Can We Treat Select Terrible Triad Injuries Nonoperatively?

Kevin Chan MD, MSc, Joy C. MacDermid BScPT, MSc, PhD,
Kenneth J. Faber MD, MHPE, FRCSC,
Graham J. W. King MD, MSc, FRCSC,
George S. Athwal MD

Published online: 19 February 2014
© The Association of Bone and Joint Surgeons® 2014

Abstract

Background While the majority of terrible triad elbow injuries (ulnohumeral dislocation with radial head and coronoid fractures) are managed surgically, nonoperative treatment may be appropriate in selected patients, but results with this approach have been limited by very small studies.

Questions/purposes We assessed (1) functional outcomes using two validated questionnaires, (2) elbow ROM, strength, and stability, (3) the presence of union and arthritis on radiographs, and (4) complications among a

group of patients managed nonoperatively for terrible triad injuries.

Methods Between 2006 and 2012, we retrospectively identified 12 patients with terrible triad elbow injuries who were treated nonoperatively and met the following criteria: (1) a concentric joint reduction, (2) a radial head fracture that did not cause a mechanical block to rotation, (3) a smaller coronoid fracture (Regan-Morrey Type 1 or 2), and (4) a stable arc of motion to a minimum of 30° of extension to allow active motion within the first 10 days. Eleven patients were available for followup of at least 12 months after the injury (mean, 36 months; range, 12–90 months). Outcome measures included two patient-reported functional outcome measures (DASH, Mayo Elbow Performance Index [MEPI]), a standardized physical examination to record elbow ROM and stability, isometric strength measurements, and radiographic evidence of bony union and elbow arthrosis. Complications were also recorded.

Results At latest followup, mean $\pm$ SD DASH score was 8.0 ± 11.0 and mean MEPI score was 94 ± 9 . Mean ROM of the affected elbow was $134^\circ \pm 5^\circ$ flexion, $6^\circ \pm 8^\circ$ extension, $87^\circ \pm 4^\circ$ pronation, and $82^\circ \pm 10^\circ$ supination. No instability was detected. Strength assessments demonstrated the following mean percentages of the contralateral, unaffected elbow: flexion 100%, extension 89%, pronation 79%, and supination 89%. Four patients had arthritic changes on radiographs that did not call for treatment as of latest followup. Complications included one patient who underwent surgical stabilization for early recurrent instability and another who underwent arthroscopic débridement for heterotopic bone.

Conclusions In selected patients, nonoperative treatment of terrible triad injuries is an option that can provide good function and restore stable elbow ROM. However, nonoperative management requires close clinical and radiographic

Each author certifies that he or she, or a member of his or her immediate family, has no funding or commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research*® editors and board members are on file with the publication and can be viewed on request.

Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

This work was performed at University of Western Ontario, London, Ontario, Canada.

K. Chan
Division of Orthopaedic Surgery, McMaster University,
Hamilton, ON, Canada

J. C. MacDermid
Faculty of Health Sciences, Institute for Applied Health
Sciences, McMaster University, Hamilton, ON, Canada

J. C. MacDermid, K. J. Faber, G. J. W. King, G. S. Athwal (✉)
Hand and Upper Limb Centre, University of Western Ontario,
268 Grosvenor Street, London, ON N6A 4L6, Canada
e-mail: gathwal@uwo.ca

followup to monitor for any delayed elbow subluxation or fracture displacement.

Level of Evidence Level IV, therapeutic study. See Instructions for Authors for a complete description of levels of evidence.

Introduction

A terrible triad injury of the elbow consists of an ulnohumeral dislocation with associated fractures of the radial head and coronoid process. Ring et al. [16] previously demonstrated that these injury patterns have a propensity for persistent pain, poor function, and frequent complications, including recurrent instability and stiffness. Some studies have suggested that surgery can restore sufficient elbow stability to permit early ROM [3, 13]. Consequently, many of these elbow fracture-dislocations are currently managed surgically [10].

However, recent literature suggests that selected patients with terrible triad injuries may be treated nonoperatively. Mathew et al. [10] outlined four essential criteria for the nonoperative management of these injuries, including a concentric elbow reduction, a stable arc of active motion to a minimum of 30° extension, a small minimally displaced radial head fracture that does not cause mechanical block to motion, and a smaller coronoid tip fracture. Guitton and Ring [6] subsequently reviewed four patients, all meeting similar criteria, and reported reasonable outcomes after nonsurgical treatment. While that report helped to clarify the indications for nonoperative management, it was limited by short followup and a small sample size.

We therefore evaluated (1) the functional outcomes using two validated questionnaires, (2) ROM, strength, and stability, (3) radiographic evidence of union and arthritis, and (4) complications among a group of patients managed nonoperatively for terrible triad injuries of the elbow.

Patients and Methods

Study Design

The study protocol was approved by our institution's research ethics board. Between 2006 and 2012, 12 patients with radiographically documented terrible triad injuries underwent nonoperative management because they met the indications defined by Mathew et al. [10]. These indications were developed at our institution and first published in a review article by Mathew et al. [10]. They were also carefully applied in clinical practice to prospectively identify patients who were suitable for nonoperative treatment by three participating surgeons (KJF, GJWK, GSA). Each patient was then approached for study inclusion by an independent

physician who was not directly involved with their care (KC). One patient could not be reached for inclusion, leaving 11 patients as the study cohort.

Inclusion Criteria

Based on the indications outlined by Mathew et al. [10], the following criteria had to be met to be eligible for nonoperative treatment: (1) a concentric joint reduction on postreduction radiographs (well-aligned radiocapitellar and ulnohumeral articulations on both AP and lateral radiographs, symmetric joint space, ulnohumeral distance < 4 mm on lateral radiographs), (2) a radial head fracture that did not cause a mechanical block to rotation, (3) a smaller coronoid fracture (Regan-Morrey Type 1 or 2), and (4) a stable arc of active motion to a minimum of 30° of extension to allow early ROM within the first 10 days. Additionally, each patient underwent evaluation using CT scans and was required to have a minimum of 12 months of followup to be eligible for study inclusion.

Patient Demographics

Each patient's medical records were retrospectively reviewed for demographic information and clinical course. Radial head fractures were classified according to the Mason system [9] and coronoid fractures according to the Regan-Morrey system [15]. CT images were used to measure maximal fracture displacement. Additionally, we measured the coronoid fracture height based on a method described by Doornberg et al. [5] using sagittally reconstructed CT images, which has been shown to have excellent intra- and interobserver reliability.

Of the 11 patients included, there were six women and five men, with a mean age of 51 years (range, 26–76 years) (Table 1). Three patients had Mason Type 1 radial head fractures and eight patients had Mason Type 2 radial head fractures. All Type 1 radial head fractures involved less than approximately 10% of the articular surface, whereas the Type 2 fractures involved a mean of approximately 24%. The mean displacement of the Type 2 radial head fractures was 4 mm (range, 2–8 mm). All coronoid fractures were classified as Regan-Morrey Type 2. The mean height of the coronoid fragment was 28% of normal (range, 15%–39%), with a mean displacement of 3 mm (range, 0–10 mm). Mean followup was 36 months (range, 12–90 months).

Description of Treatment

In the acute setting, all patients underwent closed reduction under conscious sedation for their elbow fracture-dislocation

Table 1. Summary of patient characteristics

Patient	Age (years)	Sex	Mechanism of injury	Dominant elbow?	Mason classification	Regan-Morrey classification	Followup (months)
1	49	Female	Cycling	No	1	2	42
2	60	Male	Fall (standing height)	Yes	2	2	90
3	63	Female	Fall (standing height)	No	2	2	68
4	51	Male	Fall during soccer	No	2	2	35
5	43	Male	Fall (greater height)	No	2	2	43
6	58	Female	Fall (greater height)	No	2	2	20
7	76	Female	Fall (standing height)	Yes	2	2	49
8	64	Male	Fall (standing height)	No	2	2	12
9	26	Female	Fall (standing height)	No	2	2	12
10	29	Female	Fall (standing height)	No	1	2	12
11	41	Male	Motor vehicle accident	Yes	1	2	12

and were subsequently immobilized in a posterior elbow splint with the forearm in neutral rotation. Patients were assessed by one of three fellowship-trained elbow surgeons (KJF, GJWK, GSA) within 1 week of injury. They underwent a physical examination and a CT scan to characterize the radial head and coronoid fractures. If patients met the prespecified indications for nonoperative treatment, an early referral to therapy was made to begin supervised ROM exercises within a stable arc in the first 10 days after injury (Fig. 1). Patients were seen weekly thereafter for clinical and radiographic examinations to monitor for complications, including recurrent subluxation or dislocation. This occurred for at least 4 weeks or more, depending on individual patient factors and surgeon preference.

Early active and active-assisted elbow flexion/extension exercises with the forearm in neutral rotation and forearm rotation exercises with the elbow at 90° of flexion were initiated. Supine positioning with overhead exercises may facilitate early effective ROM [12]. The optimal amount of therapy is unknown, but we typically recommended 10 to 15 repetitions every 2 to 3 hours as tolerated [12]. Posterior elbow resting splints with the elbow maintained at 80° to 90° of flexion and neutral forearm rotation were employed for up to 6 weeks. Active ROM was progressively increased weekly until maximum mobility was restored. Passive stretching and strengthening exercises were added as fracture and soft tissue healing progressed, usually by around 6 to 8 weeks after injury. Static progressive extension splints were employed as required to manage flexion contractures after 6 weeks.

Description of Outcome Measures

After consenting to participate in the study, each patient was evaluated by the same independent research physician

(KC). The outcome measures included two patient-reported functional outcome measures (DASH and Mayo Elbow Performance Index [MEPI]) [8], a standardized physical examination to record elbow ROM and stability, isometric strength measurements, and radiographic evidence of bony union and elbow arthrosis. All outcome questionnaires were self-reported, but research personnel were available for clarifications, if necessary.

Elbow ROM was recorded using a standard long-arm goniometer for flexion, extension, pronation, and supination. Measurements were performed using techniques reported by Armstrong et al. [1]. Forearm rotation was based off of the hand. Elbow stability was tested with varus and valgus stress at 20° of flexion. Posterolateral rotatory instability was evaluated using the chair rise sign [14] and the posterolateral pivot shift test [11]. Stability was graded according to the MEPI as 1 (stable), 2 (moderate instability), or 3 (gross instability).

Isometric strength measurements were performed using the Biodex System 4 Pro (Biodex Medical Systems, Shirley, NY, USA) with the patient sitting, the shoulder in neutral flexion/abduction, and the elbow at 90° of flexion and neutral rotation. Patients were instructed on how to conduct the exercises. Three maximal contractions were performed and the mean torque was recorded. These measurements were repeated for flexion, extension, pronation, and supination, and they were compared to the contralateral unaffected elbows.

Standard AP and lateral radiographs of the affected elbow were performed at the followup study visits. Each radiograph was examined for evidence of bony union and elbow arthrosis, which was graded according to the system of Broberg and Morrey [2, 7]. This consisted of Grade 0 (normal joint), Grade 1 (mild joint space narrowing with minimal osteophytes), Grade 2 (moderate joint narrowing and osteophytes), and Grade 3 (severe).

Fig. 1 The therapeutic algorithm for the nonoperative management of acute terrible triad elbow injuries is shown.

We also reviewed patient medical records for the presence of complications, including instability, stiffness, ulnar neuritis, and need for surgical intervention.

Statistical Analyses

Descriptive statistics were used to report summary data. Means and SDs were calculated for continuous data, where applicable.

Results

Patient-reported Outcomes Scores

At final followup, the mean DASH score was 8.0 ± 11.0 and mean MEPI was 94 ± 9 , corresponding to an excellent functional outcome (Table 2).

ROM and Strength

The mean ROM of the affected elbow was $134^\circ \pm 5^\circ$ of flexion, $6^\circ \pm 8^\circ$ of extension, $87^\circ \pm 4^\circ$ of pronation, and $82^\circ \pm 10^\circ$ of supination. This corresponded with mean percentages of the contralateral side of 98%, 97%, 100%, and 99%, respectively. Eight patients were available for strength assessments, demonstrating the following mean percentages of the contralateral, unaffected elbow: flexion 100%, extension 89%, pronation 79%, and supination 89%. There were no elbows with evidence of clinical instability to varus or valgus stress. The chair rise test and posterolateral pivot shift test were negative in all patients.

Osseous Union and Arthritis

Three patients developed a fibrous nonunion of their coronoid fracture with no clinical sequelae (Fig. 2). Four patients had ulnohumeral arthritic changes on imaging that

Table 2. Summary of patient outcomes

Patient	ROM (°)*				Biodex strength measurements (Nm)*				Functional outcome measures (points)	
	Flexion	Extension	Pronation	Supination	Flexion	Extension	Pronation	Supination	DASH	MEPI
1 [†]	140/140	0/5	80/80	80/80	34/30	24/32	4/6	7/5	0	100
2	125/142	11/2	90/90	90/90	39/32	42/37	7/5	3/3	0	100
3	134/132	22/0	81/81	80/87	NR	NR	NR	NR	23	80
4	130/138	4/5	88/90	89/75	33/26	35/29	10/5	5/6	0	100
5	140/145	5/–5	80/80	80/80	53/41	72/56	12/13	6/5	1	100
6	136/136	2/0	90/90	90/90	1/22	17/23	2/3	3/8	17	85
7 [†]	130/130	20/10	90/90	85/90	NR	NR	NR	NR	23	85
8	130/125	0/25	90/90	70/66	46/39	38/44	9/17	7/6	0	100
9	138/140	6/1	90/90	60/75	NR	NR	NR	NR	9	100
10	130/130	–3/–5	90/90	90/90	33/38	30/28	7/7	7/6	13	85
11	140/140	0/0	90/90	90/90	57/56	57/53	12/13	9/10	0	100

* The first value represents the affected elbow and the second represents the contralateral elbow; [†]required surgical intervention; MEPI = Mayo Elbow Performance Index; NR = not recorded.

Fig. 2A–D A 51-year-old man fell during soccer and sustained a terrible triad injury of his nondominant elbow. (**A**, **B**) Postreduction radiographs and (**C**) a three-dimensional CT image demonstrate displaced fractures of the radial head and coronoid. (**D**) At 35 months' followup, his lateral radiograph demonstrated a concentric joint reduction with an asymptomatic fibrous nonunion of the coronoid.

Fig. 3A–F A 76-year-old woman sustained an injury to her dominant elbow after a fall from standing height. She was treated nonoperatively after (A, B) initial postreduction films were satisfactory. She was followed clinically and radiographically at weekly intervals. (C,

D) Unfortunately, at the 3-week followup appointment, her elbow had subluxated in the splint. (E, F) She subsequently underwent a radial head arthroplasty, suture repair of the coronoid fracture, and repair of the lateral collateral ligament.

called for no treatment; they were all classified as Grade 1 according to the Broberg-Morrey system. At the most recent radiographic followup, all elbow radiographs demonstrated concentric reductions.

Complications

One patient underwent surgical stabilization after the elbow subluxated in a splint when seen at 3 weeks postinjury (Fig. 3). This required suture fixation of the coronoid fracture, radial head arthroplasty, and repair of the lateral collateral ligament. After 49 months' followup, the patient had no pain or instability. Final elbow ROM was 20° extension to 130° flexion, 85° supination, and 90° pronation. Another patient underwent an arthroscopic débridement for impingement from heterotopic bone that developed posterior to the capitulum.

Discussion

A terrible triad injury represents a complex fracture-dislocation of the elbow that destabilizes the joint. Operative intervention can successfully restore sufficient stability to permit early elbow ROM. However, the literature contains very limited information regarding the specific indications for nonsurgical treatment of this injury pattern. We therefore reviewed the clinical results of a selected cohort of patients with terrible triad injuries managed nonoperatively at our center after meeting specific criteria [10].

The limitations of this study include the lack of long-term followup. While our series represents the largest cohort of nonoperatively treated terrible triad injuries with the longest mean followup of which we are aware, it is likely still insufficient to adequately comment on the risks of posttraumatic arthritis and the need for future surgeries. However, surgical repair of acute terrible triad injuries may

continue to be at risk for posttraumatic arthritis. Rodriguez-Martin et al. [17] reviewed the literature and found that arthritis remained a common complication after surgery, with 55 cases of an available 105 patients. Additional studies are warranted to clarify the association between terrible triad injuries and posttraumatic arthritis.

We also acknowledge that there may be substantial variation among different orthopaedic surgeons and institutions in terms of their approaches to the nonsurgical management of patients with these injuries, and the results we achieved with our protocol may not generalize to all approaches to the nonoperative management of the terrible triad injury. However, a standardized treatment protocol currently does not exist in the literature and the evidence on the rehabilitation after such injuries is limited [12]. Finally, it is worth emphasizing that our patients were carefully selected and likely represented a very small percentage of the overall number of patients treated for terrible triad injuries [10].

Overall, at a mean followup of 3 years, these patients regained good elbow function. Only one patient required surgical intervention due to early recurrent instability. Our results suggest that selected patients with terrible triad injuries can be successfully treated without surgery, but the orthopaedic surgeon must maintain close vigilance to monitor for complications, such as recurrent subluxation. Our results are comparable to the four patients in the series by Guitton and Ring [6], which included four Mason Type 2 radial head fractures and four O'Driscoll tip coronoid fractures, involving approximately 15% to 30% of the coronoid height. These patients had good results at latest followup, with only one individual undergoing surgery to address heterotopic ossification, elbow contracture, and ulnar neuropathy [6].

Our inclusion criteria included patients with a closed, neurovascularly intact acute terrible triad elbow injury that was concentrically reduced on plain radiographs. The associated radial head fractures did not cause a mechanical block to elbow motion and the coronoid fractures were smaller (Regan-Morrey Type 2) [10]. Additionally, there was a stable arc of motion to a minimum of 30° of extension to allow early active ROM within the first 10 days [10]. We believe that these criteria may define an osteoligamentous injury pattern that is sufficiently stable without surgical intervention, possibly reflecting adequate remaining soft tissue and bony support. Biomechanical studies have shown that smaller fractures are generally more stable injury patterns. Closkey et al. [4] demonstrated increasing elbow instability in response to axial loading with larger coronoid fracture fragments, particularly Regan-Morrey Type 3. Schneeberger et al. [18] also showed that an absent radial head and removal of 30% of the coronoid caused ulnohumeral dislocation, despite intact

collateral ligaments. However, additional prospective clinical studies are needed to validate these findings in vivo. The coronoid fracture height in terrible triad injuries can be variable and the overall stability of the elbow is likely related to the injury pattern and fracture morphology [5].

In conclusion, our results indicate that good elbow function can be obtained using nonoperative management in selected patients with terrible triad injuries of the elbow. We recommend routine cross-sectional imaging with CT scans for these injuries in the acute period to assess for elbow congruency and to obtain detailed fracture characterization. Furthermore, these patients require close interval followup during the early postinjury period to monitor for complications, including recurrent subluxation.

Acknowledgments The authors thank Ms. Kate Kelly MSc, MPH for her training in the use of equipment required for measurement of outcomes in this study.

References

1. Armstrong AD, MacDermid JC, Chinchalkar S, Stevens RS, King GJ. Reliability of range-of-motion measurement in the elbow and forearm. *J Shoulder Elbow Surg.* 1998;7:573–580.
2. Broberg MA, Morrey BF. Results of treatment of fracture-dislocations of the elbow. *Clin Orthop Relat Res.* 1987;216:109–119.
3. Chemama B, Bonneville N, Peter O, Mansat P, Bonneville P. Terrible triad injury of the elbow: how to improve outcomes? *Orthop Traumatol Surg Res.* 2010;96:147–154.
4. Closkey RF, Goode JR, Kirschenbaum D, Cody RP. The role of the coronoid process in elbow stability: a biomechanical analysis of axial loading. *J Bone Joint Surg Am.* 2000;82:1749–1753.
5. Doornberg JN, van Duijn J, Ring D. Coronoid fracture height in terrible-triad injuries. *J Hand Surg Am.* 2006;31:794–797.
6. Guitton TG, Ring D. Nonsurgically treated terrible triad injuries of the elbow: report of four cases. *J Hand Surg Am.* 2010;35:464–467.
7. Lindenhovius A, Karanicolas PJ, Bhandari M, Ring D. Radiographic arthrosis after elbow trauma: interobserver reliability. *J Hand Surg Am.* 2012;37:755–759.
8. Longo UG, Franceschi F, Loppini M, Maffulli N, Denaro V. Rating systems for evaluation of the elbow. *Br Med Bull.* 2008;87:131–161.
9. Mason ML. Some observations on fractures of the head of the radius with a review of one hundred cases. *Br J Surg.* 1954;42:123–132.
10. Mathew PK, Athwal GS, King GJ. Terrible triad injury of the elbow: current concepts. *J Am Acad Orthop Surg.* 2009;17:137–151.
11. O'Driscoll SW, Bell DF, Morrey BF. Posterolateral rotatory instability of the elbow. *J Bone Joint Surg Am.* 1991;73:440–446.
12. Picicelli JG, Chinchalkar SJ, Grewal R, Athwal GS. Rehabilitation considerations in the management of terrible triad injury to the elbow. *Tech Hand Up Extrem Surg.* 2011;15:198–208.
13. Pugh DM, Wild LM, Schemitsch EH, King GJ, McKee MD. Standard surgical protocol to treat elbow dislocations with radial head and coronoid fractures. *J Bone Joint Surg Am.* 2004;86:1122–1130.

14. Regan W, Lapner PC. Prospective evaluation of two diagnostic apprehension signs for posterolateral instability of the elbow. *J Shoulder Elbow Surg.* 2006;15:344–346.
15. Regan W, Morrey B. Fractures of the coronoid process of the ulna. *J Bone Joint Surg Am.* 1989;71:1348–1354.
16. Ring D, Jupiter JB, Zilberfarb J. Posterior dislocation of the elbow with fractures of the radial head and coronoid. *J Bone Joint Surg Am.* 2002;84:547–551.
17. Rodriguez-Martin J, Pretell-Mazzini J, Andres-Esteban EM, Larrainzar-Garijo R. Outcomes after terrible triads of the elbow treated with the current surgical protocols: a review. *Int Orthop.* 2011;35:851–860.
18. Schneeberger AG, Sadowski MM, Jacob HA. Coronoid process and radial head as posterolateral rotatory stabilizers of the elbow. *J Bone Joint Surg Am.* 2004;86:975–982.