

# Crisscross-type screw fixation for transcondylar fractures of distal humerus in elderly patients

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## Abstract

**Introduction** This study presents the outcomes of low transcondylar fractures of the distal humerus treated by closed reduction and internal fixation with two screws in a crisscross orientation.

**Materials and methods** Between 2003 and 2009, ten consecutive elderly patients (1 man and 9 women) with transcondylar fractures of distal humerus (AO 13A2.3) were included in this study. The average age at the time of injury was 72 years (range 63–82). All were closed injuries without nerve injury. The mechanism of the injuries was low-energy fall or slip. Six patients had medical or other systemic diseases. **Surgical technique:** After a closed reduction of the fracture fragments, two guide wires were inserted in a crisscross orientation; one from the lower lateral edge of the capitellum to the medial cortex of the distal humerus, and the other from the lower medial edge of the trochlea to the lateral cortex of the distal humerus. After drilling, fully threaded cannulated screws (4.5 mm in diameter) were inserted along the each guide wire. Functional outcome was assessed with Mayo Elbow Performance scores.

**Results** The mean operation time was 55 min (range 40–100 min). The average follow-up duration was 26.8 months (range 24–35 months). The mean Mayo Elbow Performance scores were 93.8 (range 90–99). The elbow extension–flexion arc was 12°–125°. The mean pronation–supination angle was 74°–72°.

**Conclusion** In geriatric patients with transcondylar fractures of the distal humerus, a crisscross fixation with two cannulated screws provides satisfactory results that allow a nearly full range of elbow motion with minimal surgical morbidity.

**Keywords** Transcondylar fractures · Distal humerus · Screw · Crisscross

## Introduction

Transcondylar fractures of the distal humerus are transverse fractures that extend from the lateral epicondyle just proximal to the articular surface of the distal humerus through the olecranon and coronoid fossa to the medial epicondyle [18]. Fractures of the distal humerus are relatively rare in adults, comprising approximately about 2 % of all fractures [9, 15]. Transcondylar fracture, which is a subgroup of distal humerus fractures, is even much rarer, consisting of about 9 % of all distal humerus fractures. This means that pure transcondylar fractures account for about 0.18 % of all skeletal fractures.

Few papers address this fracture due to its rarity, and even the majority of those reports are grouped together with multiple subtypes of distal humerus fractures [4, 8, 18, 20, 23]. Thus, the treatment of transcondylar distal humerus fractures in adults is not well established [16]. Most of these fractures occur in elderly osteopenic patients due to low-energy injuries, such as a slip down [16]. The small size of the fragment and the fact that this fragment is covered with articular cartilage makes stable internal fixation difficult to achieve [8, 13, 18, 21, 22, 27]. This anatomic characteristic makes firm fixation with plate and screws too difficult, with extensive surgical exposure increasing the risk of

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postoperative morbidity and hindering rehabilitation. Some authors suggest total elbow arthroplasty as the primary treatment for these reasons [3, 12, 19].

We have used a treatment method that consisted of interfragmentary fixation with two screws in crisscross orientation through minimal incisions. Our proposal is that this provides more firm and stable fixation than simple percutaneous pinning as commonly used for pediatric supracondylar fractures. The authors report this technique in transcondylar fractures of the distal humerus in elderly patients. Our method allows early range of motion without extensive surgical dissection as in plating that might cause postoperative stiffness and morbidity.

The purpose of this study was to describe our surgical technique and to evaluate the outcomes achieved by using this technique. Our expectation was that this technique would provide high union rate and satisfying range of motion without surgical morbidity.

## Materials and methods

This study was approved by the Institutional Review Board. Our hospital is in accordance with the Declaration of Helsinki. From January 2003 to December 2009, fourteen consecutive patients with distal humerus fractures treated with the crisscross screw fixation technique were included in this study. Four patients were lost to follow-up and the remaining 10 patients were followed for more than 2 years (Table 1). The patients' mean age at the time of the operation was 72 years (range 63–82 years). The mechanisms of injury included a slip injury in 8 cases (80 %) and a fall from a height in 2 cases (20 %). According to the AO classification, all fractures were classified as type 13 A2.3. All were closed fractures. Two patients had chronic obstructive pulmonary disease, one had ankylosing spondylitis, and three had diabetes mellitus (Table 1). Preoperative evaluation included anterior posterior and lateral radiographs of the elbow. Additional computed tomography scans with multiplanar reconstruction were performed to identify the comminution status and to evaluate the fracture pattern accurately.

### Surgical technique

Patients were anesthetized with either general anesthesia or brachial plexus block, and then placed in the lateral decubitus position. Using a supporting bar, the affected arm was hung vertically. Closed reduction was done under fluoroscopy. One-centimeter-sized skin incisions were made on both sides, exposing each epicondyle. The incision on the medial side of elbow was made carefully, so not to injure the ulnar nerve, which lies in the vicinity of the medial epicondyle. A smooth K-wire (1.50 mm in diameter) was

introduced in a crisscross fashion in each epicondyle to maintain reduction. The starting point was centered in the epicondyles and the guide wires were directed up each distal humerus columns. In the lateral direction, a gap of at least 5 mm was kept between each K-wire to prevent the impingement of the two screws that were to be placed. Care was taken to ensure that the wires did not cross at the fracture, and that they exit the diaphyseal bone. Of note, the wires might exit posteriorly, considering the anteflexion of the distal humerus. Using a cannulated drill, full penetration was made to introduce the screws. We measured the screw length with a cannulated depth gauge. If the screw was longer than the gauge, we used a 2-wire measuring technique with a third guide wire of equal length to determine the depth. This was done by placing the free guide wire adjacent to the earlier drilled wire on the bone and subtracting the overhanging length from the total wire length. Then we placed a fully threaded 4.5-mm cortical screw along the guide wire.

### Postoperative treatment and follow-up

Postoperative immobilization was done in a long-arm plaster splint with the elbow in 90° of flexion and the wrist in neutral rotation. Five to seven days after surgery, the splint was changed to hinged elbow brace, and gentle active-assisted range-of-motion exercise took place under the assistance of a physical therapist. The arc of motion was progressively increased as tolerated. Four to six weeks after the surgery, the brace was removed and muscle strengthening exercises began. The rehabilitation program was individually tailored to each patient's condition and bone healing status. No radiotherapy or medication was given to prevent heterotopic ossification. Follow-up examinations took place 6 and 12 weeks postoperatively, and after a final follow-up time. Radiological follow-up included standard anteroposterior and lateral radiographs for examination of reduction status, overall alignment, fracture union, and hardware migration. Range of motion, including arc of flexion–extension and pronation–supination, was measured with a hand-held goniometer. Elbow stability was evaluated on the basis of history and physical examination. The Mayo Elbow Performance score was measured to determine functional results. Pain according to the visual analog scale (VAS) was also measured on each visit. An independent investigator performed clinical and radiological follow-up examinations, and this person was not involved in the primary treatment.

## Results

The mean operation time was 55 min (range 40–100 min). The mean time from injury to operation

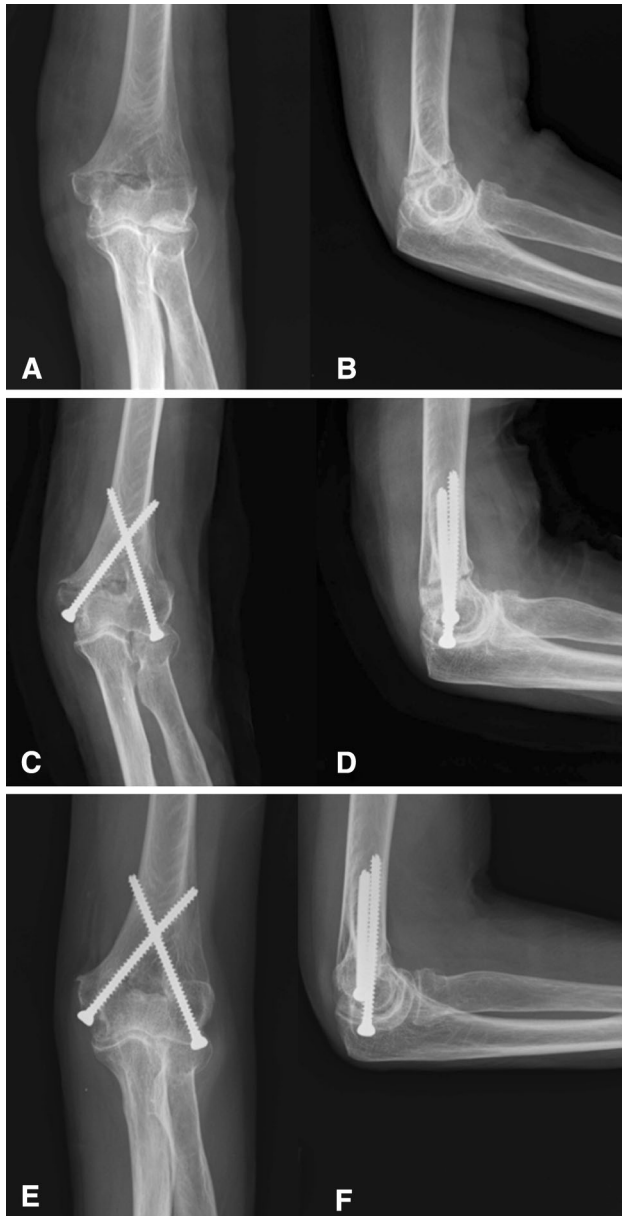
**Table 1** Patient data

Case	Age	Gender	Injury side	Mechanism	Fracture type(OTA)	Associated diseases	Days from injury to operation	Follow-up duration (mos.)	Extension (degree)	Flexion (degree)	Arc	Pronation (degree)	Supination (degree)	Pain (VAS)	Mayo Elbow Performance score
1	82	F	Right	Slip down	13-A2	Chronic obstructive pulmonary disease	21	25	10	125	115	85	75	1	93
2	65	F	Left	Fall from height	13-A2		2	27	15	130	115	70	70	1	91
3	72	F	Right	Slip down	13-A2		6	22	10	125	115	80	75	0	95
4	63	M	Left	Fall down	13-A2	Ankylosing spondylitis	10	30	15	125	110	70	70	1	95
5	79	F	Right	Fall from height	13-A2	Chronic obstructive pulmonary disease	11	25	10	120	110	85	75	1	90
6	68	F	Left	Slip down	13-A2	Iatrogenic Cushing, DM, HiBP	25	35	12	130	118	60	70	0	98
7	80	F	Left	Slip down	13-A2	DM, HTN	30	25	10	125	115	80	75	1	98
8	68	F	Left	Slip down	13-A2	DM, HTN	10	30	13	120	107	70	70	2	94
9	72	F	Right	Fall down	13-A2		10	24	10	125	115	70	70	0	90
10	68	F	Right	Slip down	13-A2		11	25	15	125	110	70	70	1	95
Avera	72						13.6	26.8	12.0	125.0	113	74.0	72.0	0.8	93.9

DM Diabetes mellitus, HTN hypertension

was 13.6 days (range 2–30 days). Postoperatively, none of the fractures showed a step-off or gap in the inter-surface fracture of more than 2 mm. The average time of follow-up was 26.8 months (range 24–35 months). In all cases, follow-up ultimately revealed good bony union. Distal humeral tilt was within the normal range, and there were no radiologic signs of nonunion (Fig. 1). The average time to union could not be calculated because serial weekly radiologic examinations were not performed. However, all fractures showed union evidence

3 months postoperatively. Nine patients were older than 65. No case of pseudoarthrosis, loss of reduction, or nonunion was observed in this age group. Sample pre-operative and postoperative radiographs are shown in Fig. 1. No ulnar nerve complications occurred in relation to insertion of the K-wires or screws through the medial epicondyle. There was neither redisplacement of fracture site, nor nonunion. The mean range of motion was as follows: flexion, 125° (range 120°–130°); extension, 12° (range 10°–15°); mean arc of motion, 113° (range 107°–115°); pronation, 74° (range 60°–85°); and supination, 72° (range 70°–75°). The mean VAS pain score was 0.8 (range 0–1), with three patients (30 %) being completely pain free. At the final follow-up, the mean MEPS was 93.9 (range 90–98), representing an excellent result in five cases (50 %), a good result in five cases (50 %); neither fair (60–74) nor poor (less than 60) results were seen.



**Fig. 1** A 79-year-old woman with a transcondylar fracture of the left distal humerus (AO 13-A2, **a, b**). After closed reduction, two 4.5-mm cannulated screws were inserted (**c, d**). Twenty-five months after the surgery (**e, f**)

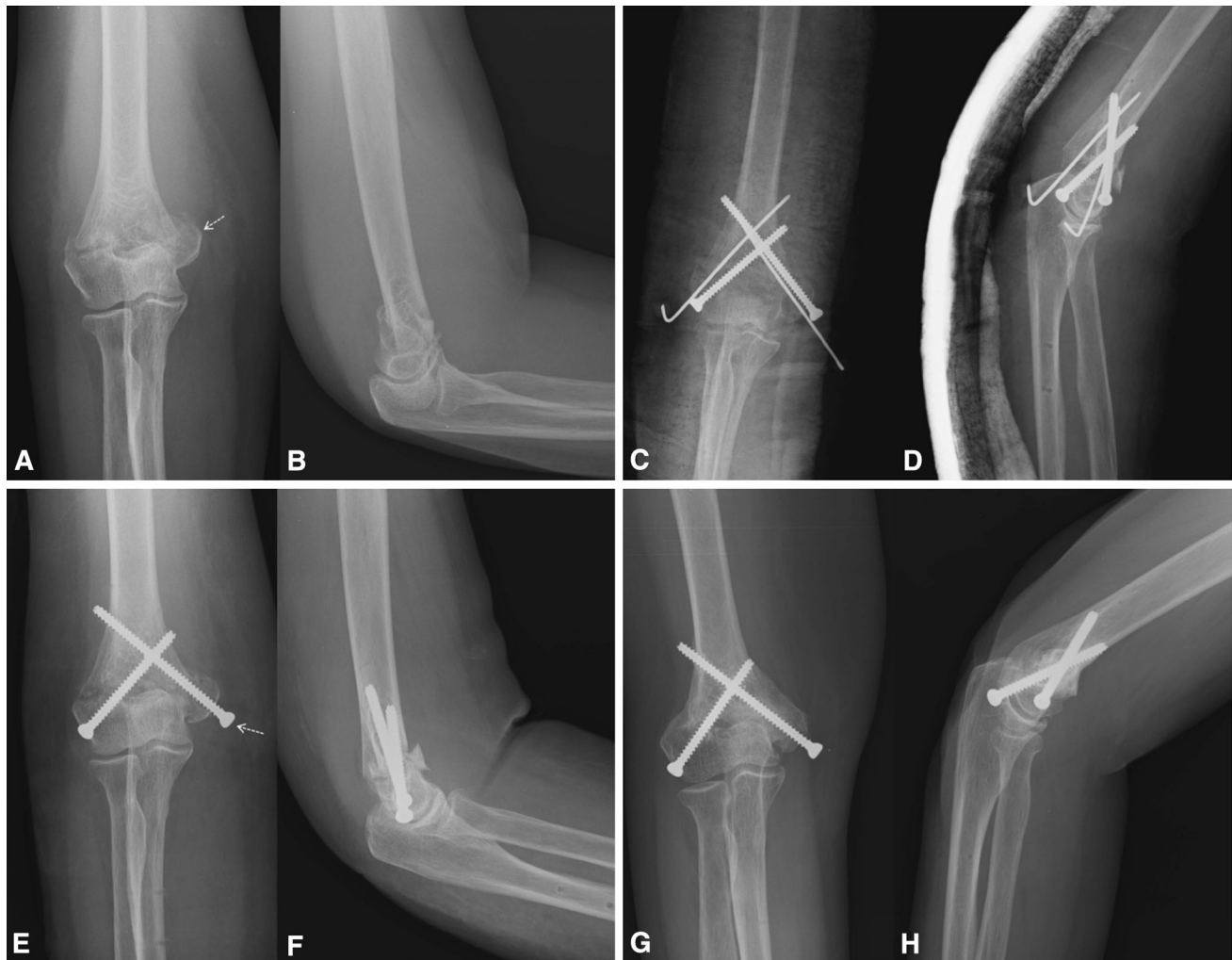
## Case series

### Case 1

A 79 year-old woman (case no. 5, Table 1) sustained a transcondylar fracture of the left distal humerus (AO type 13-A2) confirmed by anteroposterior and lateral radiographs (Fig. 1a, b). After closed reduction, two 4.5-mm cannulated screws were inserted through each column of the distal humerus to stabilize the fracture (Fig. 1c, d). Seven days after surgery gentle supervised active range of motion was begun. Twenty-five months after the surgery, the range of elbow flexion and extension was 120°/10°, and pronation and supination was 85°/75°. The MEP score was 90 and VAS pain score was 1 (Fig. 1e, f).

### Case 2

An 80-year-old woman (case no. 7, Table 1) sustained a slightly displaced transcondylar fracture with fragmentation of the lateral epicondyle (AO 13-A3 type) confirmed by anteroposterior and lateral radiographs (Fig. 2a, b). After closed reduction, two 4.5-mm cannulated screws with adjuvant K-wires were inserted through each column of distal humerus to stabilize the comminuted fracture fragments together (Fig. 2c, d). The K-wires were removed one week after operation, with no change in stability (Fig. 2e, f). The medial cannulated screw was purposefully left protruded to prevent causing too much compression force against the fragmented medial epicondyle, but no ulnar nerve symptoms or overlying skin irritation took place. Seven days after surgery, the splint was changed to a hinged elbow brace and gentle active-assisted range of motion was started. Twenty-five months after the surgery,



**Fig. 2** A 80-year-old woman with a slightly displaced transcondylar fracture with fragmentation of lateral epicondyle (white arrow in A, AO 13-A3). Two 4.5-mm cannulated screws with adjuvant K-wires were inserted through each column of distal humerus to stabilize the comminuted fracture fragments together (c, d). The K-wires were

removed 1 week after operation, supposed to be no problem in stability (e, f). The medial cannulated screw was left protruded for prevention of too much compression on the fragmented medial epicondyle (e). Twenty-five months after the surgery (g, h)

the range of elbow flexion and extension was  $125^{\circ}/10^{\circ}$  and pronation and supination was  $80^{\circ}/75^{\circ}$ . The MEP score was 98 and VAS pain score was 1 (Fig. 2g, h).

## Discussion

Fracture of the distal humerus in the elderly is a challenge for orthopaedic surgeons [2, 5, 7, 10, 16, 22, 26]. Traditional treatment for nondisplaced fractures in this group has included plaster treatment [18, 24], although many non-unions have been reported with this technique [1, 6, 21]. Stiffness of elbow joints also occurs with prolonged casting, which can be functionally limiting and particularly debilitating in elderly patients [1, 6, 16, 18, 21, 24]. During the last two decades, dual-plate fixation has become an

accepted standard method in the treatment of distal humeral fractures [11]. Although these methods have proven to be effective for the majority of distal humeral fractures, they are not seemed to be fit for the transcondylar fractures (OTA 13A2.3) due to osteoporosis and the much smaller distal fragment than in ordinary distal humeral fractures [8, 16]. Therefore, the traditional plating method in treating transcondylar fractures has a high rate of complications [21, 23]. Simone et al. [23] reported 14 cases of transcondylar fractures treated with dual plating techniques, resulting in 7 cases (40 %) of complications, and 29 % were required to undergo additional surgery. Robinson et al. [21] reported delayed union and nonunion in 37.5 % of their series they studied. Furthermore, primary elbow arthroplasty does not show optimistic results, with a complication rate of  $21.5 \% \pm 9.2 \%$  [25].



Bone healing rates may not be only affected by the biomechanical stability of the fracture fixation but also by biological factors, especially in the elderly patient population [23]. The intraosseous circulation of the elbow is provided mainly from perforating vessels arising from neighboring extraosseous vessels. Extensive dissection around the elbow during plating may damage these perforating arteries, hindering the biological healing of the bone [23, 28]. Together with biological circulation characteristics, the fact that transcondylar fractures usually occur in geriatric patients needs treatment methods minimizing the surgical risk and postoperative morbidity [16–18, 21].

The crisscross style of fixation was first proposed by Miller [14] in a schematic drawing to our knowledge, but with no images or records of real clinical cases. Perry et al. [18] described the technique of a crisscross form of fixation, however, showed only one clinical case. Recently Paryavi et al. [16] reported five cases of transcondylar distal humeral fractures in geriatric patients fixed by two column screws in a crisscross fashion. No complications were noted, and all fractures healed at an average of 7.2 weeks. The average range of motion was 22° extension, 114° flexion, and 92° arc of motion. However, they noted that no conclusion regarding long-term stability could be made because of the short follow-up period (10.2 weeks), mentioning the possibility of late failure of fixation.

Previous biomechanical researches reported the crisscross form fixation being biomechanically weaker compared to the plating methods. Shimamura et al. [22] compared various plating techniques involving two screw fixation methods in a crisscross orientation in cadavers and tested them for fixation rigidity after creating and fixing transcondylar fractures. These biomechanical studies revealed that the crisscross method has a significantly lower fixation stability compared to plate fixation. But in our study, there was no case of fixation failure or problems, such as nonunion or hardware failure, took place. Mayo Elbow Performance scores showed excellent results, with pain scores below 1.0 in our study.

Our series has shown that this method provides the adequate interfragmentary fixation necessary for primary bone healing and fracture union. The crisscross-type screw fixation creates a stable bony construct that allows for range-of-motion exercises at 2 weeks, therefore, allowing the patient to gain nearly full recovery of original function. No instability of the fracture site was seen. Usually, a 4.5-mm-diameter screw will suffice, and in theory, a half-threaded screw is apt to yield a gliding effect, providing pressure at the fracture site. For the elderly, bone mass at the proximal and the distal sides of the fracture site is insufficient, so the expected advantage of the gliding effect of the half-threaded screws sacrifices stability. Therefore,

an insertion of a fully threaded cannulated screw enables enough purchase of the distal and proximal fracture fragments to maintain stability (Fig. 1).

The weakness of our study is the small number of cases and retrospective nature of study design. Because this specific fracture pattern is very few in nature, statistical study establishing standard treatment proposal can be difficult. Previously published articles showed their clinical cases with not more than 14 cases at most [23]. However, our series has showed one option of minimally invasive surgical methods that is mandatory for geriatric patients who are susceptible to this type of fractures.

Future studies may be needed to compare this type of treatment with present plating technique to determine any significant difference in functional outcome or morbidity.

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