

Classic Floating Elbow in Adults: A Case Series

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Background: The aim of this study was to assess demographics, clinical outcomes, and complications of classic floating elbow in adults.

Methods: Six patients with ipsilateral diaphyseal fractures of the humerus, radius, and ulna were reviewed retrospectively. All patients were treated operatively and available for follow-up at a minimum of 1 year after surgery. The average age of the patients was 45.2 years (22–64 years) and the average follow-up period was 37.0 months (14–103 months). They were evaluated with postoperative outcome measures, including a visual analog scale (VAS) for pain, Mayo elbow performance score (MEPS), and American Shoulder and Elbow Surgeons (ASES) shoulder score. Residual complications were also evaluated.

Results: Five patients (83.3%) had open fracture, and 4 patients (66.7%) presented with associated nerve injury. All fractures were united within postoperative 4 months, except 1 delayed union. The average VAS pain score, MEPS, and ASES shoulder score at the final follow-up examination was 2.5, 79.8, and 67.5 respectively. Three patients including 2 cases of joint stiffness with incomplete recovery from nerve injury and 1 case of complex regional pain syndrome had poor clinical outcome.

Conclusions: Although the classic floating elbow is rare, these injuries potentially have associated problems such as open fracture or nerve injury. The presence of residual neurological symptoms predispose to poorer clinical outcomes.

(Clin Shoulder Elbow 2015;18(1):8-12)

Key Words: Humerus; Radius; Ulna; Fracture; Floating elbow

Introduction

Floating elbow is an extremely rare injury typically described as ipsilateral fractures of the humerus and forearm.^{1,2} Because of the result of high-energy trauma, it can be combined with severe soft tissue damage, leading to open fracture and neurovascular injury.³⁻⁵ For this reason, injuries usually have unpredictable clinical outcome after treatment.³

Although literature describing functional outcomes in patients with floating elbow is limited, surgical treatment has been widely accepted. Evidence that these injuries are treated most effectively with surgical stabilization of the humerus and the forearm using a plate or intramedullary nail has been well reported in the literature.⁶⁻¹¹ However, most studies have emphasized the complexity of these injuries and the potentially unpredictable long-term functional results.^{3,4,12,13}

The classic floating elbow in adults has been defined as ipsilateral diaphyseal fractures of the humerus, radius, and ulna.² Several studies have described floating elbow variant injuries including humerus shaft and intra-articular olecranon and/or radius fractures, humerus intercondylar and forearm shaft fractures, humerus shaft and radius or ulna shaft fractures.^{3,4,14} Most published articles on floating elbow have dealt with both classic floating elbow and floating elbow variant injuries. We thought that classic floating elbow injuries have different entity from floating elbow variant injury. Furthermore, only 2 clinical studies on classic floating elbow have been reported.^{2,15} In this study, only patients with ipsilateral diaphyseal fractures of the humerus, radius, and ulna were included. The aim of this study was to assess demographics, clinical outcomes, and complications of classic floating elbow in adults.

Received September 1, 2014. **Revised** October 20, 2014. **Accepted** October 31, 2014.

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Financial support: None. **Conflict of interests:** None.

Methods

Ten patients who had sustained classic floating elbow injury were treated in Keimyung University Dongsan Medical Center between December 2002 and March 2013. The classic floating elbow was defined as ipsilateral diaphyseal fractures of the humerus, radius, and ulna. Of these patients, 4 patients were excluded because 1 had trans-humeral amputation, 1 had died, and 2 were lost to follow-up. Patients aged younger than 18 years or patients with floating elbow variant injuries according to Ditsios et al.'s classification³⁾ were also excluded. Six patients who were available for follow-up at a minimum of 1 year after surgery were reviewed retrospectively.

The average age of the patients at the time of injury was 45.2 years (range, 22–64 years), and there were 5 men and 1

woman. Two dominant arms and 4 non-dominant arms were affected. Five patients (83.3%) had roller injury and 1 (16.7%) had a motor vehicle accident. The average follow-up period after surgery was 37.0 months (range, 14–103 months) (Table 1).

According to location of fractures, there were 4 middle 1/3 and 2 distal 1/3 fractures in the humerus. There were 3 middle 1/3 and 3 distal 1/3 fractures in the radius and ulna.

Surgical Treatment

All fractures were managed operatively by two surgeons. The method of treatment of any individual patients was at the discretion of the attending surgeon. Irrigation and debridement were performed in all patients with open fracture. Four patients (case 1, 3, 4, and 5) had external fixation for management of soft tissue damage. For definite treatment, all humerus fractures were

Table 1. Patients' Clinical Data

Case no.	Age (yr)	Sex	Injury mechanism	Open fracture	Nerve injury	Humerus treatment	Radius and ulna treatment	Final VAS score	Final MEPS	Final ASES score	FU period (mo)	Complications
1	45	M	Roller	H (IIIA)	BP	IM nail	Plate	3	75	62	34	IRN, stiffness (S, E)
2	55	M	Roller	F (II)	-	IM nail	IM nail	0	95	98	24	-
3	22	M	MVA	-	RN	IM nail	Plate	1	85	90	103	-
4	44	M	Roller	F (II)	-	IM nail	Plate	0	100	100	22	-
5	64	F	Roller	F (II)	MN	IM nail	Plate	5	69	39	25	CRPS
6	41	M	Roller	H, F (I)	RN	IM nail	Plate	6	55	16	14	IRN, DU, Stiffness (E)

VAS: visual analogue scale, MEPS: Mayo elbow performance score, ASES: American Shoulder and Elbow Surgeons, FU: follow-up, M: male, F: female, MVA: motor vehicle accident, H: humerus, F: forearm, BP: brachial plexus, RN: radial nerve, MN: median nerve, IM: intramedullary, IRN: incomplete recovery of nerve injury, S: shoulder, E: elbow, CRPS: complex regional pain syndrome, DU: delayed union.

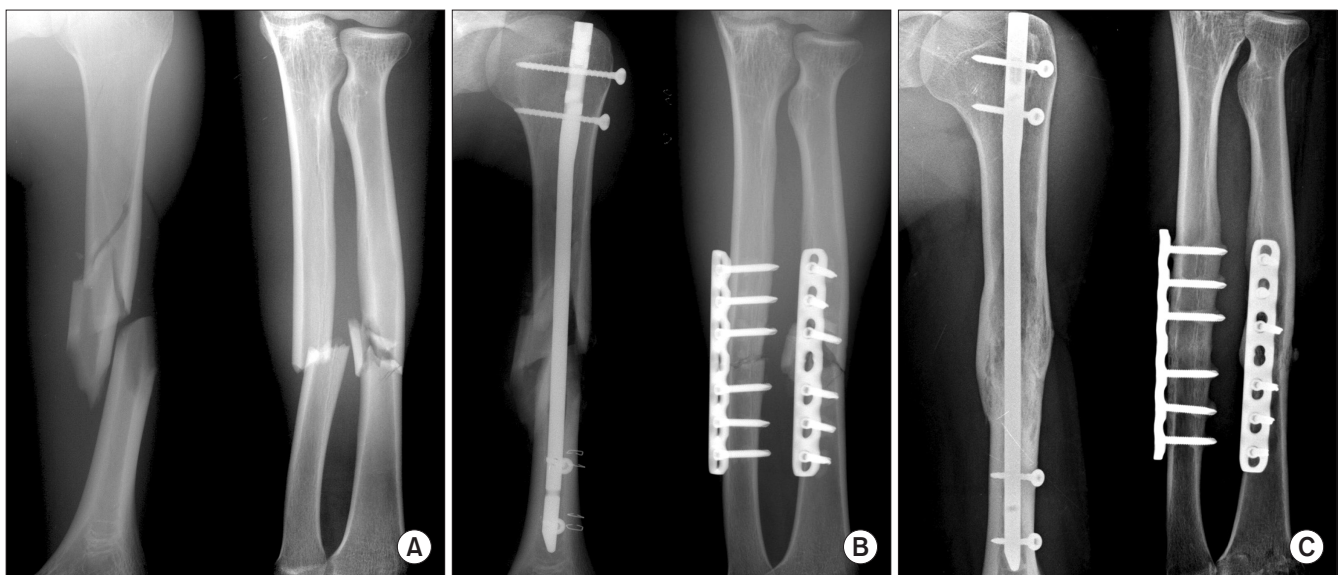


Fig. 1. A 22-year-old man with floating elbow associated with radial nerve injury, multiple fractures, and internal organ injuries. (A) Preoperative radiographs show ipsilateral midshaft fractures of the humerus, radius, and ulna. (B) Postoperative radiographs after delayed surgery show internal fixation with intramedullary nailing for the humerus and plating for the radius and ulna. (C) Radiograph at 8.6 years after the surgery shows complete bony union with satisfactory clinical outcome.

treated by closed reduction and interlocking intramedullary nailing. In management of forearm fractures, five patients had open reduction and plate fixation and 1 patient had closed reduction and intramedullary nailing using a Rush pin.

In case 1, forearm fractures were fixed immediately using a plate. Type IIIA open humeral fracture had external fixation for management of severe soft tissue injury with third degree burn. After skin grafts 2 times, closed reduction and intramedullary fixation using an interlocking nail was performed 14.5 weeks after initial trauma. In case 2 with Type II open fracture of the forearm, the humerus and forearm fractures were treated simultaneously with immediate closed reduction and intramedullary fixation using an interlocking nail and Rush pin. In case 3, the humerus and forearm fractures had delayed fixation 30 days after initial trauma because of internal organ injuries and multiple fractures (Fig. 1). In cases 4, 5, and 6, open fractures (time interval from injury to internal fixation: 25 days, 32 days, and 18 days) had final internal fixation after management of soft tissue injury using external fixation and closed fractures had immediate internal fixation.

Postoperatively, patients began active and passive range of motion for shoulder, elbow, and wrist within 1 week after definite internal fixation. Rehabilitation protocols during temporary external fixation or soft tissue management were individualized.

Radiological and Clinical Assessment

Radiological outcomes were evaluated using serial plain radiographs. Pain intensity was assessed using visual analog scale (VAS) pain scores (0=no pain; 10=unbearable pain). Functional outcomes for shoulder and elbow were assessed using American Shoulder and Elbow Surgeons (ASES) shoulder score and Mayo elbow performance score (MEPS). The ASES shoulder scoring system is a self-rated scale composed of the VAS pain score (50%) and the cumulative activities of daily living score (50%). The MEPS scoring system was used to assess pain (maximum score, 45 points), motion (maximum score, 20 points), stability (maximum score, 10 points), and daily functional activities (maximum score, 25 points). Residual complications were also evaluated.

Results

Five patients (83.3%) presented with open fracture. Three patients had open fracture of the forearm only, 1 open fracture of the humerus only, and 1 open fracture of the humerus and forearm. According to Gustillo-Anderson classification, there was 1 Type I and 1 Type IIIA injury in humeral fractures. There were 3 Type II and 1 Type I injuries in forearm fractures.

Four patients (66.7%) presented with associated nerve injury. Two patients had radial nerve injury, 1 with brachial plexus injury, and 1 with median nerve injury. At the final follow-up examination, only 1 patient (case 3) had complete recovery of

nerve injury.

All fractures were united within postoperative 4 months, except 1 delayed union was healed at postoperative 10 months. The average VAS pain score, MEPS, and ASES score at the final follow-up examination was 2.5, 79.8, and 67.5 respectively. Three patients had residual complications and poor clinical outcomes. Case 1 had shoulder (100° of forward flexion, 30° of external rotation, and L4 level of internal rotation) and elbow (-20° of extension, 100° of flexion, 60° of pronation, and 60° of supination) stiffness with incomplete recovery of brachial plexus injury. Case 5 had complex regional pain syndrome. Case 6 had elbow stiffness (-30° of extension, 110° of flexion, 70° of pronation, and 60° of supination) with delayed union of the humerus and incomplete recovery of radial nerve injury. At 14 months after surgery, the patient did not want to undergo any further operation for radial nerve palsy for personal reasons.

Discussion

The combination of ipsilateral fractures of the humerus and forearm creates an unstable intermediate articulation.¹³⁾ In 1980, Stanitski and Micheli¹⁶⁾ introduced the term 'floating elbow' to describe the injury pattern of ipsilateral supracondylar humerus and forearm axis fractures that disconnect the elbow from the remaining limb in children. This description was recently extended to adults who sustain concomitant fractures of the humerus and forearm in the same limb.^{2,13,15)}

Classic floating elbow injuries may be a different entity than floating elbow variant injury. Floating elbow variant injuries, including elbow fractures, may have different injury mechanisms and poorer clinical outcomes because of direct elbow injury. In our study, patients with ipsilateral diaphyseal fractures of the humerus, radius, and ulna were only included for assessment of demographics, clinical outcomes, and complications of classic floating elbow in adults.

Although their injuries show a very rare fracture pattern, combined problems can usually occur.³⁻⁵⁾ Associated neurovascular injury or soft tissue damage not only adds to the complexity of the surgical management but also, more often than not, adversely influences the functional outcome of the upper extremity.¹³⁾ Jockel et al.⁴⁾ reported that floating elbow represents high-energy trauma and there are significant associated injuries. They concluded that nerve injury is correlated with lower subjective clinical outcomes. Simpson and Jupiter¹³⁾ reported that the floating elbow was an exceptionally complex injury and that complications such as nonunion, infection, or neurological sequelae, which led to the potential for long-term functional disability of the involved limb, could be considerable. In our study, we observed open fracture in 5 patients (83.3%), nerve injury in 4 patients (66.7%), and combined injuries including other fractures or internal organ damage in 3 patients (50.0%).

Floating elbow injuries may require temporary fixation, staged fixation, or late reconstruction if accompanied by associated problem or complication.⁴⁾ Since 1984, when Rogers et al.¹⁰⁾ reported a 100% nonunion rate in the humerus on floating elbow injuries treated without rigid fixation in the humerus, rigid internal fixation of the humerus and forearm fractures has been accepted as the treatment of choice for this injury. When the injuries have serious soft tissue damage, temporary external fixation can be used in management of soft tissue injury for maintenance of length and rotational alignment.¹³⁾ A few investigators reported a relatively large series of floating elbow injuries in adults.

Yokoyama et al.¹⁵⁾ reported that good or excellent clinical results were achieved in 67% of patients with floating elbow injuries. Rogers et al.¹⁰⁾ documented 19 floating elbow injuries in adults and concluded that the open reduction and internal fixation of both humeral and forearm fractures was preferable for management of these injuries.

Previous studies have attempted to identify factors that predict functional outcomes after floating elbow injury.^{2,4,15)} According to Yokoyama et al.¹⁵⁾, who reported on 15 floating elbows in 14 patients, there was no difference in outcomes based on multiple factors, including open fracture, vascular injury, time to fixation, injury severity score, and nerve injury. However, they concluded that these injuries potentially have many complications, such as infection, nonunion, and neurovascular damage, which led to the potential for long-term functional disability of the involved limb.

As we saw in this study, joint stiffness and neurological sequelae are common complications in patients with floating elbow injury. Loss of elbow motion is commonplace, particularly involving elbow flexion and extension, although loss of forearm rotation has also been noted, particularly in the setting of associated high energy trauma to the forearm.¹³⁾ Pierce and Hodurski⁹⁾ reported that the most common injury associated with floating elbow was residual nerve damage, which occurred in more than 50% of patients and was a factor contributing to poor function. Vascular injuries associated with severe soft tissue injuries and neurologic deficits were speculated to be factors contributing to the poor outcome from the findings.¹⁵⁾ Solomon et al.²⁾ showed that patients with associated nerve injury have lower functional outcomes. They reported that patients with floating elbow injuries tend to have a bimodal distribution of long-term outcome. These findings are consistent with those of our study. In our study, case 1 with shoulder and elbow stiffness with incomplete sensory recovery of brachial plexus injury, case 5 with complex regional pain syndrome, and case 6 with elbow stiffness and incomplete motor recovery of radial nerve injury had poor clinical outcomes. Although we did not perform statistical analysis because of a small number of patients, three patients (50%) with incomplete recovery of nerve injury had poor clinical outcomes.

This study will be helpful to surgeons in the effort to provide more accurate counseling to patients with floating elbow regarding the long-term clinical outcomes and the implication of concomitant problems such as neurological sequelae.

This study had limitations, including a small number of patients, retrospective design. Unfortunately, this limitation is a product of the available data because floating elbow injuries are rare. Prospective multi-center studies are required for objective evaluation of clinical outcomes and complications and to assess prognostic factors affecting clinical outcomes.

Conclusion

Although the classic floating elbow is rare, these injuries potentially have associated problems such as open fracture or nerve injury. The presence of residual neurological symptoms predispose to poorer clinical outcomes.

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