SCIENTIFIC CULTURE
www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 11, No. 4, (2025), pp.3597-3606
Open Access. Online & Print

DOI: 10.5281/zenodo. 1425185

COMPARATIVE OUTCOMES OF LATERAL VERSUS COMBINED LATERAL–ANTEROMEDIAL APPROACHES IN THE SURGICAL MANAGEMENT OF TERRIBLE TRIAD ELBOW INJURIES: A PROSPECTIVE COHORT STUDY

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Received: 09/02/2025
Accepted: 10/09/2025

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Abstract

Introduction: The terrible triad is frequently observed in accidents with great force, like vehicle crashes or falls from heights, and is frequently related to collateral ligament injuries. We aimed to compare the efficiency of the lateral approach versus the combination of lateral and anteromedial approaches in managing these patients.

Methodology: Prospective cohort research has been conducted at Al-Zahraa University Hospital and Mataria Teaching Hospital between 2023 and 2025. We involved cases aged 18-60 years old with a terrible triad injury of the elbow, either open or closed fractures. The primary outcome was the functional outcomes evaluated via the Mayo Elbow Performance Score, while the 2[ry] outcomes were the range of motion, pain score, and complication rates. An independent t-test has been applied to compare the two approaches.

Results: 20 patients were enrolled, 12 in the combination approach, and 8 were in the lateral group. The mean age was 30.05 ± 12.93, and 12 were males (7 in the combination, and 5 in the lateral approach). A statistically insignificant variance was observed among the two approaches in achieving functional outcome (t-test: 0.438, p-value: 0.666). Also, no difference was found in the range of motion or pain score.

Conclusion: our results revealed comparative results of both approaches in managing cases with terrible triad injury of the elbow, which suggests using either approach would reveal significant results.

Keywords: terrible triad injury of the elbow, surgical management, lateral approach, combined lateral and anteromedial approach.

INTRODUCTION

The elbow joint is one of the most inherently stable joints in the body. It completes the sphere of motion offered via the shoulder, permitting the hand to be situated in a wide variety of locations. It derives its stability from soft tissue and bony components. The arrangement of its three joints together, ulno-humeral, radio-capitellar, and proximal radio-ulnar joints, produces the two main arcs of motion in a unique way of balance with stability (1, 2).

The elbow ranks as the 2nd most frequently displaced main joint among adults. The frequency of dislocation is 6 per 100,000 individuals over their lives. Dislocations account for between ten and twenty percent of all elbow injuries. The mean age of an individual receiving this injury is thirty years old. The incidence in males is 2 to 2.5 times greater than that in females. Around forty percent of elbow dislocations exhibit a poorly characterized mechanism of injury (3).

Elbow fracture-dislocations are among the most challenging injuries to treat. It needs a considerable time to build experience and comfort with elbow examination and anatomy. Orthopaedic surgeons face elbow pathology less frequently than conditions affecting other anatomical locations such as the hip or knee. (4).

Usually, the combination of elbow displacement, a radial head or neck fracture, and coronoid process fracture has shown consistently unfavorable outcomes; thus, Hotchkiss termed it the "terrible triad."(5)

The terrible triad frequently occurs in high-impact incidents, like vehicle crashes or falls from elevations, and is typically related to collateral ligament damage. The injuries render the elbow unstable, necessitating surgical surgery. However, because of the complexity of injury, results have traditionally been poor, with long-term complications (6, 7).

Recent work has enhanced our comprehension of elbow biomechanics and the patho-anatomy of the TTI, facilitating the progress of a systematic method for rehabilitation and treatment. Advances in knowledge, along with enhanced surgical and implants methodologies, has resulted in superior results. The selection of surgical method, fixation strategy, and necessity for MCL repair are determinants that affect the comprehensive management of these intricate injuries.(5)

A number of investigations have been conducted comparing the lateral method with combined medio-lateral techniques. Despite the small sample size and methodological quality, these investigations indicated that the combined lateral and medial approaches resulted in greater elbow range of motion, enhanced forearm rotation, and improved performance of elbow. Nonetheless, utilizing the lateral technique significantly reduces operation duration, hemorrhage, and wound recovery time.(8)

Management now is codified as an emergency reduction followed by surgical repair of lateral compartment and radial head reconstruction by internal fixation. Efforts must be made to conserve the radial head; if unsuccessful, radial head arthroplasty should be conducted. Stability must be assessed post-reconstruction. If the elbow still unstable during the operation, the medial collateral ligament should be repaired, and an adynamic external fixator should be added if instability continues. (9)

The combined surgical methods should be considered for treating of cases with medial collateral ligament injuries and unstable coronoid process fractures that must be fixed. (10)

In spite of the difficulty of treating these injuries and the elevated rates of complications, recent studies showed improved outcomes when systematized surgical treatment is followed. According to primary result measures (range of motion, function, stability, and pain), nearly all investigations have reported favorable or excellent functional results. (11). The objective of this research is to assess clinical, radiographic, and functional outcomes and assessment of postoperative recovery, rehabilitation, stability, and complications of using the lateral approach versus using both the lateral and antero-medial approaches in the surgical management of terrible triad injury of the elbow

METHODOLOGY

Prospective cohort research over a period of 18-24 months on cases with terrible triad injury of the elbow. All the procedures were performed at Al-Zahraa University Hospital and Mataria Teaching Hospital. Ethical approval has been gathered from the Institutional Review Board of Al-Azhar University for Girls. We followed the STROBE guidelines for reporting the findings (12).

Eligibility criteria

We included patients aged 18-60 years old with a terrible triad injury of the elbow, either open or closed fractures. We excluded patients with post-traumatic infection, paralytic or malignant condition, previous attempt of fixation, or neglected cases of malunion or nonunion.

All patients were assigned to either combined lateral and anteromedial fixation or lateral fixation alone.

Preoperative evaluation

All patients had X-ray pre-operatively, either anteroposterior or lateral views. Patients were assigned to general or regional anesthesia while lying supine with the injured upper limb placed

perpendicular to the case's body on a side table. Preoperative testing for elbow instability was done clinically and radiologically under image intensifier to evaluate collateral ligaments and rotational stability. A well-padded tourniquet has been applied to the arm, and the skin was marked for surgical approaches. See Figure 1

Figure 1: Preoperative preparation. A) Showing clinical and radiological testing for instability. B) Showing skin marking for anteromedial and lateral approaches.

Figure 1: Preoperative preparation. A) Showing clinical and radiological testing for instability. B) Showing skin marking for anteromedial and lateral approaches.

Surgical technique

Surgical repair and fixation strategy were done from deep to superficial. In the lateral approach coronoid fracture was the first to be addressed and fixed, if possible, followed by replacement or fixation of the radial head, then repair of the anterior capsular tear, & ended by repair of the LCL complex. Type I coronoid fractures may not need repair.

If the size of the radial head fragment is fewer than twenty-five percent of the radial head, fragment excision may be considered. Neck osteotomy is performed in anticipation of radial head replacement. Radial head excision is not a viable strategy in the treatment of TTI. (13). See figure 2

The Lateral Approach:

Through the lateral approach, the elbow was irrigated and cleaned of hematoma. Any loose fragments were removed. Assessment of bony and soft elements has been carried out from superficial to deep, starting from the lateral soft

tissues and ending with the coronoid. Surgical repair and stabilization done out from deep to superficial structures.

Typically, the LCL complex with the common extensor origin were avulsed off the lateral epicondyle and didn't requirement separation but rather were repaired as one mass. This coincided with the bare lateral epicondyle sign. The capsulotomy and annular incision were performed anterior to the LUCL to avoid its injury. Annular incision was tagged by hanging sutures for easier later on repair.

Coronoid Fixation:

The coronoid injury was the first to be addressed and fixed if it was fixable through a lateral approach; otherwise, we fixed it through an anteromedial approach.

With cases undergoing radial head arthroplasty, it was easier to deal with the coronoid fracture through the lateral approach (better visualised and easier accessed) in contrast to cases requiring fixation. Some tricks were used to facilitate exposure of the coronoid from a lateral approach, as loose fragments of the radial head were temporarily removed from the field, and the elbow could be subluxed postero-laterally to deliver the coronoid into the field.

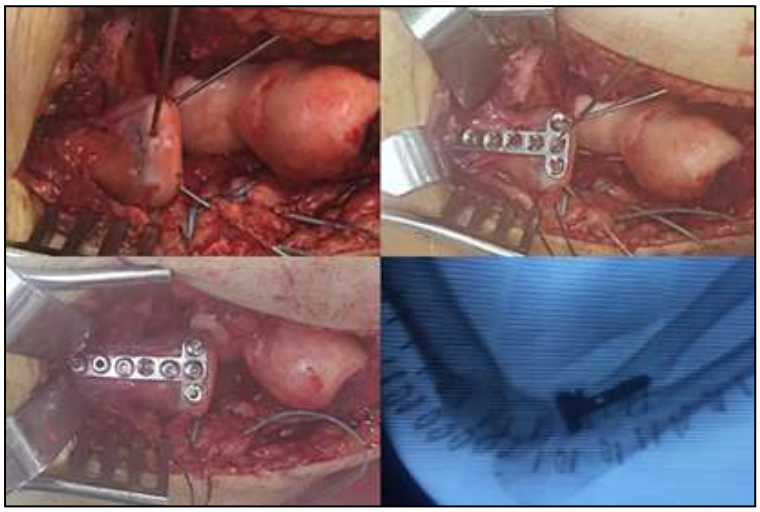

Figure 3: Intraoperative photographs and fluoroscopic image showing steps of reduction and fixation of radial head fractures by mini plate and screws.

Figure 4: Intraoperative photographs and fluoroscopic image showing replacement of a comminuted radial head fracture by a radial head prosthesis

In cases that had repaired by sutures, the manoeuvre was accomplished by locking non-absorbable sutures (Ethibond or FiberWire sutures) passed within the anterior capsule, then encircling the coronoid fragment (if small) or passing through drill holes in the fragment if large enough.

2 drill holes within the fracture bed (one medial and one lateral) were done in a retrograde manner from the dorsal border of ulna (at least one cm. apart) through a small dorsal incision on the proximal forearm. Sutures were retrieved through the fracture bed by a surgical loop made of Prolene suture, which was introduced through the bone tunnels by a cannula. Tying of sutures was postponed till the end of the procedure. This step was done with freehand technique and sometimes with the aid of a targeting guide

In cases that had planned to be repaired by screws, the coronoid fragment was secured in the optimum reduction position, and provisional fixation was attained with small-diameter Kirschner wires. Then, the screws were directed anteroposteriorly or posteroanteriorly, according to the facility of fixation and the size of the fragment. The hardware used was cannulated headless compression screws or partially threaded countersunk lag screws to achieve the best degree of stable fixation. See Figure 3

Radial Head Fixation:

The next step was addressing the radial head fracture. With the fixation decision, the articular surface was reduced under direct visualization, and provisional fixation was attained with small-diameter Kirschner wires.

Headless screws, countersunk mini screws, or plates were utilized. Hardware was then placed at the safe zone, which was defined by an approximately 90–110° arc on the lateral part of the radial head/neck between the perpendicular axes through the radial styloid and Lister's tubercle. With the use of screws outside the safe zone of the radial head, burial under cartilage was confirmed. With distal dissection for the use of plates, pronation of the forearm was applied to move the PIN medially and away from the operative field. Care was given to the length of the used screws. Finally, fixation was checked clinically and radiologically. See Figure 4

Radial Head Replacement:

With radial head replacement, the residual head was resected at the metaphyseal flare with preservation of the radial neck as much as possible. Aggregation of the excised fragments and comparison to the present radial head prostheses were done to obtain the ideal size.

Under direct visualization, the articular surface of prothesis was confirmed flush with the proximal border of the lesser sigmoid notch. The lateral ulno-humeral joint was inspected for any gapping. The elbow ROM was evaluated. Fluoroscopic imaging was then gathered for ensuring apposite sizing. Prior to the placement of the prosthesis, an ongoing locking non-absorbable suture had been passed through the LCL complex and the posterolateral capsule. The isometric point on the lateral epicondyle was located at the midpoint of the capitellum arc using a Kirschner wire under imaging guidance. The concluding stage involved applying tension to all sutures, beginning with the coronoid followed by the lateral collateral ligament complex. The sutures were tightened while the elbow was concentrically positioned at ninety degree flexion and in complete forearm supination. Complete supination was utilized to prevent gapping of the medial ulnohumeral joint. The annular ligament and the common extensor layer were subsequently reconstructed in a side-to-side manner, closing the Kocher interval utilizing absorbable sutures (Vicryl).

The Anteromedial Approach:

After closure of the lateral approach, the congruency and stability of the elbow with examining ROM and valgus stress was evaluated clinically and fluoroscopically. In cases with persistent medial instability (MCL injury) or not fixable fracture of the coronoid from a deep lateral approach, a combination of the medial approach was carried out to repair the MCL and medial structures. Through the anteromedial approach, ulnar nerve exploration and anterior transposition was done, coronoid fracture was fixed by antero-posterior screws or trans osseous non-absorbable sutures. MCL injury was repaired by anchor sutures in 5 cases, and by trans osseous sutures in 3 cases, while it was intact in 4 cases. The direct anterior approach was used in 2 cases from the 12 cases included in the combined approach group to explore the anterior neuro-vascular bundle and repair the anterior capsular tear. After repair and before closing the wound, the elbow was examined clinically and fluoroscopically for stability and a safe range of motion and forearm rotation. In cases with a stable elbow and an accepted range of motion and forearm rotation, skin and subcutaneous closure were done, and a posterior slab was applied.

Follow-up: All patients were followed 1, 2,4,6, and 8 weeks postoperatively, and after 6 months postoperatively.

Outcomes:

The primary outcome was the functional outcome assessed via the Mayo Elbow Performance Score (MEPS) (14). This score evaluates pain, ulno-humeral mobility, stability, and the capacity to execute five functional tasks. The overall score varies from 5 to 100, with an elevated number signifying better

results. A total score ranging from 90 to 100 points is deemed exceptional; 75 to 89 points is classified as good; 60 to 74 points is regarded as fair; and below 60 points is deemed poor.
The secondary outcomes included pain assessment via the Visual analogue score (VAS) (15) and range of motion (ROM) of the ulno-humeral motion.

Statistical analysis

Information was summarized via frequency and percentage for categorical information, and mean ± SD for continuous information. An independent t-test was performed to compare the functional outcomes among both groups. The analysis was conducted in SPSS version 27.

RESULTS

20 cases have been involved in the research, of which 12 were in the combination group (lateral and anteromedial approach), and the other 8 were in the lateral approach only. The mean age of the cases was 30.05 ± 12.93. and 7 were male in the combination group, while 5 were males in the lateral approach group. Most patients were type II in the coronoid fracture classification (6 cases) in the combination group, and half of the lateral approach group were in Type I. See Tables 1and 2.
40% of the patients (8 patients) had the trauma due to a fall to the ground, while 4 patients had a motorbike accident. 13 patients had isolated terrible triad injury, 5 had concomitant fracture in the same limb, and the other two had concomitant other fractures. The treatment option was ORIF in 11 patients, while 7 patients had radial head prothesis, and the other 2 had fragment excision. See Table 2.

Table 1: Baseline characteristics of the involved patients

	combined lateral and anteromedial (CLAM) (Group I)	lateral approach (LA) only (Group II)
Patients number	12	8
Sex: Male/Female	7/5	5/3
Radial head fracture classification	I:II: III=0:7:5	I:II: III=1:3:3 Neck # =1
Coronoid fracture classification	I:II: III=5:6:1	I:II: III=4:3:1

Table 2: Continue baseline data

Variable	**Number**	**Percentage**
Age	39.05 ± 12.93	
Mode of trauma		
Road traffic accident	2	10%
Motorbike accident	4	20%
Fall to the ground	8	40%
Fall from height	3	15%
Falling downstairs	3	15%
Distribution of concomitant injuries		
Isolated terrible triad injury	13	65%
Concomitant same limb fractures	5	25%
Concomitant other fractures	2	10%
Distribution of coronoid fractures according to O'Driscoll classification		
Tip < 2 mm	9	45%
Tip > 2 mm	8	40%

Anteromedial facet	3	15%
Distribution of radial head treatment options		
ORIF	11	55%
Radial Head Prothesis	7	35%
Fragment excision	2	10%

Outcomes

Time of Union

The mean time of union of fractures treated by internal fixation was 2.3 months (range from 6 weeks to 3 months). Only one patient presented with coronoid fracture nonunion after 6 months of follow-up and need revision of fixation.

Functional Outcome

Post-operatively, most of the patients' elbows (85%) were stable with acceptable functional ROM and pain score. The severity of the coronoid and radial head fractures had no impact on the functional outcomes. For all patients after surgery, the flexion-extension arc mean was 104.75°, the supination-pronation arc mean was 137.75°, and the MEPS mean was 83.96, with 80% excellent and good results score and the mean of VAS for pain was 2.1. See Table 3

Table 3: study outcomes

	EFA°	SPA°	MEPS	VAS
Group I (CLAM Group)				
Mean	106.25	138.75	85.42	1.92
SD	±21.76	±18.11	±13.05	±1.83
Group II (LA Group)				
Mean	102.50	136.25	82.50	2.38
SD	±26.59	±19.59	±16.69	±2.26
T test	0.346	0.239	0.438	-0.48
P value	0.733	0.773	0.666	0.64

SPA: degree of supination-pronation arc, EEA: degree of flexion-extension arc

Range of Motion;

In the CLAM approach, patients (Group I), the results were registered as: The mean ± standard deviation arc of flexion-extension was 106.25° ± 21.76° and the arc of forearm rotation was 138.75° ± 18.11°.

In the LA approach, patients (Group II), the results were registered as: The mean ± standard deviation arc of flexion-extension was 102.50° ± 26.59° and the arc of forearm rotation was 136.25° ± 19.59°. See Table 3.

Visual Analogue Score (VAS) for Pain;

The postoperative Visual Analogue Score for Pain was lower in patients treated with the combined lateral and anteromedial approach (Group I) than in those managed with the lateral approach only (Group II). The mean ± SD VAS results were 1.92 ± 1.83 in Group I, compared to 2.38 ± 2.26 in Group II. The results weren't statistically significant among both groups (t-test: -0.48, p-value: 0.64)

Functional Activity:

The postoperative functional activity was followed up clinically utilizing the Mayo elbow performance scale (MEPS). The overall functional activity outcomes were excellent and good in 80% of cases, while they were fair and poor in 20% of patients.

Comparing both groups, the functional activity results were better in group I than in group II. The outcomes were registered as follows: In the CLAM approach, patients (Group I), the mean ± SD of MEPS was 85.42 ± 13.05 points. Excellent and good results were observed in 10 elbows (83.3%), fair results in 1 case, and poor results in 1 case. In the LA approach, patients (Group II), the mean ± SD of MEPS was 82.50 ± 16.69 points. Excellent and good results were noticed in 6 elbows (75%), fair results in one case, and poor results in one patient. The results weren't statistically significant among both groups (t-test: 0.438, p-value: 0.666)

Complication

In the CLAM approach, the patients' complication rate was 41.7% (5 cases). Stiffness, heterotopic ossification, ulnar neuropathy, and signs of post-traumatic arthritis were more noticeable (2 cases each). Non-union was noticed in one patient, and postoperative instability in one patient. Revision surgery was done for 2 cases.

In the LA approach patients' complication rate was 37.5% (3 cases). Post-operative instability and post-traumatic arthritis were more commonly noticed (2 cases each), and recurrent dislocation was noticed in one patient. Revision surgeries were done for 2 cases

Discussion

In this research, twenty cases with terrible triad injury. The mean age of all patients was 39.05 with SD ±12.93 years, with male patients more prevalent (60%) than females (40%), and falling on the ground was the most common mode of trauma (40%) (low-energy trauma). Also, the non-dominant side is the most affected (65%).

Patients were grouped according to the approach used in their management into two groups. Group I, including 12 patients (60% of cases), was managed by a combination of both lateral and anteromedial (CLAM) approaches, and group II, including 8 patients (40% of cases), was managed through the lateral (LA) approach only. All cases were managed and monitored over a period of 18 – 24 months.

In all cases, soft tissue and bony injuries associated with the terrible triad elbow were fixed by the most suitable manner and approach according to the algorithm of surgical treatment of TTI of the elbow.

Considering the coronoid fractures, Regan-Morrey type I and II consist of 90% of cases (45% for each), and with regard to O'Driscoll classification, tip fracture type represents most cases (85%). With regard to Mason's classification for radial head fractures, type II was the most common (45%) followed by type III (40%). The LCL complex has been injured in all patients, while the MCL was injured and needed to be repaired in only 8 patients (40%).

Coronoid fracture was fixed in 17 cases (85% of cases), 10 of them were fixed through an anteromedial approach, while 7 were fixed through a lateral approach (Table 4,5). Anterior capsular tears have been repaired in all cases with sutures. Radial head fracture was fixed in 11 cases (55%); 6 with plates and 5 with screws, while replacement by radial head arthroplasty was done for 7 cases (35%). Two cases (with small fragment fractures) underwent for just fragment excision.

LCL complex injury was repaired in all cases; mainly by anchor sutures in 15 cases (75%), and by trans osseous sutures in 5 cases (25%). MCL was repaired in 8 patients (40%) through an anteromedial approach, as the MCL is a important structure in valgus stability of the elbow.

According to our study, the most common technique of radial head treatment was by ORIF, followed by prosthesis. Functional outcomes of both techniques were similar. No role for radial head excision in TTI management.

Cases with fixable coronoid fractures have been fixed by either screws or trans-osseous sutures nearly in the same ratio. Follow up of cases fixed by trans-osseous sutures showed better functional results than cases fixed with screws with greater ROM and higher score by MEPS. The LCL had been routinely repaired throughout our study as a basic necessary step, either by anchors or trans-osseous sutures. The MCL had been acutely repaired in all elbows, which showed intraoperative valgus instability following repair of the lateral structures. Others(16, 17) had generally repaired the MCL only when there was recurrent instability following repair of other structures.

Many studies discussed the management of TTI and its results. We are going to present some of their results and compare them with our study to conclude the best way for the management of this terrible injury.

Sanjay Meena and his colleagues (8) analyzed 4 studies involving 470 cases with TTI of the elbow in a systematic review, with the mean monitoring following surgery of twenty-four to thirty months. Cases have been separated into 2 groups: the combined lateral and anteromedial approach group and the lateral approach group.

Their analysis demonstrated significant more range of elbow motion, forearm rotation and MEPS in the combined approach group as compared to the lateral approach group. While operative time, blood loss, and overall complications were more in the CML group; nevertheless, the variance wasn't significant.

In another recent retrospective study, 50 cases (19 female, 31 male) with TTI operated on via an isolated lateral approach (31 cases with -MCL injury) or combined medial-lateral approach (19 cases with +MCL injury). Clinical assessment comprised MEPS, flexion-extension, and pronation-supination, and complications. Mean monitoring was twenty-four months.

For the combined approach (+MCL) group, the mean MEPS, flexion-extension, and pronation-supination at the last monitoring was 93.8 (70-100) points, 120° (80°-140°) and 151° (50°-170°), respectively, with total late complications noticed in 4 patients (21%), 3 of them underwent revision surgery. For the lateral approach (-MCL) group, the mean MEPS, flexion-extension, and pronation-supination at the last monitoring was

86.2 (55-100) points, 110° (70°-135°), 129° (0°-170°) respectively, with total late complications noticed in 11 patients (35%), 10 of them underwent revision surgery.(18)

Ikemoto and colleagues (19) retrospectively evaluated 20 patients with 21 elbows with triad elbow injuries. 15 elbows were treated by lateral approach, 5 elbows were treated by combined lateral and medial approach and one elbow was treated through posterior approach. The post-operative functional results for the lateral approach group were better than the results for the combined approach group. For the lateral approach group, the averages of flexion-extension, pronation-supination arcs, and MEPS were 109° (60°-140°), 119° (0°-180°), and 85 (80-100) points, respectively. While for the combined mediolateral approach group, the averages of flexion-extension, pronation-supination arcs, and MEPS were 83° (20°-135°), 98° (60°-140°), and 77 (60-100) points, respectively. Considering the complication, post-operative instability was noticed more in the lateral group (27% of cases) compared to 20% in the combined mediolateral group.

Liu et al (10) in a retrospective study evaluated data from 22 cases (fifteen men, seven women; mean ± standard deviation age, 47.5 ± 11.4 years) with terrible triad elbow injuries with anteromedial coronoid fracture, four of them have MCL injuries. All patients had surgical intervention that comprised radial head repair or replacement, repair of the medial and lateral collateral ligaments, and fixation of coronoid fractures using combined lateral and anteromedial techniques. The mean monitoring duration was 31.6 ± 11.9 months. The mean ± standard deviation arc of flexion–extension was 110.3° ± 26.3°, while the arc of forearm rotation was 139.5° ± 17.1°. The mean ± standard deviation of the MEPS was 88.1 ± 12.2 points, yielding excellent and good outcomes in eighteen elbows. Of the complications seen, four individuals exhibited heterotopic ossification (eighteen percent), three cases had secondary procedures (fourteen percent), and six cases presented radiographic indications of post-traumatic arthrosis classified as type I and II.

In another series, 19 patients with TTI with a mean age of 48 years, were operated through lateral Kocher approach. The final functional outcome has been evaluated by ROM and MEPS. The final flexion-extension arc mean ± SD was 112° ± 28°. In relation to pronation-supination, the final mean ± SD was 127.9° ± 48°. The mean MEPS was 86 points, with 15 patients having excellent and good outcomes. Regarding complications, 5 patients (26%) had complications, three of whom were related to peripheral nerves.(20)

The data collected from our study and other comparable studies (8, 10, 18-20) indicated that the best outcomes happen when patients are treated by combined lateral and anteromedial approaches in cases with MCL injury, and there is intraoperative valgus instability. The management plan should comprise fixation of the coronoid fracture, repair of the capsular tear, either replacement or fixation of the radial head, and primary restoration of the injured LCL and MCL.

Limitations

Numerous limitations appeared in the research. First, the sample size is relatively small, limiting the generalizability of the results. Also, the type of study, being a cohort, increases the selection bias of the patients. Finally, the relatively short follow-up time of the study.

CONCLUSION

Our study assessed the effectiveness of a combination of lateral and anteromedial approaches vs the lateral approach in managing the terrible triad injury of the elbow. Our outcomes revealed no difference between the two approaches in achieving functional outcomes or range of motion following the operation.

Statements and Declarations:

Conflict of interest:

No conflict of interest related to this research

Funding:

This research didn't receive any particular grant from funding agencies in the public, commercial, or not-for-profit sectors

Artificial intelligence usage:

The author did not use any artificial intelligence in any step of the study process.

Ethical approval:

Ethical approval has been gathered from the institutional review board (IRB) of Al Zahraa University Hospital, and the study acknowledged the following code: **…..**. We followed the principles of the Declaration of Helsinki (2013 revision).

Consent for participation:

Prior to the initiation of the trial, informed consent has been gathered from each participant. They were apprised of the study's objectives, the procedures entailed, and any associated risks or advantages. Also, they were informed that they could withdraw at any time from the investigation. We adhered to the principles stated in the Declaration of Helsinki (2013 revision).

Consent for publication:

All participants were informed that their operation results would be used for research purposes only, and they agreed to that

Data availability:

All data are provided in the manuscript and its related supplementary material

No acknowledgment in this study

Acknowledgment

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