East Asian Journal of Multidisciplinary Research (EAJMR)
Vol.5, No. 6, 2026: 2477 - 2496

Conservative Treatment of Stable Terrible Triad Elbow Injuries After Closed Reduction: A Systematic Review

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A R T I C L E I N F O

Keywords: Terrible triad elbow, conservative treatment, closed reduction

Received : 12, April
Revised : 13, May
Accepted: 30, June

A B S T R A C T

Terrible triad injuries of the elbow have traditionally been treated surgically because of their association with instability, stiffness, and poor functional recovery. However, selected injuries that remain stable after closed reduction may be suitable for nonoperative treatment. This systematic review evaluated outcomes of nonoperative management in selected stable terrible triad injuries of the elbow. PubMed, Cochrane Library, and ScienceDirect were searched for studies reporting adult terrible triad injuries managed nonoperatively after closed reduction. Outcomes included elbow stability, delayed surgery, range of motion, functional scores, pain, complications, and post-traumatic arthritis. Functional outcomes were favorable, with reported mean MEPI/MEPS around 94–95 in several cohorts and excellent/good MEPS in 77% in the largest series. Delayed surgery occurred in up to 13% of patients, while complications included clicking, stiffness, heterotopic ossification, coronoid fibrous union or nonunion, and mild post-traumatic arthritis.

DOI prefix: https://doi.org/10.55927/eajmr.v5i6.201
ISSN-E: 2828 – 1519 (Online)
https://journaleajmr.my.id/index.php/eajmr

INTRODUCTION

Terrible triad injury of the elbow is classically defined as elbow dislocation accompanied by fractures of the radial head and coronoid process. Despite its concise definition, this injury pattern represents a complex disruption of the elbow's osseous and ligamentous stabilizers, particularly the ulnohumeral joint, radiocapitellar articulation, radial head, coronoid process, and lateral collateral ligament complex. Historically, the term "terrible triad" reflected the tendency of these injuries to produce recurrent instability, stiffness, persistent pain, post-traumatic arthritis, and unsatisfactory functional recovery when inadequately treated. Contemporary understanding of elbow biomechanics has clarified that restoration of joint congruency and early protected motion are central to successful treatment, because prolonged immobilization increases stiffness while insufficient stability risks redislocation or chronic subluxation.

Operative management has therefore become the conventional standard for most terrible triad injuries. Surgical treatment generally aims to restore stability by repairing or replacing the radial head, addressing the coronoid fracture or anterior capsule when required, and repairing the lateral collateral ligament complex. In unstable injuries, additional medial collateral ligament repair or external fixation may be necessary. Modern surgical protocols have substantially improved outcomes compared with earlier historical reports, and recent reviews suggest that terrible triad injuries are no longer uniformly associated with poor prognosis when treated according to contemporary principles. Nevertheless, operative treatment remains technically demanding and is not free from complications. Reported postoperative problems include elbow stiffness, heterotopic ossification, nerve symptoms, infection, hardware-related complications, recurrent instability, radiographic arthritis, and reoperation.

This has led to renewed interest in whether selected terrible triad injuries can be treated without surgery. The rationale for nonoperative management is not that terrible triad injuries are inherently benign, but that a small subset may remain sufficiently stable after closed reduction. In such cases, if the ulnohumeral and radiocapitellar joints are concentrically reduced, the radial head fracture does not cause a mechanical block, the coronoid fracture is small or acceptably positioned, and the elbow remains stable through an early functional arc, surgery may expose the patient to avoidable morbidity without clearly improving stability or function. This concept is particularly relevant for patients with major comorbidities, those at high anesthetic risk, or those who strongly prefer to avoid surgery.

Early reports of nonsurgical treatment were cautious but clinically important. Guitton and Ring described four patients treated without surgery after closed reduction, emphasizing that the elbow must be well aligned, the radial head and coronoid fractures relatively small or minimally displaced, and motion free of mechanical block. Three of four patients achieved good results, although one required later surgery for stiffness, ulnar neuropathy, heterotopic ossification, and radial head deformity. Chan et al. subsequently provided more structured criteria for nonoperative treatment, including concentric joint

reduction, absence of radial head mechanical block, a smaller Regan-Morrey type I or II coronoid fracture, and a stable arc of motion allowing early active rehabilitation. Their cohort demonstrated good functional scores, stable elbow motion, and low disability, but one patient required early surgical stabilization for recurrent subluxation, reinforcing the need for close surveillance.

More recent studies have expanded the available evidence but also highlighted persistent uncertainty. Najd Mazhar et al. prospectively evaluated selected patients managed nonsurgically and reported excellent Mayo Elbow Performance Index scores and low DASH scores, although limitation of forearm rotation and radiographic arthritic change were notable concerns. Baker et al. reported good long-term patient-reported outcomes after nonoperative treatment, including some patients with more complex fracture patterns, and proposed that maintenance of ulnohumeral congruency and absence of mechanical block may be more important than radial head fracture grade alone. Factor et al. later presented one of the largest nonoperative series, reporting generally satisfactory functional outcomes over medium- to long-term follow-up, but also documenting delayed surgery, mechanical clicking, and post-traumatic degenerative changes in a meaningful proportion of patients.

Although these studies collectively suggest that nonoperative management may be feasible, the evidence remains fragmented. Published cohorts are small, mostly observational, and heterogeneous in their selection criteria, rehabilitation protocols, fracture classifications, follow-up duration, and outcome measures. Some studies strictly limited inclusion to smaller fractures and stable motion arcs, whereas others included patients treated nonoperatively because of comorbidities or patient preference. Moreover, the clinical significance of residual radiographic findings such as fibrous coronoid union, mild arthritis, radiocapitellar incongruency, or mechanical clicking remains uncertain when functional outcomes are otherwise acceptable. These issues make it difficult for clinicians to determine which patients can safely avoid surgery and what trade-offs should be discussed during shared decision-making.

Therefore, this systematic review aimed to synthesize the available evidence on nonoperative management of selected stable terrible triad injuries of the elbow after closed reduction, focusing on elbow stability, delayed surgery, range of motion, functional outcomes, pain, complications, and post-traumatic arthritis.

THEORETICAL REVIEW

Anatomy and Biomechanics of Elbow Stability

The elbow is a highly congruent synovial joint that functions as a complex articulation between the humerus, ulna, and radius. Stability is maintained through the interaction of static and dynamic stabilizers. Static stabilizers include the ulnohumeral articulation, radial head, coronoid process, joint capsule, lateral collateral ligament (LCL) complex, and medial collateral ligament (MCL). Dynamic stability is provided by the surrounding musculature, particularly the flexor-pronator and extensor-supinator muscle groups.

The coronoid process acts as a critical anterior buttress against posterior translation of the ulna and contributes significantly to varus and posteromedial stability. The radial head serves as a secondary valgus stabilizer and contributes to axial load transmission through the radiocapitellar joint. The lateral collateral ligament complex, especially the lateral ulnar collateral ligament (LUCL), is the primary restraint to posterolateral rotatory instability. Injury to these structures can disrupt elbow kinematics and result in recurrent instability or chronic dysfunction.

Terrible Triad Injury of the Elbow

Terrible triad injury is classically defined as a combination of elbow dislocation, radial head fracture, and coronoid process fracture. The injury typically results from a fall onto an outstretched hand with the elbow in slight flexion and forearm supination. This mechanism generates axial compression, valgus stress, and posterolateral rotational forces that sequentially disrupt the lateral collateral ligament complex, fracture the radial head, and fracture the coronoid process before causing elbow dislocation.

Historically, TTI was associated with poor outcomes because the injury involves simultaneous damage to multiple stabilizing structures. Patients frequently developed recurrent instability, elbow stiffness, heterotopic ossification, chronic pain, and post-traumatic arthritis. Advances in understanding elbow biomechanics and improvements in treatment protocols have significantly improved outcomes; however, TTI remains one of the most challenging elbow injuries to manage.

Principles of Nonoperative Management

Traditional treatment algorithms recommend surgical stabilization for most terrible triad injuries because of the high risk of recurrent instability. Nevertheless, increasing evidence suggests that a carefully selected subgroup of patients can achieve satisfactory outcomes with nonoperative treatment.

The theoretical basis for conservative management relies on maintaining sufficient residual stability following closed reduction. Successful nonsurgical treatment generally requires:

1. Concentric ulnohumeral and radiocapitellar reduction
2. Absence of mechanical block to motion
3. Small or minimally displaced radial head fractures
4. Small coronoid fractures (typically Regan-Morrey type I or II)
5. Stable arc of motion allowing early rehabilitation
6. Reliable patient compliance and close follow-up

When these criteria are met, early motion may preserve function while avoiding surgical morbidity.

Importance of Early Mobilization

Early mobilization is a cornerstone of successful nonoperative treatment. The elbow is particularly susceptible to stiffness because of its highly congruent anatomy and propensity for capsular contracture after trauma.

Prolonged immobilization can lead to:

1. Joint stiffness
2. Muscle atrophy
3. Capsular fibrosis
4. Loss of forearm rotation
5. Functional limitation

Most modern conservative protocols therefore begin supervised active motion within the first week after injury. Motion is typically performed within a protected range that minimizes stress on healing ligamentous structures while maintaining joint mobility.

Potential Advantages of Nonoperative Treatment

Potential benefits of conservative management include:

1. Avoidance of surgical complications
2. Elimination of anesthesia-related risks
3. Reduced healthcare costs
4. No implant-related complications
5. Preservation of native anatomy
6. Earlier return to daily activities in selected patients

These advantages may be particularly relevant in elderly patients, patients with significant medical comorbidities, or those who decline surgery.

Potential Risks and Complications

Despite encouraging outcomes in selected patients, nonoperative treatment is associated with several potential risks:

1. Recurrent instability or subluxation
2. Delayed need for surgery
3. Loss of forearm rotation
4. Elbow stiffness
5. Mechanical clicking
6. Heterotopic ossification
7. Ulnar nerve symptoms
8. Fibrous union of coronoid fractures
9. Post-traumatic osteoarthritis

Several studies have demonstrated radiographic degenerative changes despite satisfactory functional outcomes, suggesting that structural deterioration may occur even when clinical function remains acceptable.

Theoretical Basis for Patient Selection

Current evidence suggests that patient selection is the most important determinant of success in nonoperative management. Across published studies, common selection principles include:

1. Concentric reduction after closed reduction.
2. Stable ulnohumeral alignment.
3. No progressive subluxation on serial radiographs.
4. No mechanical block to forearm rotation.
5. Small coronoid fractures.
6. Minimally displaced radial head fractures or fractures not compromising stability.
7. Ability to participate in structured rehabilitation.

Therefore, nonoperative treatment should not be viewed as an alternative for all terrible triad injuries but rather as a treatment strategy for a carefully selected subgroup with demonstrable post-reduction stability.

METHODOLOGY

Study Design and Reporting Guideline

This systematic review was conducted to evaluate the clinical and radiographic outcomes of nonoperative management in selected stable terrible triad injuries of the elbow. The review was designed and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guideline. The review focused on adult patients with terrible triad elbow injuries who were managed without definitive surgical stabilization after closed reduction, with particular attention to elbow stability, delayed surgical intervention, range of motion, functional recovery, pain, complications, and radiographic post-traumatic arthritis. Because of the small number of available studies, heterogeneous outcome reporting, and absence of controlled comparative data, the synthesis was performed qualitatively rather than through meta-analysis.

Literature Search Strategy

A systematic literature search was performed using PubMed, Cochrane Library, and ScienceDirect. The search was designed to capture studies describing nonoperative, nonsurgical, or conservative management of terrible triad injuries of the elbow. The databases were searched from inception to the final search date, without restriction on publication year. The search strategy combined terms related to terrible triad injury, elbow fracture-dislocation, radial head fracture, coronoid fracture, and conservative treatment.

For PubMed, the following search string was used:

("terrible triad" OR "terrible triad injury" OR "terrible triad injuries" OR "elbow fracture dislocation" OR "elbow fracture-dislocation") AND (elbow OR ulnohumeral OR radiocapitellar) AND (radial head OR coronoid) AND (nonoperative OR non-operative OR nonsurgical OR non-surgical OR conservative OR "without surgery" OR "closed reduction" OR rehabilitation)

For the Cochrane Library, a broader search strategy was intentionally used to maximize sensitivity because conservative-treatment terminology may not be consistently indexed. The main Cochrane search used:

("terrible triad" OR "terrible triad injury" OR "terrible triad injuries" OR "elbow dislocation" OR "elbow fracture-dislocation" OR "fracture dislocation of the elbow" OR "radial head fracture" OR "coronoid fracture")

For ScienceDirect, the search strategy was simplified to accommodate database-specific Boolean limitations while maintaining sensitivity. The final ScienceDirect search string was:

"terrible triad" AND elbow AND (nonoperative OR "non-operative" OR nonsurgical OR nonsurgically OR "non-surgical" OR conservative)

The reference lists of relevant articles were also screened manually to identify additional eligible studies. Search results were reviewed to ensure that all known eligible studies on nonoperative management of terrible triad elbow injuries were captured.

Eligibility Criteria

Studies were eligible for inclusion if they met the following criteria: adult patients with terrible triad injury of the elbow, defined as elbow dislocation with associated radial head and coronoid process fractures; treatment with nonoperative, nonsurgical, or conservative management after closed reduction; and reporting of at least one clinical or radiographic outcome, including elbow stability, delayed surgery, range of motion, functional score, pain, complications, or post-traumatic arthritis. Studies were considered eligible regardless of whether nonoperative treatment was chosen because of strict radiographic stability criteria, patient preference, or medical comorbidity, provided that the patients were initially managed without definitive surgical stabilization.

Studies were excluded if they evaluated primarily operative management, lacked extractable data for nonoperatively treated terrible triad injuries, included pediatric patients without separable adult data, included inappropriate participant characteristics, or used an inappropriate study design such as narrative review, technical note, commentary, or biomechanical study. Studies involving elbow dislocation without both radial head and coronoid fractures were also excluded.

Study Selection

All records identified from the database search were screened by title and abstract. Articles that clearly did not address terrible triad injury of the elbow, nonoperative management, or relevant clinical outcomes were excluded at this stage. Potentially relevant articles were retrieved in full text and assessed against the eligibility criteria. Duplicate records were removed before full-text eligibility assessment. Disagreements during study selection were resolved through re-evaluation of the full text and discussion until consensus was reached.

Data Extraction

Data were extracted using a standardized extraction table developed for this review. Extracted variables included first author, year of publication, country, study design, study period, sample size, patient demographic characteristics, injury mechanism, inclusion criteria for nonoperative management, fracture classification, treatment and rehabilitation protocol, duration of follow-up, outcome measures, elbow stability, delayed surgery, range of motion, functional outcomes, pain outcomes, complications,

radiographic findings, post-traumatic arthritis, summary of findings, and risk of bias.

For injury classification, radial head fractures were extracted according to the Mason classification when available, while coronoid fractures were extracted according to the Regan-Morrey, Morrey, or O'Driscoll classification systems as reported by the original studies. Functional outcomes included Mayo Elbow Performance Score or Index, Disabilities of the Arm, Shoulder, and Hand score, Oxford Elbow Score, American Shoulder and Elbow Surgeons score, Broberg-Morrey score, and subjective functional recovery when reported. Range-of-motion outcomes were extracted separately for flexion, extension deficit, pronation, and supination. Complications were grouped descriptively into delayed surgery, recurrent subluxation or instability, stiffness, heterotopic ossification, mechanical clicking, nerve symptoms, nonunion or fibrous union, and radiographic degenerative change.

Outcomes

The primary outcome of interest was maintenance of elbow stability without delayed surgical stabilization. Stability-related outcomes included recurrent dislocation, subluxation, clinical instability, need for surgical stabilization, and failure of initial conservative management. Secondary outcomes included elbow range of motion, functional scores, pain, return to work, mechanical symptoms, complications, radiographic union, and post-traumatic arthritis.

Because the included studies used different outcome measures and reported data in heterogeneous formats, outcomes were not pooled quantitatively. Instead, results were synthesized narratively, with emphasis on consistency of findings across studies, variability in selection criteria, and clinically relevant patterns of treatment success or failure.

Risk of Bias Assessment

Risk of bias was assessed at the study level using criteria adapted for observational case series and cohort studies. Assessment domains included clarity of inclusion criteria, representativeness of the study population, completeness of follow-up, consistency of treatment protocol, objectivity of outcome assessment, adequacy of radiographic evaluation, and transparency of complication reporting.

Data Synthesis

A qualitative synthesis was performed because the included studies were few in number, observational in design, and heterogeneous in patient selection, fracture pattern, rehabilitation protocol, follow-up duration, and outcome reporting. The synthesis was organized around study characteristics, selection criteria for nonoperative management, injury classification, treatment protocol, elbow stability and delayed surgery, range of motion, functional outcomes, pain, complications, and radiographic outcomes.

Where possible, numerical outcomes were summarized descriptively using the values reported in the original studies. No meta-analysis was performed

because the studies lacked comparable effect estimates, had no consistent comparator group, and reported outcomes using different functional instruments and time points. The overall interpretation focused on whether nonoperative management appeared feasible in selected stable injuries, which selection criteria were repeatedly associated with acceptable outcomes, and what complications remained clinically important despite conservative treatment.

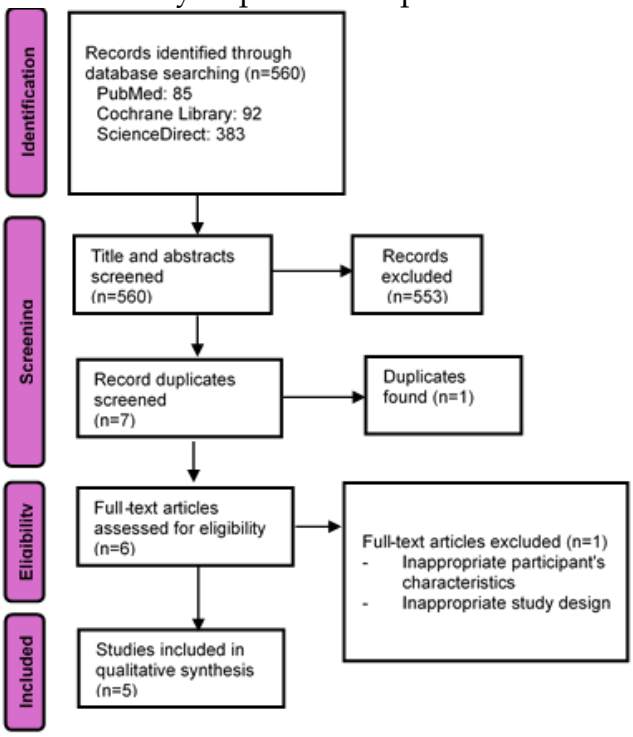

Figure 1. Diagram flow of literature search strategy for this systematic review

RESULTS

Study Selection

The database search identified 560 records, consisting of 85 records from PubMed, 92 from the Cochrane Library, and 383 from ScienceDirect. After title and abstract screening, 553 records were excluded because they were not relevant to nonoperative management of terrible triad injuries of the elbow. The remaining 7 records underwent duplicate screening, and 1 duplicate was removed. Therefore, 6 full-text articles were assessed for eligibility. One full-text article was excluded because of inappropriate participant characteristics and inappropriate study design. Finally, 5 studies were included in the qualitative synthesis.

Study Characteristics

The five included studies were published between 2010 and 2025 and collectively included 83 patients with terrible triad injuries of the elbow treated nonoperatively. The included studies were conducted in Israel, Iran, the United Kingdom, Canada, and the United States, reflecting a geographically diverse but still limited evidence base. All studies were observational in design, consisting of retrospective case series, prospective cohort/case series, or descriptive case

reports. No randomized or comparative trial directly evaluating nonoperative versus operative treatment was identified.

Injury Selection Criteria for Nonoperative Management

Across all included studies, nonoperative treatment was reserved for a highly selected subset of terrible triad injuries. The most consistent selection criterion was maintenance of concentric elbow reduction after closed reduction, usually confirmed by radiographs and/or computed tomography. Most studies emphasized the need for a well-aligned ulnohumeral and radiocapitellar joint, absence of recurrent subluxation, and absence of gross clinical instability.

A second key selection feature was the absence of a mechanical block to motion, particularly forearm rotation. Chan et al. required a radial head fracture that did not block rotation and a stable arc of motion to at least 30° of extension. Najd Mazhar et al. used even more explicit criteria, including no active supination-pronation block up to 60°, no intra-articular fragments, and a free and stable joint to at least 45° of extension. Factor et al. selected patients with good alignment, concentric joint reduction on CT, fracture displacement of ≤2 mm, no mechanical block, and no palpable instability or recurrent subluxation. Baker et al. used similar principles but also included patients treated nonoperatively because of comorbidities or patient preference, leading to inclusion of more complex fracture patterns.

Injury Pattern and Classification

All included studies evaluated terrible triad injuries consisting of elbow dislocation with associated radial head and coronoid fractures. However, the severity of included injuries differed across studies. Earlier series tended to restrict inclusion to smaller and less displaced fractures, whereas later studies included broader injury patterns.

Chan et al. included only Mason type I and II radial head fractures and Regan-Morrey type II coronoid fractures, while Guitton and Ring mainly described Mason type II radial head fractures with O'Driscoll type I coronoid tip fractures. Najd Mazhar et al. included Mason type I–II radial head fractures and Regan-Morrey type I–II coronoid fractures. In contrast, Baker et al. included a wider range of injuries, including Mason type III radial head fractures in 47% and Morrey type III coronoid fractures in 16%. Factor et al. also included some more severe injuries, with Mason type III radial head fractures in 10% and Regan-Morrey type III coronoid fractures in 3%.

Nonoperative Treatment Protocols

Nonoperative protocols were broadly similar across studies and centered on brief immobilization, close radiographic surveillance, and early protected motion. Most patients underwent closed reduction followed by temporary splinting or sling immobilization. Post-reduction CT was commonly used to evaluate fracture morphology, joint congruency, and suitability for conservative treatment.

Rehabilitation typically began within the first 1–10 days after injury. Chan et al. initiated supervised active and active-assisted motion within the first 10

days, with forearm rotation performed at 90° of elbow flexion and weekly radiographic follow-up early after injury. Najd Mazhar et al. began active motion 3–5 days after reduction if stability criteria were met, initially limiting extension and progressively increasing it by 10°–15° per week. Baker et al. used a standardized elbow-instability rehabilitation program, gradually increasing permitted range of motion from 90° to full flexion initially, then 60° to full flexion at 4 weeks, 30° to full flexion at 6 weeks, and full range of motion by 8 weeks. Factor et al. similarly removed the splint at the first clinic visit around 10 days and allowed progressive motion with full range of motion by 8 weeks.

Elbow Stability and Delayed Surgery

Elbow stability was generally maintained in most nonoperatively treated patients, but delayed surgery or treatment failure was not negligible. Across the five studies, delayed surgical intervention occurred in several patients, most often because of recurrent instability, stiffness, heterotopic ossification, radial head-related symptoms, or residual functional limitation.

Range of Motion Outcomes

Range of motion outcomes were generally favorable, particularly for flexion-extension. Mean final flexion across studies was consistently around 128°–134°, with mean extension deficits generally ranging from 6° to 11°. Factor et al. reported mean flexion of approximately 128.2° with an 8.2° extension deficit, while Baker et al. reported mean flexion of 131° and extension deficit of 8°. Chan et al. reported mean flexion of 134° and extension deficit of 6°, and Najd Mazhar et al. reported mean flexion of 131° and extension deficit of 11°.

Forearm rotation was more variable. Chan et al., Baker et al., and Factor et al. reported near-functional or near-normal pronation-supination, with mean pronation and supination generally above 80°. In contrast, Najd Mazhar et al. reported lower rotational recovery, with mean supination of 58° and pronation of 53°, indicating that rotational limitation may remain a clinically relevant issue even when flexion-extension recovery is acceptable. Guitton and Ring also reported one patient with marked early rotational restriction before subsequent surgery, although the remaining patients generally regained full or near-full forearm rotation.

Functional Outcomes

Functional outcomes were generally good to excellent across the included studies, although different scoring systems were used. Factor et al. reported MEPS outcomes as excellent in 11 patients, good in 19, and fair in 9, meaning 77% achieved excellent or good outcomes. Chan et al. reported a mean MEPI of 94 and mean DASH score of 8.0, indicating excellent functional recovery. Najd Mazhar et al. reported a mean MEPI of 95 and mean DASH score of 4.76, also suggesting excellent function despite reduced forearm rotation. Baker et al. reported a mean Oxford Elbow Score of 46, consistent with good patient-reported function at long-term follow-up. Guitton and Ring reported good or excellent outcomes in 3 of 4

patients, while one patient required later surgery before achieving an excellent result.

Return-to-work data were inconsistently reported. Factor et al. reported an average return to work of 2.8 months, with one patient unable to resume the prior occupation. Najd Mazhar et al. reported return to routine work in most patients within 1.5–5 months, although one mechanic required a change in work position.

Pain Outcomes

Pain was not uniformly reported across studies. Factor et al. provided the clearest pain-specific data, with a mean VAS pain score of 2.13, suggesting low residual pain at final follow-up. Najd Mazhar et al. did not report a separate VAS score but described painful clicking in two patients. Guitton and Ring reported mild pain in one patient, while other patients had minimal or no pain-related disability. Baker et al. and Chan et al. did not report pain as a separate pooled endpoint, although their functional scores indirectly suggest acceptable symptom control in most patients.

Complications and Radiographic Outcomes

Complications varied between studies but included mechanical clicking, stiffness, heterotopic ossification, ulnar nerve symptoms, nonunion or fibrous union of the coronoid, recurrent subluxation, and radiographic post-traumatic arthritis.

Mechanical clicking was particularly frequent in Factor et al., occurring in 16 of 39 patients (41%), although it did not necessarily correspond to major functional impairment. Baker et al. reported clicking in 1 patient, and Najd Mazhar et al. reported painful clicking in 2 patients. Stiffness requiring arthrolysis was reported by Baker et al., while Guitton and Ring described one patient requiring contracture release, ulnar nerve transposition, radial head resection, and heterotopic bone removal.

Radiographic degenerative changes were also reported. Factor et al. found post-traumatic degenerative changes in 8 patients (20.5%), mostly Broberg-Morrey grade 1. Chan et al. reported arthritic changes in 4 patients, all grade 1 and not requiring treatment. Najd Mazhar et al. reported grade 1 arthritic changes in 3 of 10 patients (30%). Guitton and Ring could not reliably evaluate long-term arthritis because of short and heterogeneous follow-up. Baker et al. discussed the risk of progressive arthritic change but did not provide a specific arthritis incidence.

Risk of Bias Assessment

Risk of bias was assessed as low in four studies and moderate in one study. The main sources of methodological concern were small sample sizes, observational study designs, heterogeneous selection criteria, absence of randomized or matched operative control groups, and inconsistent follow-up duration. Guitton and Ring had the greatest limitations because of its very small sample size, case-report structure, and heterogeneous follow-up. Despite these limitations, the included studies were generally consistent in showing that

selected stable terrible triad injuries can achieve acceptable outcomes with nonoperative care when strict stability criteria and close follow-up are applied.

Interpretation of Stability and Delayed Surgery

Elbow stability is the central concern in deciding whether a terrible triad injury can be treated without surgery. The included studies consistently required either radiographic concentric reduction, clinical stability, or both before conservative care was continued. Chan et al. used particularly strict criteria, including concentric joint reduction, no radial head mechanical block, a small Regan-Morrey type I or II coronoid fracture, and a stable arc of motion to at least 30° of extension.[7] Najd Mazhar et al. similarly required a congruent joint, no intra-articular fragments, no active rotation block up to 60°, and stability to at least 45° of extension.[8] These criteria reflect the practical clinical question: not simply whether the injury contains three components, but whether the reduced elbow behaves as a stable joint.

Delayed surgery remained an important issue. Factor et al. reported delayed surgery in 13% of patients, Chan et al. reported one patient requiring early surgical stabilization after recurrent subluxation, and Guitton and Ring reported one patient requiring surgery for stiffness, ulnar neuropathy, heterotopic ossification, and radial head deformity.[6,7,9] Baker et al. reported no conversion to fixation, but one patient required arthrolysis for stiffness.[9] These findings suggest that nonoperative treatment is not equivalent to "no risk." Even in selected patients, early subluxation, stiffness, heterotopic ossification, or symptomatic radial head pathology may later require intervention.

The timing and nature of these failures are clinically relevant. Recurrent subluxation appears to occur early, usually within the initial post-reduction surveillance period, while stiffness, heterotopic ossification, or mechanical symptoms may become evident later. This supports the use of close early radiographic monitoring, especially during the first several weeks after injury, when fracture displacement or subtle instability may still declare itself.[7,8]

Range of Motion and Functional Recovery

Flexion-extension recovery was generally favorable. Most studies reported final mean flexion of approximately 128° to 134°, with modest extension deficits of around 6° to 11°. These values fall within or close to the functional range required for most activities of daily living, commonly cited as approximately 30° to 130° of elbow flexion-extension.[1,9] This is clinically important because the traditional argument for surgery is that stable fixation permits early motion and avoids stiffness. In selected stable injuries, nonoperative protocols using brief immobilization and early protected rehabilitation may achieve a similar goal without exposing the patient to surgical morbidity.

Forearm rotation, however, was more variable. Chan et al., Baker et al., and Factor et al. reported generally preserved pronation and supination, whereas Najd Mazhar et al. reported substantially lower rotational recovery, with mean supination of 58° and pronation of 53°.[8–10] This difference may reflect variation

in fracture morphology, rehabilitation protocol, patient selection, or the degree of radial head involvement. Since the radial head is central to forearm rotation and radiocapitellar mechanics, even a stable ulnohumeral joint may not guarantee normal pronation-supination if the radial head fracture heals with deformity, incongruity, or impingement.

Functional scores were generally encouraging. Chan et al. and Najd Mazhar et al. reported excellent mean MEPI scores of 94 and 95, respectively, while Factor et al. reported excellent or good MEPS outcomes in most patients.[8,10] Baker et al. reported a favorable long-term Oxford Elbow Score, and Guitton and Ring observed good or excellent recovery in three of four patients.[9] These results suggest that patients can tolerate some residual radiographic abnormality or minor mechanical symptoms if elbow congruency, stability, and functional motion are preserved.

Radiographic Findings and Post-traumatic Arthritis

Radiographic abnormalities were common but not always clinically decisive. Mild post-traumatic degenerative changes were reported by Factor et al., Chan et al., and Najd Mazhar et al., usually classified as Broberg-Morrey grade 1 and not requiring treatment. Coronoid fibrous union or nonunion was also reported in several studies, yet many of these patients remained asymptomatic. These findings suggest that radiographic healing and clinical recovery may not perfectly align in this injury pattern.

Nevertheless, the risk of post-traumatic arthritis should not be minimized. Terrible triad injuries disrupt both osseous and soft-tissue stabilizers, and even subtle residual incongruity may increase long-term joint loading. Earlier literature on operative terrible triad injuries also reported arthritis as a frequent long-term concern, indicating that degenerative change may be related to the initial injury severity as much as the treatment strategy itself.[15] The current evidence for nonoperative care remains limited by relatively small cohorts and variable follow-up, so the true long-term incidence of arthritis after conservative treatment remains uncertain.

Comparison With Operative Management

Operative management remains the standard of care for most terrible triad injuries because many are unstable after reduction. Contemporary surgical principles emphasize restoration of the radial head, coronoid, and lateral collateral ligament complex to create a stable elbow that allows early motion.[11,14] However, surgery also introduces specific risks, including stiffness, heterotopic ossification, nerve symptoms, infection, hardware problems, and reoperation.[4,5] For selected stable injuries, the potential advantage of nonoperative treatment is avoidance of these surgical risks while still preserving functional recovery.

The available evidence does not allow direct superiority claims. None of the included studies was a randomized trial, and most lacked a matched operative comparator. Moreover, patients selected for nonoperative care likely had more stable injury patterns than those treated surgically. Therefore, good outcomes after nonoperative care should not be interpreted as proof that conservative treatment is equivalent to surgery for all terrible triad injuries.

Instead, the evidence supports a selective decision pathway: surgery remains appropriate for unstable, incongruent, blocked, or progressively subluxating elbows, while nonoperative care may be considered when strict stability criteria are met.

Clinical Implications

The clinical implication of this review is that treatment decisions should be made after reduction, not solely from the initial injury label. A terrible triad injury that appears severe on presentation may behave differently after closed reduction. If post-reduction radiographs and CT demonstrate concentric ulnohumeral and radiocapitellar alignment, if the radial head fracture does not block rotation, if the coronoid fracture is small or stable, and if the elbow permits early protected motion without subluxation, nonoperative treatment may be a defensible option.

However, nonoperative treatment should be active rather than passive. The successful protocols in the included studies used early follow-up, repeated radiographs, protected range of motion, and progressive rehabilitation. This is distinct from prolonged immobilization, which could worsen stiffness and compromise outcome. Patients should also be counseled clearly that delayed surgery may still be required if instability, fracture displacement, stiffness, heterotopic ossification, or disabling mechanical symptoms develop.

A practical candidate for nonoperative treatment would be an adult patient with a closed terrible triad injury, successful closed reduction, concentric joint alignment on radiographs and preferably CT, no mechanical block, preserved neurovascular status, stable early range of motion, and the ability to comply with close follow-up and rehabilitation. In contrast, persistent subluxation, incongruent reduction, mechanical block, large displaced coronoid fracture, unstable radial head fracture, progressive displacement, or inability to attend follow-up should lower the threshold for surgery.

Strengths and Limitations of the Evidence

This review synthesizes all available clinical studies specifically addressing nonoperative management of terrible triad elbow injuries. The included studies consistently reported clinically relevant outcomes, including stability, delayed surgery, range of motion, functional scores, complications, and radiographic findings. This allows a focused evaluation of a treatment pathway that remains uncommon but increasingly discussed.

The limitations are substantial. The evidence base consists only of small observational studies and case series, with no randomized trials or robust comparative cohorts. Selection bias is unavoidable because only the most stable or surgically unsuitable patients were treated nonoperatively. Follow-up duration varied widely, and outcome measures were inconsistent across studies. Some studies used MEPI or MEPS, others used DASH or Oxford Elbow Score, and pain was not uniformly reported. Radiographic assessment of arthritis was also inconsistent, and longer follow-up is needed to determine whether mild

early degenerative change progresses over time. These limitations prevent quantitative pooling and require cautious interpretation.

DISCUSSION

Terrible triad injury of the elbow remains one of the most challenging injuries in orthopedic trauma due to the combination of osseous and ligamentous disruption that compromises elbow stability. Historically associated with poor clinical outcomes, advances in surgical techniques, fixation methods, and rehabilitation protocols have significantly improved patient prognosis. The findings of this systematic review demonstrate that contemporary management strategies generally result in satisfactory functional outcomes, although complications and reoperations remain relatively common.

The reviewed studies consistently emphasize the importance of restoring elbow stability through a comprehensive approach that addresses all injured structures. Surgical treatment typically includes fixation or replacement of the radial head, repair of the lateral collateral ligament complex, management of coronoid fractures when indicated, and assessment of residual instability requiring additional procedures such as medial collateral ligament repair or external fixation. This comprehensive strategy aligns with current biomechanical understanding of elbow stability, where both bony and soft-tissue structures contribute synergistically to joint function.

A major finding across the literature is the critical role of the radial head in maintaining valgus and longitudinal stability of the elbow. Preservation through open reduction and internal fixation is preferred when feasible; however, radial head arthroplasty has demonstrated favorable outcomes in comminuted fractures not amenable to reconstruction. Several studies reported comparable or superior stability with arthroplasty in complex fracture patterns, highlighting the importance of individualized treatment selection based on fracture characteristics.

Coronoid process fractures also play a significant role in determining elbow stability. While small coronoid fragments may not always require fixation if stability is restored after addressing other structures, larger fractures involving the anteromedial facet often necessitate direct fixation. The reviewed evidence suggests that surgical decision-making should be guided by residual instability rather than fracture size alone, reflecting a shift toward functional rather than purely anatomical treatment algorithms.

Despite improvements in treatment, complications remain a significant concern. The most commonly reported complications include elbow stiffness, heterotopic ossification, post-traumatic arthritis, ulnar neuropathy, instability, and hardware-related problems. Elbow stiffness was particularly prevalent, emphasizing the need for stable fixation that permits early mobilization. Early rehabilitation has been repeatedly identified as a key factor in achieving favorable functional outcomes and minimizing long-term loss of motion.

Another important observation is the variability in reported outcomes among studies. Differences in injury severity, surgical techniques, rehabilitation protocols, and outcome measures contribute to heterogeneity within the literature. Most studies utilized functional assessment tools such as the Mayo Elbow

Performance Score (MEPS), Disabilities of the Arm, Shoulder and Hand (DASH) score, and range-of-motion measurements, making direct comparison challenging. Nevertheless, the overall trend suggests that modern treatment protocols achieve good-to-excellent functional results in the majority of patients.

This systematic review also highlights several limitations within the current body of evidence. Most available studies are retrospective case series with relatively small sample sizes and limited follow-up durations. High-quality randomized controlled trials are scarce, largely due to the rarity and complexity of the injury. Consequently, definitive conclusions regarding the superiority of specific surgical techniques remain difficult to establish. Future multicenter prospective studies with standardized outcome measures are needed to strengthen the evidence base and optimize treatment algorithms.

Overall, the findings of this review support the contemporary multidisciplinary approach to terrible triad injuries, emphasizing anatomical restoration, stable fixation, ligamentous repair, and early mobilization. While substantial progress has been achieved in the management of these injuries, continued research is necessary to further reduce complications, improve functional recovery, and establish evidence-based treatment guidelines for diverse injury patterns.

CONCLUSIONS AND RECOMMENDATIONS

Nonoperative management may be a viable option for carefully selected adult patients with stable terrible triad injuries of the elbow after closed reduction. Across the available evidence, acceptable outcomes were most consistently observed when the elbow demonstrated concentric ulnohumeral and radiocapitellar alignment, no mechanical block to motion, preserved early stability through a functional arc, and the ability to undergo close clinical and radiographic follow-up. Most patients achieved functional range of motion, favorable functional scores, and low residual pain or disability. However, conservative treatment should not be generalized to all terrible triad injuries. Delayed surgery, recurrent subluxation, stiffness, mechanical clicking, heterotopic ossification, rotational limitation, coronoid fibrous union or nonunion, and mild post-traumatic arthritis were reported across studies. Therefore, nonoperative treatment should be considered a selective, surveillance-dependent strategy rather than a replacement for operative stabilization in unstable or incongruent injuries. Future prospective multicenter studies are needed to define reproducible stability criteria, standardize rehabilitation protocols, and clarify long-term degenerative outcomes**.**

FURTHER STUDY

The current evidence suggests that nonoperative management may be a feasible treatment option for carefully selected patients with terrible triad injuries of the elbow; however, the available literature remains limited by small sample sizes, retrospective study designs, heterogeneous patient selection criteria, and inconsistent outcome reporting. Therefore, several areas warrant further investigation.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to all researchers and clinicians whose published work contributed to this systematic review. Their efforts in advancing the understanding and management of terrible triad injuries of the elbow provided the foundation for this study.

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