Original Article

Terrible triad injury of the elbow: How to improve outcomes?

B. Chemama, N. Bonnevialle, O. Peter, P. Mansat*, P. Bonnevialle

Orthopaedics-Traumatology Department, Toulouse-Purpan university hospital, place du Dr-Baylac, 31059 Toulouse, France

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Keywords
Elbow dislocation; Radial head; Coronoid process; Joint instability

Summary
Introduction: Dislocation of the elbow joint combined with fractures of the radial head and ulnar coronoid process is referred to as Terrible Triad Injury (TTI). The purpose of this study is to report our experience in the management of this specific injury and to validate the therapeutic choices of our treatment.

Material and methods: Between 1996 and 2006, 23 TTI in 22 patients were treated in our department. Fifteen males and seven females of mean age 46 years were included in this series. Internal fixation of the radial head was performed in 13 cases and arthroplasty in four. Fractures of the coronoid process were managed by surgical fixation in 10 cases. All torn ligaments were reconstructed which include 19 lateral and six medial ligament reconstructions.

Results: Thirteen patients (14 elbows) were reviewed at a mean follow-up of 63 months, four patients at a mean follow-up of 11 months (range, 6 to 18 months), and five patients were lost to follow-up. All patients had stable elbow joint and in 90% of the cases, patients reported mild or no elbow pain. The arc of extension—flexion ranged from 18 to 127°, while the average arc of pronation—supination was 134°. The mean Mayo Elbow Performance Score was 87. Only one patient suffered from osteoarthritis 8 years after trauma and all elbows were centred on X-rays. Negative prognosis factor was associated with Mason type 3 radial head fractures.

Discussion and conclusion: The principle of the surgical management is based on two main objectives: restoration of bony stabilizing structures (radial head and coronoid process) and lateral collateral ligament reconstruction. A medial surgical approach is recommended in the case of persistent posterolateral instability following lateral collateral ligament reconstruction or when fixation of a large coronoid process fragment is indicated. The use of an external fixator is only advocated in case of persistent instability following the reconstruction of bony and ligamentous structures.

Level of evidence: Level IV: Retrospective study.
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* Corresponding author. Tel.: +33 5 61 77 21 39; fax: +33 5 61 77 76 17.
E-mail address: mansat@cict.fr (P. Mansat).

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Introduction

Posterolateral dislocation of the elbow joint is the most common acute traumatic elbow instability and occurs secondary to a traumatic valgus elbow instability, forearm supination and axial compression [1,2]. Such traumatism will induce damages to the radial collateral ligamentous complex extending to the capsule and up to the ulnar collateral ligament compartment [2]. Early treatment will positively affect the outcome [1].

Complete dislocation of the elbow joint associates ligament damages with radial head, coronoid process, olecranon or epicondyle fractures. The “terrible triad injury” of the elbow, as named by Hotchkiss, is the combination of an elbow dislocation, a radial head fracture and a coronoid process fracture. The main objective in the management of such injuries is to restore the stabilizing bony structures of the elbow to convert a complex dislocation of the elbow joint into a simple one. However, proper identification of these lesions is quite demanding and their early management is a favourable prognostic factor for final outcome [5].

The principles of this treatment were detailed by McKee et al. [6] as well as Ring et al. [7], however relatively few clinical reports are available in the literature. The purpose of that study was to report our experience in the treatment of this specific pattern of injury in order to precise its therapeutic and diagnostic aspects and evaluate the quality of the results.

Patients and methods

Patients

Over a 10-year period, between 1996 and 2006, 22 patients sustaining an elbow dislocation with associated radial head and coronoid process fractures were enrolled in the study and their clinical results were retrospectively assessed.

This series included 15 males and seven females of mean age 46 years (range, 26 to 75 years) at the time of trauma. One of the patients sustained a bilateral injury; therefore, 23 terrible triad injuries were evaluated.

Seven patients had sustained the initial trauma during a road traffic accident, five during a fall from bicycle, four after a fall from height, three during a sport accident and three after a fall of mechanical origin. All patients were early evaluated. All dislocations were closed injuries and no neurovascular deficits could be noted. The initial assessment included A/P and lateral radiographs of the elbow to rule out associated bony pathology.

In all cases, it was a posterolateral dislocation of the elbow joint with associated fractures of the radial head and coronoid process of the ulna. Fractures of the radial head were graded according to the Mason classification as modified by Johnson [8]: type I: non-displaced fractures; type II: non-comminuted displaced fractures; type III: comminuted fractures. Our series included two type I fractures, nine type II fractures, 10 type III fractures and two radial neck fractures.

Fractures of the coronoid process were graded according to the Regan and Morrey classification [9] which distinguishes three different types of fractures: Type I: Avulsion of the tip of the bone, type II: detached fragment of less than 50% of the coronoid process; type III: detached fragment of more than 50% of the coronoid process. According to this classification, there was 16 type I fractures and seven type II fractures. No type III fractures were reported (Figs. 1 and 2).

Operative technique

Early surgical reconstruction was performed in all patients, after fracture reduction, under general anaesthesia and
image intensifier, stability was then assessed. In all cases, a lateral surgical approach was carried out through the Kocher interval, between the extensor carpi ulnaris and anconeus muscles. The lateral approach was associated with a medial approach in nine cases, thus providing better access to the coronoid process and the ulnar collateral ligament. In two cases, an anterior transbrachial surgical approach according to Ameur et al. [10] was associated for osteosynthesis of the coronoid process. No posterior surgical approach was performed.

Surgical exploration revealed a persistent damage to the radial ligaments, which were disinserted from the humerus in all case. Six out of the nine cases with medial surgical approach had an injury to the ulnar collateral ligament of the elbow.

Osteosynthesis of the radial head was performed in 13 cases, which included seven type II fractures, four type III fractures and two radial neck fractures. Fixation was carried out using small-sized 2.0 mm diameter screws in all cases, except for both radial neck fractures which fixation was performed using two small T-plates. Among the four cases of non-reconstructible type III fractures, a modular and bipolar radial head prosthesis (GUEPAR - DePuy) was placed in three cases and a monoblock metal prosthesis (Swanson—Wright Medical) was placed in 1 case. In four type III fractures, the radial head was resected. Two resections were partial (< 30%) and two were complete. Both complete resections resulted in instability of the humeroulnar joint, thus requiring the insertion of a stabilizing humeroulnar pin.

Regarding the coronoid process, 10 type I fractures were neglected. Ten other patients were managed with osteosynthesis performed via the lateral approach in three cases, the medial approach in five and the anterior approach in two. Among these patients, five had a type I fracture which was secured using transosseous sutures tied over the olecranon in three cases (one lateral approach, two medial approaches) and reinsertion with absorbable anchors in two cases (one lateral approach and one medial approach). Five other patients sustaining a type II fracture underwent an osteosynthesis featuring an anteroposterior anterograde screw system in four cases (one lateral approach, one medial approach and one anterior approach) or an anteromedial plating system through a medial approach in one case. Finally, resection of the coronoid fragment was performed in three cases (one type I and two type II fractures) (Fig. 3).

All damaged radial and ulnar collateral ligaments were reconstructed via a transosseous suture repair according to the technique of Osborne and Cotterill [11] or using absorbable anchors (Table 1).

Postoperative management

The elbow was maintained in a static orthosis at 90° of flexion, for 15 days. In the case of isolated suture of the radial collateral ligament, the forearm was placed in pronation. When associated with suture of the ulnar collateral ligament, the forearm was placed in the neutral position. After 15 days, a hinged orthosis was applied allowing a flexion—extension and pronosupination rehabilitation protocol to be initiated with maximum extension limited to 30° during a 4-week period after which the orthosis could be definitely removed. Early active mobilization was initiated on the 15th day 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 the lateral ligamentous structures. Active pronation and supination movements were allowed with the elbow placed in 90° of flexion. Up to 6 weeks, maximum extension was limited to 30 or 60° according to the elbow stability assessment performed after reduction, and to prevent the risk of dislocation. Once complete healing was achieved, active maximum range of motion exercises were initiated through physical postures. A mus-
### Table 1: Presentation of the reviewed patients from the series.

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>Follow-up (months)</th>
<th>Trauma</th>
<th>RH</th>
<th>CR</th>
<th>Surgical Approach</th>
<th>Treatment RH</th>
<th>Treatment CR</th>
<th>MEPS</th>
<th>Ext-Flex (in degrees)</th>
<th>P/S (in degrees)</th>
<th>Rev</th>
<th>Osteoarthritis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>47 M</td>
<td>94</td>
<td>Fall from height</td>
<td>3</td>
<td>1</td>
<td>Lat</td>
<td>Prosthesis</td>
<td>Orthopaedic</td>
<td>85</td>
<td>−35 /140</td>
<td>50/30</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>39 M</td>
<td>75</td>
<td>RTA 4W</td>
<td>2</td>
<td>1</td>
<td>Lat &amp; med.</td>
<td>Screw</td>
<td>Suture</td>
<td>85</td>
<td>−10 /130</td>
<td>80/80</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>48 M</td>
<td>72</td>
<td>RTA (bike)</td>
<td>1</td>
<td>2</td>
<td>Med &amp; Lat</td>
<td>Orthopaedic</td>
<td>Plate</td>
<td>100</td>
<td>0/140</td>
<td>80/80</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>46 M</td>
<td>120</td>
<td>Fall</td>
<td>2</td>
<td>2</td>
<td>Lat &amp; Med.</td>
<td>Partial resection</td>
<td>Resection</td>
<td>85</td>
<td>−20 /130</td>
<td>80/80</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>50 M</td>
<td>105</td>
<td>Fall</td>
<td>2</td>
<td>1</td>
<td>Lat</td>
<td>Partial resection</td>
<td>Orthopaedic</td>
<td>85</td>
<td>−30 /135</td>
<td>80/80</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>52 F</td>
<td>24</td>
<td>Fall from Height</td>
<td>3</td>
<td>1</td>
<td>Lat.</td>
<td>Prosthesis</td>
<td>Orthopaedic</td>
<td>95</td>
<td>−35 /120</td>
<td>85/50</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>40 M</td>
<td>70</td>
<td>RTA 2W</td>
<td>3</td>
<td>2</td>
<td>Lat &amp; ant</td>
<td>Pin</td>
<td>Screw</td>
<td>90</td>
<td>−25 /120</td>
<td>60/60</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>30 M</td>
<td>52</td>
<td>RTA 4W</td>
<td>2</td>
<td>1</td>
<td>Lat &amp; Med.</td>
<td>Screw</td>
<td>Anchor suture</td>
<td>100</td>
<td>−5 /135</td>
<td>80/60</td>
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<td>0</td>
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<tr>
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<td>30 M</td>
<td>52</td>
<td>RTA 4W</td>
<td>3</td>
<td>1</td>
<td>Lat</td>
<td>Prosthesis</td>
<td>Orthopaedic</td>
<td>85</td>
<td>−15 /125</td>
<td>70/50</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>40 M</td>
<td>33</td>
<td>Fall from height</td>
<td>4</td>
<td>2</td>
<td>Lat</td>
<td>Plate + Screw</td>
<td>Screw</td>
<td>100</td>
<td>0/140</td>
<td>80/80</td>
<td>0</td>
<td>0</td>
</tr>
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<td>26 M</td>
<td>19</td>
<td>RTA 4W</td>
<td>3</td>
<td>1</td>
<td>Lat</td>
<td>Screw</td>
<td>Orthopaedic</td>
<td>85</td>
<td>−10 /150</td>
<td>50/50</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>29 M</td>
<td>14</td>
<td>Sport</td>
<td>3</td>
<td>1</td>
<td>Lat</td>
<td>Prosthesis</td>
<td>Orthopaedic + Ext. fix (3 weeks)</td>
<td>75</td>
<td>−50 /90</td>
<td>50/30</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>41 F</td>
<td>24</td>
<td>Fall</td>
<td>3</td>
<td>1</td>
<td>Lat</td>
<td>Partial resection + screw</td>
<td>Anchor suture</td>
<td>100</td>
<td>0/130</td>
<td>80/80</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>44 M</td>
<td>5</td>
<td>Fall from height</td>
<td>2</td>
<td>1</td>
<td>Lat</td>
<td>Screw</td>
<td>Orthopaedic</td>
<td>85</td>
<td>−35 /115</td>
<td>80/60</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

cular rehabilitation protocol was initiated at 3 months post-trauma to strengthen the periarticular stabilizing muscles.

**Method of evaluation**

Thirteen patients (14 elbows) were reviewed at a mean follow-up of 63 months (range, 15 to 128 months) and were clinically and radiographically evaluated. Four other patients were evaluated by telephone at a mean follow-up of 11 months (range, 6 to 18 months) and sent their radiographic for assessment. Five patients were lost to follow-up. Patients were clinically assessed according to the Mayo Elbow Performance Score, on the basis of pain, mobility, stability and functional evaluation [12]. Radiographic assessment of the elbow, based on A/P and lateral views, was also performed at last follow-up.

**Results**

**Complications**

A single early complication was reported in a 44-year-old patient demonstrating a persistent instability in the sagittal and frontal plane, after osteosynthesis of a type II radial head fracture and reinsertion of the lateral collateral ligament. The associated type I coronoid fracture had been ignored. An isolated lateral approach was performed. At one month, this persistent instability required surgical revision performed through a medial approach and revealing a disinserted ulnar collateral ligament, which was then repaired. An external fixator was applied at the end of the operation to secure the whole reconstruction.

A late complication was reported in a 47-year-old patient who had sustained a type III radial head fracture and type I coronoid fracture. A Swanson metal radial head prosthesis had then been implanted through a lateral approach. Six month later, the implant had to be removed due to the patient complaining of severe pain on the lateral column. An anterior arthrolysis was associated with prosthesis removal. Six month later, an ulnocarpal impingement was reported, due to the inversion of the distal radioulnar index, thus requiring an ulnar shortening osteotomy.

**Global results**

The mean Mayo Elbow Performance Score, evaluated in 13 patients (14 elbows) was 87 (range, 75 to 100). The outcomes were classified as excellent in four elbows and good in 10.

**Clinical outcomes**

Eleven patients had no pain while seven reported mild pain. None of the patients suffered from severe pain. Mean flexion at last follow-up was 127°, ranging from 90° to 140°. Mean extension loss was 18°, ranging from 0° to 80°. Mean pronation was 70° (range, 30° to 85°) while mean supination was 64° (range, 30° to 80°). The poorest results regarding pronosupination were found in patients with type III radial head fractures and a mean mobility arc of 60° in pronation and 50° in supination. Elbows were stable in flexion-extension and varus-valgus in all cases.

**Radiographic findings**

A/P and lateral radiographs were systematically performed in all reviewed patients and in those evaluated by telephone (18 elbows). All elbows were well centred on radiographs (Figs. 4 and 5). Only one patient had osteoarthritis of the humeroulnar joint. This patient had previously reported signs of ulnocarpal impingement following the removal of his radial head prosthesis. Eight years after the trauma, he complained of anterior and medial pain. Radiographs confirmed a narrowing of the humeroulnar joint space.

**Discussion**

Terrible triad injuries of the elbow have been individualized by Hotchkiss in 1996 as a clinical entity [4]. This uncommon injury accounts for only 10% of all radial head fractures according to the epidemiological study of Van Riet et al. [13]. In the GEEC 2008 multicenter study, Pierrart et al. report an incidence of 26 out of 229 dislocations of the elbow joint (11%) [14]. Associated lesions represent a significant diagnostic and therapeutic issue. Complete dislocations of the elbow joint should be systematically considered as a terrible triad injury unless otherwise proven, since lack of knowledge of this clinical pattern of injury might be detrimental to elbow function. Once reduction has been achieved, a CT scan assessment should be systematically performed to investigate the associated bone lesions and plan the most adapted therapeutic management [1,5,7,15]. Surgical treatment is highly advocated, whereas orthopaedic management should be avoided due to the high instability of this condition. The principle of that surgical management is based on two main objectives: Restoration of bony stabilizing structures (radial head and coronoid process) and radial collateral ligament repair [3,6,7,15].

The first series published about fracture-dislocation of the elbow joint only reported radial head fractures...
After dislocation reduction, many authors advocate early complete excision of the radial head. However, Broberg and Morrey [16], as well as Joseffson et al. [17], underline the risk of instability and osteoarthritis when resorting systematically to that treatment option. In the French literature, Heim [18] reports the results of the Swiss experience about the management of fractures occurring in the elbow region: Severe osteoarthritis and valgus instability are the most common terrible triad injury complications after isolated resection of the radial head. More recently, Ring et al. [7] in 2002 have published the results of a series of 11 patients having sustained a terrible triad injury of the elbow, and reviewed at a mean follow-up of 7 years. Complete resection of the radial head was performed in four patients while lateral collateral ligament was left unrepaired in three patients. Among the 11 patients, five reported a recurrent instability, four out of which occurred after radial head excision. Seven patients developed osteoarthritis of the humeroulnar joint at last follow-up. The authors advocate systematic reconstruction of the radial head, coronoid process and lateral ligament complex to reduce complications. In our series, four radial heads were resected: two partial resections of less than 30% of the articular surface, with no effect on stability and two complete resections resulting in intraoperative instability requiring additional stabilization with humeroulnar pinning. Therefore, it is now well admitted that type II radial head fractures and, as long as it is possible, type III fractures should be preserved and treated with osteosynthesis in case of terrible triad injuries of the elbow. Non-displaced type I fractures may be left untreated. However, type III non-reconstructable radial head fractures should be managed with arthroplasty for proper reconstruction of the lateral stabilizing column as advocated by several authors [19–22].

The coronoid process is the key element in the humeroulnar joint stability. According to the work of Morrey et An [23], 50% of the height of the coronoid process is necessary to ensure humeroulnar sagittal stability. In terrible triad injuries of the elbow, most coronoid process fractures are type I fractures as confirmed by the series of Doornberg et al. [24] and Pierrart et al. [14]. Such fractures may be neglected even if some authors recommend capsular reinsertion via anchors with possible excision of the fragment, or a retrograde suture repair tied over the olecranon. Type II and III fractures require stable osteosynthesis with screws or plate. Osteosynthesis might be performed through a lateral approach after radial head resection, or via a medial or an anterior approach. Armstrong [5] and Ring et al. [7] advocate the use of a single posterior approach for easier access to the lateral and medial columns. In our series, 10 type I fractures were ignored and five were secured via sutures or anchors. Two type II fractures were screwed through a medial approach, two through an anterior approach and the last one via a lateral approach. In the GEEC 2008 series [14], 13 out of 14 type I fractures were neglected along with two type II fractures. Only a single type I fracture was sutured and two type III fractures were screwed.

Reinsertion of the lateral ligament complex in the management of elbow joint instabilities was first described by Osborne and Cotterill [11]. In their series, McKee et al. [25] report a disinsertion of the radial ligament complex in 100% of the cases which is confirmed in our study. Armstrong [5] also report a similar incidence of this ligamentous lesion and recommend transosseous suture of the ligament. Since this ligament is isometric, a careful reinsertion should be performed at the centre of rotation of the elbow, which corresponds to the centre of the lateral epicondyle, to prevent the occurrence of any varus or posterolateral instability [26].

Systematic approach of the ulnar ligament complex remains controversial. Pugh et al. [15] have recently published the results of the management of 36 terrible triad injuries. An isolated lateral approach was used in 26 of the cases. Osteosynthesis of the coronoid process was performed first using sutures in type I fractures, retrograde screwing in type II and type III fractures. Radial head fixation was performed in 16 cases and arthroplasty in 20 cases. After reconstruction of the lateral ligament complex, stability of the elbow was evaluated in flexion–extension. In the absence of any instability, the medial approach was not performed. In case of instability, a medial approach was chosen for reconstruction of the ligament complex and an external fixator was placed in some patients. The authors advocate a systematic lateral approach, fixation of
The terrible triad injury of the elbow: How to improve outcomes?

The terrible triad injury of the elbow is a complex, often catastrophic injury that combines fractures of the radial head, coronoid process, and olecranon process. It represents a severe injury pattern that can result in significant loss of function and morbidity. The management of these injuries remains challenging, and various surgical techniques have been proposed to improve outcomes.

The radial head fracture is a common component of the terrible triad injury. Radial head fractures can be associated with radial collateral ligament (RCL) injuries, and initial treatment often involves closed reduction with percutaneous pinning or open reduction with internal fixation. However, in patients with RCL injuries, persistent instability and/or significant valgus instability may develop, requiring additional procedures such as collateral ligament reconstruction or radial head resection.

The coronoid process fracture is another critical component of the terrible triad injury. The coronoid process is a key component of the elbow's articular surface and plays a significant role in elbow stability. Fractures of the coronoid process can lead to posterolateral instability, which may require osteosynthesis or replacement.

Mobilization after reconstruction of bony and ligamentous structures is crucial for optimal outcomes. Early mobilization with protection can reduce the risk of secondary stiffness and allow for quicker recovery. However, mobilization must be balanced with the need to ensure proper stability to prevent redislocation or other complications.

Conclusion

The terrible triad injury of the elbow is a complex pattern of all dislocations since it combines ligament damages with radial head and coronoid process fractures. Complete dislocations of the elbow joint should be systematically considered as a terrible triad injury unless otherwise proven, since the lack of knowledge of this clinical pattern of injury might be detrimental to elbow function. CT scan assessment should be systematically performed after dislocation reduction for proper investigation of bony lesions. The principle of that surgical management is based on two main objectives: restoration of the bony stabilizing structures (radial head and coronoid process) and radial collateral ligament reconstruction. Isolated radial head resection should be avoided since it appears as a bad prognosis factor for short and long-term outcome whereas arthroplasty is advised if radial head fracture cannot be reliably managed with osteosynthesis. A medial surgical approach is recommended in the case of persistent posterolateral instability following radial collateral ligament reconstruction or when fixation of a large coronoid process fragment is indicated. Early external fixation is advocated only in the case of persistent instability following the reconstruction of bony and ligamentous structures. It provides joint stability, protects reconstruction and allows early mobilization. However, some authors systematically advocate the use of external fixation since it maintains reduction of the elbow and offers early mobilization within this protected range while assuring secure ligament and fracture healing.

Conflict of interest statement

None.

References


