

Bicolumnar 90–90 plating of AO 13C type fractures



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ABSTRACT

Objective: The aim of this study was to evaluate functional results and complication rate of patients who underwent medial-dorsolateral plating for intra-articular distal humeral fracture (Müller AO type 13C). **Methods:** Twenty-four patients (14 men, 10 women; mean age: 47 years) with AO type 13C distal humerus fracture were included in the study. Mean follow-up time was 28 months. Nine patients were in 13C1 subgroup, according to AO classification system, 11 patients were categorized as 13C2, and 4 patients were 13C3. Final follow-up assessment of outcomes included Broberg and Morrey radiological criteria; Mayo Elbow Performance Score, disabilities of the Arm, Shoulder and Hand (DASH) Outcome Measure, score based on Jupiter criteria; and range of motion (ROM) values.

Results: The mean carrying angle of operated elbows was 11.37° (range: 0–20°). According to Broberg and Morrey radiological criteria, 14 patients, had radiologically normal elbow, 4 patients had mild change, 3 patients had moderate change, and 3 patients had severe radiological change. Mean DASH score was 21.91 (range: 0–50), and mean Mayo rating was 83.37 (range: 55–100). Jupiter criteria evaluation revealed excellent results in 10 cases, good in 12, and fair results in 2. One patient with fair result had open fracture, and the other had previous hemiparesis in the same extremity. There was no instance of nonunion observed at follow-up.

Conclusion: Osteosynthesis with medial-dorsolateral plating is a safe and effective method for the treatment of intra-articular fractures of distal humerus.

Level of evidence: Level IV, Therapeutic study.

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Introduction

The overall incidence of distal humerus fracture is 5.7 in 100,000. Distal humeral fracture has bimodal distribution: In younger patients, fracture is often result of high-energy trauma, while simple fall may cause distal humerus fracture in elderly, osteoporotic patients.¹ Treatment of these fractures is challenging because of complex anatomy, limited bone stock, and tendency to comminute nearby neurovascular structures.²

There are many surgical options for anatomical reconstruction.³ The main purpose of surgical treatment is anatomical reduction with early mobilization. Bicolumnar plating is frequently used technique for functional extremity, even in comminuted fractures.⁴

Parallel and 90–90 plating (2 plates perpendicular to each other) are preferred methods for surgical repair of AO 13C fracture. Comprehensive studies have reported similar results for post-operative elbow function, union rate, and complication rate.^{5,6} Although parallel plating has some biomechanical advantages,⁷ 90–90 plating provides good purchase for distally located fractures and versatility for proper screw placement. As result of these qualities, 90–90 plating is generally preferred at our clinic.

There are many classification methods for distal humerus fractures. Among these, Jupiter and Mehne, and Müller AO classification systems are frequently used.^{8,9} Complex distal humerus fracture can be defined as 1) severely comminuted intra-articular or metaphyseal fracture, 2) comminuted osteoporotic fracture, 3) bone fragment loss, or 4) previous unsuccessful surgery.^{10,11} AO type 13C fracture is prone to nonunion and implant failure,¹² especially in elderly osteoporotic women.¹

The aim of this study was to evaluate functional results and complication rate of medial-dorsolateral plating for AO type 13C fractures.

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Patients and methods

Twenty-four patients with AO type 13C distal humerus fracture repaired with surgical medial-dorsolateral plating between January 2009 and March 2014 were included in this study. All patients were operated on by the same surgeon (CK). Mean follow-up time was 28 months (range: 12–56 months). There were 14 men and 10 women, with mean age of 47 years (range: 18–97 years).

Mechanism of injury was a simple fall in 15 patients, falling from height in 5 patients, auto accident in 3 patients, and motorcycle accident in 1 patient. In addition, 2 calcaneal fractures, 1 acetabular fracture, and 1 humeral shaft fracture were present. Comorbidities were as follows: cerebrovascular disease in 1 patient, hemiparesis in same extremity in 1, Alzheimer's disease in 1, hypertension and diabetes mellitus in 3, and chronic renal failure in 1 patient. Also, 1 patient had subdural hematoma. One patient had Type I open fracture and 2 patients had Type II open fracture, according to Gustilo-Anderson classification. None of the patients had compartment syndrome or neurovascular injury. According to AO classification, 9 patients were 13C1, 11 patients were 13C2, and 4 patients were 13C3. Mean time before surgery was 5 days (range: 1–15 days). Patients with subdural hematoma and chronic renal failure were operated on after stabilization of their physiological condition.

Surgical technique

All patients were managed using standard surgical approach, including same patient position, and the same surgeon performed all operations. Posterior longitudinal incision and V-shaped olecranon osteotomy were performed in customary manner in prone position with tourniquet. Ulnar nerve was exposed and protected. Distal intra-articular fragments were reduced and temporarily stabilized with Kirschner wires (K-wires), and medial and dorso-lateral plating was applied. At proximal portion of the fracture, 3 screws were placed medially and dorsally. In distal part of the fracture, interfragmentary and medial-posteriolateral screws were used for fixation. Dorsolateral plate design allowed for additional locked screws to be placed from dorsolateral side to medial condyle (Fig. 1). Iliac autografting was used for 2 patients who had severe bone loss on lateral condyle. Intraoperative fluoroscopy was used to check correct positioning of distal screws. Ulnar nerve was not transferred anteriorly in any case, and was left in the cubital groove. V-type olecranon osteotomy was fixed with tension band wiring; no plates or screws were used for olecranon osteotomy fixation. Submuscular hemovac drain was used for all patients. Heterotopic ossification (HO) prophylaxis was not required for any of the patients.

Postoperative rehabilitation

A long arm splint was used postoperatively by all patients. Splints were removed after resolution of edema at 15–21 day check-up, and subsequently, arm sling was used. Gentle physiotherapy was initiated with one physiotherapist, and standard therapy protocols were implemented immediately after splint removal. Follow-up exams were performed by the same surgeon (CK) every 20 days. Night splint was added in 5 cases due to extension deficit.

Outcome measures

Final evaluation of outcome included several tools: radiological assessment of elbow using Broberg and Morrey criteria (normal, slight change, moderate change, or severe alteration)¹³; carrying

angle measured with anteroposterior elbow radiography; range of motion (ROM) measured with goniometer; Mayo Elbow Performance Score¹⁴; Disabilities of the Arm, Shoulder and Hand (DASH) Outcome Measure¹⁵; and Jupiter elbow score.¹⁶

Statistical analysis

NCSS (Number Cruncher Statistical System) 2007 (NCSS, LLC, Kaysville, UT, USA) program was used for statistical analysis. Descriptive statistical methods (mean, SD, median, frequency, and rate) were used for analysis. Wilcoxon signed rank test was applied for analysis of variables when comparing to healthy side. Results in 95% confidence interval and $p < 0.05$ were considered statistically significant.

Results

At last follow-up, mean DASH score was 21.91 (range: 0–50). Mayo rating mean score was 83.37 (range: 55–100). Jupiter criteria yielded 10 excellent, 12 good, and 2 fair results.

There was statistically significant difference between ROM values (flexion, extension, supination, and pronation) of operated and healthy elbows (Table 1) ($p < 0.01$). Most significant difference was in flexion (23°) ($p = 0.008$). Mean distal humerus carrying angle was 11.37° (range: $0-20^\circ$). According to Broberg and Morrey radiological criteria, 14 patients had normal elbow radiograph, 4 patients had mild change, 3 patients had moderate alteration, and 3 patients had severe degenerative changes.

Two of 3 patients with C3 fractures were classified as fair using Jupiter criteria: a 69-year-old with cerebrovascular stroke in same side and a 50-year-old patient with a type 3A open fracture due to a high-velocity injury.

Two patients had second operation due to irritation caused by the K-wires used for fixation of olecranon osteotomy. No instance of HO, nonunion, or reduction failure was observed in any patient, nor was any motor or sensory pathology of ulnar nerve seen.

There was 1 instance of superficial infection, which was treated with antibiotherapy and wound care.

All patients were previously active and employed, and only 2 had to change their occupation after the operation due to lasting impairment.

Discussion

As result of anatomical properties, distal humeral fractures are problematic for both surgeons and patients. Main surgical principle in repair of these intra-articular fractures is to achieve stable and absolute fixation.¹⁷ Conventional plate systems had failure rates of 5–30%, especially in osteoporotic bones.^{18,19} Those unsatisfactory results led to development of new plate designs. Currently, locked, low-profile, anatomical plate systems for distal humerus have gained in popularity for bicolumnar fixation. New designs of headless compression screws have made it possible to manage small intra-articular fragments. These new inventions allow for stable fixation and early physiotherapy of the joint.

In AO type 13C fractures, it is difficult to achieve indirect reduction with plates. Absolute reduction is only possible with direct inspection of the joint. Olecranon osteotomy provides direct visualization of the joint. In cadaver studies, it has been demonstrated that 60% of the distal humeral joint can be visualized with olecranon osteotomy.²⁰ Khalid et al²¹ compared functional results after olecranon osteotomy versus triceps-sparing approach for distal humerus fracture. The authors concluded that olecranon osteotomy approach is more effective and preferable to triceps-sparing approach.

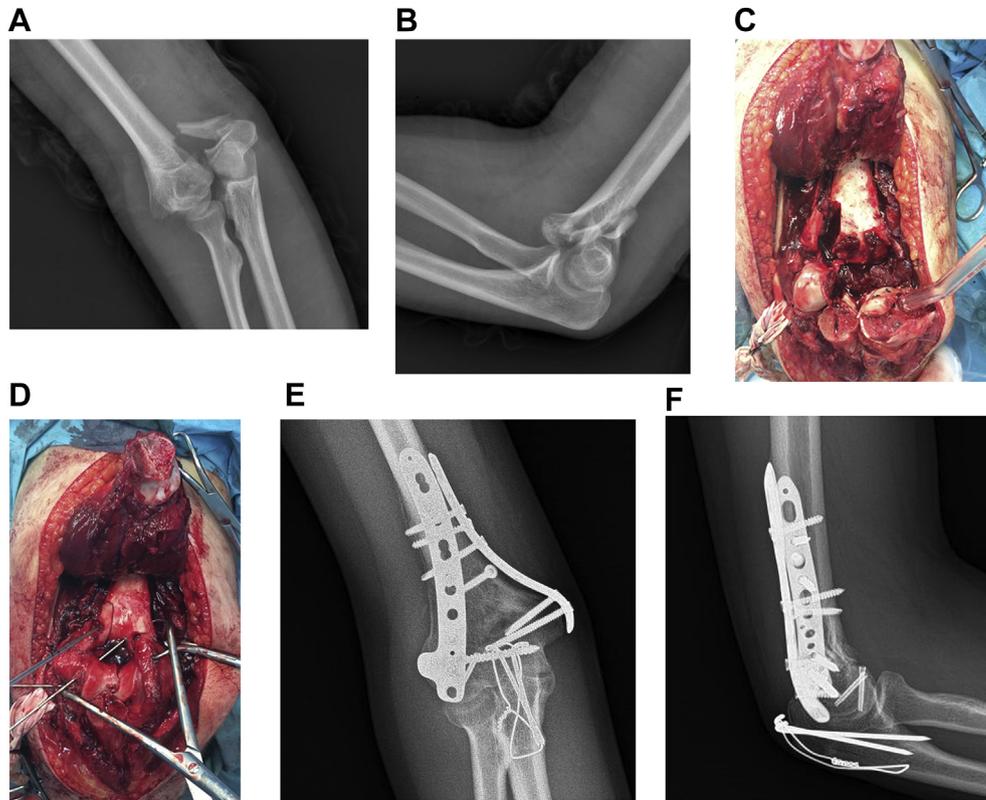


Fig. 1. 19-year-old man, fall from height, humerus distal AO 13C2 fracture. A) Anteroposterior radiograph of elbow, B) Lateral radiography of elbow, C) Intraoperative photo of same patient, D) Temporary fixation with Kirschner wires, E) Postoperative 14th month anteroposterior radiograph, F) Postoperative 14th month lateral radiograph.

Table 1
Comprehension of elbow range of motions.

	Affected side			Unaffected side			P
	Mean ± SD	Median	Min–Max.	Mean ± SD	Median	Min–Max.	
FLEX.	110,00 ± 20,05	110	70–145	133,13±14,13	140	100–145	<i>p</i> < 0,01**
EKST.	–6,25 ± 6,63	–7,5	–20–0	1,04±3,61	0	–10–10	<i>p</i> < 0,01**
PRO.	70,63 ± 14,47	75	20–85	81,67±4,58	82,5	70–90	<i>p</i> < 0,01**
SUP.	65,54 ± 18,21	72,5	15–85	78,96±4,66	80	70–85	<i>p</i> < 0,01**

Wilcoxon signed rank test. Statistically significant if ***p* < 0,01.
SD, Standard deviation.

There are different techniques for olecranon osteotomy. In our study, Chevron osteotomy and tension band wiring were used in standard manner. No nonunion was experienced in these osteotomies, but in 2 cases (8%) we had to remove K-wires due to skin irritation. Coles et al also reported that 8% (5 patients of 67) had K-wire irritation at tension band site.²² Skin irritation has also been reported with plate fixation of the osteotomy site⁵ and can be problematic in those cases as well. Special intramedullary fixation of osteotomy site had union rate of 19 out of 21 in literature.⁶ Woods et al compared different fixation methods for olecranon osteotomy after distal humerus fracture and concluded that age, sex and Charlson comorbidity index were related to nonunion and implant removal after olecranon osteotomy.²³

Controversy continues concerning plate position in terms of providing optimal stability for distal humerus fractures. Perpendicular plating systems provide greater rigidity and fatigue resistance than the single Y-plate.²⁴ Some biomechanical studies have demonstrated that parallel plating system is significantly stronger and stiffer than perpendicular plating system in terms of resisting sagittal bending forces.²⁵ On the other hand, Got et al stated that

90–90 plating had greater resistance to torsional loading compared with parallel plating in cadaver models.²⁶ In clinical aspect, comprehensive studies have shown similar results for postoperative elbow function, union rate, and complication rate.^{27,28} However, in more distally transverse and comminuted fractures, studies indicate that parallel plating has more stable reconstruction compared to 90–90 fixation, with the advantage of more distal screw placement.^{28,29} Bogataj et al²⁹ compared biomechanical characteristics of 90–90 and parallel plating, and they concluded that bone contact is the most important factor for biomechanical strength. If there is no bone contact, parallel plating is superior to the 90–90 plating.

In our series, a medial-dorsolateral plating system was used for fixation. This allowed us to use long, locking screws distally from lateral plate to medial condyle, thus providing additional stability to the reconstruction. In the literature, highest complication rate was reported in Gofton's study,³⁰ but these complications were minor and resolved without further surgery. The author also reported 13% nonunion and 8% infection with 90–90 unlocked plating system^{8,30,31} (Table 2). Schmidt-Horlohe reported 64%

Table 2
Review of literature, Humerus Distal AO Type C fractures plate fixation.

Study	No	Follow-up (months)	Plate configuration	Nonunion rate	Infection rate	Reoperation rate	Mean flexion arc (°)	Mean DASH
Gofton, 2003	23	45	90, nonlocking	3/23	2/23	8/23	122	12
Sanchez-Sotelo, 2007	34	24	180, locking	1/34	2/34	9/34	99	–
Atalar, 2009	21	28	180, locking	0/21	1/21	7/21	118	7,6
Schmidt-Horlohe, 2011	31	12	90, locking	0/31	–	20/31	102	24
Flinkkila, 2014	47	19	180, locking	–	1/47	13/47	123	26

reoperation rate for implant removal and nonunion in 31 patient series of 90–90 locked plating.³² In our study, there were no deep infections or nonunions, and re-operation rate was only 8%, which was due to K-wire irritation.

Ulnar nerve neuropathy is common complication (up to 51%) after surgical treatment for distal humerus fracture.³³ Initial injury, intraoperative manipulation of ulnar nerve, scar tissue, and irritation of implant are main reasons for ulnar nerve neuropathy. Recent studies have demonstrated that anterior transposition of ulnar nerve does not decrease neuropraxia.³⁴ Flinkkila et al³¹ did not transpose ulnar nerve anteriorly, and they reported neuropraxia in 4 of 47 patients. Sensory disturbance of all patients healed without sequelae. In our study, we did not transpose ulnar nerve anteriorly, and there was no sensory disturbance in any patient.

HO is one of the problems that can reduce functional results in these fractures and rate of HO after surgical treatment is variable.³⁵ Head injury, revision surgery, bone grafting, and long postoperative immobilization are risk factors.³⁶ In our patient population, including patients with risk factors (autografting and prolonged immobilization), we did not see any incidence of HO. We did not start any medication for HO because we think the most important factors in prevention of HO are meticulous surgical technique and respect for soft tissues rather than medication.

DASH scores of our patient group, as well as flexion measurements, were consistent with the literature.^{30–32,34} Two major factors adversely affected ROM and functional results in our series: severe soft tissue injury and mental-central nervous system disease, which diminish postoperative rehabilitation.

The weakness of our study is relatively small patient group with C-type fracture. Due to comminution, clinical results may differ according to fracture type. It is clear that it would be better to compare different surgical techniques in this type of study, as in the literature,²⁷ both surgical methods have been reported to have favorable results, but our aim was to examine results of same type of surgery performed by a single surgeon.

The strengths of the study are as follows: All patients were operated on by the same surgeon, using the same technique and implant. In addition, same physiotherapy protocol was used for all patients.

In conclusion, for good functional results, precise preoperative planning, adequate surgical approach, anatomical interfragmentary stabilization, medial-posterolateral plating, and adequate physiotherapy are obligatory for distal humeral intra-articular fractures. This step-by-step approach results in satisfactory functional results.

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