ORIGINAL ARTICLE

Acta Orthop Traumatol Turc 2015;49(3):233–240
doi: 10.3944/AOTT.2015.14.0178

Fracture-dislocations of the proximal ulna

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Objective: To investigate the relationship between injury patterns, complications, and the functional outcomes of patients with proximal-ulna fracture-dislocations.

Methods: Retrospective analysis of 15 patients (10 men, 5 women; mean age, 49.1 years; mean follow-up 49 months) with 6 anterior and 9 posterior fracture-dislocations of the proximal ulna. The proximal ulna was reconstructed with plates and screws in 13 patients and tension-band wiring in 2 patients. At the final follow-up, elbow range of motion (ROM) was measured and Mayo elbow scores (MEPS) were recorded. Broberg-Morrey criteria were used for osteoarthritis staging.

Results: Concomitant radial-head fracture was seen in all posterior fracture-dislocations. Four ligamentous injuries occurred in this group. All anterior dislocations had trochlear-notch fractures without associated injuries. Mean flexion ROM was 130.6° (100°–140°) and mean loss of extension ROM was 12.6° (0°–30°) in the study group. The mean MEPS score was 92.3 (70–100). Patients with posterior fracture-dislocations showed lower ROM and MEPS and higher level of osteoarthritis than patients with anterior fracture-dislocations. Recurrent dislocations occurred in 2 patients who had ulna fractures fixed with tension-band wiring.

Conclusion: Radial-head fracture and ligamentous injury are specific components of posterior fracture-dislocations. The injury is limited to the trochlear notch in anterior fracture-dislocations. Posterior fracture-dislocations have lower functional outcomes. Proximal-ulna fractures should be fixed with rigid internal fixation (plate and screw) even if the fracture is a simple 2-part fracture.

Keywords: Proximal ulna; elbow dislocation; fracture-dislocation.

Proximal-ulna fracture-dislocations comprise an uncommon subset of traumatic elbow injuries. These injuries can occur in either anterior or posterior directions. Anterior fracture-dislocations, otherwise referred to as trans-olecranon fracture-dislocations, have been described as olecranon and trochlear-notch fractures accompanied by the anterior displacement of the forearm that do not affect the radioulnar relationship.[1–7] Posterior fracture-dislocations of the proximal ulna are characterized by a posterior dislocation of the radial head and an apex-posterior proximal-ulna fracture. These injuries can be considered proximal type posterior Monteggia fractures (Bado type II).[1,6–13] There have been various studies investigating the identification and classification of these injuries, but a consensus has not been achieved.[8,14,15]

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Submitted: May 11, 2014 **Accepted:** September 28, 2014

Available online at
www.aott.org.tr
doi: 10.3944/AOTT.2015.14.0178
QR (Quick Response) Code

Studies indicate that proximal-ulna fracture-dislocations occur in specific patterns, and the identification of the pattern of injury helps to predict possible complications and guide treatment. However, few published studies have specifically addressed these injuries.[1,2,4,5,8,9,11–13]

The purpose of the study is to define specific patterns of injury and investigate the relationship between injury pattern and functional outcomes and complications in proximal-ulna fracture dislocations. Clear definition of the injury may enable us to predict complications and functional outcomes from preoperative radiographs.

Patients and methods

Between January 2004 and January 2012, we identified 19 patients who were surgically treated for proximal-ulna fracture-dislocations. After obtaining the institutional review board approval, medical records and radiographs of these patients were retrospectively analyzed. Four patients were excluded from the study because of various reasons, including insufficient data, geographic restrictions, or unavailability for final follow-up. The remaining 15 patients formed the study group. The sample included 10 men and 5 women with a mean age of 49.1 (range: 33–75) years. The mechanism of injury was fall on level ground in 10 patients, traffic accident in 3 patients, and fall from a height in 2 patients. The dominant elbow was injured in 8 patients. Two patients had distal radius fractures in the contralateral wrist and 1 patient had a laceration in the ipsilateral lower limb.

With regard to the type of ulna fracture-dislocations, 9 (60%) were posterior and 6 (40%) were anterior. In the posterior fracture-dislocation group, there were 4 women and 5 men with a mean age of 55 (range: 34–75) years, and 5 were dominant-extremity injuries. In the anterior fracture-dislocation group, there were 5 men and 1 woman with a mean age of 40 (range: 33–54) years, and 3 were dominant-extremity injuries.

Three patients in the posterior fracture-dislocation group had trochlear-notch fractures, and the ulnohumeral relationship was disrupted in all 3 patients. The proximal-ulna fracture was just distal to the trochlear notch in 3 patients. Two patients had fractures distal to the trochlear notch, and 1 patient had a facture at the trochlear notch extending to the proximal ulna. With regard to the Jupiter classification for posterior Monteggia fractures,[8] there were 3 type-IIa (ulnohumeral joint involvement), 3 type-IIb (just distal to ulnohumeral joint), 2 type-IIc (distal to ulnohumeral joint) and 1 type-IId (complex fracture involving multiple levels) fractures. All anterior fracture-dislocations were accompanied with comminuted trochlear-notch fractures and disruptions to the ulnohumeral relationship. There were 9 radial-head fractures as classified by the Mason system: 3 were type III and 6 were type II. There were 10 coronoid fractures in the study group, and 6 were coronoid-base fractures with a single large fragment. The remaining 4 were classified according to Regan–Morrey system: 2 were type II and 2 were type III.

Surgical interventions are summarized in Table 1. Surgical treatment was performed within 72 h of injury in all patients. A posterior approach was used in all patients. Coronoid fragments were reduced through the proximal-ulna-fracture fragments and fixed together. Fixation of the ulna was performed by using a 3.5-mm titanium precontoured locking-compression olecranon plate (Synthes, West Chester, US or Acumed, Beaverton, US) in 13 patients and tension-band wiring in 2 patients. Additional plate and screw fixation was needed in 7 coronoid fractures; the coronoid was fixed with same olecranon plate 3 other patients. A structural allograft was used in the remaining 5 patients. Reduction and fixation of the radial-head fracture was performed through the proximal-ulna-fracture fragments in 4 patients in the posterior fracture-dislocation group. In 5 patients, an additional lateral incision extending through the Kocher interval was necessary because of a prosthetic replacement or plate fixation. Radial-head fractures were fixed with mini-plates/screws in 8 patients (Synthes, Paoli, US) and replaced with a radial-head prosthesis in 1 patient (Acumed, Beaverton, US). We observed lateral-collateral-ligament rupture from the humeral attachment in 4 patients. Ligament repair was performed with suture anchors at the isometric point. (DePuy Mitek Surgical Products, Massachusetts, USA).

The elbow was immobilized in a posterior splint in 90° of flexion for edema control for 2 weeks. Immobilization was provided by a hinged elbow brace (EpicoROM, Medi, Germany) for an additional 4 weeks, ROM was gradually increased over this period. Active motion was allowed 6 weeks after surgery depending on the radiological evidence of fracture union. No patients received nonsteroidal anti-inflammatory drugs or radiotherapy for heterotopic ossification.

The final follow-up examination included elbow flexion, extension, and forearm supination–pronation and elbow stability assessment. Functional outcomes were evaluated using the Mayo Elbow Performance Score (MEPS). Physical examinations were performed by an investigator not involved in initial treatment. Elbow ROM was measured using a standard goniometer. The elbow was tested for varus–valgus instability, and posterolateral rotatory instability was evaluated by the pivot-shift test.

Table 1. Patient demographics and clinical results.

No	Age	Sex	Radial-head fracture (Mason)	Coronoid fracture (Regan–Morrey)	Ligament repair	Injury type/ fixation	Follow-up (mo)	ROM (°)	Pronation supination	MEPS	Broberg–Morrey osteoarthritis classification	Complications
1	73	F	M3 mini-plate/screw	–	–	Posterior dislocation Jupiter IIc Plate+graft	51	20–120	60/60	80	I	
2	43	M	M3 mini-plate/screw	RM2 additional screw	LCL	Posterior dislocation Jupiter IIa Plate	34	20–130	60/60	100	II	
3	75	F	M2 mini-screw	–	–	Posterior dislocation Jupiter IIb Plate	41	10–130	80/70	90	I	
4	49	F	M2 mini-screw	–	–	Posterior dislocation Jupiter IIc Plate	19	20–130	70/70	90	II	
5	51	M	M2 mini-screw	–	–	Posterior dislocation Jupiter IIb Plate	72	0–140	70/70	100	I	
6*	53	M	M3 radial-head prosthesis	RM3 additional plate	LCL	Posterior dislocation Jupiter IId Plate	87	20–110	70/60	80	III	- HO resection - Ulnar neuropathy Anterior transposition of ulnar nerve
7	34	M	M2 mini-screw	RM3 Additional plate	LCL	Posterior dislocation Jupiter IIa Plate+graft	65	10–130	70/70	100	II	
8*	52	M	M2 mini-screw	RM2 additional screw	LCL	Posterior dislocation Jupiter IIa	84	30–100	80/70	70	III	Recurrent dislocation after tension-band wiring Revision with plate and screw + radial-head resection
9	65	F	M2 mini-screw	–	–	Posterior dislocation Jupiter IIb Plate	96	0–140	70/60	85	I	
10	33	M	–	Coronoid base fracture	–	Anterior dislocation Plate+graft	40	10–140	80/70	100	I	
11*	34	M	–	Coronoid base fracture	–	Anterior dislocation Plate+graft	83	20–130	70/60	90	II	Recurrent dislocation after tension-band wiring Revision with Plate and screw
12	54	M	–	Coronoid base fracture, additional screw	–	Anterior dislocation plate	12	10–140	70/70	100		
13	34	M	–	Coronoid base fracture, additional screw	–	Anterior dislocation plate	14	0–140	0** Previously radioulnar synostosis	100		
14	47	M	–	Coronoid base fracture, additional screw	–	Anterior dislocation plate	24	20–140	80/70	100	I	
15	40	F	–	Coronoid base fracture	–	Anterior dislocation plate	13	0–140	80/70	100		

M: Mason classification; RM: Regan–Morrey classification; LCL: Lateral collateral ligament, HO: Heterotopic ossification, ROM: Range of motion; *Functional status after second operation; **Excluded from forearm rotation arc measurements because of the previous synostosis.

Preoperative, postoperative, and follow-up radiographs as well as preoperative computed tomography images were retrospectively evaluated for each patient to evaluate the components of injury and the presence of heterotopic ossification. The final follow-up radiographs were evaluated for the presence of osteoarthritis according to the Broberg-Morrey system. Operative reports and patient charts were reviewed for surgical findings and complications.

Results

Patients with posterior fracture-dislocations were older than patients with anterior fracture-dislocations (mean: 55 and 40, respectively). Four of the 9 patients were women (44%) in the posterior fracture-dislocation group. One of the 6 patients was a woman (28.7%) in the anterior fracture-dislocation group.

Patient demographics and injury patterns are summarized in Table 1. All patients who had a posterior fracture-dislocation had had a radial-head fracture. No patients with anterior fracture-dislocations had radial-head fractures. Trochlear-notch fragmentation involving the coronoid base was seen in all anterior fracture-dislocations. In the posterior fracture-dislocation group, only 4 (44%) patients with Jupiter IIa and IId fractures had proximal-ulna fractures involving the trochlear notch. Coronoid fractures (2 with type II and 2 with type III according to Regan–Morrey system) occurred with trochlear-notch fractures in these 4 patients. Although the lateral collateral ligament was not evaluated routinely, no evidence was found that lateral collateral ligament was ruptured in the anterior fracture-dislocation group. Intraoperative elbow instability was not observed after reconstruction and secure fixation of the trochlear notch in the anterior fracture-dislocation group. Secure fixation of the proximal ulna alone could not provide intraoperative elbow stability in the posterior fracture-dislocation group. During the radial-head fixation or replacement in this group, lateral-collateral-ligament avulsion from the humeral epicondyle was detected in 4 (44%) patients. Patients who had ligamentous injury in the posterior fracture-dislocation group had proximal-ulna fractures involving the trochlear notch and coronoid fractures which can be classified by the Regan–Morrey system.

Functional results are shown in Tables 1, 2 and 3. Patients were evaluated at the final follow-up at an average of 49 (range: 12–96) months after the injury. The mean flexion ROM was 130.6° (range: 100°–140°) and the mean loss of elbow extension ROM was 12.6° (range: 0°–30°). The mean total elbow ROM was 118° (range: 70°–140°). The average arc of forearm ROM measured was 138.5° (range: 120°–150°), with a mean supination ROM of 66.4° (range: 60°–70°) and a mean pronation ROM of 72.1° (range: 60°–80°). The mean MEPS was 92.3 (range: 70–100) in the study group. None of the patients had symptoms or signs of instability. Patients with posterior fracture-dislocations showed lower ROM and MEPS scores than those with anterior fracture-dislocations. Functional results were particularly poor in patients with trochlear-notch involvement (Jupiter IIa and IId) in the posterior fracture-dislocation group.

Final follow-up radiographs were available for all pa-

Table 2. Functional results of groups.

	Posterior fracture-dislocations (n=9)	Anterior fracture-dislocations (n=6)
	Mean±SD	Mean±SD
Elbow range of motion	111.11±22.61	128.33±11.69
Flexion	125.56±13.33	138.33±4.08
Loss of extension	14.44±10.14	10.00±8.94
Supination	65.56±5.27	68.00±4.47
Pronation	70.00±7.07	76.00±5.48
Rotation arc of forearm	135.56±11.30	144.00±8.94
Mayo Elbow Performance Scores	88.33±10.61	98.33±4.08

Table 3. Functional results of posterior fracture-dislocations according to trochlear-notch involvement.

	Intact trochlear notch (n=5)	Trochlear-notch involvement (n=4)
	Mean±SD	Mean±SD
Elbow range of motion	122±17.8	97.5±22
Flexion	132±8.3	117.5±15
Loss of extension	10±10	20±8
Supination	66±5.4	65±5.7
Pronation	70±7	70±8
Rotation arc of forearm	136±11.4	135±13
Mayo Elbow Performance Scores	89±7.4	87±15

tients. All fractures united in proper alignment and ulnohumeral joint congruity.

According to the Broberg–Morrey system, 4 patients had grade-I, 3 grade-II and 2 grade-III osteoarthritis in the posterior fracture-dislocation group. There were 2 patients with grade-I and 1 grade-II osteoarthritis in the anterior fracture-dislocation group. Patients with posterior fracture-dislocations had a higher level of osteoarthritis than those with anterior fracture-dislocations. Osteoarthritis was more pronounced in the patients with trochlear-notch involvement (Table 1).

Complications are summarized in Table 1. Three patients had a complication requiring reoperation in the study group. Recurrent dislocations occurred in 2 patients who had proximal-ulna fracture treated with tension-band wiring. In 1 of these (patient no 8), who had a posterior fracture-dislocation, the coronoid fragment was not adequately fixed. Recurrent dislocations occurred 10 weeks after the initial operation. After revision of the fixation with a plate and radial-head resection, we were able to initiate the rehabilitation process immediately. In another patient (patient no 11), who had an anterior fracture-dislocation, the tension-band wiring failed and recurrent dislocations occurred 6 weeks after the initial operation. The fixation was revised with a plate. Both patients regained an adequate ROM without pain and instability after the second operation. The third patient (patient no 6), who had a posterior fracture-dislocation, was reoperated on because of ulnar neuropathy and heterotopic ossification 6 months after the initial operation. Heterotopic ossification removal and ulnar-nerve anterior-transfer operations were performed. Patient complaints were resolved and adequate ROM was obtained. There were 2 (22%) complications in 2 patients who had proximal-ulna fracture-dislocations involving the trochlear notch in the posterior fracture-dislocation group. There was one (16%) complication in the anterior fracture-dislocation group.

Discussion

Identification of injury pattern is of utmost importance in the treatment of proximal-ulna fracture-dislocations. Recognition of the injury components may help to predict concomitant soft-tissue injury and guide treatment.[14]

We found a significant relationship between posterior fracture-dislocations of the proximal ulna and radial-head fractures in this study, and all radial-head fractures required either fixation or replacement. The radial-head fracture is a natural part of posterior fracture-dislocations of the proximal ulna (Figure 1).[8,11] This is specifically important when the relationship between the radius, ulna and the ulnotrochlear joint have been restored either spontaneously or by manipulative reduction.[3] Apart from the fracture configuration of the proximal ulna, if the radial head is fractured, consideration should be given that the displacement may have been posterior (Figure 2).

Various configurations were seen in coronoid fractures that accompanied proximal-ulna fracture-dislocations. In our series, we observed a coronoid-base fractures due to trochlear-notch fragmentation in the

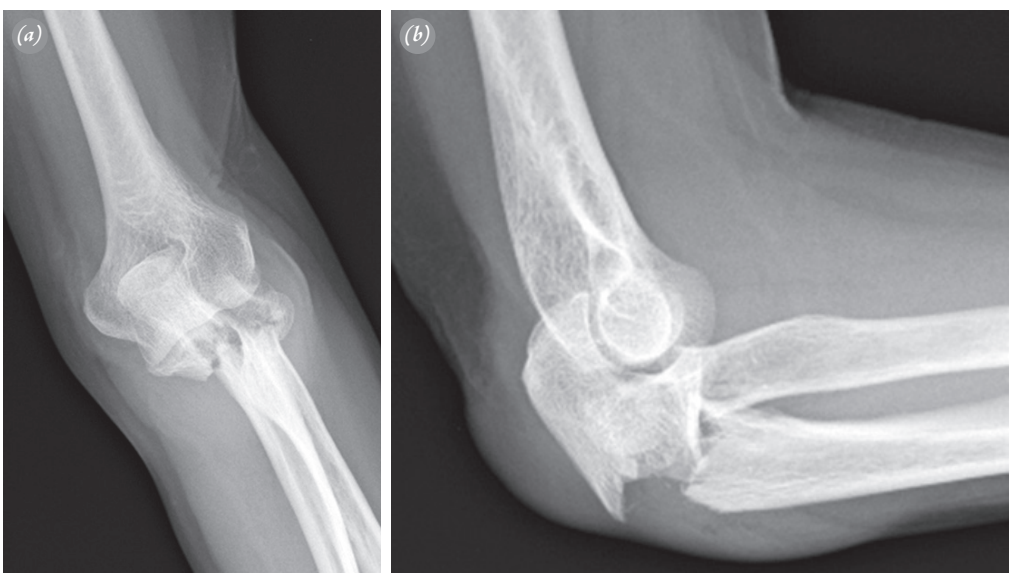

Fig. 1. **(a, b)** Anterior-posterior and lateral radiographs of a posterior fracture-dislocation of the proximal ulna with a preserved ulnotrochlear joint. Coronoid can be protected but the radial-head fracture is a natural part of this injury.

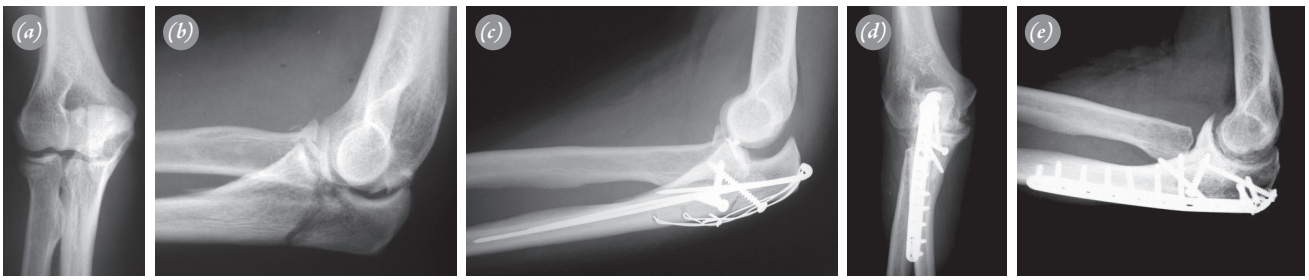

Fig. 2. Posterior fracture-dislocations of the proximal ulna. Ulnotrochlear joint can be restored either spontaneously or by manipulative reduction **(a, b)**. Recurrent dislocation after fixation with tension-band wiring. The coronoid fragment was not adequately fixed **(c)**. Revision with a plate fixation and radial-head resection. Final follow-up radiograph **(d, e)**.

anterior fracture-dislocation patients. Conversely, coronoid-body fractures were seen in patients with posterior fracture-dislocation. These fractures can be classified by the Regan–Morrey system because the fracture line is essentially involving the coronoid body.

As pointed out in recent studies, olecranon fracture also involves the base of the coronoid in patients with anterior fracture-dislocations.[16] The Regan–Morrey system was used in many studies on this topic, but only the O'Driscoll classification system specifically recognizes coronoid-base fractures in anterior fracture-dislocations.[3,10]

Our study suggests that there may be an association with coronoid fracture pattern and soft-tissue injury. Previous studies of proximal-ulna fracture-dislocations also suggest that specific fracture patterns occur along with certain soft-tissue injuries.[1,12,14,17] Lateral-collateral-ligament injury should be considered when the posterior fracture-dislocation is accompanied by a coronoid-body fracture and trochlear-notch involvement.

In this study, all anterior fracture-dislocations were comminuted but limited to the trochlear notch (Figure 3). Conversely, less comminuted but more extensive injuries involving more than one anatomical region were observed in posterior fracture-dislocations. One possible explanation could be that the energy of the trauma was discharged from weakest point on relatively strong bones in the relatively younger patients with anterior fracture-dislocations, sparing other areas. As a result, reconstruction and rigid fixation of bony structure of the proximal ulna yields favorable results in anterior fracture-dislocations.

The effects of trauma in posterior fracture-dislocations are more extensive.[1,3,7,9,13] This, in combination with the lower functional results of posterior dislocation patients, indicates that age and bone quality affects functional outcomes in proximal-ulna fracture-dislocations. Involvement of the trochlear notch is a further negative prognostic factor for outcomes in posterior fracture-dislocations (Table 3).

We observed higher levels of osteoarthritis in the posterior fracture-dislocation group. The older age of the posterior fracture-dislocation group may have contributed to the post-traumatic osteoarthritis because older patients are more prone to developing arthritic changes. Older age in the posterior fracture-dislocation group can be considered as a predisposing factor. In addition, ligamentous injuries and coronoid fractures that accompany posterior fracture-dislocations increase os-

Fig. 3. **(a)** Anterior fracture-dislocation of elbow. These injuries are comminuted but limited to the trochlear notch. Concomitant radial-head fractures or ligamentous injuries are not expected. **(b, c)** Follow-up radiographs of same patient.

teoarthritis risk.[7,12] The possible explanation of lower osteoarthritis rate in anterior fracture-dislocations could be limited fractures to the trochlear notch without associated injuries. Trochlear-notch reconstruction to provide congruent articular surfaces is an adequate measures for preventing osteoarthritis in these patients.[5]

The most catastrophic complication is a recurrent dislocation, and it is mostly related with inadequate fixation. A common mistake is misidentification of a proximal-ulna fracture as a simple olecranon fracture. Tension-band wiring may not to be a proper fixation method in proximal-ulna fracture-dislocations as demonstrated by this study (Figure 2). In this study, a 3.5-mm titanium precontoured locking-compression olecranon plate was used for fixation in most patients. This fixation method provided reliable stability and led to favorable results. The precontoured locking-compression plate allows for the insertion of a greater number of screws in the proximal fragment and the direct dorsal placement of the plate resists tension forces on the olecranon.[18–21] Thus, contoured plates provide the greatest rigidity even if the bone is osteoporotic.

Heterotopic ossification is a known complication following elbow injuries. The prevalence of heterotopic ossification causing motion deficits has been reported as 10%–20%. Proximal-ulna fracture-dislocations have a higher prevalence, and multiple trauma, number of repeated surgeries and delay in definitive surgery have been reported as associated risk factors.[22] Despite not using treatment for preventing heterotopic ossification, only one patient had restrictive heterotopic ossification in the study group. This may indicate that the control of modifiable risk factors, such as delay and number of repeated surgery, can decrease the risk of restrictive heterotopic ossification.

This study had a number of limitations. The small patient number decreased the possibility of statistical analysis. The evaluation was performed by an investigator who was not involved in the treatment plan. However, the presence of surgical scars may have introduced a bias. The study was designed as a retrospective comparison. Despite these shortcomings, the study provides additional data for this relatively rare injury type for Turkish literature.

This study suggests a relationship between the injury types, injury components and the functional results. Radial-head fracture and lateral-collateral-ligament injury may be related to posterior fracture-dislocations. Coronoid fracture and trochlear-notch involvement may increase the risk of ligament injuries in patients with posterior fracture-dislocations. Limited injury to the trochlear notch is a specific pattern for anterior fracture-dislocations. Lower functional results and higher complication rates may be associated with posterior fracture-dislocations (Table 2). Trochlear-notch involvement is a further negative prognostic factor for posterior proximal-ulna fracture-dislocations (Table 3). Clear definition of all injury components on preoperative radiological studies may help to predict associated soft-tissue injuries, possible complications and functional outcomes. Because of the tension-band wiring tends to fail, proximal-ulna fractures should be fixed with rigid internal fixation (plate and screw) even if the fracture is a simple 2-part.

Conflics of Interest: No conflicts declared.

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