clinical status. All fractures united in average 3.2 months (range 7-19 weeks). 66.47% (113/170) patients had union in 45 to 90 days, 22.35% (38/170) patients in 90 to 150 days, in younger age

group, union occurred between 4-6 weeks, in the middle age group, between 6-8 weeks and in older age group, between 8-12 weeks. The results were graded according to the range of motion, excellent postoperative results (Extension < 15, Flexion 130) were observed in 66.47% (113/170) patients and good results (Extension < 30, Flexion 120) were observed in 22.35% (38/170) patients at final follow-up. 7.05% (12/170) patients had fair results (Extension < 40, Flexion 90-120), and 5.83% (7/170) patients had poor results (Extension < 40, Flexion <90). Non-union was not seen in this study.

Functional evaluations of elbow joints were evaluated with Broberg and Morrey functional rating index (Table 2) [9]. The grading scale was weighted as follows: normal motion, 40 points; no pain, 35 points; normal strength, 20 points; and normal stability, 5 points (Table 2).

Complications were found in 22.35% of patients who had insignificant delayed unions (which were united next 3 weeks) and 7.05% insignificance malunion. 5.83% (7/170) patients had symptomatic olecranon wire prominence and created pain during elbow movement. These wires were removed after 3 to 4 weeks when a callus formed at the fracture site. 7.05% (12/170) patients developed an early superficial wound infection. This infection subsided spontaneously with three weeks of antibiotic treatment. There were seven cases of ulnar nerve neurapraxia, which resolved. 7.05% (12/170) cases developed moderate osteoarthritic changes at the elbow joint. 5.83% (7/170) patients had only pain with activity, but a "poor" result due to elbow stiffness. During this study, complications like vascular injury, compartment syndrome, myositis ossifications, and significant non-union were not red.

The results were excellent in 66.47% (113/170) patients, good in 22.35% (38/170), fair in 7.05% (12/170) and poor in 5.83% (7/170) patients at final follow-up (Table 4). In subjective overall assessment 66.47% (113/170) patients were fully satisfied and 22.35% (38/170) patients were satisfied with the result of treatment.

Table 3: Percentage of cases who had unions, mal-unions, delayed unions, or non-unions in study group (n=170)

Fracture healing	Total cases	% of cases
Union	113	66.47%
Non-union	0	0%
Delayed union	38	22.35%
Mal-union	12	7.05%

Table 4: Outcome of results in study group (n=170)

Out comes	No.	%
Excellent	113	66.47%
Good	38	22.35%
Fair	12	7.05%
Poor	7	5.83%

Discussion

Treatment of intraarticular distal humerus fractures is difficult and needs a great deal of experience with them [10]. Displaced intraarticular fractures of the distal humerus can be treated successfully with anatomical reduction, stable fixation and early elbow mobilization [11, 12]. Several different surgical approaches have been described [13, 14]. The posterior approach through an olecranon osteotomy is most often used [11, 15, 16]. This approach provides excellent visualization of the distal articular fragment and exposure for plate fixation [17]. In our study, all the intraarticular fractures of the distal humerus were operated by the posterior approach through an olecranon osteotomy. Articular restoration of the distal humerus is the most essential step for the stabilization of the two columnar fragments. Several fixation methods have been used for the fixation of humerus condyle to humerus metaphysic such as single plate, Y-shaped plate, double K- wire, and K-wire with tension band wiring [18, 19]. The objective is to facilitate the biomechanical reconstruction of the two-column structure of the distal humerus. Bilateral plate fixation was done in all 170 cases in our study. Fracture reduction and stable fixation were satisfactory in all cases and post-operative mobilization was also satisfactory.

Several complications have been reported following surgical fixation of type c distal humerus fractures. These include joint stiffness, heterotopic ossification, infections, nerve injury, nonunion and delayed union [20, 21]. Kundelet *et al*. found 49% heterotopic ossification and 33% nerve injuries in their study [20]. In our study, 5.83% (7/170) cases had elbow pain during movement due to olecranon wire prominence. These wires were removed after 3 to 4 weeks when a callus formed at the fracture site. Superficial wound infection was seen in 7.05% (12/170) cases. The infection subsided spontaneously with 3 weeks of antibiotic treatment. Ulnar nerve neuropraxia was seen in 7 cases which resolved. Moderate osteoarthritis around the elbow joint was seen in 7.05% of cases. 5.83% of cases had poor results due to elbow stiffness. During this study, complications like vascular injury, compartment syndrome, myositis ossifications, and significant non-union were not seen. In comparison, it is below the rate reported by beck *et al*. [20] this is due to intraoperative protection of the ulnar nerve. Saragaglia *et al*. reported postoperative 13% heterotopic ossification in type c distal humerus fractures [21]. In our study, heterotopic ossification was not seen due to early mobilization. 22.35% insignificant delayed union which was united in next 3 weeks and 7.05% insignificant malunion. We did not encounter nonunion at the olecranon osteotomy and at distal humerus postoperatively. In contrast to the findings of distal humeral nonunion in previous reports [22, 23], no instances of fixation failure were detected in this study. Presumably, this was a reflection of strong bilateral plate fixation and satisfactory fracture reduction. This is due to early mobilization of elbow joint. Healing ensued in all of these patients following decrease in the level of exercise intensity. We achieved bone union in an average of 3.2 months. All the fractures united without implant failure. All our cases achieved union within four months. Nonunion or delayed union is not a problem in these fractures as shown by previous studies [24-28]. The operative treatment in expert hands has yielded 75-85% excellent to good results. In the Singh *et al*. series, they treated 25 adult patients with distal humeral fractures both articular as well as extraarticular, with age ranging from 22-59 years. They obtained 96% of excellent to good results, 4% of fair and no poor results which are similar results reported with the use of pre-contoured LCP by other authors [29-31]. In our series, excellent to good results were seen in 88.82% patients. 88.82% patients were satisfied with the results of treatment.

A potential limitation of our study was the absence of a control group treated by a different modality. Thus, we cannot actually determine if any other method of treatment would have led to different results. Nevertheless, our results are better than those of the previous studies in which other plates have been used.

We suggest locking recon plate and locking compression plate technology can be useful to get better results for articular fractures with osteoporotic bone.

Conclusion

We found that the olecranon osteotomy approach with double plate fixation was efficacious for the treatment of type C distal

humerus fractures. Early mobilization was possible in the majority of cases, which may be a prerequisite for satisfying functional results. Complications were minimal and healing satisfactory.

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