



Optimizing Surgical Management for Terrible Triad Injuries of the Elbow: A Prospective Outcome-Based Study

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Abstract

Background: Terrible triad injuries of the elbow—comprising a radial head fracture, coronoid process fracture, and posterolateral dislocation—pose significant challenges in restoring joint stability and function.

Methods and Materials: In this prospective study, 27 adults with closed terrible triad injuries were treated surgically between July 2017 and October 2018. Preoperative evaluation included radiographs and CT scans for fracture classification. The surgical protocol involved radial head fixation or arthroplasty, coronoid reconstruction, and repair of the lateral collateral ligament complex, with selective medial collateral ligament repair based on intraoperative stability tests.

Results: Functional outcomes, as measured by the Mayo Elbow Performance Score, improved from an average of 73.1 at 3 months to 87.0 at 6 months. Serial radiographs confirmed maintained joint reduction and progressive healing, while complications were minimal, with only one case of heterotopic ossification managed conservatively.

Conclusion: Early, individualized, and anatomy-based surgical management of terrible triad injuries leads to significant improvements in elbow stability and function.

Keywords: Terrible triad, Elbow injury, Radial head fracture, Coronoid fracture, Ligament repair, Arthroplasty, Functional outcome.

Introduction

Terrible triad injuries of the elbow were first described by Hotchkiss [1] as a complex injury pattern involving fractures of the radial head and coronoid process combined with elbow dislocation. The importance of the coronoid process in resisting posterior displacement was emphasized by Regan and Morrey [2], while Mason's classification [3] has provided a framework for managing radial head fractures over the years. Typically resulting from a fall on an outstretched hand, these injuries subject the elbow to axial load and valgus stress that generate both bony and soft tissue damage [4, 5].

Restoration of the bony anatomy is paramount; fixation or replacement of the radial head re-establishes the radiocapitellar

articulation, and reconstruction of the coronoid process reconstitutes the anterior buttress of the ulnohumeral joint [6]. Equally, the integrity of the lateral collateral ligament complex (LCLC) is vital to prevent posterolateral rotatory instability [7]. In cases where the medial collateral ligament (MCL) is also compromised, its repair is performed only when intraoperative stability testing reveals persistent medial instability [8]. Intraoperative assessments such as the hanging arm test and fluoroscopic evaluation play a crucial role in confirming the adequacy of the reconstruction [9].

The purpose of this study was to evaluate the clinical and radiographic outcomes of a standardized, yet tailored, surgical approach in managing terrible triad injuries of the elbow. We



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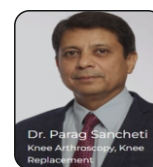
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hypothesized that early, meticulous reconstruction of both bony and ligamentous structures would lead to improved stability and function, as reflected by serial MEPS assessments and radiographic healing.

Materials and Methods

This prospective study enrolled 27 patients (17 males and 10 females) over the age of 18 with closed terrible triad injuries of the elbow treated surgically at our institution between July 2017 and October 2018. Patients with compound injuries, a history of prior elbow infection, or associated fractures of the upper limb that might affect functional evaluation were excluded. Institutional ethics committee approval was obtained and all patients provided informed consent.

Preoperative Evaluation

All patients underwent detailed clinical examination and standard anteroposterior and lateral radiographs of the injured elbow. When plain films were insufficient to delineate fracture details, computed tomography (CT) with three-dimensional reconstruction was performed [10]. Coronoid fractures were classified using the Regan–Morrey system [2]: Type I (tip fractures), Type II (fractures involving $\leq 50\%$ of the coronoid height), and Type III (fractures involving $> 50\%$ of the height). Radial head fractures were classified according to Mason's criteria [3]. Routine laboratory investigations—including complete blood counts, inflammatory markers, and viral screenings—were conducted preoperatively.

Operative Technique

Surgical procedures were performed under general anaesthesia, with or without regional block, based on patient factors. Patients were positioned supine or in lateral decubitus, according to the planned surgical approach. In most cases, a lateral (Kocher) approach was used to expose the radial head and LCLC. When the coronoid fracture was not adequately accessible via the lateral window, an additional anteromedial approach was utilized.

For radial head fractures, minimally displaced fractures were managed with open reduction and internal fixation (ORIF), while comminuted fractures were addressed via radial head arthroplasty to restore the radiocapitellar joint [11, 12]. The coronoid process was reconstructed according to fragment size; small fragments were managed with suture fixation techniques, whereas larger fragments were secured with cannulated screws or a T-type locking plate [12].

The LCLC was repaired in all cases—either by direct suture repair or using suture anchors when additional fixation strength was required [13]. Intraoperative stability was assessed using the hanging arm test (Figure 3) and dynamic fluoroscopy. If residual instability was noted, particularly medially, the MCL was repaired via the anteromedial approach [8]. In cases with persistent instability despite reconstruction, a temporary

hinged external fixator was applied to maintain reduction while allowing early mobilization [14].

Postoperative Management and Follow-Up

Postoperatively, patients received prophylactic antibiotics—typically a combination of a third-generation cephalosporin and an aminoglycoside—and were immobilized in an above-elbow back slab for three weeks. Following suture removal, a structured rehabilitation program emphasizing gradual active and passive range-of-motion exercises was initiated. Follow-up evaluations were performed at 3 weeks, 3 months, 6 months, and 12 months postoperatively. Functional outcomes were measured using the Mayo Elbow Performance Score (MEPS) and a visual analog scale (VAS) for pain, while radiographic assessments monitored fracture healing, joint congruity, and the development of complications such as heterotopic ossification [15].

Results

The study cohort had a mean age primarily within the 18–30 years group (33.3%), with 55.5% of injuries resulting from two-wheeler accidents. Radiographically, 59.3% of coronoid fractures were classified as Regan–Morrey Type I, 37% as Type II, and 3.7% as Type III. Radial head fractures were managed surgically in 96.3% of patients. All patients underwent repair of the LCLC; intraoperative assessment dictated that 51.9% also required MCL repair.

MEPS improved from an average of 73.1 at 3 months to 87.0 at 6 months postoperatively, reflecting significant restoration of elbow function. Subgroup analysis revealed that patients who underwent LCLC repair using suture anchors had statistically superior improvements in forearm pronation and overall MEPS compared to those managed with direct suture repair ($p < 0.05$) [13, 16]. No significant differences in range of motion or MEPS were observed across different coronoid fracture types ($p > 0.05$).

Complications were minimal. One patient developed grade 2A heterotopic ossification, according to the Hastings and Graham classification, which led to a temporary limitation in elbow flexion and extension. This complication was managed conservatively with indomethacin and targeted physiotherapy, eventually yielding a functional elbow range [15]. Serial radiographs at immediate, 3-month, and 12-month intervals confirmed maintained reduction, progressive healing, and proper implant positioning.

Discussion

Our study demonstrates that an individualized, anatomy-based surgical approach can effectively restore elbow stability in patients with terrible triad injuries. Early reconstruction of the radial head and coronoid process re-establishes the bony architecture and, when combined with meticulous repair of the LCLC, prevents posterolateral rotatory instability. Our results

support the findings of Hotchkiss [1] and Regan and Morrey [2], who stressed the critical role of these structures in elbow stability.

Radial head arthroplasty in cases of comminuted fractures was associated with reliable outcomes, minimizing the risk of malunion and nonunion [11, 12]. Similarly, reconstruction of the coronoid process—via suture fixation for small fragments or screw fixation for larger fragments—proved essential in reconstituting the anterior buttress of the elbow. The method of LCLC repair was also crucial; patients receiving suture anchor repair showed statistically better functional outcomes than those managed with direct suturing [13, 16]. Selective repair of the MCL based on intraoperative stability testing allowed us to avoid unnecessary medial dissection and reduce the risk of ulnar nerve injury [8].

Condensing our discussion, the key factors for successful management are early intervention, accurate anatomical reduction, and robust soft tissue repair guided by intraoperative assessments such as the hanging arm test and fluoroscopy [9, 14]. Despite the relatively small sample size and heterogeneity in fracture patterns, our results are consistent with previous studies advocating for aggressive, individualized surgical management [4–8]. Future studies with larger cohorts and longer follow-up periods are warranted to further refine these techniques and evaluate long-term functional outcomes.

Conclusion

The management of terrible triad injuries of the elbow requires a comprehensive strategy that addresses both the osseous and ligamentous components of the injury. Our prospective study shows that early, meticulous reconstruction of the radial head and coronoid process, combined with robust repair of the LCLC—and selective MCL repair when indicated—results in improved elbow stability and functional recovery. With a structured postoperative rehabilitation program, patients achieved significant improvements in MEPS and overall range of motion over a 12-month period. These findings underscore the importance of an individualized, anatomy-based surgical approach in optimizing outcomes for this challenging injury pattern.

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