Outcomes following surgical management of complex terrible triad injuries of the elbow: a single surgeon case series

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Abstract

Background: Terrible triad injuries of the elbow are complex injuries to treat and we report our outcomes following surgical management.

Methods: Twenty-two consecutive patients who underwent fixation of terrible triad injuries between 2007 and 2012 were identified. Clinical outcomes were assessed by examination, visual analogue scores (VAS), Oxford Elbow Score (OES), Mayo Elbow Performance Index (MEPI) and QuickDash score (QD).

Results: The mean age of patients was 47 years, with a mean follow-up of 32 months. All patients underwent lateral ligament repair, with additional medial ligament repair in four cases. Thirteen patients required repair of the coronoid and 18 patients required surgery to the radial head. The mean flexion–extension arc was 113°, with mean pronosupination of 136°. The functional elbow scores revealed good outcomes in the majority (mean OES of 37, MEPI of 79 and QD of 21). The overall complication rate was 41%. In total, 23% required reoperation, with one patient requiring fasciotomy for acute compartment syndrome and four requiring subsequent removal of metalwork as a result of stiffness.

Conclusions: Recognition of this complex injury pattern and appropriate restoration of the joint stability are the prerequisites. Systematic surgical approach is effective and can provide both stability and good function, in most cases.

Keywords

elbow, fracture dislocation, outcomes, terrible triad injuries, treatment

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Introduction

Fracture dislocations of the elbow represent a significant management challenge because they cause instability of the elbow and thus prevent functional rehabilitation. Historically, these fractures have had poor outcomes, even following surgical management, as a result of long-term stiffness, pain, ongoing instability and post-traumatic arthritis.¹ The combination of an elbow dislocation with associated fractures of the coronoid and radial head has been termed the terrible triad² of the elbow for these reasons.³ The evolution of implant technology, in combination with a better understanding of elbow biomechanics, has modernized the approach^{4,5} and appears to be associated with improved outcomes.⁶

The principle of management is to restore a congruent elbow joint, which is sufficiently stable to allow a range of movement and thus prevent stiffness. The majority of the literature relates to a single universal

posterior approach; however, a two-incision technique has also been reported with good outcomes.⁷ We present a single surgeon case series of outcomes of these injuries managed via separate lateral and medial incisions.

Materials and methods

Patients who had undergone surgical management of terrible triad injuries between 2007 and 2012 were

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identified retrospectively. These patients were subsequently invited for clinical review and assessed by independent clinicians who were not involved in the surgical or postoperative treatment. Follow-up consisted of a focused history to assess for function and instability, and examination for instability and distal neurovascular status. The measurement of range of movement with goniometer was compared with the uninjured contralateral side to calculate loss of motion in all planes. Pain was measured using Visual Analogue Score (VAS). Function was quantified using QuickDash (QD), Oxford Elbow Score (OES) and the Mayo Elbow Performance Index (MEPI). Radiographs were then reviewed separately to assess for initial fracture pattern, union and the presence of heterotopic ossification (HO) or arthritic changes. We classified preoperative radial head fractures according to the Mason classification^{8,9} and coronoid fractures according to the Regan–Morrey classification.¹⁰

All large, displaced and unstable coronoid fractures were investigated further with preoperative computed tomography scans, for adequate surgical planning. The surgical approach was standard in all cases, with sequential repair of damaged structures to achieve a congruent stable joint. The lateral approach was performed first in all cases, which allows access to the coronoid for fixation (via the fractured radial head), the radial head itself to treat the fracture depending on the severity and the lateral ligament complex to repair. Following this, all large, displaced and unstable coronoid fragments were fixed routinely via a medial approach. All the other cases after the initial lateral side reconstruction were screened under image intensifier (II) in the operating theatre to confirm sagittal stability, through the useful flexion–extension arc of motion in forearm pronation. If there were any signs of persistent flexion–extension instability with the lack of concentric reduction of the joint and/or significant valgus instability, an additional reconstruction of the medial ligament via a separate incision was performed.

All patients followed the same rehabilitation regime. Initially, 10 days of immobilization in plaster cast with

the elbow at 90° of flexion to allow the wound to settle. Following this, the physiotherapy was started without brace: table top exercises, active flexion and gravity extension without forcing the last 30°, avoidance of passive supination of the wrist and shoulder abduction for the initial 6 weeks. All patients were reviewed at 6 weeks with follow-up radiographs and were kept under review for 12 months postoperatively.

Statistical analysis was performed using Prism, version 5.0 (GraphPad Software Inc., San Diego, CA, USA). Student's *t*-test was used to analyze differences between the pre- and postoperative data.

Results

Twenty-six patients were identified with fracture dislocation of the elbow and 22 patients were available for the clinical and radiological review (15 females and seven males). The mean age of these patients was 47 years (27 years to 84 years) and the mechanism of injury was a simple fall in the majority ($n = 13$) of cases (fall from height in seven and road traffic accident in two cases). The preoperative injury patterns are summarized in Table 1 and there was no associated ulnar nerve damage, open wound trauma or vascular compromise. All injuries were treated with the same technique by the senior author (AW), within an average of 2 days (0 days to 10 days) after injury.

All 22 cases had lateral ligament repair using anchor fixation. Eighteen out of the 22 required radial head surgery acutely: nine fixation with Aptus radial head plate 2.0 (Medartis, Basel, Switzerland), with the other nine requiring replacement (Acumed Anatomic Radial Head; Acumed, Hillsboro, OR, USA). Four patients had a small, undisplaced stable fracture of the radial head, and so only lateral soft tissue reconstruction was performed. Thirteen out of 22 patients required fixation of a coronoid fracture, with anchor fixation for smaller fractures in eight patients and the requirement for plate fixation (i.e. a larger fragment) in a further five cases, via medial incision. Following

Table 1. The preoperative injury patterns.

Injury patterns	Total number of patients	Classification type I	Classification type II	Classification type III
Lateral ligament injury	22 patients			
Radial head fracture	22 patients	Mason 1 to 6	Mason 2 to 9	Mason 3 to 7
Coronoid fracture	22 patients	Regan–Morrey 1 to 9	Regan–Morrey 2 to 8	Regan–Morrey 3 to 5
Medial ligament injury	4 patients with repair			

lateral fixation and II screening, another four patients required additional soft tissue reconstruction of the medial side with a separate incision (Figures 1 and 2). No additional hinged external fixation was required to achieve a stable congruent joint, in all cases.

For the purpose of the present study, we invited patients back for an additional review in clinic at a minimum of 24 months and a mean of 32 months (24 months to 80 months). All underwent clinical examination and a focused history. According to the criteria of Morrey,¹¹ 72% of patients achieved a functional range of movement with mean flexion–extension arc of 113° and mean pronosupination arc of 136°. Two patients had evidence of mild residual laxity but no patient had persistent subluxation or dislocation. Two other patients showed mild and intermittent symptoms of cubital

tunnel syndrome. Outcome scores were good, with low VAS scores for pain, a mean OES of 37, a mean MEPI of 79 and a mean QD of 21 (Table 2).

The overall complication rate was 41% in nine patients and five patients had multiple postoperative problems (Table 3). Four cases required subsequent surgery to remove three radial plates (Figure 3) and one radial head implant to improve range of movement, especially in the pronosupination arc. One other patient required emergency fasciotomy for compartment syndrome. All fractures have united and the final radiographs revealed HO in five and arthritic changes in four cases, without causing significant functional deficit in most cases (Table 3). In total, 50% of the radial head implants had asymptomatic resorption of the proximal radial neck. There was no clinical or

Figure 1. (a) Pre-operative antero-posterior, lateral view radiographs and (b) computed tomography scan image of fracture dislocation of the elbow.

Figure 2. (a) Postoperative antero-posterior and (b) lateral view radiographs of the same elbow after systematic reconstruction of the injured bony and soft tissue structures.

Table 2. Clinical outcomes with subjective and objective scores.

Outcomes	Mean	Range	CI
Range of movement			
Flexion	134°	90 to 150	
Flexion deficit	10°	0 to 40	3.53 to 15.29
Extension deficit	21°	0 to 45	15.26 to 31.21
Supination	64°	20 to 85	
Supination deficit	20°	0 to 50	9.41 to 25.88
Pronation	73°	50 to 90	
Pronation deficit	7°	0 to 25	3.28 to 11.43
Clinical scores			
VAS pain	2	0 to 6	
OES	37	10 to 47	
MEPI	79	45 to 100	
QD	21	68 to 0	

CI, 95% confidence interval; VAS, Visual Analogue Score; OES, Oxford Elbow Score; MEPI, Mayo Elbow Performance Index; QD, QuickDash score.

Table 3. Complication and reoperation rates.

	Number of patients
Complication (41%)	Nine patients (five with multiple problems)
Scar tenderness	6
Ulna nerve symptoms	2
CRPS	1
Stiffness	5
HO	5
Post-traumatic arthritis	4 (one mild, three moderate)
Reoperation (23%)	
Fasciotomy	1
Metalwork removal	4 (three radial plates, one radial head prosthesis)

CRPS, Chronic Regional Pain Syndrome; HO, heterotopic ossification.

radiological evidence for infection or loosening of any radial head prosthesis.

Discussion

We present a series of patients who were treated with a two-incision approach for fracture dislocations of the elbow, with good outcomes at a mean follow-up of almost 3 years. Different surgical approaches can be used. Some surgeons advocate the single posterior longitudinal approach, which can also be used for elbow arthroplasty if required later.^{12,13} The disadvantage of a posterior incision is that the relatively large medial and lateral skin flaps increase the possibility of seromas and hematomas, and flap necrosis is another potential complication.^{14,15} At present, the results of some studies suggest that the lateral approach alone is sufficient for solving most problems.^{1,7,16,17} However, along with some other researchers, we felt that the combined medial and lateral elbow approaches could facilitate exploration and repair simultaneously and that treatment of each injured structure could improve the results.^{18,19}

Our understanding of terrible triad injuries is still incomplete. Further biomechanical studies may be helpful in clarifying the relationship between the medial collateral ligament and the coronoid, in providing stability to the elbow. In addition, we do not clearly know when radial head fractures can be fixed and preserved.²⁰ Furthermore, there is a much controversy over whether repairing the medial collateral ligament can increase the stability of the elbow joint, with different reconstruction techniques being described.^{21,22} Some surgeons advocate medial collateral ligament repair^{16,23} to improve stability and outcomes; however, others report satisfactory and comparable outcomes without routine medial soft tissue reconstruction.^{15,24} Through biomechanical research, Beingsner et al.²⁵ verified that medial collateral ligament injury had an obvious influence on activity and stability of the elbow joint. Therefore, if the elbow joint is still unstable after bony fixation, consideration of whether there is a medial structure injury that needs to be repaired is required. As Toros et al.¹⁹ suggested, repair of medial collateral ligament can also reduce the occurrence of heterotopic ossification of ligament injury position and cubital tunnel syndrome.

Our surgical approach is related to the sequential repair of damaged structures, with the primary goal of reconstructing a stable congruent joint. The coronoid is not always treated with fixation because type 1 and 2 fractures with associated radial head fracture may be stabilized adequately with radial head surgery alone.²⁵ Similarly, the radial head was treated with internal fixation where possible and replacement only when unreconstructable, although short-term studies may suggest no difference in outcome.^{26,27} Under

Figure 3. (a) Postoperative antero-posterior and (b) lateral view radiographs of the same patient's elbow after reoperation and metalwork removal as a result of stiffness.

ideal circumstances, the plates were positioned in the 'Safe Zone'²⁸ to avoid impingement during rotation; however, in three patients, the fracture pattern dictated sub-optimal plate positioning and these plates therefore required subsequent removal. This can be avoided in appropriate cases by using fixation with headless compression screws in crossed configuration.²⁹ One other patient required radial head implant removal as a result of stiffness. This accounts for 80% of our re-operations and the final re-operation for a forearm compartment syndrome in the postoperative period. Our rate of re-operation (23%) is also comparable to most previous studies and significantly less than some.^{27,30–32} Surgeons should be fully aware of these potential risks and all patients should be carefully consented about them preoperatively.

This series compares well with other published data and adds to the growing body of evidence to justify this approach.^{5,33} We have purposefully gathered several (subjective and objective) scores to allow the comparison with other published work, and have included VAS pain scores as a simple method of assessing patient satisfaction. We show a relatively high complication rate (in nine patients; 41%), which again is similar both in type of complication and in frequency, to previously published data.^{32,34} Patients with postoperative complications had worse clinical outcomes with lower clinical scores and a lower range of movements. However, because most of the case series are relatively small, it is difficult to estimate the incidence of these complications.

The main limitation of our retrospective study is again the relatively low number of patients enrolled, which meant that it was not possible to compare different subgroups or to perform different statistical

analyses. However, the very low incidence of such injuries may to some extent justify the limited number of patients enrolled in our study. The strength of the present study is represented by the fact that (i) all the patients in this series were operated on by a single upper limb surgeon with the same technique, thereby reducing the variability of the clinical results; (ii) all cases were assessed blindly by standard protocol; and (iii) all of the patients had several (subjective and objective) scores to allow comparison with other studies.

Conclusions

Although terrible triad injuries have been traditionally described as having a poor long-term prognosis, good and excellent results have been achieved with increased understanding of elbow anatomy and physiology. The aim remains the same: to obtain a stable pain-free elbow within a functional arc of motion, and so a standardized approach to reconstruct bony and ligamentous anatomy is necessary to achieve the goal of early mobilization. The current diagnostic and therapeutic protocols allow satisfactory clinical outcomes to be obtained in the majority of cases, although a high number of major and minor unpredictable complications still persist. This can be reduced by surgical experience and application of appropriate treatment algorithms. Our case series adds to the current literature. It shows good outcomes, with a wide variety of scoring systems, from a sequential approach to this complex injury using dual incisions. Systematic surgical approach is effective and can provide good function and restore stable elbow range motion in most cases.

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Ethical Review and Patient Consent

This study has been reviewed and approved by the Peterborough and Stamford Hospitals NHS Foundation Trust R&D committee.

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