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MINIREVIEWS

Review of management of unstable elbow fractures

Omer Ozel, Emre Demircay

Omer Ozel, Emre Demircay, Department of Orthopedic Surgery, Baskent University, 34662 Istanbul, Turkey

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Correspondence to: Emre Demircay, Associate Professor, Department of Orthopedic Surgery, Baskent University, Oymaci Sokak No: 7 Altunizade, 34662 Istanbul, Turkey. emredemircay@hotmail.com
Telephone: +90-216-5541500
Fax: +90-216-6519746

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Abstract

Stable and painless elbow motion is essential for activities of daily living. The elbow joint is the second most commonly dislocated joint in adults. The goals of treatment are to perform a stable fixation of all fractures, to achieve concentric and stable reduction of the elbow and to provide early motion. The treatment modality for complex elbow instability is almost always surgical. The treatment objectives are anatomic reduction, stable fixation, and early rehabilitation of the elbow. The common complications of these unstable fractures include recurrent instability, stiffness, myositis ossifications, heterotopic calcification, and neurovascular dysfunction. We analyzed the management of complex elbow fractures and instabilities on the basis of recent literature and suggested possible guidelines for the treatment in this paper. In conclusion, recognition of the injury pattern and restoration of the joint stability are the prerequisites for any successful treatment of an unstable elbow injury.

Key words: Transolecranon fracture; Coronoid fracture; Monteggia injury; Radial head fracture; Terrible triad

Core tip: As the elbow joint is the second most commonly dislocated joint in adults, we aimed to analyze the management of complex elbow fractures and instabilities, on the basis of recent literature and suggested possible guidelines for the treatment in this paper.

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INTRODUCTION

Basic elbow function requires stable and painless elbow motion. The three articulations, namely the ulnotrochlear, radiocapitellar, and proximal radioulnar joints, provide elbow flexion/extension and supination/pronation. Static and dynamic constraints create stability of the elbow joint. The ulnohumeral articulation, anterior bundle of the medial collateral ligament, and lateral collateral ligament complex form the primary static constraints. The joint capsule and radial head are among the secondary static constraints. The dynamic constraints, such as the common flexor and extensor

muscle groups, are any muscles crossing the elbow joint that exert a compressive force on the joint[1].

The elbow is the second most commonly dislocated joint in adults[2]. The dislocations may be complex or simple. When dislocations are associated with fractures, they are designated as complex. The reported annual incidence of simple and complex elbow dislocations is 6.1 per 100000 patients[3]. Radial head fractures/dislocations, coronoid fractures, terrible triad injuries, transolecranon fracture-dislocations, and Monteggia-like lesions can be listed as common causes of complex elbow injuries.

Complex elbow fractures and instability typically present with edema, tenderness, pain in active/passive movement, and restriction of motion. A fall onto the extended outstretched hand or a direct trauma to the elbow is usually described as the mechanism of the injury. Anteroposterior and lateral standard radiographs and computerized tomography scans (either standard or 3D) are needed to properly evaluate the bone injuries and to accurately plan their surgical treatment. Neurovascular examination and documentation of the injuries before and after any manipulation are of critical importance. A temporary fracture alignment with cast immobilization may be done until definitive surgery in patients with severe injuries.

The treatment modality for complex elbow instability is almost always surgical. The treatment objectives are anatomic reduction, stable fixation, and early rehabilitation of the elbow.

The common complications of these unstable fractures include recurrent instability, stiffness, myositis ossifications, heterotopic calcification, and neurovascular dysfunction.

In this review, we analyze the management of complex elbow fractures and instability on the basis of recent literature, and suggest possible guidelines for the treatment of these injuries.

RADIAL HEAD FRACTURES

Radial head fractures are among the most common elbow fractures, occurring in up to 20% of all elbow injuries[4]. Radial head fractures are mostly associated with complex injuries like elbow dislocation, and lateral collateral ligament (LCL) and medial collateral ligament (MCL) tears. Impaction fractures of the capitellum may also be associated with radial head fractures, and can easily be overlooked[5]. Only about 5% of cases have a radial head fracture as an isolated injury[6,7]. In a large incidence study[8], the mean age was found to be 36 years and the female-to-male ratio was 47.7/53.3. A thorough physical examination is essential to diagnose associated ligament injuries. Fluoroscopy may be used to confirm an MCL injury if medial pain and ecchymosis are present. If the MCL is injured, the role of the radial head in valgus resistance increases up to 30%[9,10]. Stable anatomic reconstruction of the radial head is the primary objective of the treatment.

The Mason classification system[11] divided radial head fractures into three categories: type Ⅰ, non-displaced fractures; type Ⅱ, displaced partial head fractures; and type Ⅲ, comminuted displaced fractures involving the whole head.

Modifications to the Mason classification were introduced to guide treatment. The Hotchkiss modification[12] defines type Ⅰ fractures as non-displaced fractures (< 2 mm displacement) without mechanical blockage that do not require surgery, type Ⅱ fractures as displaced fractures (> 2 mm displacement) of the radial head or neck that lack severe comminution, may have mechanical blockage to movement, and usually require open reduction and internal fixation, and type Ⅲ fractures as severely comminuted fractures of the radial head and neck. Satisfactory reconstructions of these fractures are not possible, and therefore the radial head is either excised or replaced with a prosthesis[13]. Fragment excision is avoided in complex elbow instability to prevent valgus instability[14]. If there is an associated LCL rupture, it should be repaired after appropriate management of the radial head fracture, either by fixation or by prosthetic replacement. Suture anchors or transosseous sutures can be used for the reconstruction. The joint stability should be confirmed by dynamic fluoroscopic examination. If residual instability persists, MCL reconstruction and/or dynamic elbow fixation should be done[15,16].

CORONOID FRACTURES

The coronoid process plays a pivotal role as an anterior buttress in providing elbow stability. Although coronoid fractures may occur in isolation, they are more commonly seen as a component of unstable elbow fractures[17].

The classification proposed by Moon *et al*[18], which defines anteromedial facet lesions, may be better for guiding the surgical management of coronoid fractures. Type Ⅰ injuries involve fractures of the coronoid tip, and are divided into two subtypes based on the fracture size. Subtype 1 fractures are smaller than 2 mm, and subtype 2 fractures are larger than 2 mm. In type Ⅱ injuries, the anteromedial aspect of the coronoid is fractured. These injuries are divided into three subtypes based on the anatomic location. Subtype 1 fractures involve the rim, subtype 2 fractures involve the rim and the tip, and subtype 3 fractures involve the rim and the sublime tubercle with or without the tip. Type Ⅲ fractures are basal coronoid fractures involving at least 50% of the height of the coronoid. They are divided into two subtypes depending on whether the fracture involves the base of the olecranon. Stable fixation and ligament repair are essential for the treatment of coronoid fractures[19,20].

TERRIBLE TRIAD INJURIES

Terrible triad injuries have the most common complex pattern. They comprise a radial head fracture and elbow

Table 1 Reviewed studies investigating unstable elbow fracture diagnosis and treatment

Author Year	Ring *et al*[16] 2002	Chemama *et al*[22] 2010	Konrad *et al*[26] 2007	Mouhsine *et al*[29] 2007	Zeiders *et al*[21] 2008	Winter *et al*[13] 2009	Mortazavi *et al*[30] 2006	Strauss *et al*[27] 2006
Mean age (range)	36 (17-62)	46 (26-75)	42.1 (21-72)	54 (22-82)	NA	40 (18-77)	35 (22-58)	UHD+: 46.8 UHD-: 55
n (female/male)	56 (21/35)	23 (7-16)	63 (22/41)	14 (8/6)	32 (NA)	13 (4/9)	8 (1/7)	UHD+: 6 (2/4) UHD-: 17 (12/5)
Radial fracture Mason classification	Type 2: 30 Type 3: 26	Type 1: 2 Type 2: 9 Type 3: 10 Radial neck: 2	Type 2: 7 Type 3: 9	NA	NA	13 non-reperable RH fracture	Type 1: 1 Type 3: 1	UHD+: Type 1: 1 Type 2: 2 Type 3 : 3
Coronoid fracture classification R-M	NA	Type 1: 16 Type 2: 7	NA	NA	NA	Type 1: 5 Type 2-3: 8	Type 3: 4	UHD+: Type 1: 4 Type 3: 2
Monteggia fracture classification (BADO)	NA	NA	Type 1: 19 Type 2: 37 Type 3: 5 Type 4: 2	NA	NA	NA	NA	Type 2: 6 (UHD+) Type 2: 17 (UHD-)
Time to surgery	NA	NA	First 24 h	NA	NA	1.9 d (1-4)	3.8 d	NA
Monteggia fracture Ulna treatment	NA	NA	Bado 1, 3, 4 (26 3.5 mm DCP) Bado 2 (26 plate, 11 tension band)	NA	NA	NA	NA	UHD+: Small fragment plates UHD-: Small fragment plates
Transolecranon fracture treatment	NA	NA	NA	K-wire and tension band: 7 3.5 mm 1/3 plate: 2 3.5 mm DCP: 1 3.5 mm recon. plate: 4	NA	NA	3.5 mm AO recons. Plate: 7 K-wire and tension band: 1	NA
Coronid treatment	NA	None: 10 TOS: 3 Anchor: 2 Screw: 4 Plate: 1 Resection: 3	Lag screws through the ulnar plate or indirect repositioning	NA	32 patients repair of coronoid brachialis Complex pull-through suture tec	NA	4 patients interfragmentary Screws through the plate	UHD+: Type 3 (lag screws)
Radial head treatment	Mason 2: 26 (screw), 4 (plate, screw) Mason 3: 22 (plate, screw), 4 (screw)	13 mini screws Radial neck: 2 plate RHP: 4 PRHR: 2 TRHR: 2	46 luxation CR 12 RH ORIF 4 RH resection	NA	6-intact RH 7-reconst 19-prothesis	13 RHP	1 type 1: Mini screws 1 type 3: Total exicision RH	Type 1, 2: mini fragment plates Type 3: 3 replacement
LCL repair	NA	NA	NA	None	18 (anchor) 12 (mcl + lcl rep)	No: 4 abs suture Used for repair	NA	UHD+: 6
MCL repair	NA	NA	NA	None	2 (ancor) 12 (mcl + lcl rep)	NA	NA	UHD+: 0
External fixator	NA	None	NA	None	21 hinged ex-fix	NA	NA	UHD+: 1 hinged ex-fix
Follow-up	48 mo	63 mo	8.4 yr (5-14) (47 patients)	42 mo (7-84)	3 yr (1-5)	25 mo (15-48)	37.4 mo (10-50)	UHD+: 28 mo (14-48) UHD-: 29 (12-60)
Range of motion	MFA Mason 2: 119 Mason 3: 111	MFA: 109 MSA: 64 MPA: 70	MFA: 97.5 MFR: 125	MFA: 103 MSA: 76 MPA: 68	MFA: 100	MFA: 120	MFA: 93 MFR: 157.5	UHD+: MFA 95, MSA 55, MPA 50 UND-: MFA 122, MSA 67, MPA 60

Mean score	Mason 2: BM: 92 Mason 3: BM: 86	MEPS: 87 (75-100) 14 patients result	BM: 87.2 (45-100) DASH: 17.4 (0-70)	BM: 82 (78-100)	DASH: 23 (19/28)	BM: 86.5 (55-100)	BM: 88 (71-100) ASES: 89 (69-100)	UHD+: DASH 34 (0-80), BM: 73.8 UHD-: DASH 23 (0-70), BM: 83
Unsatisfactory	Mason 2: 4 Mason 3: 14	BM: 0	BM: (9 fair) (4 poor) result	BM: 2 fair 2 poor		2 (stiffness, infection)	BM: 1 fair	UHD+: 2 UHD-: 7

NA: Not applicable; UHD: Ulnohumeral dislocation; RH: Radial head; R-M: Roger Morrey; DCP: Dynamic compression plate; TOS: Transosseous suture; RHP: Radial head prosthesis; PRHR: Partial radial head resection; TRHR: Total radial head resection; MFA: Mean flexion arch; MSA: Mean supination arch; MPA: Mean pronation arch; MFR: Mean forearm rotation; BM: Broberg and Morrey index; MEPS: Mayo elbow performance score; DASH: Disabilities of the arm shoulder and hand; ASES: American Shoulder and Elbow Surgeons assessment system; LCL: Lateral collateral ligament; MCL: Medial collateral ligament.

dislocation along with a coronoid fracture. Both medial and lateral compartments can be exposed through a posterior incision. The Kocher approach can be used for the radial head fracture. Hotchkiss type Ⅰ and type Ⅱ radial head fractures can be fixed with headless screws or a plate[12]. Prosthetic replacement is mandatory for comminuted radial head fractures (type Ⅲ) to avoid chronic instability. There is often a comminuted type 1 fracture in the coronoid, and it can usually only be fixed with a transosseous suture. If there is an isolated fragment that is sufficiently large, fixation with K wires or screws can be done[19]. The LCL is repaired last, and elbow stability is assessed by fluoroscopy. In the presence of a residual instability, the MCL should also be repaired or a hinged external fixator should be applied[7,21,22] (Table 1).

MONTEGGIA-LIKE LESIONS

Monteggia injuries comprise a fracture of the ulnar shaft with an associated radial head dislocation. Monteggia originally described the lesions as a fracture of the proximal third of the ulna and an anterior dislocation of the proximal epiphysis of the radius[23]. Bado[23] classified these injuries by primarily focusing on the radial component. Jupiter *et al*[24] modified this classification by defining subtypes for the posterior Monteggia lesions (Bado type 2). Ulnohumeral dislocation, radial fracture, proximal and/or distal radioulnar dislocation, and interosseous membrane lesions may also accompany the ulnar fracture and radiohumeral dislocation. Each of these must be recognized and treated. The varying combinations of these injured structures explains the complexity and diversity of the management procedures.

Anatomic reduction and stabilization of the ulna and the ulnohumeral joint is the primary objective of surgical treatment for posterior elbow fracture-dislocations[25]. The radial head fracture is addressed initially. If the radial head cannot be salvaged satisfactorily, radial head arthroplasty is preferred. To size the radial head properly, the ulnar length should be restored by a provisional fixation[17]. The coronoid process is stabilized after the ulnar shaft fracture has been addressed, and the olecranon is fixed with a dorsal plate. Finally, ligamentous components of the injury are addressed[26,27] (Table 1).

TRANSOLECRANON FRACTURE-DISLOCATIONS (ANTERIOR OLECRANON FRACTURE-DISLOCATIONS)

The radial head is dislocated anteriorly with an associated olecranon fracture in this injury pattern[28]. Two subtypes have been described: One with a simple olecranon fracture, and one with a comminuted olecranon fracture[28]. The second subtype is more common and may be associated with trochlear and coronoid fractures. This injury pattern is distinct from the anterior Monteggia (Bado type 1) lesion, because in transolecranon fracture-dislocation, the ulnohumeral stability is lost but the radioulnar relationship remains intact. Bony disruption is the main reason for the failure of the ulnohumeral joint rather than the ligamentous structures.

Anatomic reduction with particular attention to restoring the ulnar length and greater sigmoid notch is essential in the treatment[29] (Table 1). Restoration of the ulnohumeral anatomy is crucial to prevent radiocapitellar instability or subluxation[25,30] (Table 1).

CONCLUSION

Surgical treatments of complex elbow fracture dislocations are among the most challenging procedures for orthopedic surgeons. Interpretation of the underlying mechanisms for elbow instability and accurate identification of the injured structures are crucial for surgical planning. Stable elbow fracture fixation is important for early elbow motion and avoiding joint stiffness. Recognition of the injury pattern and restoration of the joint stability are the prerequisites for any successful treatment of an unstable elbow injury.

In this review, we have examined the diagnosis, classification, and treatment of unstable elbow fractures. Future studies should be conducted to determine the optimal management strategies, the role of ligament reconstruction, and reductions in the complication rate.

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