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Research Article

Terrible Triad Fracture Dislocation Injury Review of Current Fixation Protocols and Illustration of Single Incision Technique in 8 cases "Case Series."

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Abstract

Background: Terrible triad injuries are devastating clinical entities with different approaches described in the literature for fixation. Stability and an ideal range of motion are paramount for a favorable clinical outcome. The purpose of the study was to review the current protocols and surgical management of this complex injury and to assess the stability and range of motion of eight cases reported.

Methods: Case series of patients involved in a non-salvageable radial head fracture. After surgery, the follow-up period was 27 months. The primary outcome measures were a range of motion and elbow stability intra-operatively and postoperatively. Secondary outcome measures were Mayo elbow performance scores.

Results: Seven patients were included in the study, with a total of eight elbows presented with a terrible triad in our institute between February 2020 and May 2022. All cases reached the desired stability following coronoid repair, radial head replacement, and lateral ulnar collateral ligament repair (LUCL). Range of motion got 10 to 125 degrees on the twelfth week postoperatively. Mayo elbow performance and Disabilities of the Arm, Shoulder, and Hand Questionnaire scores were favorable at the final follow-up, with no chronic instability in all cases.

Conclusion: Single incision using the Kocher approach, coronoid-first fixation using anchor suture is feasible following the removal of a comminuted radial head, followed by radial head replacement and LUCL repair resulting in desirable clinical outcomes. There is no superior current protocol for treating these injuries.

Keywords: Elbow; Trauma; Radial Head; Dislocation; Fixation

Introduction

Terrible triad injury (TTI) is a spectrum that involves elbow dislocation, radial head, and coronoid process fractures. The stability of the elbow has been the main concern for this type of injury, with surgical treatment being the gold standard for restoring stability and range of motion [1,2]. Non-operative management was found to have an unfavorable outcome due to persistent instability, post-traumatic osteoarthritis, and limited range of motion due to prolonged immobilization [3]. Factors affecting the clinical outcome following surgical treatment correlate with biomechanics restoration, fixation stability, and post-operative adherence to rehabilitation [4,5]. Early mobilization and stability are provided by radial head replacement, leading to preferable outcomes [6]. It was reported that 50% of the coronoid process height is required for anteroposterior elbow stability [7]. Regan-Morrey Type 3 coronoid fractures that involved more than 50% of the process mandate fixation due to sublime tubercle involvement where the medial ulnar collateral ligament (MUCL) is inserted [8]. Several studies have found that coronoid fractures involving less than 50% do not have significant instability in the setting of a radial head fracture involvement [9,10]. However, despite the small fragment, some support the need for coronoid repair as they believe it adds to elbow stability [14,15]. In this case series, we assessed the stability, range of motion, and functional outcome in 8 cases treated utilizing a single approach with a coronoid-first repair regardless of the process size involved with the replacement of unsalvageable comminuted radial fractures followed by LUCL repair.

Cases

Case 1

A 36-year-old male, medically free, presented to Our emergency department after suffering a fall from a height (10 meters), complaining of right elbow pain and deformity. This patient was treated according to Advanced Trauma Life Support protocol and required

full resuscitation. Regarding the positive findings, there was a comminuted radial head fracture with coronoid process fracture associated with posterior elbow dislocation (Figure 1), with an intact distal neurovascular. The close reduction was performed in the emergency room under conscious sedation with an above-elbow back slab utilized. After the procedure, the patient had a normal distal neurovascular examination. Computed tomography (CT) was performed, revealing a Comminution of the radius head with displaced bony fragments (Figure 2). This was accomplished by radial head replacement (Figure 3).

Figure 1: Comminuted radial head fracture with coronoid process fracture associated with posterior elbow dislocation.

Figure 2: Computed tomography (CT) was performed, revealing a Comminution of the radius head with displaced bony fragments.

Case 2

A 22-year-old male, medically free, was Referred from a secondary hospital to us with a history of fall from 4 meters height. Resuscitation of the patient was performed according to the Advanced Trauma Life Support protocol. On the orthopedic side, it appears that the individual has a history of Right elbow dislocation with a trial of reduction in the other hospital, right radial head fracture, Right distal radius fracture, right second metacarpal fracture, right

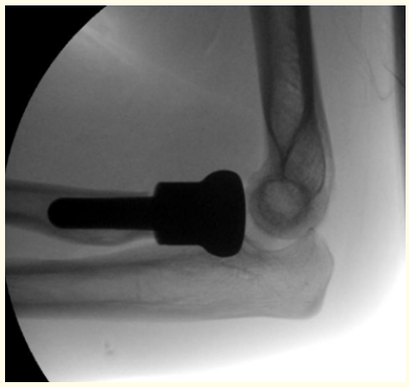

Figure 3: Operative radial head replacement.

ilium fracture, right sacra ala fracture extending to SacroIlic joint, and right superior and inferior pubic rami fracture. There was no evidence that the patient suffered from any neurological deficit. After admission, right elbow Computed tomography (CT) was conducted, showing: Combined comminuted proximal radius head and the coronoid fracture with posterior dislocation (Figure 4). As a first step, the patient underwent urgent surgery to reduce the elbow, and replacement of the radial head was carried out as well as repair of the coronoid process and the Lateral Ulnar Collateral Ligament (LUCL). Afterward, Surgical fixation of the right distal radius, right second metacarpal, and right-sided pelvic fractures were performed.

Figure 4: Right elbow Computed tomography (CT), 4a: comminuted proximal radius head fracture, 4b: Ulnar coronoid process fracture.

Case 3

A 31-year-old male, medically free, presented with a history of Fall from a height of 4 meters. Following the Advanced Trauma Life Support protocol, the patient was resuscitated. As seen from the orthopedic perspective, the patient had an ipsilateral left elbow

posteromedial dislocation, distal radius, and pelvic fractures. In the emergency room, a close reduction of the left elbow was performed, and a back slab was applied. Computed tomography (CT) for the left elbow revealed a Comminuted displaced fracture in the radial head with a displaced fracture of the coronoid process of the ulna. This patient required a surgical procedure to reduce the elbow and replacement of the radial head through a lateral approach (Figure 5,6), along with repair of the coronoid process and the Lateral Ulnar Collateral Ligament (LUCL) (Figure 7) and closure of the wound (Figure 8). After that, Surgical fixation of the left distal radius and the left-sided pelvic fracture were performed. Further follow-up after discharging the patient to determine the outcome, stability, and range of motion (Figure 9-11).

Figure 5: Open surgical reduction of the Left elbow by removing the comminuted radial head through a lateral approach.

Figure 6: Intraoperative radial head replacement.

Figure 7: Repair of Lateral Ulnar Collateral Ligament (LUCL).

Figure 8: Closure of the Surgical wound.

Figure 9: Post-operative follow-up with full elbow flexion.

Figure 10: Post-operative follow-up with full supination and elbow extension.

Figure 11: Post-operative follow-up with full elbow pronation.

Figure 12: Left proximal ulna fracture dislocation associated with radial head fracture and right elbow dislocation with radial head fracture.

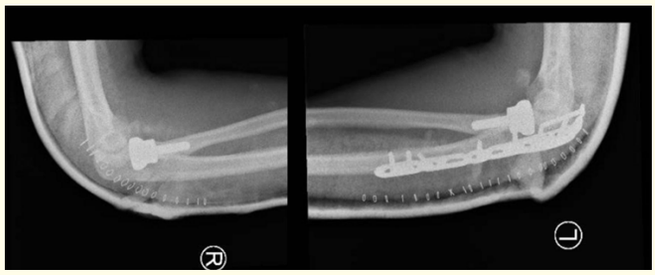

Figure 13: Post-operative fixation of Bilateral radial head and coronoid process fracture.

Case 4

A 25-year-old male, medically free, was admitted to our institute following a history of fall from an unknown height; he complained of bilateral elbow pain, deformities, and swelling. After receiving advanced trauma care according to the Advanced Trauma Life Support protocol, he was found to have a left proximal ulna fracture dislocation associated with radial head fracture and right elbow dislocation with a radial head fracture (Figure 12). Post close reduction in the emergency department, as a routine investigation for this type of fracture, Computed tomography (CT) carried out shows comminuted displaced fractures involving the head of the left and right radius and bony avulsion fragment anterior to the distal aspect of the left humerus, likely fractured coronoid process of the left ulna. There is a fracture of the coronoid process of the right ulna. It was necessary to operate to fix these fractures (Figure 13).

Case 5

A 36-year-old male, medically and surgically free, presented to the hospital due to falling from a ladder, complaining of right elbow pain. After undergoing advanced trauma care and upon focused examination of the right elbow, marked swelling with obvious deformity. However, no open wounds, Tenderness felt over the lateral aspect of the elbow, distal neurovascular was intact, Flexion and extension were limited due to pain, and Pronation and supination were limited due to mechanical block.

X-Rays and Computed tomography (CT) showed Displaced comminuted fractures involving the radial head with coronoid process fracture. Surgical intervention was required to fix these fractures.

Case 6

A 41-year-old female, free of medical or surgical conditions. She was admitted to our hospital after a history of falling from a height. Following the Advanced Trauma Life Support protocol, It was found that the right elbow had been dislocated. Further injuries included were a right acetabulum fracture extending to the right superior pubic rami along with a right iliac crest fracture. The dislocation was reduced during emergency department care, and a

backslap was applied. Post reduction of the right elbow, computed tomography (CT) was made, showing a Comminuted fracture of the proximal radial head with lateral displacement with lateral humerus condyle fracture (Figure 14). Surgical operation was carried out with the fixation of the lateral humeral condyle with Headless screws and replacement of the radial head (Figure 15). Other injuries were managed conservatively.

Figure 14: In right elbow Computed tomography (CT), the green arrow shows the lateral humerus condyle fracture red arrow shows the radial head comminuted fracture.

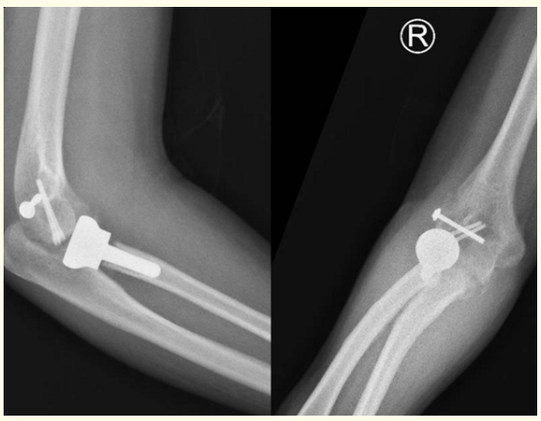

Figure 15: Fixation of lateral humeral condyle with Headless screws and replacement of the radial head.

Case 7

A 33-year-old male, known to have asthma, is found to have fallen on an outstretched left arm and sustained Left elbow fracture-dislocation with a small puncture wound proximal to the olecranon process with active oozing. The close reduction was attempted in the Emergency Department, backslap was applied, and computed tomography (CT) of the left elbow was done. Urgent surgery was carried out with irrigation, debridement, and application of external fixation to the lt elbow. A later procedure was scheduled for him; replacement of the radial head with the repair of the coronoid process and the Lateral Ulnar Collateral Ligament.

Method and Materials

A retrospective study was conducted in a tertiary level-1 trauma Centre following obtaining approval from the institutional review board (IRB) at King Saud Medical City. There were eight elbows out of 7 patients included in the study, one female and six males aged between 22-41 years, and were all operated on by a single surgeon. In order, all patients were informed that the procedure would involve removal of the comminuted radial head, anchor fixation of the coronoid process and capsule, radial head replacement, and then LUCL repair with anchor suture and, if needed, MUCL to be repaired or reconstructed. Included cases were TTIs with coronoid process fractures and unsalvageable radial fractures that mandate a radial head replacement. Cases with radial head fixation or medial side incision to repair/reconstruct MCL +/- External fixator application were excluded from the study. The follow-up duration was 30 months (6-30 Months). Primary outcome measures were stability and range of motion intraoperatively and postoperatively on follow-up visits. Secondary outcome measures were functional outcomes and were assessed using the Mayo elbow performance score (MEPS) [16]. And the DASH score (Disabilities of the Arm, Shoulder, and Hand Questionnaire) [17]. Coronoid Fractures were identified with Regan-Morrey Classification [18]. Radial head fractures were identified with Mason Classification [19]. We examined patients intra-operatively following every step of the procedure and postoperatively on follow-up. All patients were on an above elbow back slab in neutral rotation for two weeks till wound healing and removal of sutures, then supervised active ROM of flexion, extension, and rotation through a stable arc at 90 degrees of elbow flexion was advised. Terminal elbow extension was prohibited in the first six weeks period postoperatively. X-ray films were done after six weeks, three months, six months then every six months.

Surgical technique

All patients underwent the same surgical approach. They were placed supine with the injured arm on a radiolucent table with tourniquets applied. We utilized the Lateral Kocher approach; a skin incision was about 2 cm above the lateral epicondyle and then curved toward the radial neck. The fascia overlying the interval was incised between the Extensor Carpi ulnaris and Anconeus muscles in a fully pronated forearm to protect the Posterior Interosseous Nerve (PIN). The Lateral ulnar collateral ligament (LUCL) was avulsed from the superolateral condyle in all patients. Since the radial head was unsalvageable in all cases, they were excited to facilitate coronoid fracture fixation. Lesions at the Ulno-humeral

or capitulum were excluded by direct visualization. Preparation for radial head replacement was done by ensuring the correct measurement using the native parts of the radial head, use of the trail, and assessment under imaging. Afterward, the coronoid fracture was approached before radial head prosthesis implantation, which was all cementless. In our cases, all the coronoid fractures were fixed with a 2.8mm suture anchor to the base of the fracture to reattach the anterior capsule. Tightening of the suture was done after radial head prosthesis implantation. Over-stuffing of the radial head was avoided using the same size as the native radial head parts or 2 mm smaller to maintain the LUCL tensioning. We evaluated the measurements intraoperatively by directly visualizing its position to the lesser sigmoid notch and under fluoroscopic assessment. Finally, we used a 2.8mm, suture anchor for LUCL repair, and we incorporated the deep facia of the extensor pronator mass to augment the repair. A hanging arm test was used to check the elbow joint's stability, and an image intensifier was used to check congruity in full flexion, 90, 30 degrees flexion, and full extension.

Results

Most patients were male, and all patients presented following a fall from height. Four cases involved the right side, 2 cases the left side, and one was bilateral. Two cases had an ipsilateral distal radius fracture, and each had another associated injury: a pelvic fracture. The female patient had an ipsilateral capitulum fracture fixed with headless screws and a pelvic fracture treated conservatively. The bilateral case had ipsilateral trans-scaphoid peri-lunate fracture-dislocation on the right side treated with ORIF of the scaphoid and multiple K-wires fixations of the carpal bones after repair of the dorsal scapholunate ligament and left olecranon fracture treated with ORIF. Three cases were isolated terrible triad fractures. One of them was open fracture dislocation Gustilo Anderson type II, initially treated with debridement and application of an external fixator followed by ORIF and Radial head replacement. The average days from admission to surgery was 4.75 days. According to Regan Morrey's classification, there were six types I, II, and two types III coronoid fractures. All radial head fractures were Mason type III. Mayo Elbow Performance Score was used to assess the patients' function and showed 6 cases with an excellent score and 2 cases with a good score at the final follow-up. The average DASH score was 5.8 in all cases. No infection, dislocation, instability, or stiffness was documented. The average ROM was -10 to 130, and all patients had painless functional ROM at the final follow-up (Table 1).

Case	Gender	Age (y)	MOI	Side	Coronoid process	Radial Head	Associate injuries	Days to surgery	Follow-up (m)	MEPS	DASH
1	Male	36	Fall from Hight	Right	I	Ill	Nil	4	3	100	3.3
2	Male	22	Fall from Hight	Right	II	Ill	Right distal radius (ORIF) 2nd MC bone fractures (CRPP)	7	8	100	5.8
3	Male	31	Fall from Hight	Left	I	Ill	Left distal radius (ORIF) Pelvic fractures (ORIF)	3	3	85	6.7
4	Male	25	Fall from Hight	Bilateral	R: II L: II	lll	Right distal radius scaphoid fractures	5	1	85	7.5
5	Male	36	Fall from Hight	Right	I	lll	Nill	6	1	100	3
6	Female		Fall from Hight	Right	I	lll	RT acetabulum RT iliac bone	3	1	85	6
7	Male		Fall from Hight	Left	I	lll	Nill	4	1	100	3.5

Table 1: Demographics, characteristics, and outcome measures of the injured cases.

MOI: Mechanism of Injury; F<1M: Fall from the Height of more than 1 Meter; ORIF: Open Reduction and Internal Fixation; CRPP: Closed Reduction and Percutaneous Pinning; MEPS: Mayo Elbow Performance Score; DASH: Disabilities of the Arm, Shoulder, and Hand Questionnaire

Discussion

Terrible triad injuries (TTIs) of the elbow are challenging to manage, with elbow stability and range of motion being the primary treatment goals as having been advocated by multiple studies. Most advocate the need to restore the radio-capitellar stability and articulation through radial head fixation or replacement surgery and LUCL reconstruction or repair of an insertional avulsion. There needs to be a clear consensus regarding whether grade 1 and 2 coronoid fractures definitively need to be fixed in the setting of a terrible triad of the elbow.

Papatheodorou LK., *et al*. argued that arthrosis and heterotopic ossification rates could be related to lower injury severity or as a result of leaving coronoid unfixed, avoiding drilling of the ulna needed for fixation [10]. Indeed, that was our concern when we elected to repair the coronoid tips, as it can lead to an increased constraint at the ulna-humeral joints and aggravate heterotrophic bone formation due to the dissection needed. Antoni M., *et al.* however, found that the only difference in their retrospective cohort study concerning whether to repair or not repair the coronoid (type 1) in terrible triad injuries is that the radio-capitellar joint was more arthritic in the no-repair group in their mean follow-up period of 54 months. No statistically significant difference between the two groups was found regarding ulna-humeral arthrosis or instability [11]. IN THEIR CADAVERIC STUDY, cage DJ., *et al*. found that the average anterior capsule attachment to the ulna is 6.4 mm distal to the coronoid tip and speculated that rarely, type 1 fractures could involve capsular detachment [20]. However, we found that all capsules were injured and avulsed from their insertion anteriorly. Beingessner DM., *et al.* could not find any significant role of coronoid tip fractures in unstable elbows compared to cases with intact coronoids in their cadaveric study [13]. Their findings suggested the importance of reconstructing the medial ulnar collateral ligament (MUCL) instead, given its contribution to elbow stability more than the coronoid tip. The radial head contributes to the valgus stability of the elbow; hence, the re-establishment of the radial head adds to the valgus stability of the elbow [13]. Hartzler RU., *et al.* found that when less than 50%, coronoid fixation contributes to varus internal rotation instability.

In contrast, valgus external rotation stability reliably depends on radial head integrity [12]. Partial excision of the radial head with coronoid tip repair with sutures if small or fixation if large with concomitant LUCL repair yielded a good outcome in the Yang HS., *et al*. series [14]. This can signify the anterior capsule-osseous stabilizing structures' role in the stability of fracture-dislocation of an elbow when repaired accordingly. Despite almost 70% of their cases, the MUCL was injured as suggested on intra-operative examination, coronoid tip fixation, and LUCL were sufficient for restoring the treated cases' stability without needing MUCL reconstruction or the use of a hinged elbow fixator [14]. Zhang J., *et al*. advocated for coronoid tip repair in terrible triads injury as they found good clinical and radiographic outcomes postoperatively [15]. They suggested that a universal posterior midline incision is beneficial in medially and laterally approaching the elbow. Alternatively, a dual incision approach as fixation of the coronoid might be challenging, given the limited space [15]. What aided in exposure in our cases is that the radial heads were excised as they needed replacement; this provided a sufficient area to work on the coronoid as we utilized a single lateral incision.

Kim BS., *et al.* found no statistically significant difference in cases with coronoid fracture type I and II surgically treated with or without fixation to clinical outcome [9]. However, they did not repair type 1 or 2 injuries, and if any involved case with persistent instability, MUCL reconstruction without coronoid fixation was elected. There was no recurrent elbow instability in all of their cases, and the follow-up was satisfactory [9]. Their fixation sequence was composed of radial head management, followed by LUCL reconstruction. If there is remaining instability, a separate medial approach was used to fix the coronoid if it is a type 3 or repair the MUCL alone in cases with coronoid type 1 and 2 injuries [9]. We elected to repair the coronoid process with suture anchors as we hypothesized that a type 1 fracture of the coronoid can affect the buttress mechanism of the ulna-humeral joint, especially since the capsules were avulsed anteriorly; moreover, the space given following radial head excision allowed us to access the coronoid tip with its subsequent repair.

Conclusion

Approaching and fixation of the coronoid through a lateral approach can be achieved in the setting of the removed comminuted radial head before replacement. The coronoid-first repair might factor in stabilizing the elbow without needing a medial incision. Future randomized control trials should focus on whether coronoid repair is a must when injured, as there needs to be more high-level evidence for this answer.

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