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The impact of suture fixation on elbow extension and clinical outcomes in coronoid tip fractures in terrible triad injuries

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Abstract

This study aimed to evaluate the effect of coronoid/anterior capsule fixation on long-term clinical and radiological outcomes, complication rates, and the need for revision in patients with type 1 coronoid fractures associated with terrible triad elbow injury (TTEI). We hypothesized that coronoid fixation would not provide significant functional benefits and might lead to increased complication rates, particularly extension limitation due to anterior capsular tightness. A retrospective analysis was conducted on 30 patients (mean age 51 years) who underwent surgical treatment for TTEI with type 1 coronoid fractures between 2012 and 2022. Patients were grouped into those who received coronoid fixation (n=13) and those who did not (n=17). Clinical and radiological outcomes were evaluated using Mayo Elbow Performance Score (MEPS), Quick DASH score, range of motion, and radiographic assessment of joint stability and arthrosis. Complication rates and reoperation requirements were also recorded. There were no significant differences between the groups in demographic or surgical variables. The coronoid fixation group showed a higher mean extension deficit (17°) compared to the non-fixation group (6°) (p=0.006). Complications occurred more frequently in the coronoid fixation group (53%) than in the non-fixation group (35%), although this difference was not statistically significant (p=0.516). Reoperation rates were also higher in the fixation group. Coronoid fixation in type 1 coronoid fractures associated with TTEI did not provide functional advantages and was associated with higher complication and reoperation rates. Extension limitation due to anterior capsular tightness was more common in the fixation group. These findings suggest that routine coronoid fixation may not be necessary for type 1 fractures. Further prospective studies are needed to confirm these results.

Keywords: Terrible triad injury, anterior capsule, elbow instability, dislocation, coronoid process

Introduction

The 'terrible triad' injury (TTEI) of the elbow is a complex injury that accounts for 10% of radial head fractures and approximately 11% of elbow dislocations [1,2]. This injury is characterized by a combination of posterolateral elbow dislocation, radial head fracture, and coronoid fracture [3]. If left untreated, this combination can lead to severe instability, pain, limitation of movement, and long-term post-traumatic osteoarthritis. Therefore, surgical treatment is generally required [3-6].

The primary goal of surgical treatment for TTEI is to restore stability and allow early mobilization. In general, repair or replacement of the radial head with a prosthesis, repair of the lateral collateral ligament (LCL) complex and fixation of the coronoid fracture have been accepted as the standard approach [3,4,6,7]. There is consensus that internal fixation of coronoid fractures involving the base (type 3) or anteromedial facet (type 2) is critical for elbow stability, particularly according to the Regan and Morrey classification [8]. However, the need for fixation in fractures involving only the coronoid tip (type 1) remains controversial [3,4,7,9-11]. In this type of fracture, the medial collateral ligament (MCL) insertion is not involved; fixation to the coronoid tip essentially allows the anterior capsule to be re-tensioned. However, its functional, clinical and radiological benefits are unclear [9-12].

The aim of this study is to investigate the effect of coronoid/

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anterior capsule fixation on long-term cli-nical and radiological outcomes, complication rates, and the need for revision in patients with type 1 coronoid fractures associated with TTEI. We hypothesize that re-fixation of the anterior capsule with this small fragment is unlikely to provide significant additional benefit and may even contribute to extension limitations.

Material and Methods

Patient Selection

Ethical approval for this study was granted by the Baltalimanı Metin Sabancı Bone Diseases Training And Research Hospital review board (number: 33/240, date: 26.02.2025). Patients who underwent consecutive surgical treatment for TTEI in the orthopaedics and traumatology department of our hospital between 2012 and 2022 were retrospectively analyzed. Inclusion criteria were as follows: Surgical treatment within 3 weeks of injury, fracture of the coronoid tip (type 1, according to Regan and Morrey [8] or O'Driscoll [13] classification), follow-up of at least 2 years. Patients with multiple trauma, other fractures in the same extremity, nonoperative treatment and external fixation were excluded.

The study included 36 patients who had terrible triad injury with coronoid type fracture and were operated consecutively. Six patients were lost to follow-up and were not included in the study. Thus, 30 patients (16 females, 14 males; mean age 51 years, range 21 to 84 years) were included. For statistical analysis, two groups were formed as those in which coronoid fixation was performed during surgery (n=13) and those in which it was not (n=17).

Injury Characteristics

The majority of injuries were caused by low-energy falls (22 out of 30 patients, 73%). High-energy sports-related injuries were reported in 5 patients (17%), while 3 patients (10%) sustained injuries from falls from height. Most patients (93%) had an isolated injury to the elbow, with no other associa-ted fractures or trauma. The dominant limb was affected in 14 patients (47%).

Preoperative radiographs and computed tomography (CT) scans were available for all patients to accu-rately assess the injury pattern and plan the surgical approach. One patient presented with a Type 1 open fracture, which was managed according to established guidelines for open fracture care.

Surgical Technique

The mean injury-operation time was 3.9 days (0-13 days). Seven patients underwent emergency surgery on the day of trauma, 23 patients were operated on within a few days after reduction. The lateral approach was used in all patients; in addition, MCL repair was performed via the extended medial approach in 4 patients (13%).

Anterior capsule/coronoid fixation was performed in 13/30 (37%) patients (anchor in 5, suture fixation with a tunnel technique in 8) (Figure 1), but without fixation 17/30 (63%) patients (Figure 2). Radial head fracture was repaired with prosthesis in 17 patients (56%), with plate/screw in 13 patients (44%), and with collateral ligament repair anchor in 25 patients (83%).

Figure 1. Preoperative and postoperative radiographs of a patient who underwent radial head fixation with coronoid suture fixation and ligament repair

Figure 2. Preoperative and postoperative radiographs of a patient who underwent radial head fixation without coronoid suture fixation and ligament repair

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Intraoperatively, the elbow was examined for stability by clinical examination and fluoroscopy before suturing. Clinical stability was demonstrated by concentric reduction of the ulnohumeral joint in the flexion-extension range of 20° to 130° in all patients without coronoid fixation. Reduction was confirmed fluoroscopically with the forearm in pronation, supination and neutral position with the elbow in flexion and extension. No posterior or posterolateral elbow subluxation or dislocation was observed. Postoperatively, all patients were immobilised with a long arm splint for 1 week. Rehabilitation was then performed using the overhead rehabilitation protocol. Strengthening was initiated after adequate bone and ligamentous healing had occurred.

Evaluation

At the last follow-up visit, clinical and radiological outcomes were evaluated, including Mayo Elbow Performance Score (MEPS), Quick DASH score, flexion-extension and pronation-supination angles, radiographic assessment of subluxation or dislocation, alignment of the humeroulnar and humeroradial joint lines, degree of arthrosis according to the Broberg-Morrey classification, and loosening of the radial head prosthesis.

Statistical Analysis

In this study, quantitative variables were defined as mean±SD when normally distributed, otherwise as median [interquartile range]. Qualitative variables are defined as n (%). For between-group comparisons of quantitative variables, Student's test or Analysis of variance (ANOVA) or Wilcoxon or Kruskal-Wallis test was applied. Proportions were compared between groups using the Chi-square test or Fisher exact test. Spearman's method was chosen to calculate correlation coefficients, taking into account the non-normal distribution of the variables in question. Significance was set at 0.05.

Results

There were no statistically significant differences between the coronoid fixation and non-fixation gro-ups in terms of age at the time of surgery, dominant limb involvement, time from injury to surgery, procedure used to treat the radial head fracture (screw, plate, or replacement), and duration of postoperative immobilization. Patient characteristics are summarized in Table 1.

Table 1. Patient characteristics

Parameter	Coronoid fixation (n=13)	No coronoid fixation (n=17)	p-value	
Age (Mean±SD)	52.4±14.3	49.8±13.7	0.614	**n.s.**
Gender (female/male)	7/6	9/8	0.851	**n.s.**
Dominant side involvement (%)	46	47	0.936	**n.s.**
Injury-to-surgery time (days)	4.1±2.6	3.7±2.3	0.743	**n.s.**
Radial head treatment	Prosthesis (54%)-Plate-screw (46%)	Prosthesis (59%)-Plate-screw 41%)	0.782	**n.s.**
Postoperative immobilization (weeks)	1.1±0.3	1.0±0.4	0.587	**n.s.**

n.s.: non significant, S.D: standart deviation

The mean follow-up duration was 74.4 months (range: 27 to 134 months). At the final follow-up vi-sit, the mean Mayo Elbow Performance Score (MEPS) was 78.4 (range: 65 to 100). The mean flexion-extension range was 104.2° (range: 70° to 145°), and the mean pronation-supination range was 152.2° (range: 20° to 180°). The mean extension deficit was 17° (range: 0 to 30°) in the coronoid fixation group, compared to 6° (range: 0 to 20°) in the non-fixation group. There was a statistically significant difference in the range of motion (extension deficit) between the coronoid fixation group and the non-fixation group (p=0.006). Detailed clinical outcomes for both groups are presented in Table 2.

Table 2. Clinical outcomes

Clinical parameter	Coronoid fixation (n=13)	No coronoid fixation (n=17)	p-value
Follow-up duration (Months)	73.2±28.4	75.1±27.6	0.812
MEPS (Mean±SD)	76.3±12.5	80.1±11.7	0.432
Flexion-extension range (°)	98.7±26.4	108.9±24.1	0.214
Pronation-supination range (°)	149.3±22.5	154.4±20.7	0.497
Extension deficit (°)	17 (0-30)	6 (0-20)	**0.006**
QuickDASH score	25.6±17.4	21.9±16.3	0.551

MEPS: Mayo Elbow Performance Score

Intraoperative or postoperative complications were observed in 13 out of 30 patients (43%). Compli-cations occurred in 7 out of 13 patients (53%) in the coronoid fixation group and in 6 out of 17 pati-ents (35%) in the non-fixation group (p=0.516). Intraoperative complications were observed in 2 pati-ents, both in the coronoid fixation group. One patient experienced anchor

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pull-out, and another patient developed ulnar nerve palsy, which fully resolved during follow-up. Anchor pull-out was the only intraoperative complication directly related to reattachment of the anterior capsule.

Reoperation was required in 11 out of 30 patients (30%). The reasons for reoperation included imp-lant removal from the radial head in 3 patients, column release procedure due to stiffness in 5 patients, lateral collateral ligament (LCL) reconstruction in 2 patients, and radial head prosthesis removal in 1 patient. Of the 5 patients who underwent column release due to stiffness, 4 were in the coronoid fixa-tion group, and 1 was in the non-fixation group. A statistical trend was observed regarding the need for release due to stiffness between the two groups (p=0.08).

Non-symptomatic heterotopic ossification was observed in 4 patients in the coronoid fixation group and 3 patients in the non-fixation group. There was no statistically significant difference between the two groups (p=0.684). Detailed complications and reoperation rates for both groups are summarized in Table 3.

Table 3. Complications and reoperation rates

Parameter	Coronoid fixation (n=13)	No coronoid fixation (n=17)	p-value
Total complication rate (%)	53%	35%	0.516
Intraoperative complications	2 (15%)	0	0.205
Anchor pull-out	1 (7.7%)	0	-
Ulnar nerve palsy	1 (7.7%)	0	-
Postoperative complications	5 (38%)	6 (35%)	0.861
Heterotopic ossification	4 (31%)	3 (18%)	0.684
Extension limitation	4 (31%)	1 (5.9%)	**0.08**
Reoperation requirement (%)	38%	24%	0.429
Implant removal	2 (15%)	1 (5.9%)	-
Column procedure due to stiffness	4 (31%)	1 (5.9%)	**0.08**
LCL reconstruction	1 (7.7%)	1 (5.9%)	-
Radial head prosthesis removal	1 (7.7%)	0	-

LCL: lateral collateral ligament

Discussion

The most important finding of our study is that suture fixation (capsular attachment fixation) of type 1 coronoid fractures in TTEI cases did not significantly differ in clinical and functional outcomes compared to the patient group without suture fixation, however, it was associated with higher complication and reoperation rates. In addition, the group with suture fixation showed more extension limitation compared to the group without fixation.

First, while the standard approach to treating TTEI includes repair or prosthetic replacement of the radial head, repair of the LCL, and repair of the MCL if necessary, it is still unclear in which cases coronoid fixation is mandatory [3,5,6]. Although there is a consensus that internal fixation is critical for elbow stability, particularly in Regan and Morrey [8] type 3 coronoid fractures (base fractures) or in cases involving the anteromedial facet (type 2), this requirement is controversial in cases where only the coronoid tip (type 1) is fractured [4,10,11].

Many studies in the literature have questioned whether coronoid fixation and thus re-fixation of the anterior capsule in type 1 fractures provides a significant contribution to elbow stability. Some investigators have theorised that repair of type 1 fractures may provide additional stability by re-tensioning the anterior capsule [6,14]. Garrigues er al. have shown that coronoid fixation may increase stability in complex elbow injuries [6]. Similarly, some authors have argued that every coronoid fracture should be fixed regardless of the size of the fragment [15,16].

However, Beingessner et al. reported in a cadaveric study that capsular fixation or coronoid fixation in type 1 coronoid fractures did not significantly contribute to elbow kinematics in a scenario where the radial head and ligaments were repaired [11]. Similarly, Papatheodorou et al., have reported that in type 1 and 2 fractures, only radial head and LUCL repair without coronoid fixation may provide sufficient stability in Regan-Morrey type 1 and 2 fractures and functional results are also very satisfactory in this way [3]. Kim et al. reported that type I-II coronoid fractures do not always require fixation in TTEI cases managed with a standardised treatment protocol and that satisfactory functional results can be obtained even if the coronoid is not repaired [9]. However, Antoni et al., emphasised that anterior capsular fixation does not provide an additional benefit to surgery [10]. In our study, we observed that patients who underwent anterior capsular reattachment did not provide any additional benefit compared to those who did not, and it also brought some risks.

In this study, no unfavourable situation in terms of osteoarthritis development was detected in patients without coronoid fixation compared to patients with fixation. This result suggests that the

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absence of anterior capsule or coronoid fixation does not lead to long-term joint degeneration or functional disadvantage. Therefore, the absence of coronoid fixation neither increases the risk of instability-induced arthritis nor causes clinically significant limitation of motion or loss of function. This provides further evidence that coronoid fixation may not be routinely necessary in type 1 coronoid fractures.

In addition, complication rates after TTEI have been reported in a wide range in the literature (20–89%) [3,4,9,17]. In our series, the total complication rate and the need for revision were similar, but coronoid fixation increased these rates statistically significantly. Our results show that patients without coronoid fixation have better extension motion, but the complication rates and the need for additional surgery are lower in this group. These results are consistent with the studies in the literature which indicate that coronoid or anterior capsule fixation may not always provide functional advantage in type 1 coronoid fractures [6,10].

In type 1 fractures, the significant contribution of coronoid fixation to elbow stability is controversial, and it has been reported that it may increase the risk of complications such as stiffness, heterotopic ossification, iatrogenic damage to additional stabilising structures or ulnar nerve irritation, especially with extended medial approaches or the use of additional fixation materials [3,9,10]. Furthermore, our current findings show that patients without coronoid fixation achieved a greater range of extension, although not statistically significant. These findings suggest that the extension motion can be relatively preserved with less restriction of soft tissues due to not stretching the anterior capsule. The literature is insufficient in this regard to support our results. Certainly, anterior capsular tightening is not the only cause of extension limitation. Possible residual subluxations, heterotopic ossification, brachialis tightness and a generalised arthrofibrosis can also cause extension restriction. What we want to emphasise in our study is that a coronoid fixation, which is not essential, may increase these risks.

Strict exclusion criteria were applied to ensure a relatively homogenous sample of the dreaded triad injuries, which is a highly variable group of patients. Nevertheless, there are some limitations due to the inherent nature of our study. The fact that the decision of which coronoid fractures to fix and which not to fix is not determined by a strict criterion but at the surgeon's discretion creates a selection bias. However, it is not possible to avoid this in this retrospective study. Nevertheless, we aimed to overcome this limitation by selecting a homogeneous patient population.

Conclusion

In conclusion, when the available literature and the findings of this study are considered together, it can be concluded that coronoid fixation is not routinely necessary in TTEI patients with type 1 coronoid fracture because it does not provide any advantage in terms of functional results in addition to the stability provided by radius head and LCL repair. Furthermore, this study demonstrated that extension limitation may develop due to anterior capsular tightness. The necessity of coronoid fixation should be questioned with careful evaluation on a patient-by-patient basis and the potential benefits that can be obtained should be carefully weighed against the increased risk of complications as we have shown in our study. In the future, larger series, prospective and randomised studies may provide clearer answers on this issue

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
Baltalimanı Metin Sabancı Bone Diseases Training And Research Hospital institutional review board approved the study protocol (number: 33/240, date: 26.02.2025).

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