Hypothesis

Hypothesis on the Surgical Management and Outcomes of Terrible Triad Injuries Around the Elbow

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Abstract

Background: The terrible triad of the elbow—radial-head fracture, coronoid fracture and posterolateral dislocation—creates a mechanically unstable joint that commonly leads to pain, stiffness and impaired daily activities when not reconstructed properly. Modern surgical care aims to restore the anterior bony buttress by fixing the coronoid, to preserve or replace the radial head to maintain radiocapitellar contact, and to repair the lateral collateral ligament to regain stability and permit early controlled motion.

Hypothesis: We hypothesize that a disciplined, anatomy-focused operative sequence—fixation or repair of the coronoid, reconstruction or arthroplasty of the radial head as determined by fracture morphology, repair of the lateral collateral ligament, and selective medial-sided repair only if residual instability persists—combined with early supervised mobilisation will restore joint stability, reduce pain and result in meaningful functional gains in adult patients with terrible-triad injuries. Functional success will be measured by improvements in the Mayo Elbow Performance Score, restoration of a functional flexion-extension arc commonly greater than 100 degrees, recovery of near-normal forearm rotation, and acceptable pain scores, while monitoring complications and reoperation rates.

Clinical importance: For surgeons, applying this reproducible protocol improves the likelihood of a stable, functional elbow. Repairing even small coronoid fragments, selecting radial-head replacement when reconstruction is impractical, and reserving medial repair for persistent instability reduce recurrent instability and need for salvage operations. Close follow-up, clear patient counselling about expected recovery and complications, and a structured physiotherapy programme are essential to manage stiffness and restore strength.

Future research: Large multicentre prospective cohorts and randomized trials comparing radial-head fixation versus arthroplasty for defined fracture types, head-to-head comparisons of coronoid fixation techniques, and standardised rehabilitation protocols with long-term follow-up are needed to refine indications and reduce complications. Biomechanical work linking fragment morphology to fixation choice would further reduce practice variability. Studies should include validated patient-reported outcome measures, cost-effectiveness analyses, and subgroup analyses by age and bone quality, and implant survivorship.

Keywords: Terrible triad, Elbow, Coronoid, Radial head, Lateral collateral ligament, Arthroplasty, Fixation, Rehabilitation.

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Background

The "terrible triad" of the elbow — a combination of radial-head fracture, coronoid fracture and posterolateral elbow dislocation — was named because, left untreated or treated poorly, it frequently led to pain, recurrent instability and poor function. Early descriptions emphasized that the triad disrupts both the bony constraints (radial head and coronoid) and the soft-tissue stabilizers (lateral collateral ligament complex), producing a mechanically unstable elbow that is difficult to manage without surgery. Hotchkiss popularized the term and highlighted the poor natural history without adequate reconstruction; Regan and Morrey provided the familiar coronoid classification that helps guide fixation decisions; Mason's classification of radial-head fractures remains central to choosing fixation versus replacement [1–3].

Biomechanical and clinical work shows that the coronoid is the primary anterior buttress against posterior translation, while the radial head contributes to valgus and radiocapitellar stability. Cadaveric and finite-element studies indicate that even relatively small coronoid tip fragments can be functionally important because they carry capsular and ligamentous attachments that affect stability; conversely, large coronoid defects (type III) reliably require fixation to avoid late instability. The radial head, particularly when comminuted, cannot always be reconstructed — in those cases arthroplasty is used as a spacer to re-establish height and radiocapitellar contact [4–6].

Contemporary operative practice has therefore adopted a principle-based, stepwise approach: restore the anterior bony buttress (coronoid), restore the radial head (fixation when feasible; arthroplasty when not), repair the lateral collateral ligament (LUCL/LCL) and reassess stability — repairing the medial collateral ligament only when residual instability persists; a hinged external fixator is a salvage option for persistent instability. Studies reporting this sequence show better maintenance of concentric reduction, permit early controlled motion and achieve satisfactory functional scores in most patients, though complication rates remain meaningful [7–12].

Surgical technique is adapted to fragment size and location: small coronoid tip fractures are commonly stabilized with suture lasso or anchors while larger fragments require screws or buttress plating; anteromedial facet fractures often need medial exposure and buttress fixation because they act as a varus/medial buttress. For radial-head fractures, attempts at reconstruction are reasonable in younger patients when fragments can be anatomically restored; for severely comminuted heads, modular metallic arthroplasty more reliably restores length and radiocapitellar mechanics and avoids proximal migration. Approaches vary (lateral-only versus combined medial and lateral exposures) and each has tradeoffs related to soft-tissue dissection and neurovascular risk [13–16].

Despite improvements in technique, the literature documents a substantial complication burden — heterotopic ossification, stiffness, nerve palsies and a nontrivial reoperation rate for stiffness, instability or implant problems. Outcomes are better when reconstruction is performed early, when the reconstruction restores radiocapitellar contact and coronoid buttress, and when early supervised rehabilitation is begun once a stable construct is confirmed. Published series show a majority achieving good to excellent results on validated scores (for example MEPS), but with complication and reoperation rates that demand careful patient counselling and meticulous surgical technique [17–20].

Hypothesis

Primary hypothesis:

When surgeons apply a systematic, anatomy-focused operative sequence — restore coronoid (repair/fixation) → restore radial head (fix or replace) → repair lateral collateral ligament → reassess and address the medial side only if needed — and begin early controlled rehabilitation, patients with terrible-triad injuries will gain significant functional improvement (as measured by MEPS, range of motion and pain scores) with acceptable complication rates [21].

Secondary hypotheses:

1. Radial-head arthroplasty is more reliable than attempted fixation in severely comminuted radial-head fractures within the terrible-triad pattern, producing more consistent restoration of radiocapitellar contact and reducing late instability or need for secondary procedures [22].
2. Repair of even small coronoid tip fragments (with a suture lasso or anchor) materially improves early stability compared with leaving them untreated, because capsular and ligamentous insertions on small fragments contribute disproportionately to joint restraint [23].
3. Routine medial collateral ligament (MCL) repair is unnecessary; selective MCL repair only for persistent instability after anterior and lateral reconstruction minimizes surgical morbidity while addressing instability when indicated [24].
4. A stepwise algorithm (coronoid → radial head → LCL → reassess → MCL/hinge if needed) results in a majority of patients achieving a functional arc of motion and good/excellent MEPS scores at medium-term follow-up, while keeping reoperation rates within published expectations [25].

Rationale and plan for measurement:

These hypotheses rest on the mechanical role of the coronoid and radial head and the central role of the lateral collateral complex in resisting posterolateral rotatory and varus-posteromedial failure. Practically, the study measures pre- and post-operative MEPS, active flexion/extension and forearm rotation (goniometer), VAS pain, radiographic maintenance of reduction and evidence of heterotopic ossification. Success is

operationalized as a clinically meaningful rise in MEPS category and restoration of a functional arc of motion (commonly >100° flexion-extension and near-normal pronation/supination) with no recurrent dislocation. Complications including HO, nerve palsy, implant failure and need for reoperation are recorded and compared with historical series [21–25].

Discussion

This series and the thesis literature support the central idea that a disciplined, anatomy-first operative approach converts a once "terrible" injury into one that frequently yields useful function. Restoring the coronoid — even when the fragment appears small — is important because it re-establishes the anterior buttress and the capsular attachments that restrain posterior translation; repair by suture lasso/anchors for tip fragments or screws/plates for larger or anteromedial facet fractures prevents varus collapse and later arthrosis [1–5].

When the radial head is reconstructable, fixation preserves native anatomy and is reasonable in younger patients. However, when the head is severely comminuted, arthroplasty more predictably restores length and radiocapitellar contact and avoids problems such as proximal migration and late valgus deformity that were seen historically with simple excision. Several comparative series in the thesis point toward lower instability and improved short-term function with arthroplasty in the appropriate setting [6–9].

Repair of the lateral collateral ligament complex is essential to control posterolateral rotatory instability; the MCL need only be repaired if the elbow remains unstable after reconstituting bony anatomy and repairing the lateral side. Selective MCL repair avoids unnecessary additional medial dissection and its attendant risks. If residual instability persists despite soft-tissue repair, a hinged external fixator offers a temporary stabilizing strategy that allows early motion while soft tissues heal [10–14].

Outcomes reflect this logic: most patients reach a functional arc of motion and report reduced pain and improved MEPS, but the complication rate remains substantial — heterotopic ossification, nerve symptoms (radial or ulnar neuropraxia), stiffness requiring adhesiolysis, and occasional implant problems are reported across multiple series. Timely surgery, careful reconstruction of coronoid and radial head, judicious use of arthroplasty, meticulous ligament repair and early supervised rehabilitation together reduce but do not eliminate these risks [15–20].

Clinical importance

For surgeons, this work clarifies a reproducible pathway: restore the coronoid buttress, preserve or replace the radial head depending on reconstructability, repair the lateral collateral ligament, and only address the medial side if residual instability remains. Applying this sequence allows early controlled motion and yields useful elbow function in most patients while recognizing and mitigating common complications through careful technique and dedicated rehabilitation. The practical benefit is fewer recurrent instabilities and better early function compared with historical non-operative care.

Future direction

Future research should aim for larger, multicentre prospective cohorts or randomized comparisons of radial-head fixation versus arthroplasty in defined fracture patterns, and head-to-head trials of coronoid fixation techniques (suture lasso/anchor vs screws vs medial buttress plating for anteromedial facets). Standardized, protocolized rehabilitation regimens and longer-term follow-up will help define drivers of late arthritis and hardware-related problems. Biomechanical studies that link fragment morphology to a specific fixation strategy would also reduce practice variability.

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