

DISPLACED - COMMINUTED INTRAARTICULAR FRACTURES OF THE ADULT DISTAL HUMERUS: FUNCTIONAL RESULTS AFTER INTERNAL FIXATION

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ABSTRACT

Background: Intra-articular T-type or Y-type fractures of the distal end of the humerus are relatively rare, and consequently few surgeons will be able to attain extensive experience with the surgical treatment of these injuries. The current emphasis is on operative intervention with rigid internal fixation and early mobilization.

Methods: In this prospective and retrospective study, we reviewed a series of 38 displaced-comminuted intra-articular T-type or Y-type fractures of the distal end of the humerus that were operated through the trans-olecranon approach by a single surgeon and fixed by multiple pins and /or screws over an 8 year period from June 1995-July 2003. The fracture patterns were classified according to RR (Risborough-Radin) and a strict rating scale (Jupiter et al.) incorporating subjective data, objective motion, and the functional status of the involved elbow was used for the results.

Results: At a mean follow up of 18 months, 14 results were rated as excellent; 15 results as good; 6 results as fair; and 3 results as poor. Complications included postoperative ulnar nerve neuritis in one patient; non-union in one patient; elbow joint stiffness in two patients; superficial infection in three patients; and pin protrusion in three patients. Over-all, follow up examination showed 76% excellent and good results, 16% fair results and 8% poor results.

Conclusion: We prefer anatomical reduction and stable fixation with pin and screw with limited soft tissue dissection in adults and in old patients with good bone quality.

Keywords: Humeral trans-condylar fracture, Comminuted intraarticular distal humeral fractures.

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INTRODUCTION

Intra-articular T-type or Y-type fractures of the distal end of the humerus present difficult problems for management. These fractures are relatively rare, and consequently few surgeons will be able to attain extensive experience with the surgical treatment of these injuries.

The severe comminution and displacement often encountered in these fractures make reconstruction and stabilization difficult.^{1,2,3,4}

The elbow joint tolerates immobilization poorly, and the functional outcome after surgical treatment is unavoidably worsened by prolonged immobilization.^{4,5}

Yet it seems to be generally accepted that surgical treatment and internal fixation is the method of choice in managing intraarticular T-type or Y-type distal humeral fractures.^{2,3,4,5,7,8} The aim of the surgical treatment is to restore the anatomy of the joint surface and to stabilize

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the fracture enough to allow early mobilization of the elbow joint.^{5,8}

Even if stable anatomic reconstruction of the articular surface is achieved by open reduction and internal fixation, nerve lesion, joint stiffness, and heterotopic bone formation may spoil the functional results.⁹ Riseborough and Radin¹⁰ devised a very useful classification of this type of fracture, based on its radiographic appearance. This classification provides some guide to the management and prognosis. They defined four types:

Type 1: Nondisplaced fracture between the capitellum and trochlea.

Type 2: Separation of the capitellum and trochlea without appreciable rotation of the fragments in the frontal plane.

Type 3: Separation of the fragments with rotational deformity.

Type 4: Severe comminution of the articular surface with wide separation of the humeral condyles.

Criteria

As the primary complication of this injury is decreased range of motion of the elbow,¹⁰ a rating scale based on functional range of motion was used to evaluate each patient during the follow up period. The rating system of Cassebaum was adapted to quantitate the final functional motion of the elbow.

An excellent rating was given for extension to 15 degrees and flexion to 130 degrees; a good rating for extension to 30 degrees and flexion to 120 degrees; a fair rating for extension to 40 degrees and flexion to 90-120 degrees; and a poor rating for extension to 40 degrees and flexion to less than 90 degrees.

The data on elbow motion were combined with the patients subjective symptoms to provide an overall functional rating.

Pain in the elbow, working ability and ulnar nerve function were noted. Anteroposterior, lateral, and oblique radiographs were obtained to assess bone union and any evidence of posttraumatic arthritis. We used the criteria of Jupiter et al,¹⁸ to assess the results (Table II).

In this study we report the results of surgical treatment and internal fixation by multiple pins and/or screws in a busy trauma unit and compare it with the literature.

PATIENTS AND METHODS

During an 8 years period from June 1995-July 2003, thirty-eight adult patients with an intra-articular T-type or Y-type distal humeral fracture (displaced or comminuted) who came to Chamran hospital (the major teaching orthopedic unit of Shiraz Medical University), were treated by a single surgeon.

There were twenty-two male and sixteen female patients. The average age was forty-eight years (range 20-80 years).

Using the classification system of Riseborough and Radin,¹⁰ eighteen fractures (47%) were classified as type 4; eleven (29%) as type 3 and nine (24%) as type 2 (Table I). The distribution of fractures is shown in Figure 1. Twenty-four fractures involved the right elbow, and fourteen the left.

Twenty-three fractures were caused by falling down; thirteen by car-accident; and two by motor-vehicle accident.

Nine (24%) of the fractures were open, six being grade 1 by the Gustilo classification; and three, grade 2.

Associated injuries in eleven patients included ipsilateral Colles, fracture in three patients; both calcaneus, lumbar spine (L1), pubic ramus and ipsilateral Colles fracture (multiple fractures) in one pregnant young female; both femurs supra-intercondylar and patellar fracture

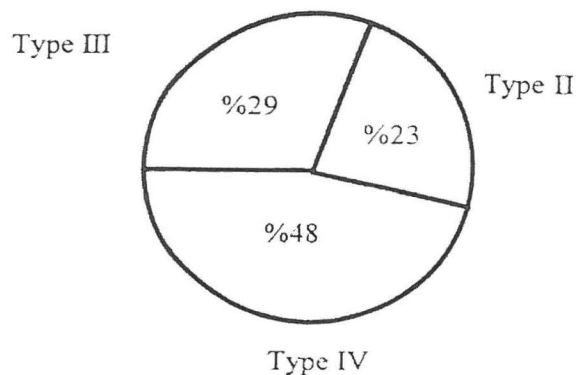


Fig. 1. The distribution of the types of fracture.

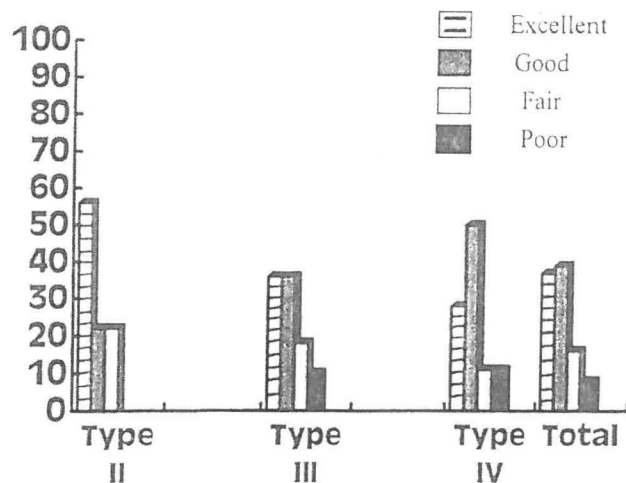


Fig. 2. The overall results according to each of the three types of fractures in the entire group of 38 patients.

Table I. Type of fractures.

Type	Number of patients	Percent
II	9	24%
III	11	29%
IV	18	42%
Total	38	100

The fractures were graded according to the classification system of Riseborough and Radin:

Type I: a simple, undisplaced T-condylar fracture.

Type II: a simple, displaced T-condylar fracture.

Type III: a condylar fracture with rotation of the fragments

Type IV: a T-condylar fracture with intraarticular comminution.

(multiple fractures) in one patient; fracture of the femur, ipsilateral ribs with pleural effusion and ipsilateral anterior dislocation of a shoulder in one; ipsilateral traumatic median nerve palsy in one and radial nerve palsy in two patients.

In this study, undisplaced T-condylar (type 1) fracture of the distal humerus was excluded.

Operative technique

Eleven fractures were operated just on the day of injury and twenty-two within the first week after injury. For the remaining five patients surgery was delayed for ten to twenty-one days after injury because of either extensive soft tissue injury or non-operative treatment at another institution, such as overhead traction.

General anesthesia was used in all of them. The operation was done with the patient supine in thirty-seven cases and prone in one. A pneumatic tourniquet was used routinely. A dorsal incision was used in all of the patients. The ulnar nerve was identified in all cases. The radial nerve was identified when the fracture was more proximal, requiring fixation close to the spiral groove.

An osteotomy of the olecranon at the level of the trochlea was done in all of the patients to improve the intra-articular exposure. Before the osteotomy is done the proximal part of the ulna is predrilled.

The first step in the osteosynthesis was reduction of the condyles and reconstruction of the joint surfaces.

Therefore we reduced and fixed both condyles with restoration of the trochlea by Kirschner-wires and/or screws.

The next step was to stabilize the supracondylar part of the fracture, in which we reduced and fixed both medial and lateral columns by Kirschner-wires and/or screws. We have not seen a fracture so comminuted as to not be amenable to proper reduction and internal fixation.

The osteotomy of the olecranon is secured by one cancellous screw-tension band wire, or parallel Kirschner wires-tension band wire.

In this study nineteen intra-articular fractures of the humerus were fixed with Kirschner wire and screw; seventeen fractures were fixed with Kirschner wire alone; and two fractures were fixed with screws.

Anterior transposition of the ulnar nerve was done in thirteen cases. Exploration of the radial nerve was done in four cases.

Immobilization in a posterior splint (31 cases) varied from 2 to 8 weeks (mean 4 weeks). Postoperatively the patients began active range of motion exercise several times a day as pain permitted, usually by the second postoperative week. Cast immobilization was used in seven cases and changed to a posterior splint two weeks after operation for early mobilization.

Outpatient physical therapy was performed two to three times a week for the first two months and as needed thereafter. Active range of motion was the rule throughout the postoperative course.

Neither cast brace nor continuous passive motion (CPM) was used in this series.

The average follow up was 18 months.

RESULTS

The overall results which are classified according to each of the three types of the Riseborough-Radin classification except for type 1, as well as for the entire group of thirty-eight fractures, is shown in Figure 2.

Table II. Criteria for grading results (Jupiter et al 1985).

Final results	Range of movement (degree)			
	Loss of extension	Flexion	Pain	Disability
Excellent	<15	>130	None	None
Good	<30	>120	Slight	Minimal
Fair	<40	>90	with activity	moderate
Poor	<40	>90	variable	Severe

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Nine patients had type 2 fracture. In this group seven (77%) had no pain, and two (22%) had mild pain on exertion. Eight patients (89%) had no functional restriction while one had some residual disability. An excellent range of motion of the elbow was found in five patients (56%); good in two (22%); and fair in two (22%). Normal motion of the forearm was present in seven patients (77%), and two patients (22%) lacked 10 to 20 degrees of complete pronation and supination. Five patients (56%) were considered to have an excellent over-all rating; two (22%) a good rating; and two (22%) a fair rating.

Eleven patients had type 3 fractures. In this group six (55%) had no pain, three (27%) had mild pain, and two patients (18%) had pain with activity. Eight patients (73%) had no functional restriction, two patients (18%) had mild discomfort and one (9%) noted severe disability. Five patients (45%) had an excellent range of motion of the elbow; five (45%) had good motion; and one (10%) poor elbow mobility. Six patients (55%) had normal motion of the forearm, and five (45%) lacked 10 to 20 degrees of mobility.

An over-all excellent rating was given to four patients (36%); a good rating to four patients (36%); a fair rating to two patients (18%); and a poor rating to one (10%).

Eighteen patients had type 4 comminuted intraarticular fractures. In this group fourteen (78%) had no residual pain while three (16%) had mild discomfort and one (6%) had pain with activity. Thirteen (72%) denied functional limitations, whereas three (17%) noted some disability; and two (11%) had severe disability.

Six patients (33%) had an excellent range of motion of the elbow; eight (45%) had good motion; two (11%) fair motion; and two (11%) poor elbow mobility. Eleven patients (61%) had normal motion of the forearm and seven (39%) lacked 10 to 20 degrees of mobility. An over-all excellent rating was given to five patients (28%) and a good rating to nine patients (50%). Two patients (11%) were considered to have a fair rating, and two (11%) were rated poor.

Considering the entire group of patients, no residual pain was noted by twenty-seven (71%), mild discomfort was felt by eight (21%), and three patients (8%) had pain with activity.

Twenty-nine (76%) reported no functional restriction, while six (16%) described some residual disability, and three patients (8%) had severe disability.

Sixteen patients (42%) had excellent range of motion of the elbow, while fifteen (39%) were rated good. Thus, thirty-one patients (81%) had good and excellent over-all motion of the elbow. Four patients (11%) were judged to have fair motion and three (8%) poor motion. A normal range of supination and pronation of the forearm was found in twenty-four patients (63%). Fourteen (37%)

lacked only 10 to 20 degrees of complete pronation and supination.

An over all excellent rating was found in fourteen patients (37%) and a good rating in fifteen (39%), so twenty-nine patients (76%) had good or excellent overall results in this series. Six patients (16%) were considered to have fair overall results and three (8%) were rated as poor.

The follow-up radiographs revealed an articular space of normal width in twenty-two patients (58%) and slight narrowing in sixteen (42%). Of the fourteen patients whose result was rated as excellent overall, nine (64%) had normal radiographs and five (36%) had slight arthrosis. Three of the latter five patients had type 4 fracture. Six of fifteen patients whose result was rated as good had mild to moderate radiographic changes of arthrosis; three of these patients had type 4 fracture.

Complications

Non-Union: One patient had nonunion of the distal end of the humerus. This case was a 65-year old female, car accident, multiple trauma with open type 1 fracture of the intra-articular distal humerus (type 3). We decided to fix the nonunion with a reconstruction plate and bone graft. She did not accept revision surgery.

Elbow joint stiffness: Two patients had stiffness which were seen in those with a severely comminuted type 4 fracture. One of these cases had associated radial nerve injury and the other had median nerve injury.

Postoperative nerve compression: One patient had ulnar nerve compression, which required neurolysis and anterior transposition of the ulnar nerve. He developed partial improvement.

Infection: One patient with open fracture (type 2) developed superficial wound infection, who was treated by intravenous antibiotic therapy and dressing. Two patients had superficial pin site infection, who were treated by oral antibiotic therapy and pin site care. No chronic osteomyelitis was seen in the patients.

Pin protrusion: Two patients had olecranon pin protrusion, which was removed three months after operation. One patient had lateral condyle pin protrusion.

No heterotopic bone formation was seen in the patients.

Over-all complication rate in this study was 26%, with a complication rate in comminuted fractures (type 4) of 21%.

DISCUSSION

Treatment options: Prior to 1960, the consensus

avored non-operative management because of poor operative results.^{10,11}

Horne¹¹ believed that the more comminuted fractures were better managed conservatively, because of greater difficulty of operative stabilization.

Since the advent of modern implants and surgical techniques permitting rigid internal fixation and early motion, recent publications favor operative management.^{1,3,4,5,6,8}

Early motion must be allowed in order to achieve a good result. DeLee et al. noted that any method of treatment that requires prolonged immobilization is likely to result in fibrosis or ankylosis of the joint and a poor result.

Nonoperative treatment methods can be divided into three categories of cast or splint stabilization, traction, and the bag of bones technique.

Operative methods include pin and plaster or external fixation, open reduction with internal fixation, or arthroplasty.

The current emphasis is on operative intervention with rigid internal fixation.^{2,3,7,8}

The indication for open reduction and internal fixation includes displaced intra-articular fractures, fractures associated with other ipsilateral injuries (floating elbow), fractures associated with neurologic or vascular injuries, and fractures in multiply-injured patients.

Relative contraindications to surgery include the elderly patient with osteopenia, severe comminution and fractures associated with severe contamination or soft tissue injury.¹²

While there have been numerous studies regarding the management of this uncommon fracture, the overall number of reported cases has been small, the fracture has been classified by varying criteria, and the results have been judged by a wide range of methods of functional evaluation. Diversity has been found even within individual series, as different treatment recommendations were proposed for selected types of fracture patterns.¹⁰

Accurate comparisons between operative and non-operative treatment remains difficult, even within the series of individual authors.^{3,4,5,6,13}

We have presented the results of a consistent, controlled surgical treatment at a single institution, making use of current operative technique, equipment, and controlled postoperative mobilization. The careful identification and temporary fixation of the articular fragments with Kirschner wire enables the surgeon to accurately assess the anatomy of the individual fracture and to tailor the placement and type of internal fixation to meet each fracture's unique requirements.

Concern has been expressed that the extensive dissection and surgical trauma of the exposure required to

achieve rigid internal fixation will lead to soft-tissue fibrosis and limitation of motion.¹⁰

We have found that the trans-olecranon approach offers excellent exposure of the articular surface and distal end of the humerus without the soft-tissue trauma associated with the triceps-splitting or tongue of triceps approach. This approach also facilitates identification and protection of the ulnar nerve. Anterior transposition is indicated when the nerve is contused from the original trauma or when the metal implants will cause a mechanical irritation.

In osteosynthesis, emphasis is placed on the accurate restoration of the trochlea^{3,5,8} and reconstruction of the joint surface. Therefore we reduced and fixed two condyles with Kirschner wires and/or screws, then reduced and fixed medial and lateral columns with wires and/or screws for stabilizing the supracondylar part.

We have removed implants, if union was evidenced. Therefore medial and lateral column pins and also bicondylar transverse pins or screws were removed three months after operation in twenty patients.

Patients of all age groups have good chances to regain satisfactory function, and there is no reason to exclude older patients from operative treatment.¹⁴

As expected, open or comminuted fractures, associated injuries of the same arm, and polytrauma adversely affected the outcome.¹⁵

Although it has been stressed by previous authors,¹⁶ this study also showed that early open reduction and stable internal fixation within 24 hours produced significantly better results than did delayed treatment.¹⁵

It is noteworthy that the clinical evaluation did not always correlate with the follow up radiograph.

The infection rate of 8% in this series is similar to other series in the literature. No patient developed chronic osteomyelitis.

Our average results of elbow movement was very good, with an average 105 degrees of flexion/extension. According to Jupiter Stringent criteria, of the intra-articular T-type or Y-type fractures, 76% were rated excellent and good.

A detailed comparison of these results is difficult because of the absence of a consistent grading scale.¹⁰

We compared this study with previous studies which used the same Jupiter criteria. Holdsworth et al. (1990) reviewed 38 adult patients after early internal fixation by dual plates for displaced fractures of the distal humerus. His results were excellent and good in 76% with an average range of elbow movement of 115 degrees.¹⁷

Jupiter et al. (1985) reviewed 34 adult patients with intercondylar fractures of the distal humerus that were fixed by dual plates, pins and screws. His results were excellent and good in 78%.¹⁸

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Kundle et al. (1996) reviewed 77 cases with intraarticular fractures of the humerus, which were fixed by dual plates and screw. Follow up examination showed 52% excellent and good results.

The 24% poor results seem rather high compared with those reported in the literature. This might be because of the high percentage of polytraumatized patients and open fractures in this series.¹⁵

Cassebaum et al. (1969) reviewed 36 intercondylar fractures of the distal humerus, fixed by pins and/or screw. Follow up examination showed 71% excellent and good results according to his criteria.¹⁹

Therefore, our study results (76%) are similar to cases reported by Holdsworth et al. (76%)¹⁷ and Jupiter et al. (78%)¹⁸ who used dual plates for fixation.

Also, our study result (76%) is better than that reported by Kundel et al. (52%)¹⁵ who used dual plates for fixation, and Cassebaum et al.¹⁹ (71%) who used pins and/or screws for fixation.

CONCLUSION

By adhering to the basic principles of atraumatic soft-tissue technique, stable anatomic reduction of the fractures by metallic devices such as pins, and early active post-operative mobilization, approximately 76% good to excellent results can be expected. Therefore we prefer anatomical reduction and stable fixation with pin and screw, instead of extensive soft-tissue dissection with dual plate fixation, in adults and in old patients with good bone quality.

REFERENCES

1. Fornasieri C, Staub C, Tourne Y, Rumelhart C, Saraglia D: Biomechanical comparative study of three types of osteosynthesis in the treatment of supra- and intercondylar fractures of the humerus in adults. *Rev Chir Orthop Reparatrice Appar Mot* 83 (3): 237-42, 1997.
2. Gupta R: Intercondylar fractures of the distal humerus in adults. *Injury Oct* 27(8): 569-72, 1996.
3. Safran O, Mosheiff R, Segal D, Liebergall M: Surgical treatment of intercondylar fractures of the humerus in adults. *Am J Orthop Nov* 28(11): 659-62, 1999.
4. Gupta R, Khanchandani P: Intercondylar fractures of the distal humerus in adults: a critical analysis of 55 cases. *Injury Jul* 33(6): 511-5, 2002.
5. Pajarinen J, Bjorkenheim JM: Operative treatment of type C intercondylar fractures of the distal humerus: results after mean follow-up of 2 years in a series of patients. *J Shoulder Elbow Surg Jan Feb* 11(1): 48-52, 2002.
6. Gupta R: Intercondylar fractures of the distal humerus in adults. *Injury Oct*; 27(8): 569-72, 1996.
7. Yang KH, Park HW, Park SJ, Jung SH: Lateral J-plate fixation in comminuted intercondylar fracture of the humerus. *Arch Ortho Trauma Surg Jun* 234-8, 123 (5): 2003.
8. Bhandari T, Shukla J, Mehrota A, Shrivastava N: Rigid osteosynthesis and early mobilization in inter-condylar fracture of humerus. *Indian Journal of Orthopaedics Oct* 32 (4): 247-9, 1998.
9. Lsetsch R, Schmit-Neuerburg KP, Stumer KM, et al: Intraarticular fractures of the distal humerus. Surgical treatment and results. *Clin Orthop* 241: 238-44, 1989.
10. Risebrough EJ, Radin EL: Intercondylar T fractures of the humerus in adults. *J Bone Joint Surg* 51A: 130-41, 1969.
11. Horne G: Supracondylar fracture of the humerus in adults. *J Bone Joint Surg* 61B: 246, 1979.
12. Henly MB: Intraarticular distal humeral fractures in adults. *Orthop Clin North Am* 18: 11-23, 1987.
13. McKee MD, Wilson TL, Winston L, Schemitsch EH, Richards RR: Functional outcome following surgical treatment of intra-articular distal humeral fractures through a posterior approach. *J Bone Joint Surg Am Dec* 82-A(12): 1701-7, 2000.
14. John H, Rosso R, Neff U, et al: Operative treatment of distal humeral fractures in the elderly. *J Bone Joint Surg* 76B: 793-6, 1994.
15. Kundle K, Braun W, Wieberneit J, et al: Intra-articular distal humerus fractures. Factors affecting functional outcome. *Clin Orthop* 322: 200-8, 1996.
16. Helfet DL, Schmeling GJ: Bicondylar intraarticular fractures of the distal humerus in adults. *Clin Ortho* 292: 26-36, 1993.
17. Holdsworth BJ, Mossad MM: Fractures of the adult distal humerus. Elbow function after internal fixation. *J Bone Joint Surg* 72B: 362-5, 1990.
18. Jupiter J, Neff U, Holzach B, et al: Intercondylar fractures of the humerus. An operative approach. *J Bone Joint Surg* 67A: 226-39, 1985.
19. Cassebaum WH: Operative treatment of T and Y fractures of the lower end of the humerus. *Am J Surg* 83: 265-270, 1969.
20. Signoret F, Feron JM, Lemseffer M, Guincestre JM: Posterior approach to the elbow preserving the extensor apparatus. Its value in the osteosynthesis of humerus plate fractures. *J Chir (Paris) Dec*; 123(12): 746-8, 1986.
21. Jamali AR, Mehbood G, Ahmad S: Extensor mechanism sparing approach to the elbow for reduction and internal fixation of intercondylar fracture of the humerus. *J Pak Med Assoc Jul* 49(7): 164-7, 1999.