Results of treatment of terrible triad injury of the elbow

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Background/aim
A complex elbow dislocation with associated radial head and coronoid process fractures was named the terrible triad by Hotchkiss because of historically poor outcomes. This study aimed at assessing the results and functional outcome of treatment of terrible triad injuries of the elbow.
Patients and methods
Between 2010 and early 2013, 11 patients suffering from terrible triad injuries of the elbow were treated at Assiut University Hospitals; eight were male individuals and three were female individuals with the mean age of 43 years (range: 26–70 years). The right elbow was injured in five, and the left was injured in six patients. The radial head was replaced by a prosthesis in five and treated by internal fixation in five patients, whereas conservative treatment was decided only in one patient; the coronoid process was fixed by screws in four, whereas four were treated by suturing of the anterior capsule and were treated conservatively.
Results
The mean follow-up was 13.3 months (range: 6–30 months) According to the Mayo Elbow Performance Score, three patients had excellent outcome, seven had good outcome, whereas only one had fair outcome.
Conclusion
Prompt surgical attention with a systematic approach to restore anatomy and provide sufficient stability to allow early motion are the key factors for a successful outcome.

Keywords:
elbow dislocation, elbow, terrible triad

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Introduction

The terrible triad of the elbow is a severe injury that is difficult to treat and has a poor prognosis in the medium-to-long term [1,2]. The injury consists of a combination of three lesions: fracture of the radial head, fracture of the coronoid apophysis, and humeroulnar dislocation (generally posterior or posterolateral). It is characterized by joint instability and development of arthrosis and joint stiffness [3].

Mason [4] classified radial head fractures into three categories: type I, nondisplaced fracture; type II, displaced partial articular fracture with or without comminution; and type III, comminuted radial head fracture involving the whole head.

Hotchkiss [5] later modified Mason's classification on the basis of clinical examination and intraoperative findings so that it could help guide treatment decisions. In the Hotchkiss modification, type I fractures are those displaced less than 2 mm, with no mechanical block; type II are those with greater than 2 mm of displacement that are repairable and may have a mechanical block to motion; and type III are comminuted fractures that are judged to be not repairable by radiographic or intraoperative findings and that require excision or replacement.

Two classification systems outline the fracture patterns seen in coronoid process injuries. The first, proposed by Regan and Morrey [6], was based on the height of the coronoid fragment. A type I fracture involved an 'avulsion' of the tip of the coronoid process, type II involved a single or comminuted fracture representing less than or equal to 50% of the coronoid process, and type III involved a single or comminuted fracture of greater than 50% of the coronoid. These authors further classified these types into A and B, representing associated absence or presence of a dislocation, respectively.

A second classification scheme was recently reported by O'Driscoll *et al*. [7] and is based on the location of the fracture with reference to local anatomy. The classification divides the coronoid process into the tip, the anteromedial facet, and the base. These groups are subcategorized to better define the anatomic site of the fracture. Coronoid tip fractures are divided into fragments that are less than or equal to

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2 mm or greater than 2 mm. Tip fractures are most frequently seen in association with terrible triad injuries. Tip fractures do not usually extend past the sublime tubercle; therefore, the ulnar attachment site of the medial collateral ligament (MCL) is usually intact. Fractures of the anteromedial facet are divided into three subtypes. Anteromedial subtype 1 fractures do not involve the coronoid tip and extend from just medial to the tip to just anterior to the sublime tubercle. Subtype 2 fractures are subtype 1 with involvement of the coronoid tip. Subtype 3 fractures involve the anteromedial rim of the coronoid and the sublime tubercle. Basal coronoid fractures consist of a fracture through the body of the coronoid process and involve at least 50% of the coronoid height. Basal fractures are divided into subtype 1, which involves only the coronoid process, and subtype 2, which consists of a coronoid body fracture in association with an olecranon fracture.

Patient history and physical examination are vital to the diagnosis and management of terrible triad injuries. The history should include the severity and mechanism of injury. High-energy injuries often involve more ligamentous and osseous disruption than do low-energy injuries, which are more commonly seen in elderly, osteoporotic patients. The mechanism of injury is also important because it allows the surgeon to better predict which structures are injured. The examination should note any signs or symptoms of neurovascular injury and skin or soft-tissue compromise [8].

The nonsurgical treatment plan requires that imagings including a computed tomography (CT) scan show a small nondisplaced or minimally displaced radial head or neck fracture that does not cause a mechanical block to forearm rotation or elbow flexion/extension. The coronoid fracture must also be a small tip fragment as confirmed by CT scans, which are routinely recommended in the evaluation and treatment of these injuries. In these circumstances, the injury may be treated as a 'simple' dislocation.

Most terrible triad elbow injuries are managed surgically. When the patient is deemed medically fit, surgery is indicated for failure to meet nonsurgical treatment criteria, for open wounds, and/or for neurologic or vascular injury [8].

Patients and methods

Between 2010 and early 2013, 11 patients suffering from terrible triad injuries of the elbow were treated at Assiut University Hospitals. This study approved by the Ethical committee of Department of Orthopedic Surgery, Faculty of Medicine, Assiut University, Assiut, Egypt.

All patients underwent evaluation including full history taking, documentation of the dominant hand, activity, and work.

Full elbow examination and evaluation of associated injuries were recorded.

Full radiological evaluation including radiography (anteroposterior, lateral, oblique views) and CT of the injured elbow were carried out.

The operative approach, technique of the operation, the modalities of management, and intraoperative complications were documented.

The injury is treated in a sequence starting by reduction of the elbow, followed by dealing with the coronoid process, then fixing or replacing the radial head and is ended by repairing of the lateral ligament.

Postoperative complications, length of hospital stay, type of postoperative rehabilitation, length of the follow-up period were also recorded.

All patients were followed up clinically to assess pain, stability, and range of motion and radiologically to check alignment, bone healing, and implant-related complications.

Results were analyzed according to the Mayo Elbow Performance Score (MEPS).

(1) Pain (45 points):
    (a) None (45).
    (b) Mild (30).
    (c) Moderate (15).
    (d) Severe (0).
(2) Motion (20 points):
    (a) Arc less than 100° (20).
    (b) Arc 50–100° (15).
    (c) Arc greater than 50° (5).
(3) Stability (10 points):
    (a) Stable (10).
    (b) Moderately unstable (5).
    (c) Grossly unstable (0).
(4) Function (25 points):
    (a) Comb hair (5).
    (b) Feed (5).

(c) Perform hygiene (5).
(d) Done shirt (5).
(e) Done shoe (5).

(5) Classification:
(a) Excellent less than 90.
(b) Good 75–90.
(c) Fair 60–74.
(d) Poor greater than 60.

Results

Among those 11 patients suffering from terrible triad injuries of the elbow, eight were male individuals and three were female individuals with the mean age of 43 years (range: 26–70 years); the right elbow was injured in five, and the left in six patients, and all the patients had the right hand as the dominant one.

The associated injuries were fracture olecranon in two, fracture spine in one, fracture shaft of radius in one, and fracture humerus with fracture ribs and hemothrax in one patient.

The mean time before surgery was 3.5 days (range: 2–6 days).

General anesthesia was used to anesthetize all patients.

All patients were operated upon using the lateral position.

Posterior midline approach was used in all patients except for one elbow, which was operated anteriorly.

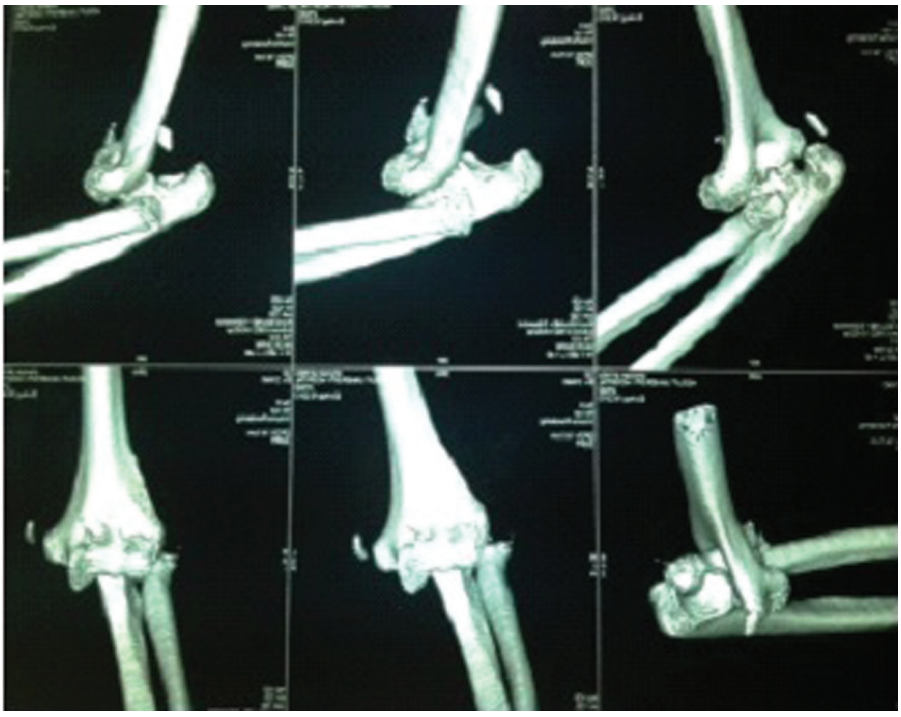
The radial head was replaced by a prosthesis in five and treated by internal fixation in five patients, whereas conservative treatment was decided only in one patient; the coronoid process was fixed by screws in four, whereas four were treated by suturing of the anterior capsule, and three were treated conservatively.

The suture used to stabilize the coronoid process was ligated first, with the elbow held in 90° of flexion.

The lateral collateral ligament complex was repaired in all cases except one in which the radial head fracture was treated conservatively, and it was stabilized with transosseous interrupted sutures, with the elbow held in 30° of flexion and the forearm in full pronation.

The mean tourniquet time was 1.5 h (range: 1–2 h). All patients were put in cast (above elbow) for 15 days, which was to be redone for another 1 month after stitches removal. The mean time of union of fractures treated by internal fixation was 2.3 months (range: 1.5–3 months). The mean time of physiotherapy was 3.5 months (range: 2–6 months). No intraoperative or postoperative complications were recorded. The mean follow-up was 13.3 months (range: 6–30 months). All elbows were stable at the end of follow-up. Six (54.5%) cases had 10° limitation of flexion and extension range,

Figure 1



Typical CT picture of terrible triad injury showing the triad of fracture head of radius, fracture of the coronoid process, and elbow dislocation.

and two (18.1%) cases had 15° limitation of flexion and extension range. The arc of motion was more than 100° in all elbows; the mean range was 10–126°. Only one (11%) case had limitation of supination; this was because the fracture head of radius was treated conservatively. According to the MEPS, three patients had excellent outcome, seven had good outcome, whereas only one had fair outcome (Figs. 1–4).

Discussion

The terrible triad of the elbow is difficult to treat and has poor outcomes, including frequent redislocations [2,9–11].

The forces producing elbow subluxation affect the joint by injuring structures sequentially from a lateral to medial direction. In the first phase, the lateral collateral complex is affected, which produces rotational instability of the elbow in varus. In the second phase, if the force continues to act, the radial head collides with the humeral condyle and fractures. In the third phase, the rotating instability produced by injury of the lateral complex enables the axial force to dislocate the elbow, usually in a posterior or posterolateral direction, and occurs together with fracture of the coronoid. The coronoid can also be affected at the beginning by rupture of the lateral ligament complex or by a direct impact of the humeral trochlea, although the second and third phases occur almost simultaneously. The medial ligament complex is also affected in most patients, but its injury is not an essential prerequisite for the terrible triad to occur [9,12].

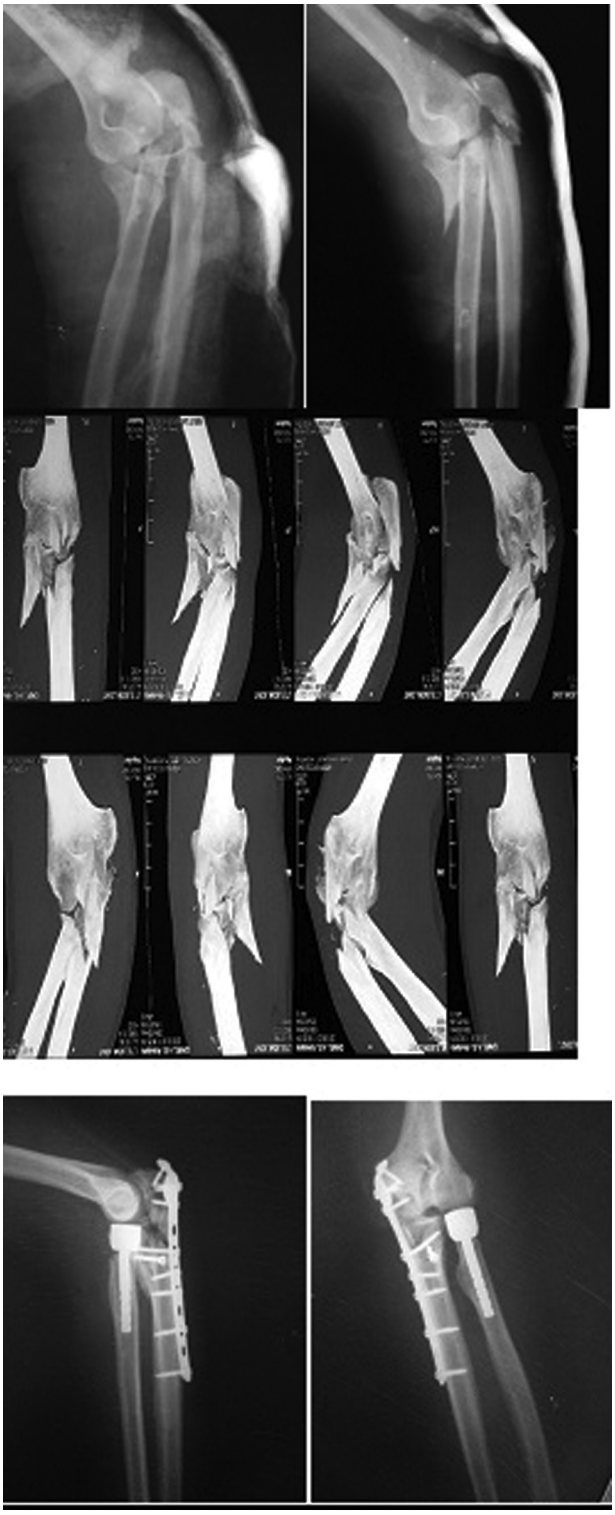
The treatment for the terrible triad of the elbow follows a sequence [13]. First is the reduction of the humeroulnar joint and osteosynthesis of coronoid fractures (if type II or III). Second is the synthesis or arthroplasty of radial head fractures (if type II or III) and repair of the lateral ligament complex, if possible. Third is the stabilization of the joint by transfixation with humeroulnar Kirschner wires or external fixation for 3– 6 weeks in 30–45° of flexion, followed by intensive rehabilitation [14–17].

Relatively few studies have documented the outcomes of terrible triad injuries of the elbow.

Our results as regards the flexion extension arc average were compared with those described in the literature. Our patients achieved a comparable range of motion (Table 1).

In the Pugh *et al.* [18] series, 15 patients were rated as excellent, 13 as good, 7 as fair, and 1 as poor by the MEPS; in our study two patients were rated as excellent, 6 as good, 1 as fair, and 1 as poor.

Figure 2

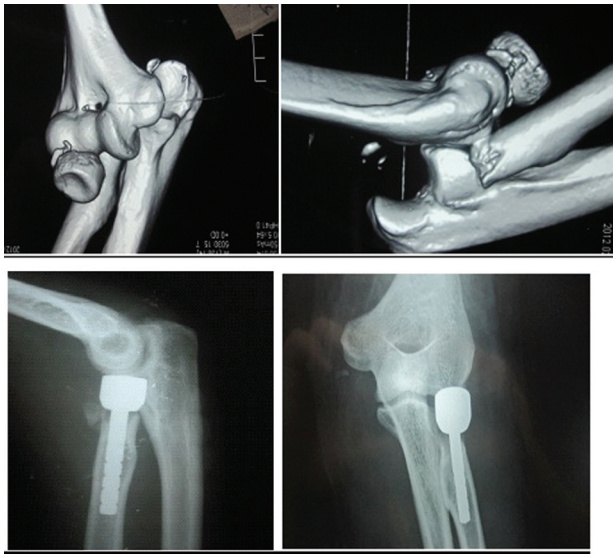


Pre-operative and pos-operative X rays of the (LT) elbow of a male patient 37 years showing terrible triad injury with fracture olecrenon treated by radial head replacement, internal fixation of both the coronoid process and the olecrenon.

Figure 3

Pre-operative and pos-operative X rays of the (RT) elbow of a female patient 29 years showing terrible triad injury with fracture shaft radius treated by internal fixation of the coronoid process, head of radius, and shaft of the radius through anterior approach.

Figure 4



Male patient with terrible triad injury of the (RT) elbow treated by radial head replacement, the coronoid process is fixed by pull out suture.

Broberg and Morrey [20] noted that immobilization for more than 4 weeks led to affection of the arc of motion. It should be noted, however, that a surgeon often has to decide between stability and mobilization. In the end, the outcome of managing a stiff congruent elbow is usually better than that of treating a mobile elbow with residual instability and incongruency [16].

Table 1 Our patients achieved a comparable range of motion

References	Number or case	Follow-up (months)	Arc motion average (deg.)
This study	11	13.3	116
Pugh *et al*. [18]	36	34	112
Forthman *et al*. [19]	30	32	117
Ring *et al*. [11]	8	84	92
Seijas *et al.* [12]	18	13.6	112

The common complications following such injury are instability, malunion, nonunion, stiffness, heterotopic ossification, infection, and ulnar neuropathy. The frequency of complications is related to the severity of the injury [3,18,19,21,22].

It was initially thought that instability was more prevalent with Regan and Morrey [6] type III coronoid process fractures; however, instability seems to be more common following types I or II coronoid fractures. This is theorized to occur because of the frequency of associated ligamentous injuries around the elbow and the technically challenging aspects of obtaining stable internal fixation of these smaller fractures. Terada *et al.* [23] and Josefsson *et al.* [24] also reported that chronic elbow instability was more common in patients with smaller fractures of the coronoid process, particularly when associated with a radial head fracture. Repair of the collateral ligaments was found to be more beneficial than suture fixation of the coronoid process in the treatment of small type I coronoid fractures [25].

Post-traumatic stiffness is a common complication after treatment of terrible triad injuries of the elbow. The best treatment is prevention, such that at the time of index surgery, the elbow should be rendered sufficiently stable to allow early range of motion.

In our study, apart from limitation of last degrees of flexion extension range of motion, none of the above-mentioned complications were encountered; this may be attributed to the few number of cases, strong fixation, repair of injured ligamentous injuries when needed, radial head replacement when indicated, and strict physiotherapy program for all patients.

Terrible triad injuries remain difficult to treat. The surgeon must carefully examine and view images of the injured arm to determine the extent of bony and ligamentous injury. Most authors agree that prompt surgical attention with a systematic approach to restore anatomy and provide sufficient stability to allow early

motion are the key factors for a successful outcome. Stiffness, a common complication after terrible triad injuries, is generally avoided by stable repair and early mobilization. The long-term outcome of terrible triad injuries remains unknown [7].

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Conflicts of interest
There are no conflicts of interest.

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