



Results of plate fixation for transcondylar fracture of the distal humerus: a rare pattern of fractures



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Background: The pattern of transcondylar fracture of the humerus is unique and the incidence rate is very low. Stable internal fixation may be difficult to achieve, and complications have been reported at a higher rate. The purpose was to report the outcomes of open reduction and internal fixation (ORIF) for transcondylar fractures of the humerus.

Methods: Seventeen patients were included between January 2014 and December 2017. ORIF was performed using anatomic distal humerus plates. Results were evaluated by range of motion, Mayo Elbow Performance Score (MEPS), and complications. We analyzed the results according to ulnar nerve transposition status and fixation pattern.

Results: The mean range of elbow motion was 117° flexion and 20° extension. The MEPS was excellent in 12, good in 3, fair in 1, and poor in 1. There were in total 5 cases of complications among 17 patients: 1 with nonunion, 1 with ulnar neuropathy, 2 with delayed union, and 1 with heterotopic ossification. The results according to ulna nerve transposition and fixation pattern showed no difference.

Conclusions: For reliable and good results, rigid fixation using anatomic plates and appropriate immobilization of the fracture site are key factors in the treatment. In our case series, the overall outcome was good and there were 2 major complications. The ORIF using anatomic plates can be a reliable treatment option for transcondylar humeral fractures.

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Transcondylar fractures of the distal humerus of the adults are extra-articular fractures in which the single transverse fracture line is usually located at the level of the condyle or below. The fracture pattern is unique, and this type of fracture occurs only in about 9% of the distal humeral fractures.^{9,18} Stable internal fixation may be difficult to achieve, and complications have been reported at a higher rate because the distal subchondral bone stock for plate fixation is very small and not strong enough to support screw fixation.^{5,12,15,19,21} Sometimes, older patients neglected the fracture and visited the hospital in a state of nonunion or delayed union a few weeks after the injury. For such patients, plate fixation may be impossible, which may require total elbow arthroplasty surgery.¹⁵

There are not many reports on the results of open reduction and internal fixation (ORIF) with anatomic plates for transcondylar fractures of the distal humerus so far. Fractures of this pattern are known to occur mostly in elderly patients¹; therefore, the incidence

of such fractures is expected to increase in the near future because of aging and ORIF should be considered as a first choice of treatment rather than joint replacement arthroplasty.^{3,11} The authors have achieved better results with ORIF with anatomic plates than previous reports. The purpose of this article was to report the results of treatment in our case series.

Methods

Medical records of patients treated in our hospital for distal humerus fractures between January 2014 and December 2017 were analyzed retrospectively. Inclusion criteria were (1) patients with low transcondylar fractures, which had a transverse fracture line at the level of or below the medial and lateral condyles; (2) patients who had open reduction and plate fixation; and (3) patients with more than 6 months of follow-up. We excluded patients with intercondylar, capitellar, trochlear, medial, or lateral condylar fracture of the distal humerus. A total of 78 patients with distal humerus fractures were identified. Fifty-eight patients with other fracture types, 2 patients with less than 12 months' follow-up, and 1 patient who had undergone total elbow arthroplasty were excluded. Finally, 17 patients with transcondylar fractures who

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underwent plate fixation and with more than 12 months' follow-up were included in this study (Fig. 1).

The average age of patients was 73.1 years (range, 41–89), and 3 patients were younger than 65 years. The injury mechanism of patients younger than 65 years involved a 3-m fall ($n = 1$) and a fall from the ladder ($n = 2$). Other patients were older than 66 years, and the injury mechanism was a fall while walking ($n = 11$) and a slip down on the stairs ($n = 3$), which were mostly low-energy injuries. Eleven patients were female.

Two orthopedic surgeons performed the operations. A triceps-sparing approach was used in 12 patients, a modified triceps tongue approach in 4 patients, and an olecranon osteotomy approach in 1 patient. During the procedures, the ulnar nerve was released and transposed anteriorly in 9 patients, and it was not transposed in 8 patients. The decision on ulnar nerve transposition and fixation pattern was based on surgeon's preference. Internal fixation was performed using a 3.5-mm LCP distal humerus plates (DePuy Synthes, West Chester, PA, USA) with an orthogonal pattern in 11 patients (Fig. 2) and an Elbow Plate System (Acumed, Portland, OR, USA) with parallel pattern in 6 patients (Fig. 3). If there was a bone defect at the fracture site, an allogene chip or demineralized bone matrix was used to fill the defect. After closing the wound, an above-elbow splint was applied with 45° elbow flexion. One week later, the splint was changed to an elbow flexion of 90°. From an average of 3.9 weeks (range, 3–4 weeks) after surgery, patients began to exercise their elbow joints gently and perform activities of daily living. Three or 4 weeks after the operation, 2 weeks of passive motion exercise was begun. Then, active-assisted and passive motion was encouraged for about 4 weeks. We sent them to the rehabilitation department for physical therapy only when the patient could not follow the exercise. Strenuous activities such as lifting heavy objects were allowed after 12 weeks postoperatively.

The clinical results were evaluated by (1) range of motion, (2) Mayo Elbow Performance Score, and (3) complications. The range of motion was measured in degrees for flexion, extension, pronation, and supination. A radiographic evaluation was performed using follow-up radiographs for evaluating bony union, delayed union, nonunion, or metal failures. Bony union was evaluated by 4 views of elbow radiographs, which were taken on every visit. Four views include anteroposterior, lateral, external oblique, and internal oblique view. We determined bony union when bony connectivity was shown in at least 3 views. Complications such as infection or ulnar nerve neuropathy were assessed at the time of the follow-up visits. The patient was also evaluated according to ulnar nerve transposition status and plate fixation pattern (orthogonal vs. parallel). The patients who had ulnar nerve anterior transposition were compared with the patients who had only in situ ulnar nerve decompression.

The patients' baseline characteristics are presented as means and range or numbers and percentages. Continuous variables are presented as means and range, and categorical variables are presented as numbers and percentages. Multivariate analysis was used to investigate the relationship between results and preoperative conditions.

Results

The average time between injuries and surgery was 5 days (range, 1–9 days). The average follow-up period was 13.6 months (range, 9–15 months). Finally, 16 of the 17 patients have achieved a bony union and the mean union time was 5.3 weeks (range, 4–12 weeks). The mean arc of flexion and extension was 101.8° (range, 60°–130°), that is, 118.8° (range, 90°–130°) of flexion and 17.1° (range, 0°–40°) of extension. The mean arc of pronation was 77.6° (range, 60°–80°) and that of supination was 77.1° (range, 60°–80°).

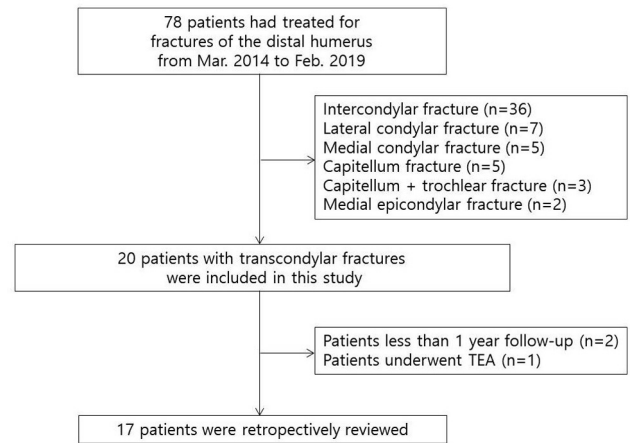


Figure 1 Flow chart of the patients reviewed in this study.

The Mayo Elbow Performance Score showed that 11 patients had an excellent score; 4, good; 1, fair; and 1, poor (Table 1). The analysis of the results according to ulnar nerve transposition and fixation pattern showed no statistically significant difference in the range of motion, Mayo Elbow Performance Score, and incidence rates of complications (Tables II and III). There were a total of 5 cases of complications (23.5%): 2 major complications and 3 minor complications. Major complications were 1 with infected nonunion (patient 9) (Fig. 4) and with an ulnar nerve neuropathy (patient 12). Minor complications were 2 with delayed union (patients 6 and 13) and 1 with heterotopic ossification (HO) (patient 1). For infected nonunion, the plates were removed and antibiotics-impregnated cement beads were inserted. Four weeks of intravenous antibiotic administration was needed. This patient refused further surgery because of a poor general condition. The patient with ulnar nerve symptoms was diagnosed with ulnar neuropathy around the elbow with very severe axonotmesis on nerve conduction study and electromyographic examination. This patient had undergone ulnar nerve transposition during surgery. A revision surgery for the ulnar nerve was considered at that time, but the patient refused the surgery. The patient has been under observation. Delayed union was defined as showing fracture lines for more than 8 weeks or screw loosening. The patients with delayed union both had a history of cerebral vascular accident and 1 of them was heavy smoker. They were instructed to be careful not to fall and to avoid excessive activities. No additional surgery was needed, and bony union was achieved finally. The patient with HO showed ossification at triceps insertion and 30° elbow extension limitation. He had elbow ORIF 2 weeks after the injury, and the delay in fixation may be the cause of HO. Because he had little discomfort due to the HO, no additional surgery was performed for HO.

Discussion

The results of our case series ($n = 17$) showed 1 case of nonunion (6%) and 2 cases of delayed union (11%). These results were better than a previous case series of 14 cases that had found a rate of nonunion and delayed union of 29%.¹⁸ We used the anatomic distal humeral plates for rigid fixation that were designed for complex distal humerus fractures. Recently, there has been a consensus that ORIF using plates is favorable for treating comminuted articular fracture in older patients.^{4–7,11,15,19} Trancondylar distal humeral fracture is an extra-articular fracture without comminution. Although these fractures are extra-articular, the fracture lines are low enough that the fracture itself is in the capsule in most cases.¹⁸

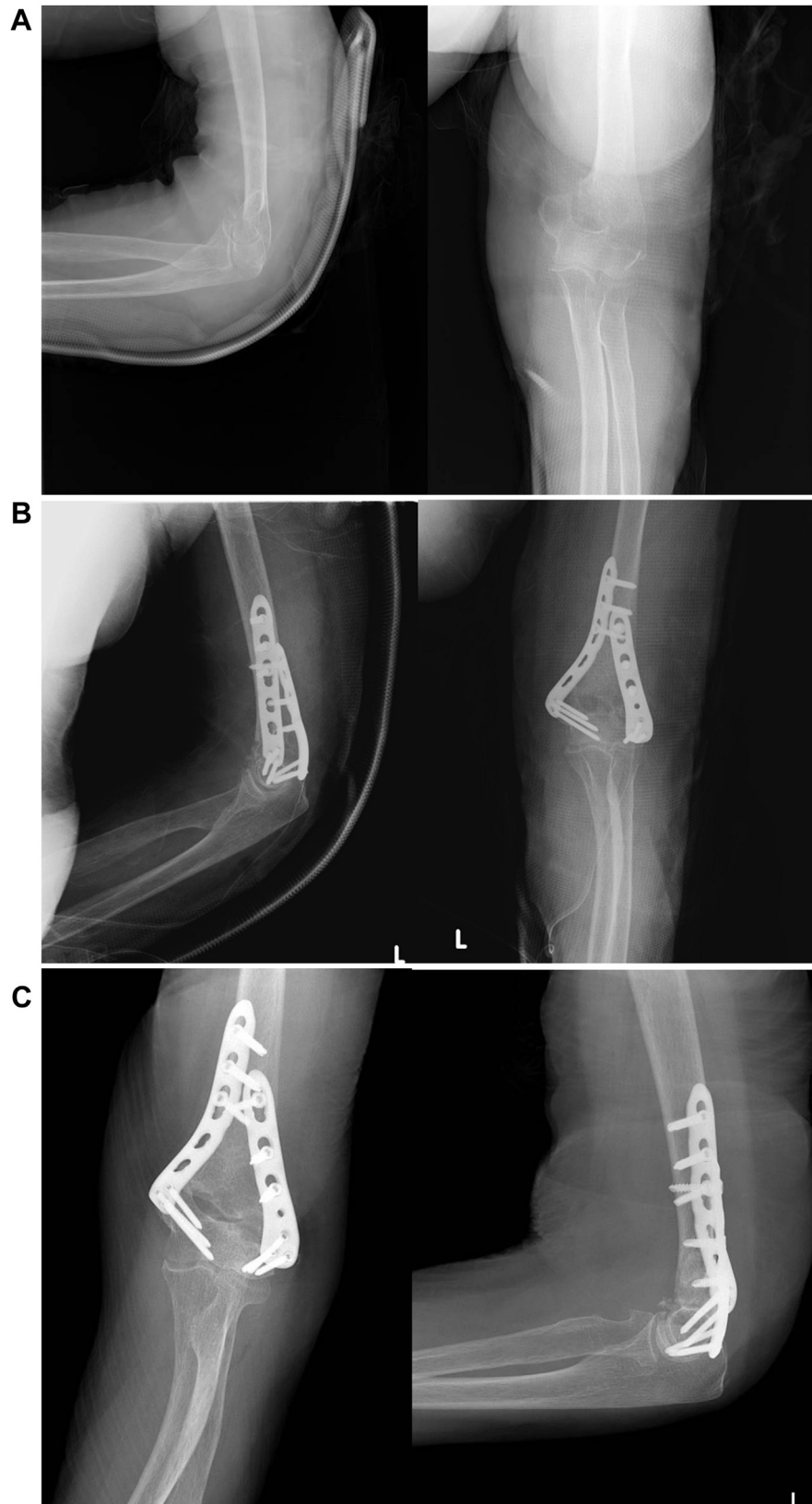


Figure 2 (A) Radiographs of the right elbow of an 87-year-old female patient with a displaced low transcondylar fracture. (B) Immediate postoperative radiographs showed a stable fixation with orthogonal pattern. (C) Union was achieved at 4.5 weeks after operation.

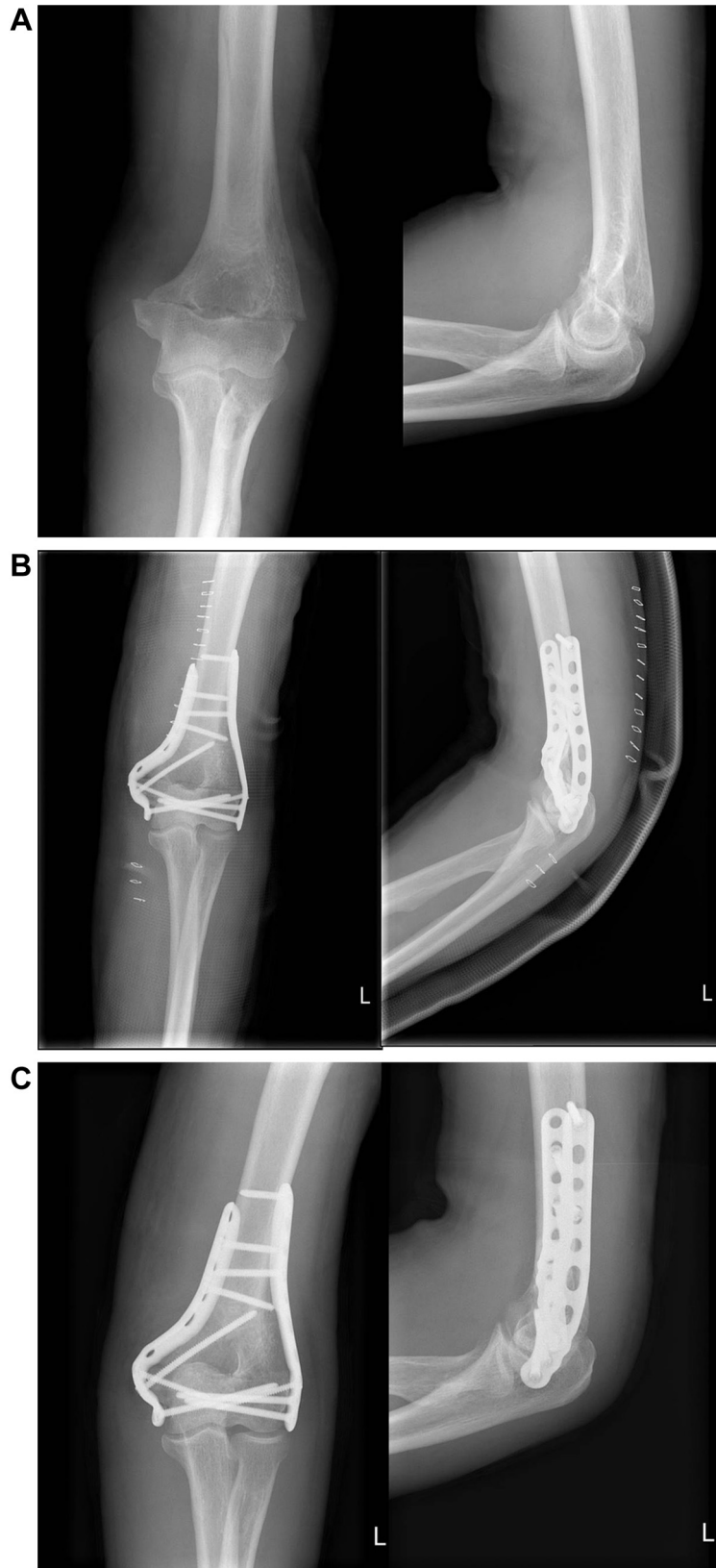


Figure 3 (A) Radiographs of the right elbow of a 79-year-old male patient with a displaced low transcondylar fracture. (B) Immediate postoperative radiographs showed a stable fixation with parallel pattern. (C) Union was achieved at 4 weeks after operation.

Table 1
Result of the patients

Case no.	Age, yr	Sex	Injury mechanism	Fixation	Approach	Ulnar nerve	Range of motion, degrees				MEPS	Underlying diseases	Complications
							Flex.	Ext.	Pro.	Sup.			
1	41	M	Fall down	Orthogonal	Triceps sparing	Transposed	130	30	80	80	E	None	HO
2	59	M	Fall down	Parallel	Olecranon osteotomy	Transposed	130	0	80	80	E	None	
3	65	M	Fall down	Parallel	Triceps tongue	Transposed	120	20	80	80	E	None	Delayed union
4	66	M	Slip down	Orthogonal	Triceps sparing	Not	120	10	80	80	E	None	
5	67	F	Slip down	Orthogonal	Triceps sparing	Transposed	120	10	80	80	E	Osteoporosis	Delayed union
6	69	M	Slip down	Orthogonal	Triceps sparing	Not	130	0	80	60	E	CVA history, diabetes	
7	72	F	Slip down	Parallel	Triceps tongue	Transposed	110	20	80	80	G	Diabetes	Infected nonunion
8	72	F	Slip down	Orthogonal	Triceps sparing	Transposed	120	10	70	70	E	Diabetes, osteoporosis	
9	75	F	Slip down	Orthogonal	Triceps sparing	Not	90	30	60	60	P	Diabetes, Parkinson	
10	76	F	Slip down	Parallel	Triceps tongue	Transposed	120	10	80	80	E	Poliomyelitis	Ulnar neuropathy
11	78	F	Slip down	Parallel	Triceps tongue	Transposed	100	40	80	80	E	Diabetes	
12	78	M	Slip down	Parallel	Triceps sparing	Not	120	20	80	80	F	Diabetes	Delayed union, screw loosening
13	79	M	Slip down	Orthogonal	Triceps sparing	Not	130	0	80	80	E	CVA history	
14	82	F	Slip down	Orthogonal	Triceps sparing	Not	120	10	80	80	E	Osteoporosis	Delayed union, screw loosening
15	86	F	Slip down	Orthogonal	Triceps sparing	Transposed	120	30	70	80	G	Osteoporosis	
16	87	F	Slip down	Orthogonal	Triceps sparing	Not	120	30	80	80	G	Osteoporosis	Delayed union, screw loosening
17	89	F	Slip down	Orthogonal	Triceps sparing	Not	120	20	80	80	E	Osteoporosis	

M, male; F, female; Flex., flexion; Ext., extension; Pro., pronation; Sup., supination; MEPS, Mayo Elbow Performance Score; E, excellent; G, good; P, poor; F, fair; CVA, cerebral vascular accident; HO, heterotopic ossification.

Nonetheless, compared with a comminuted articular fracture, transcondylar fractures may have more bone stock. Therefore, the authors think that rigid fixation can be obtained with use of the anatomic distal humeral plates even in elderly patients. A crisscross screw fixation method was introduced for transcondylar distal humeral fractures.^{9,10} They reported that this method was good to save operation time, and they achieved bony union in all cases. However, the union time was on average 7.2 weeks to 3 months and there was screw loosening in some patients, whereas the mean union time was 5.3 weeks in this study.²²

The patients were evaluated according to ulnar nerve transposition status and fixation pattern (orthogonal vs. parallel). First, there was 1 patient who had a complication with ulnar nerve neuropathy in the transposition group. There are still controversies over ulnar nerve transposition during ORIF for distal humeral fractures.^{1,14,20} A recent meta-analysis has reported a lower incidence of ulnar neuropathy in a no-transposition group than in a transposition group.¹⁶ During surgery, the ulnar nerve must be identified and protected, but ulnar nerve anterior transposition may not be routinely necessary. A surgeon should always be careful not to make an iatrogenic injury of the ulnar nerve.

Next, there were complications of 1 nonunion and 2 delayed union in patients with orthogonal fixation pattern, but it was not

statistically significant (Table II). Double-column plating consists of the principle of treatments for distal humerus fractures.⁸ Orthogonal plating and parallel plating both have produced acceptable results.^{2,17} Therefore, the authors believe that in this study, nonunion or delayed union may be due to the patient's underlying condition, not to a fixed pattern. Patient factors were retrospectively reviewed and the patient with nonunion had diabetes, high blood pressure, major depressive disorder, and Parkinson disease. Patients with delayed union both had weakness of the injured arm due to a history of cerebral vascular accident, and 1 of them was a heavy smoker. The patient's compliance with postoperative care was also found to be low. In regard to their postoperative care, the compliance of these patients was also identified as being of a low level.

It is reported that most transcondylar humeral fractures occur in older patients after low-energy injuries.^{10,12,18} Therefore, healing of geriatric fractures can be ensured not only by a stable construct of the surgery but also by biologic factors.¹⁸ The transcondylar area is thought to be prone to fractures because the bones in that region of the body are relatively thin.¹³ Most of the patients in this study were old and there are medical histories that were associated osteoporosis. Therefore, it may be reasonable to regard these fractures as characteristic of low-energy osteoporotic fractures. In addition, the authors think that the evaluation and management of

Table II
Result of the patients according to fixation pattern

Fixation pattern	Range of motion				MEPS	Complication
	Flexion	Extension	Pronation	Supination		
Orthogonal (n = 11)	120	16.4	76.4	75.5	Excellent (7) Good (3) Poor (1)	Infected nonunion (1) Delayed union (2) HO (1)
Parallel (n = 6)	116.7	18.3	80	80	Excellent (4) Good (1) Fair (1)	Ulnar nerve neuropathy (1)
P value*	.151	.582	.180	.710	.531	.713

MEPS, Mayo Elbow Performance Score; HO, heterotopic ossification.

* Results of multivariate analysis.

Table III
Result of the patients according to ulnar nerve transposition status

Ulnar nerve	Range of motion				MEPS	Complication
	Flexion	Extension	Pronation	Supination		
Not transposed (n = 8)	118.9	15	77.5	75	Excellent (5) Good (1) Fair (1) Poor (1)	Infected nonunion (1) Delayed union (2)
Transposed (n = 9)	118.8	18.9	77.8	78.9	Excellent (6) Good (3)	Ulnar nerve neuropathy (1) HO (1)
<i>P</i> value*	.820	.462	.333	.521	.196	.928

MEPS, Mayo Elbow Performance Score; HO, heterotopic ossification.

* Results of multivariate analysis.



Figure 4 Radiographs of patients with complications. (A) Postoperative 2-week radiographs showed infected nonunion. After removal of the plates, antibiotics-impregnated cement beads were inserted. (B) Postoperative 4-week radiographs showed screw loosening. This patient was diagnosed as delayed union, and union was finally achieved 8 weeks after the operation.

osteoporosis should be done together for these typical low transcondylar humeral patients.

There may be concerns about a long immobilization period for the elbow in this study. The authors applied a splint or cast for elbow fixation for an average of 3.9 weeks. From an average of 3.9 weeks (3–4 weeks) after surgery, patients began to exercise their elbow joints gently and do activities of daily lives. However, the arc of the elbow motion after the surgery was similar to or better than in previous reports. Despite the longer immobilization period, the mean flexion was 128.4°, and the mean extension was 16.8°. The authors can cautiously conclude that 1–2 weeks of delays in physical therapy do not adversely affect elbow motion recovery or clinical outcomes.

There are several limitations of this study. First, the number of cases reviewed was small, and the follow-up period was short. This may be due to the low incidence rate of these fractures, and most patients are old. Second, this is only a retrospective case series, so the comparison between groups may not be reliable.

Conclusion

The incidence of transcondylar fracture of the distal humerus is very low, and the fracture pattern is unique. Most of the fractures occur in elderly and osteoporotic patients. For reliable and good results, rigid fixation and appropriate immobilization of the fracture site are key factors in the treatment. In our case series, the overall outcome was good and there were 2 major complications (ulnar nerve problem and nonunion). In most cases, good results can be achieved with ORIF, and patients who need total elbow arthroplasty are very limited in number.

Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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