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Mid-term functional outcome assessment of early surgical intervention in complex elbow fracture dislocation in adults

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Abstract
Aim: The aim of the present study was to study mid-term functional outcome assessment of early surgical intervention in complex elbow fracture dislocation in adults.
Methods: The study was conducted in the Department of Orthopaedics, trauma centre, Institute of Medical Science, Banaras Hindu University, Varanasi, after getting clearance from the ethics committee. Patients with a complex elbow injury (instability or dislocation associated with fracture), age 18 years to 60 years, who were treated surgically between May 2016 and May 2021, who agreed to participate in the study and signed the free and informed consent with a minimum follow-up of 6 months.
Results: 34 cases made up the study group. There were 23 male and 11 female patients, aged between 18 years and 60 years, who were followed up for an average of 38.56 months (range 6 months to 5 years) and were clinically and radiologically, retro prospectively, and prospectively evaluated. The dominant side was involved in 24 patients and the non-dominant in the other 10 patients. According to Mason's classification, 44.1% were type 3 followed by type 2 (32.4%) and type 1 (14.7%). According to Regan-Moore's classification, 23.5% were in type 1 and 3. Mean flexion-extension arc and mean supination-pronation arc in excised were 115.63 degrees and 101.25 degrees in radical group and mean flexion-extension arc and mean supination-pronation arc in excised were 132.75 degrees and 121.2 degrees in coronoid group. Mean flexion-extension arc and mean supination-pronation arc in 26-35 age group were 116.5 degrees and 97.5 degrees and mean flexion-extension arc and mean supination-pronation arc in dominant were 120.42 degrees and 107.92 degrees in coronoid group. There were no malunion, infection, ulnar neuropathy and neural deficit were observed. Mild pain was present in 47.1% cases.
Conclusion: Although our number of patients and mean duration of follow-up are less than many other studies, we have achieved comparable results in view of both subjective and objective parameters of follow-up such as the mean arc of flexion-extension, supination-pronation, mean Q-DASH score, MEPI score.

Keywords: Elbow dislocation, coronoid fractures, radial head fractures, complex dislocation, ligament injury

Introduction
The elbow joint is inherently stable, but the fact that it is the second most dislocated joint reflects its vulnerability to injury [1]. When a dislocation is not associated with a fracture, it is classified as a pure dislocation and can be treated with closed reduction followed by early mobilization [2]. If there is a fracture with the dislocation, it is classified as a complex dislocation and the risk of recurrent or chronic instability is increased significantly with this type of injury [3, 4]. However, the lower incidence of complex dislocations prevents the gaining of a high degree of experience in the management of these injuries. Treatment is difficult because of the wide variety of factors accompanying dislocations, such as radial head fractures, coronoid fractures, or ligament injury.
The majority of elbow dislocation without fractures occurs in patient under the age of 30 and is managed non-surgically with good clinical outcomes. Complex elbow dislocations are a much more difficult problem to manage with the potential for significant long-term morbidity. Complex elbow dislocations encompass a large range of injuries from dislocations associated with un-displaced radial head fractures to displaced comminuted fractures with or without proximal ulna and coronoid process fractures with a ligamentous injury around the elbow. To

allow an early comfortable range of motion, and to minimize long-term sequelae these cases should be addressed early and with care. Most activities of daily living can be performed with a flexion-extension arc of 30-130 degrees, 50 degrees of pronation, and 50 degrees of supination (Hotchkiss RN. *et al*., 1996) [5]. To achieve this, it is important to understand the related anatomy, mechanisms of injury, severity of the injury, and available operative techniques for these injuries. Treatment aims to achieve a stable, pain-free, functional joint.

Historically, the combination of an elbow dislocation, a radial head fracture, and a coronoid process fracture has had a consistently poor outcome; for this reason, it is called the terrible triad injury, as named by Hotchkiss. It has an unpredictable outcome in adults and is a rare injury in children. Inappropriate treatment can lead to persistent instability, post-traumatic arthritis, stiffness, and pam. There are several well-recognized fracture dislocation injury patterns, and an understanding of these is helpful to predict associated injuries and to guide treatment. Although patient outcomes following elbow dislocations are mostly favorable, the rate of residual pain and elbow stiffness is relatively common [6-8].

The aim of the present study was to study mid-term functional outcome assessment of early surgical intervention in complex elbow fracture dislocation in adults.

Materials and Methods

The study was conducted in the Department of Orthopaedics, trauma centre, Institute of Medical Science, Banaras Hindu University, Varanasi, after getting clearance from the ethics committee. Patients with a complex elbow injury (instability or dislocation associated with fracture), age 18 years to 60 years, who were treated surgically between May 2016 and May 2021, who agreed to participate in the study and signed the free and informed consent with a minimum follow-up of 6 months included and evaluated as per below

Inclusion criteria

- Terrible triad injury
- Radial head and neck fracture-dislocation
- Coronoid process fracture-dislocation
- Type IV monteggia fracture dislocation
- Olecranon fracture-dislocation
- Age between 18-60 years

Exclusion criteria

- Pure dislocation
- Fracture of the distal articular surface ofthe humerus
- Open fractures
- Late presentation (>6 weeks)
- Osteoporotic fracture
- Fracture with neurovascular injury
- Age less than 18 years and more than 60 years
- Patient not giving consent for study

Investigations and workup:

All the patients were evaluated clinically first and after that x-rays of bilateral elbow AP and Lateral, CT scan with the 3D reconstruction of the affected elbow was produced, MRI was not applied to any patients, and injury was classified as follows-

Radial head fractures were classified according to Mason's classification. Divided into Type-I: Fractures without deviation displacement, Type-II: Fractures with deviation displacement, and Type-III: Comminuted fractures.

Coronoid process fracture. Classified according to the system described by Regan and Morrey and divided into Type-I: Apex avulsion, Type-II: Impairment of up to 50% of its height, and Type-III: involving over 50% of its height

Olecranon fracture. Classified according to mayo and divided into Type-1: un-displaced stable, Type-11: displaced stable, Type-III: displaced unstable and each type further classified as Type A: Non-comminuted and Type B: Comminuted.

Operative interventions

Radial head fractures were addressed through the Kocher interval, between extensor carpi ulnaris and anconeus muscle. The lateral approach was associated with a medial approach in a few cases where fixation of coronoid required or MCL injury was there, providing better access to the coronoid process and the medial collateral ligament. The radial head was either preserved or reconstructed with lag screw or miniplate in type 1 and some of type 2 fracture and excised or replaced in type 3 and some of type 2 fracture. Coronoid was fixed with a lag screw or fiber sutures or mini buttress plate in type 3 and some of type 2 fracture. MCL and LCL were repaired with a suture anchor or ethibond. Olecranon fracture was always addressed posteriorly and was fixed with an olecranon locking plate.

Postoperative management

The elbow was maintained in the above elbow slab at 90 degrees in the semi-prone position of flexion allowing a flexion-extension and pronation supination. Early active or active-assisted mobilization was initiated after two weeks with a broken slab and consisted of flexion-extension exercises, to recruit the dynamic stabilizers of the elbow joint. This mobilization was performed with the forearm in pronation to protect lateral ligamentous structures. Active pronation-supination movements were allowed with the elbow placed in 90 degrees of flexion. Up to 6 weeks extension was limited to 30-60 degrees according to elbow stability. Above elbow slab was removed at 6 weeks. Once complete healing was achieved, the active maximum range of motion exercise was initiated

Follow up: All the patient was followed at 6 weeks I 3 months I 6 months I 12 months I 18 months I 2 year and then yearly. All the patients were examined clinically for any complications and also taken the past followup history for any early complications and secondary intervention. Radiological final follow-up for all patients was done with AP and Lateral x-rays and CT scans if required, and the following characteristics were evaluated

- All range of motion
- MEPI and Q-DASH score
- Joint stiffness
- Instability I Subluxation
- Neural deficit
- Osteoarthritis I Arthrosis
- Heterotropic calcification
- Hardware related problem
- Myositis ossificans
- Ulnar nerve irritation or neuritis
- Bony Union I Malunion I Nonunion
- Any complication and re-operation in follow-up

The functional outcome measures consisted of 2 patient-reported functional outcome measures, the Mayo Elbow Performance Index (MEPI) and the Quick- Disabilities of the Arm, Shoulder, and Hand (Q-DASH) score.

Results

Table 1: Patient details

Age (in years)	Number	Percentage
≤25	10	29.4
26-35	10	29.4
36-45	9	26.5
46-55	3	8.8
≥ 56	2	5.9
Gender		
Male	11	32.4
Female	23	67.6
Side involved		
Dominant	24	70.6
Non-dominant	10	29.4
Radial head fracture type according to Mason's classification		
Type 1	5	14.7
Type 2	11	32.4
Type 3	15	44.1
Radial head not fractured	3	8.8
Coronoid fracture type according to Regan- Moore's classification		
Type 1	8	23.5
Type 2	9	26.5
Type 3	8	23.5
Coronoid not fractured	9	26.5

34 cases made up the study group. There were 23 male and 11 female patients, aged between 18 years and 60 years, who were followed up for an average of 38.56 months (range 6 months to 5 years) and were clinically and radiologically, retro prospectively, and prospectively evaluated. The dominant side was involved in 24 patients and the non-dominant in the other 10 patients. According to Mason's classification, 44.1% were type 3 followed by type 2 (32.4%) and type 1 (14.7%). According to Regan- Moore's classification, 23.5% were in type 1 and 3.

Table 2: Mean values in the different radial head groups and coronoid fracture groups

Radial head status	Mean flexion-extension arc	Mean supination-pronation arc	Mean MEPI score	Mean q-DASH score
Excised	115.63	101.25	85.63	11
Preserved (not fixed)	127.22	107.78	87.22	9.78
Replaced	128.75	119.38	91.25	9
Osteosynthesis	115.83	112.5	84.17	11.67
Not fractured	110.67	122.33	83.33	10.33
p-value	0.019	0.004	0.175	0.401
Coronoid Fracture				
Fixed	132.75	121.2	88.9	8.24
Not fixed	130.6	124.3	86.6	9.1
Not fractured	135.9	120.1	89.5	8.8
p-value	0.103	0.126	0.213	0.335

Mean flexion-extension arc and mean supination-pronation arc in excised were 115.63 degrees and 101.25 degrees in radical group and mean flexion-extension arc and mean supination-pronation arc in excised were 132.75 degrees and 121.2 degrees in coronoid group.

Table 3: Mean value in the different age groups and side involved

Age groups	Mean flexion- extension arc	Mean supination- pronation arc	Mean MEPI score	Mean q-DASH score
≤25	116.5	97.5	84	11.1
26-35	122	111.5	88.5	9.5
36-45	121.11	108.33	89.44	9.11
46-55	121.67	96.67	86.67	11
≥ 56	102.5	92.5	82.5	14
P Value	0.535	0.752	0.670	0.189
Side involved				
Dominant	120.42	107.92	87.29	10.13
Non-Dominant	115.5	98.3	86	10.6
p-value	0.469	0.556	0.552	0.617

Mean flexion-extension arc and mean supination-pronation arc in 26-35 age group were 116.5 degrees and 97.5 degrees and mean flexion-extension arc and mean supination-pronation arc in dominant were 120.42 degrees and 107.92 degrees.

Table 4: Complications

Complications		Number	Rate
Bony Union	Present	34	100
Instability	None	34	100
Hardware loosening or dislocation	None	34	100
Infection	None	34	100
Arthrosis	No	23	67.6
	Yes	11	32.4
Pain	Mild pain	18	52.9
	No	16	47.1
Ulnar neuropathy	None	34	100
Neural deficit	None	34	100
Malunion	None	34	100

There were no malunion, infection, ulnar neuropathy and neural deficit were observed. Mild pain was present in 47.1% cases.

Discussion

Complete dislocations of the elbow joint should be systematically considered as terrible triad injury unless proven otherwise, because isolated elbow dislocation is rare in adults populations, almost always associated with fractures and ligamentous injury [9-11]. Associated lesions represent a significant diagnostic, therapeutic and prognostic issue. CT scan assessment should be performed preoperatively to investigate the associated bone lesions and plan the most adapted therapeutic management.

The principle of surgical management is based on two main objectives: Restoration of bony stabilizing structures (radial head, olecranon, and coronoid process) and lateral collateral ligament repair. The surgical protocol for complex elbow injuries is well established as follows: (1) Reduce and fix the coronoid fracture first; (2) Use a metal prosthesis in preference to open reduction and internal fixation (ORIF) for the radial head fracture; (3) Repair the LCL complex and the common extensor origin and/or the posterolateral capsule to restore lateral stability; and (4) If residual instability of the elbow joint persists, apply a hinged external fixator. Although this treatment protocol has been proved effective, still instability, contracture, re-

operation, and progression to arthrosis remain significant problems. After dislocation reduction, many authors advocate early complete excision of the radial head. However, severe osteoarthritis and valgus instability are the most common terrible triad injury complications after isolated resection of the radial head. In 2005 Morrey *et al*., [12] soft-tissue and articular surfaces that provide stability to the elbow share the capacity as a function of joint position and loading configuration, the radial head is defined as a secondary stabilizer to resist valgus force.

Radial head prosthesis replacement suggests that it is a technically difficult procedure for the treatment of complex elbow injuries. First, the height of the radial head should correspond to the height of the excised fragments; however, in cases of radial neck comminuted fractures, under-sizing of the removed head fragments is a common problem, which can result in elbow valgus instability if accompanied by MCL injury. On the other hand, oversizing of the removed head fragments may cause increasing the height of the radial head and overstuffing of the humeroradial joint, with the potential risk of stiffness and capitellar erosion [13-16].

In our series, we had 5 types I, 11 types II, 15 types III radial head fractures. 3 patients did not have any radial head fracture. Out of this three, one Patient had a radial neck fracture. We have replaced the radial head with the radial head prosthesis in 10 patients with type III radial head fracture. The radial head was excised in 5 type III radial head fractures and one patient with a radial neck fracture. The radial head was preserved not fixed in 7 patients and was repaired in 11 patients. Based on Regan-Moore's classification [17], 8 patients had type I coronoid fracture, whereas 9 patients had type II fracture, 8 patients had type III Fracture. 9 patients did not have any coronoid fracture. Out of these all types III and 6 types, II was fixed. 3 type II and all type I fracture was left alone.

In 2007 Doornberg *et al*., [18] reported 27 patients with traumatic elbow instability in whom radial head replacement with a modular metal head prosthesis was done. At a mean 40 months of follow-up, the average flexionextension arc was 131 degrees, supination pronation was 130 degrees. 22 patients had an excellent or good result according to MEPI, which is almost comparable to our results. 7 patients underwent a secondary procedure for residual instability, heterotropic ossification, elbow contracture, ulnar neuropathy, or misplaced screw which is comparable to our secondary procedure rate. Eventually, all 27 elbow was stable. In 2017 Jones ADR *et al*., [19] reported Surgical treatment of terrible triad injuries carries a high risk of complications with an average reoperation rate of 22%. In our study reoperation rate was 26%, common complications that we saw in our study were required reoperation, residual instability, exposed olecranon locking plate, and infections. Lindenhovius *et al*., [20] compared the acute treatment of 18 versus the subacute treatment (3 or more weeks after injury) of 14 terrible triad injuries. The acute treatment group most closely parallels the treatment protocol in our study. All coronoid fractures in this group were classified as type II, and all were repaired. The mean flexion-extension arc was 119 degrees which are comparable to the current study and the mean forearm rotation was 141 degrees at final follow up which is superior to the current study.

This study had several limitations. First, this study had no comparison groups with the same type of injuries and included a relatively small number of patients with shorter follow-up, also due to covid pandemics, many of the patients were lost to follow-up or did not come for regular follow-up. The absence of a control group precludes making definitive recommendations, and the small size of the series would make it less likely we would detect uncommon complications of treatment. A homogenous group of the patient could not be formed. Furthermore, as elaborated on in the text subsequently, direct comparison with other complex elbow injury studies may be difficult to interpret as a result of the small sample size.

Conclusion

Although our number of patients and mean duration of follow-up are less than many other studies, we have achieved comparable results in view of both subjective and objective parameters of follow-up such as the mean arc of flexion-extension, supination-pronation, mean Q-DASH score, MEPI score. Early rehabilitation, lack of ligament lesions, younger age, and regular follow-up were associated with good results. Ligament and cartilage lesions, older age, and a longer period of immobilization were associated with worse results. The results of our study indicate that midterm functional outcomes after surgery for complex elbow dislocation are generally satisfactory and that complication is common. Further research is warranted to determine which surgical techniques optimize functional outcomes and reduce the risk of complications.

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Author's Contribution

Not available

Conflict of Interest

Not available

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