

Management of Terrible Triad Injury of the Elbow and their Functional Outcomes.

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Abstract

Background: This study is to report our experience in the management of terrible triad injury of the elbow and to validate the therapeutic choices of our treatment.

Materials And Methods: Between 2010 and 2014, 15 terrible triad injury of elbow with nine males and six females of mean age of 35 years were included. Complete radial head was resected in nine cases and internal fixation was performed in two cases. Coronoid fractures were treated with suturing of the capsule with vicryl sutures in eight cases and surgical fixation was performed in two cases. All cases had damage to the lateral collateral ligament and eight had an injury to medial collateral ligament which was repaired with vicryl sutures.

Results: 15 elbows were reviewed at a mean follow up of 33 months (range, 18 to 60 months) and were clinically and radiologically evaluated. No patients were lost to follow up. All patients had stable elbow. Ten patients had no pain while five reported to have mild pain on lifting weights. The arc of extension-flexion ranged from 14 to 120, while the average arc of pronation-supination was 130. The mean Mayo Elbow Performance Score was 86. Negative prognostic factor was associated with posterior approach.

Discussion and Conclusion: Principle of surgical management is based on restoring the bony anatomy and reconstructing the lateral collateral ligament of the elbow to provide enough stability. Medial approach is recommended in case of persistent instability following lateral collateral ligament reconstruction or when fixation of a large coronoid process fragment is indicated.

Keywords: Adult; Collateral Ligaments/surgery; Dislocations/epidemiology/radiography/surgery; Fracture Fixation; Internal/adverse effects/methods; Joint Instability/diagnosis/epidemiology/surgery; Postoperative Complications.

Introduction

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[1]. It has an unpredictable outcome in adults and is rare in children[2]. Terrible triad injuries are seen more commonly in men[3]. Posterolateral rotatory instability is the most common pattern of elbow instability, particularly recurrent and can be considered a spectrum according to the degree of soft tissue disruption[4]. The elbow's stability depends on static and dynamic stabilizers. Static stability is maintained by osseous and capsuloligamentous restraints, whereas muscles crossing the elbow provide dynamic stability[3].

The combination of static and dynamic stabilizers provides primary and secondary constraints that prevent elbow instability. Primary constraints are the ulnohumeral articulations, the medial collateral ligaments (especially the anterior bundle), and the lateral collateral ligament

complex (especially the lateral ulnar collateral ligament). The secondary constraints are the radiohumeral articulations, the common flexor-pronator tendons, the common extensor tendons, and the capsule[5].

The mechanisms of terrible triad injuries can be separated into low-energy falls from standing height and high-energy accidents. Most of the low-energy mechanisms are in those patients with poor bone quality[3]. The mechanism failure according to the "Hori" circle, where the sequential failure of soft-tissue constraints starts from the lateral side and moves anteriorly and posteriorly to the medial side[5].

Although the coronoid fracture was once described as an avulsion fracture, it is now understood to most often be the result of shear forces caused by posterior translation against the humeral trochlea[6]. Once the coronoid is fractured and the anterior bundle disrupted, valgus compression and radiocapitellar abutment occurs. This results in compression fractures to the radial head as the forearm dislocates posteriorly[5]. The ultimate result is gross instability due to disruption of three of the primary and secondary static stabilizers of the elbow—the ulnohumeral articulation, the anterior bundle, the lateral ulnar collateral ligament, and the coronoid as anterior bony constraint of the distal humerus[3].

The goal of treatment for terrible triad injuries is restoring the bony anatomy and reconstructing the ligamentous restraints of the elbow to provide enough stability for early

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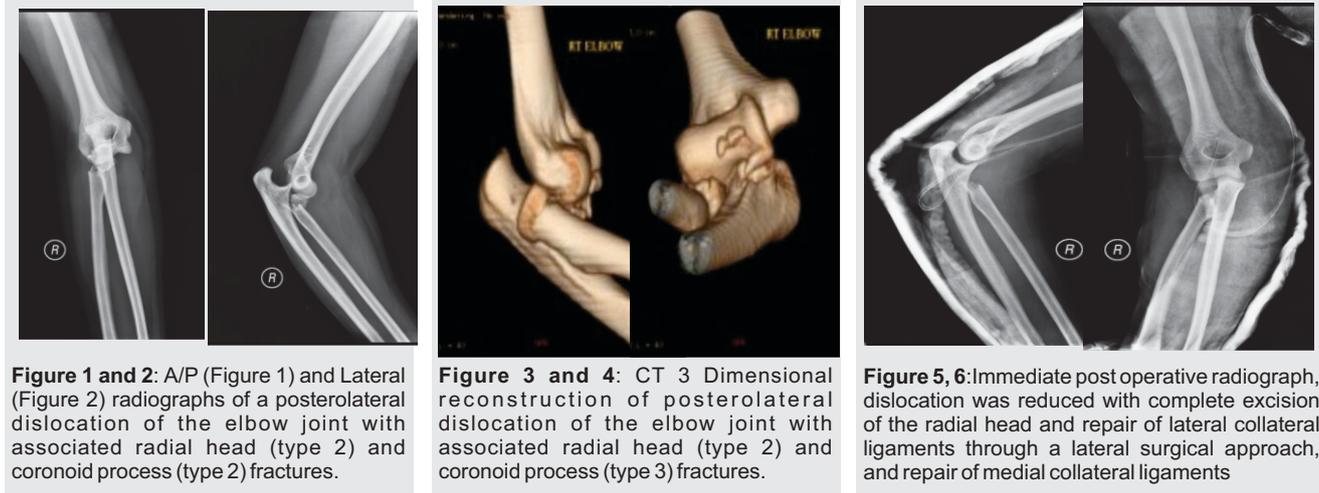


Figure 1 and 2: A/P (Figure 1) and Lateral (Figure 2) radiographs of a posterolateral dislocation of the elbow joint with associated radial head (type 2) and coronoid process (type 2) fractures.

Figure 3 and 4: CT 3 Dimensional reconstruction of posterolateral dislocation of the elbow joint with associated radial head (type 2) and coronoid process (type 3) fractures.

Figure 5, 6: Immediate post operative radiograph, dislocation was reduced with complete excision of the radial head and repair of lateral collateral ligaments through a lateral surgical approach, and repair of medial collateral ligaments

elbow range of motion and prevent elbow stiffness [3]. Early management is a favourable prognostic factor for final outcome [7]. Understanding the pathomechanics of elbow dislocation may improve diagnosis and treatment of these injuries [8].

Materials and Methods

Fifteen patients sustaining elbow dislocation with associated radial head and coronoid process fractures treated over a period of 5 years between 2010-2014 were enrolled in the study and their clinical results were assessed. The series included nine males and six females of mean age of 35 years (range, 15-58 years) at the time of trauma.

Ten patients had sustained the initial trauma during a road traffic accident and five had a fall from height. All dislocations were closed injuries with no neurovascular deficits. The initial assessment included anteroposterior (A/P) and lateral radiographs of the elbow to rule out bony pathology (Figures 1 and 2). CT scan was performed invariably in all the cases to rule out any occult coronoid process fragment (Figures 3 and 4).

In all cases, it was a posterolateral dislocation of the elbow joint associated with fractures of the radial head and coronoid process of ulna.

Fractures of radial head were graded according to the Mason classification modified by Johnson (9): type I: non-displaced fractures; type II: non-comminuted displaced fractures; type III: comminuted fractures. Our series included four type I fractures, two type II fractures, nine type III fractures.

Fractures of the coronoid process were graded according to the Regan and Morrey classification (10): Type I: avulsion of the tip of the process; Type II: a fragment involving 50 per cent of the process, or less; and Type III: a fragment involving more than 50 per cent of the process. Accordingly our series had five type I, eight type II and two type III.

Dislocation were reduced by closed method in 12 patients and three were reduced by open technique under general anaesthesia and image intensifier. Stability was assessed in each case followed by early surgical reconstruction.

In 14 cases lateral surgical approach was carried out through the Kocher interval, between extensor carpi ulnaris and anconeus muscle. The lateral approach was associated with a medial approach in 13 cases, thus providing better access to the coronoid process and the medial collateral ligament. Posterior approach was performed in one case. In two cases, an anterior transbrachial surgical approach was performed for osteosynthesis of the coronoid process.

Exploration of the surgical site revealed persistent damage to the lateral collateral ligament in all cases. Eight out of 13 cases with medial surgical approach had an injury to medial collateral ligament of the elbow.

In cases of non-reconstructible type III only radial head excision was performed and no prosthesis was used (Figures 5 and 6). Complete radial head was resected in nine type III fracture resulted in mild to moderate instability. No surgical intervention was performed thereafter. Osteosynthesis with 2.4mm synthes Herbert screw was performed in two cases of type II fractures (Figs. 7 and 8). Fixation was not performed in type I fractures.

Five type I coronoid fractures were neglected. Eight type II coronoid fractures were treated with suturing of the capsule with no.1 absorbable vicryl sutures. Osteosynthesis with screw was performed in two cases via anterior transbrachial approach. All lateral and medial collateral ligaments were repaired with no.1 absorbable vicryl sutures.

Post Operative Management

The elbow was maintained in orthofix at 90 degrees of flexion allowing a flexion-extension and pronation-supination rehabilitation protocol with maximum extension upto 30 degrees during a 6 week period

Operative Technique



Figure 7 and 8: Radiographic results at one post operative year, after dislocation reduction of the elbow joint. Osteosynthesis of radial head with 2.4mm synthes Herbert screw and repair of lateral collateral ligaments through a lateral surgical approach, and medial collateral ligaments were repaired and coronoid fracture was treated with suturing of the capsule with no. 1 absorbable vicryl via a medial surgical approach.



Figure 9 and 10: Lateral (Figure 9) and A/P (Figure 10) radiographs of elbow orthofix after radial head excision, and coronoid process repair and repair of lateral and medial ligament complex.

(Figures 9 and 10). Continuous passive motion was started on post operative day two as per patients tolerance. Early active mobilization was initiated after two weeks and consisted of flexion-extension exercises, to recruit the dynamic stabilizers of 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. Upto 6 weeks extension was limited to 30-60 degrees according to the elbow stability and to prevent the risk of dislocation. In case of radial head excision immobilization for 3 weeks followed by passive and active mobilization as per patients tolerance. Elbow orthofix was removed at 6 weeks. Once complete healing was achieved, active maximum range of motion exercises were initiated. At 3 months muscular rehabilitation programme is initiated to strengthen the periarticular stabilizing muscles.

Method of Evaluation

Fifteen patients (15 elbows) were reviewed at a mean follow up of 33 months (range, 18 to 60 months) and were clinically and radiologically evaluated. No 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[11].

Radiographic assessment of the elbow, based on A/P and lateral views was performed at last follow up.

Results

The mean Mayo Elbow Performance Score, evaluated in 15 patients (15 elbows) was 86

(range, 75 to 100). The outcomes were classified as excellent in five elbows and good in 10.

Clinical Outcomes

Ten patients had no pain while five reported to have mild pain on lifting heavy weights. None of the patients suffered from severe pain. Mean flexion at last follow up was 120, ranging from 90 degrees to 140 degrees. Mean extension loss was 14, ranging from 0 degree to 80 degrees. Mean pronation was 70 degrees (range, 30 to 80 degrees) while mean supination was 60 degrees (range, 30 to 80 degrees). Elbows were stable in flexion-extension and varus-valgus

in all the cases (Figures 11,12,13 and 14).

Radiographic Findings

A/P and lateral radiographs were systematically performed in all reviewed patients. All elbows were well centered on radiographs. Only one patient had osteoarthritis of humeroulnar joint. Patient complained of anterior and medial pain. Radiographs confirmed narrowing of the humeroulnar joint space.

Complications

A single early complication was reported in a 22 year old male patient demonstrating a persistent instability in the saggital and frontal plane, after suturing type III coronoid fracture with ethibond and no surgical intervention for type I radial head fracture and repair for lateral collateral ligament. An isolated lateral approach was performed. At one month, this persistent instability required surgical revision performed through a medial approach and revealing cut through of ethibond sutures used for coronoid process fracture, which required screw fixation and disinserted medial collateral ligament, which was then repaired. An orthofix was applied again at the end of the operation to

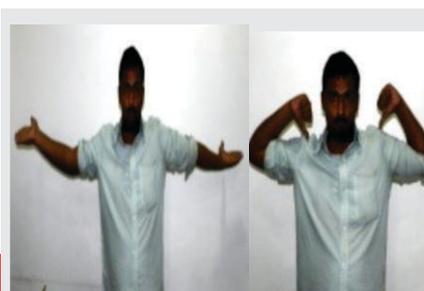


Figure 11 and 12: Range of motion in extension and flexion at one year follow up.

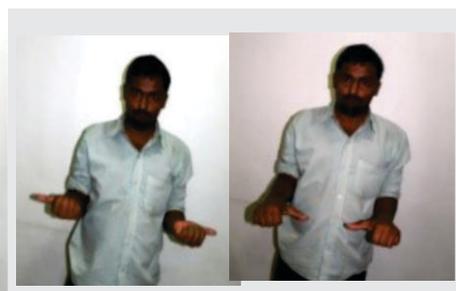


Figure 13 and 14: Range of motion in supination and pronation at one year follow up.

secure the whole reconstruction.

A late complication was reported in a 50 year old female patient with type III radial head fracture and type I coronoid process fracture operated through posterior approach and excision of radial head was performed. The patient developed posterior interosseous nerve palsy for which flexor carpi radialis tendon transfer was performed at 12 months after electrodiagnostic testing showed no signs of progression of regeneration.

Discussion

Terrible triad injuries of the elbow have been individualized by Hotchkiss in 1996 as a clinical entity [7]. This condition accounted for 4% of adult radial head fractures and 31% of elbow dislocations in a study by van Riet and Morrey [12]. Several retrospective series have been reported, with each reflecting differing injury patterns, operative strategies, and outcomes [13]. Complete dislocations of the elbow joint should be systematically considered as terrible triad injury unless proven otherwise. Associated lesions represent a significant diagnostic and therapeutic issue. CT scan assessment should be performed to investigate the associated bone lesions and plan the most adapted therapeutic management [14,15]

The anatomic features of the elbow that contribute to stability have been examined in various studies and can be divided into two main categories: primary and secondary. The primary stabilizers of the elbow are considered to be the ulnohumeral articulation, the medial collateral ligament, the lateral collateral ligament. The secondary stabilizers include the radial head, joint capsule, and the common flexor and extensor origins [1].

The optimal nonsurgical management of terrible triad injuries has not been established. Most of these injuries are managed surgically [1]. The principle of surgical management is based on two main objectives: Restoration of bony stabilizing structures (radial head and coronoid process) and lateral collateral ligament repair [16].

The surgical protocol for terrible triad of the 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, instability, contracture, re-operation, and progression to arthrosis remain significant problems [15].

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 [7]. In 2005 Morrey et al 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 [17].

Radial head prosthesis replacement suggests that it is a technically difficult procedure for the treatment of terrible triad of the 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 undersizing of the removed head fragments is common, 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 [18, 19]. Also, biomechanical study has shown that no type of radial head prosthesis can restore elbow valgus stability to the same degree as was provided by the native radial head [20]. Furthermore, Leigh and Ball [21] reported that comparable results can be obtained with repair or replacement of the radial head.

In our series, nine radial heads were resected, all were complete resections, with eight had no effect on the stability and one resulting in intraoperative instability requiring additional stabilization with humeroulnar pinning.

The most important step in achieving stability is repair of lateral collateral ligament which is the primary stabilizer. Reinsertion of the lateral ligament complex in the management of elbow joint instabilities was first described by Osborne and Cotterill [22]. Successful isometric repair is placing the sutures at the centre of rotation of the elbow, which is located at the center of the capitellar curvature on the lateral epicondyle, to prevent the occurrence of any varus or posterolateral instability. [1,7]

The coronoid is clearly the most important articular stabilizer and key element in the humeroulnar joint stability. 50% of the height of the coronoid process is necessary to ensure humeroulnar sagittal stability [17]. In terrible triad injuries of the elbow, most coronoid fractures are type I fractures as confirmed by the series of Doornberg et al [23]. The anterior capsular attachment to the coronoid fragment or fragments should not be released because protecting the attachment enhances stability [1]. Type II and III fractures require stable osteosynthesis. Osteosynthesis might be performed through a lateral approach after radial head excision, or via a medial or anterior approach. In our series, 5 type I fractures were ignored,

eight type II fractures were sutured to the capsule and two type III were fixed with screws through medial approach. Systematic approach of medial collateral ligament remains controversial. After repair of the coronoid process, radial head and lateral collateral ligament, the elbow should be fluoroscopically examined for stability, while it is flexed and extended with the forearm in supination, neutral position and pronation. In 2004 Pugh et al reviewed 36 terrible triad injuries out of which isolated lateral approach was used in 26 cases. Their surgical protocol included fixation or replacement of the radial head, fixation of the coronoid fracture if possible, repair of associated capsular and lateral ligamentous injuries. After reconstruction of the lateral ligament complex, stability of elbow was evaluated in flexion-extension. In the absence of 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 that a medial approach should be performed only in case of persistent sagittal instability after reconstruction of bony structure and lateral collateral ligament. They recommend that isolated valgus instability in the coronal plane does not systematically require medial collateral ligament repair so far as the elbow remains stable in flexion-extension[15]. Mathew et al advocated that if the elbow remains congruous from approximately 30 degrees to full flexion in one or more positions of forearm rotation, repair of medial collateral ligament is not necessary[1]. In our series thirteen out of fifteen elbows treated through a medial approach reported damage to the medial collateral ligament.

If instability persists despite repair of radial head and repair of the coronoid process, medial collateral ligament, or lateral collateral ligament, a static or hinged external fixator should be applied to maintain a concentric reduction of the elbow[24]. Zeiders et al[25] have recommended the use of the external fixator in case of insufficient stability to allow complete mobilization after reconstruction of bony and ligamentous structures. These standard hinged external fixators are centered on the elbow centre of rotation. The external fixator allows early mobilizations within a protected range of motion to reduce the risk of secondary stiffness[26, 27]. In our series we have invariably used hinged external fixators and reported that it prevents recurrent instability and protects reconstructed ligaments and soft tissue.

Yang et al in 2013 reviewed 11 patients with terrible triad of the elbow treated with hinged external fixator combined with mini-plate followed upto 12-20 months (mean, 15 months). According to Mayo elbow function evaluation standard, the results were excellent in 5 cases,

good in 4 cases, and fair in 2 cases, with an excellent and good rate of 81.8%[28].

In 2010 Chemama et al published the results of 14 patients who were examined an average of 63 months after injury. Several medial-sided ligament repairs were performed and motion results were similar to those of the current study, with an average flexion-extension arc of 18° to 127°. Mayo elbow performance score was 87 classified as excellent in 4 cases and good in 10[7].

There are limitations of this study that should be considered. First, the number of patients was relatively small. The operations were all performed by or under the direct supervision of one surgeon and at a single institution, thus the results may not be reproducible by other surgeons or at other institutions. On the other hand, the results showed that the technique provides good results with minimal morbidity.

Conclusion

“Terrible triad” elbow fracture dislocation remains an unusual and challenging injury to treat. Complete dislocations of the elbow joint should be systematically considered as 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 should be performed in all the cases to identify fracture patterns, comminution, and displacement, which may not be evident on plain radiographs. Principle of surgical management is based on restoring the bony anatomy (radial head and coronoid process) and reconstructing the ligamentous restraints(lateral collateral ligament) of the elbow to provide enough stability. A medial surgical approach is recommended in all the cases of persistent posterolateral instability following lateral collateral ligament reconstruction. Despite its small size, the coronoid process is an important capital bony stabiliser of the humeroulnar articulation and should be dealt with in all the cases of terrible triad injury. Although low risk of flap necrosis, posterior approach should be avoided because of the risk of hematoma formation, heterotopic ossification. Radial head excision is advocated in severe comminution as the main stability of elbow is achieved by secure repair of coronoid process and collateral ligaments. Careful fluoroscopic examination of the elbow to assess any residual instability and to determine the best position for immobilization as well as the safe arc of motion for rehabilitation. Use of hinged external fixator is crucial since it maintains reduction of the elbow and offers early mobilization. Optimal rehabilitation protocol is useful in allowing early motion while maintaining stability, particularly in the setting of tenuous fracture fixation or ligament repairs.

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