

# Clinical and radiological outcomes of callus preservation versus excision in gunshot-related distal humerus fractures

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## ABSTRACT

**BACKGROUND:** High-energy gunshot injuries to the distal humerus frequently result in extensive comminution, severe soft-tissue damage, and contamination, making definitive fixation both technically demanding and biologically challenging. During staged management with temporary stabilization, extra-articular callus formation may occur prior to definitive fixation, potentially influencing the surgical decision to preserve or excise this tissue. This study aimed to evaluate the clinical and radiological outcomes of a fixation strategy that preserves extra-articular callus in high-energy distal humerus fractures caused by gunshot injuries.

**METHODS:** This retrospective study included 21 male patients with Gustilo–Anderson type IIIA distal humerus fractures caused by high-velocity gunshot injuries, treated between 2016 and 2024. All patients initially underwent temporary stabilization followed by definitive fixation. Patients were stratified according to whether the extra-articular callus tissue was preserved (n=9) or excised (n=12) during surgery. Functional outcomes were assessed using the Disabilities of the Arm, Shoulder and Hand (DASH) score and the Mayo Elbow Performance Index (MEPI), and radiographic union time was recorded.

**RESULTS:** The mean patient age was 28 years (range, 22–43). According to the AO/OTA (Arbeitsgemeinschaft für Osteosynthesfragen/Orthopaedic Trauma Association) classification system, 81% of fractures were type 13C3. Nerve injury was present in five patients (23.8%), and heterotopic ossification developed in five patients (23.8%). No significant intergroup differences were observed in DASH scores, MEPI scores, range of motion, or infection rates (all p>0.05). However, union time was significantly shorter in the callus-preserved group compared with the excision group (18.0±3.1 vs. 23.5±3.3 weeks, p=0.004). Nerve injury (p=0.043) and heterotopic ossification (p=0.025) were associated with higher DASH scores, indicating poorer functional outcomes.

**CONCLUSION:** A callus-preserving fixation approach may offer a biological advantage in the management of high-energy distal humerus gunshot fractures by promoting earlier bone healing without compromising functional outcomes. When extra-articular callus does not interfere with anatomical reduction, preserving it in situ may be considered as part of a staged damage-control-to-definitive fixation strategy.

**Keywords:** Callus protection; distal humerus fracture; gunshot injury.

## INTRODUCTION

Distal humerus fractures account for approximately 2% of all fractures and one-third of all humeral fractures.<sup>[1]</sup> Various surgical techniques have been described for their management.<sup>[2,3]</sup> Open reduction and internal fixation (ORIF) is widely considered the standard treatment for these injuries. Although

ORIF facilitates early mobilization and helps prevent joint stiffness, open distal humerus fractures are associated with a high risk of postoperative infection.<sup>[4]</sup>

Fractures resulting from high-energy gunshot injuries are typically classified as type III according to the Gustilo–Anderson classification.<sup>[5]</sup> Type III open fractures around the elbow represent some of the most challenging injuries to manage, and

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achieving full functional recovery is often difficult even with appropriate reduction. In addition, these injuries impose substantial economic, psychological, and social burdens on patients. The high kinetic energy and ballistic effects of gunshot trauma further contribute to complex fracture patterns in this region.<sup>[6]</sup>

Gunshot injuries often produce fracture morphologies that do not conform to conventional classification systems, and no universally accepted treatment protocol exists. Furthermore, patients may present with concomitant injuries, such as internal organ damage or traumatic brain injury. The literature on the management of complex distal humerus fractures caused by gunshot injuries in patients with associated systemic trauma is limited.<sup>[7,8]</sup> In this study, we aimed to compare the clinical and radiological outcomes of patients with high-energy gunshot-induced distal humerus fractures who underwent definitive fixation either with preservation or excision of extra-articular callus tissue formed proximal to the fracture. All patients had initially been managed with temporary stabilization, either external fixation or splinting, due to prolonged intensive care requirements.

## MATERIALS AND METHODS

### Study Design and Patient Selection

This retrospective study was conducted at a Level I trauma center that routinely receives referrals for high-energy firearm-related injuries. Patients who sustained distal humerus fractures due to high-velocity gunshot wounds between 2016 and 2024 were included. To minimize potential confounding effects on functional and radiological outcomes, patients with additional fractures in the same limb, those requiring soft-tissue reconstruction with flap or graft coverage, and those with concomitant vascular injuries were excluded. One patient who died during intensive care follow-up was also excluded, resulting in a final study population of 21 patients.

Initial management was performed at referring Level II or III trauma centers and included wound debridement and temporary stabilization using either external fixation or long-arm splinting (Fig. 1). Upon referral, patients were admitted to the intensive care unit due to associated systemic injuries, such as head trauma or internal organ injury. Open fractures were classified according to the Gustilo–Anderson classification, and fracture morphology was categorized using the AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association) classification system. Preoperative computed tomography (CT) angiography was performed in all patients to assess for potential vascular injuries. Intravenous antibiotic prophylaxis consisting of ceftriaxone, amikacin, and metronidazole was initiated preoperatively and continued for five days.

Data regarding head trauma were obtained from cranial CT scans performed at the referring institutions. Two patients had radial nerve injuries, and one patient had an ulnar nerve injury. During intensive care follow-up, debridement was per-

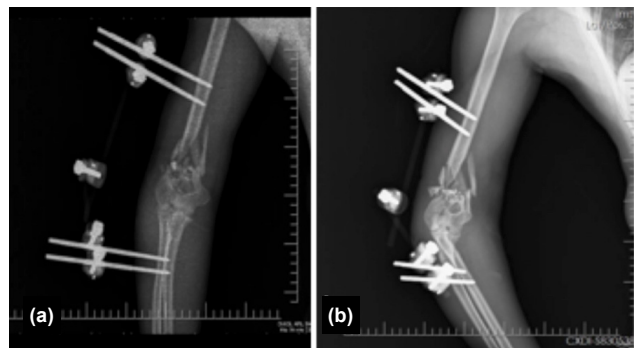
formed once in four patients and twice in three patients. Primary wound closure was achieved in all cases, and none of the patients required vacuum-assisted closure therapy. This study was approved by the Gülhane Training and Research Hospital Clinical Research Ethics Committee (Date: 25.11.2025, Decision No: 2025-555), and all procedures were conducted in accordance with the principles of the Declaration of Helsinki.

### Implants and Surgical Technique

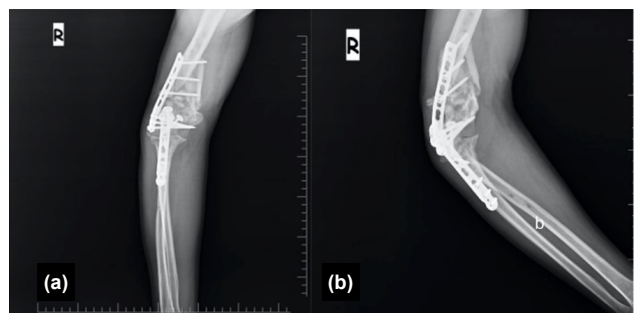
A posterior surgical approach was used in all patients for the treatment of distal humerus fractures. An olecranon osteotomy was performed to provide adequate exposure of the distal humerus and the articular surface. The osteotomy was fixed using tension band wiring, cerclage wiring, or cannulated screw fixation, according to intraoperative preference.

Intra-articular callus tissue was excised in all patients to facilitate anatomical reduction of the joint surface, and the articular fragments were stabilized using headless compression screws. The decision to preserve or excise extra-articular callus was made intraoperatively based on whether it interfered with anatomical reduction or fracture alignment.

To restore mechanical stability, dual locking plates were applied medially and laterally (Fig. 2). Early postoperative elbow range-of-motion exercises were initiated once adequate pain control and wound stability were achieved.



**Figure 1.** Temporary external fixation used as initial damage-control stabilization for a high-energy open distal humerus fracture caused by a gunshot injury.



**Figure 2.** Postoperative anteroposterior (a) and lateral (b) radiographs demonstrating dual-plate fixation of a distal humerus fracture with preservation of extra-articular callus.

## Radiographic and Clinical Evaluation

Standard anteroposterior and lateral radiographs of the elbow were obtained on admission, weekly during the intensive care unit stay, on postoperative day 15, and monthly thereafter throughout the follow-up period. In addition, elbow and cranial CT scans were performed at initial admission. Radiological bone union times were systematically recorded.

Complete union was defined clinically as the absence of tenderness at the fracture site and radiologically as the presence of callus formation in at least three of four cortices. Radiographic signs of post-traumatic arthritis, myositis ossificans, and heterotopic ossification were also evaluated and documented during follow-up.

All clinical and radiological evaluations were performed by a single independent orthopedic surgeon. Functional and clinical assessments were conducted at a minimum follow-up of one year. Elbow range of motion, including flexion, extension, supination, and pronation, was measured. Functional outcomes were assessed using the Disabilities of the Arm, Shoulder and Hand (DASH) score and the Mayo Elbow Performance Index (MEPI).<sup>[9,10]</sup>

## Statistical Analysis

Descriptive statistics are presented as mean  $\pm$  standard deviation or median (range) for continuous variables, and as frequency (percentage) for categorical variables. The Shap-

iro-Wilk test was used to assess the normality of data distribution. Between-group comparisons were performed using the Mann-Whitney U test for continuous variables and the chi-square or Fisher's exact test for categorical variables, as appropriate. Associations between DASH scores and continuous variables were evaluated using Spearman's rank correlation coefficient. Multivariate linear regression analysis was conducted to identify independent predictors of DASH scores. All analyses were performed using SPSS software (version 20.0; IBM Corp., Armonk, NY, USA), with statistical significance set at  $p < 0.05$ .

## RESULTS

A total of 21 male patients were included, with a mean age of 28 years (range, 22–43). Right-sided elbow involvement was observed in nine patients, and left-sided involvement in

**Table 1.** Demographic and clinical characteristics of the patients

n=21	Mean $\pm$ SD Median (Min-Max)
Age (years)	28.81 $\pm$ 4.47 28 (22-43)
Elbow flexion (°)	91.52 $\pm$ 8.64 93 (60-110)
Elbow extension loss (°)	6.48 $\pm$ 3.86 7 (0-20)
Pronation (°)	62.19 $\pm$ 5.38 62 (52-75)
Supination (°)	66.95 $\pm$ 8.29 67 (51-81)
DASH score	38.86 $\pm$ 14.11 35 (20-68)
MEPI score	76.33 $\pm$ 13.47 78 (50-95)
Follow-up (months)	51.62 $\pm$ 24.19 43 (13-84)
Time to union (weeks)	21.1 $\pm$ 4.2 21.1 (13.4-27.4)

**Table 2.** Distribution of clinical and radiological variables

	n	%
Head trauma		
No	14	66.7
Yes	7	33.3
Associated injury		
No	14	66.7
Yes	7	33.3
HO		
No	16	76.2
Yes	5	23.8
Infection		
No	17	81.0
Yes	4	19.0
Nerve injury		
None	16	76.2
Radial	3	14.3
Ulnar	2	9.5
AO type		
I3C2	4	19.0
I3C3	17	81.0
Stabilization		
Splint	13	61.9
EF	8	38.1
Injury side		
Right	12	57.1
Left	9	42.9
Callus excision		
No (preserved)	9	42.9
Yes (excised)	12	57.1

**Table 3.** Comparison of patient characteristics according to callus management

	Callus preserved (n=9)	Callus excised (n=12)	p value
	Mean±SD Median (Min-Max)	Mean±SD Median (Min-Max)	
Age (years)	28.89±2.42 28 (26-33)	28.75±5.67 28.5 (22-43)	0.808 <sup>b</sup>
Elbow flexion (°)	95.11±2.47 93 (87-95)	91.08±11.44 93.5 (60-110)	0.754 <sup>b</sup>
Elbow extension loss (°)	5.67±2.23 6 (1-8)	7.08±4.75 7 (0-20)	0.508 <sup>b</sup>
Pronation (°)	60.89±4.85 62 (52-66)	63.17±5.75 62 (54-75)	0.554 <sup>b</sup>
Supination (°)	67.78±6.49 68 (60-81)	66.33±9.67 65.5 (51-81)	0.702 <sup>b</sup>
DASH score	43.11±15.14 36 (28-68)	35.67±13.06 32.5 (20-65)	0.199 <sup>b</sup>
MEPI score	72.44±14.08 79 (50-95)	76.73±12.03 75.5 (63-90)	0.915 <sup>b</sup>
Time to union (weeks)	18.03±3.1 18.0 (13.1-22.1)	23.5±3.3 22.0 (17.7-27.4)	<b>0.004<sup>b</sup></b>
Follow-up (months)	59.00±26.13 72 (16-84)	46.08±22.12 43 (13-82)	0.277 <sup>b</sup>

<sup>b</sup>Mann–Whitney U test; DASH: Disabilities of the arm, shoulder and hand.

12. The mean follow-up duration was 51.6 months. According to the AO/OTA classification, 14 fractures were classified as type 13C3 and seven as type 13C2. All injuries were Gustilo–Anderson type IIIA open fractures. Five patients sustained concomitant fractures in other extremities, and seven patients had associated head trauma. Initial temporary stabilization was achieved with a long-arm splint in 13 patients and an external fixator in eight patients. The mean DASH score was 38.9±6.3 (Table 1).

The distribution of clinical and radiological variables is summarized in Table 2. Of the 21 patients, seven (33.3%) had concomitant head trauma and seven (33.3%) had additional musculoskeletal injuries. Heterotopic ossification was observed in five patients (23.8%), and postoperative infection occurred in four patients (19.0%). Nerve injury was present in five patients (three radial, two ulnar). Most fractures were classified as AO type 13C3 (81.0%). Initial stabilization was performed using a splint in 13 cases (61.9%) and an external fixator in eight (38.1%) (Table 2).

Patients were stratified into two cohorts based on whether the extra-articular callus tissue was debrided intraoperatively: Group 1 (callus preserved, n=9) and Group 2 (callus ex-

cised, n=12). Intergroup comparisons revealed no statistically significant differences in age, final range of motion, MEPI, or DASH scores (all p>0.05). However, the mean radiographic time to union was significantly longer in the callus-excised group compared with the callus-preserved group (23.5±3.3 vs. 18.0±3.1 weeks, p=0.004) (Table 3).

When DASH scores were analyzed according to clinical and radiological variables, no statistically significant differences were found with respect to the presence of head trauma, associated injuries, infection, or method of initial stabilization (splint vs. external fixator) (all p>0.05). In contrast, patients with peripheral nerve injury and those who developed heterotopic ossification had significantly higher DASH scores, indicating worse functional outcomes (p=0.043 and p=0.025, respectively) (Table 4).

## DISCUSSION

Open distal humerus fractures resulting from gunshot injuries are rare and difficult to manage. Treatment typically follows a staged approach, beginning with aggressive debridement and temporary stabilization, followed by definitive fixation once soft-tissue conditions permit. In high-energy gunshot-related

**Table 4.** Comparison of Disabilities of the Arm, Shoulder and Hand (DASH) scores according to clinical and radiological variables

	n	Mean±SD	Median (Min-Max)	p
Head trauma				
No	14	36.93±14.91	32 (20-68)	0.287 <sup>b</sup>
Yes	7	42.71±12.48	44 (27-60)	
Nerve injury				
No	15	30.53±11.48	30 (20-54)	<b>0.043<sup>b</sup></b>
Yes	6	61.57±6.21	62 (52-68)	
HO				
No	16	33.00±9.65	30 (20-60)	<b>0.025<sup>b</sup></b>
Yes	5	57.60±8.38	54 (49-68)	
Infection				
No	17	38.00±13.56	35 (20-65)	0.574 <sup>b</sup>
Yes	4	42.50±17.99	38 (26-68)	
Stabilization				
Splint	13	40.00±14.30	38 (23-68)	0.697 <sup>b</sup>
EF	8	37.00±14.55	32 (20-65)	

<sup>b</sup>Mann–Whitney U test; DASH: Disabilities of the arm, shoulder and hand.

open fractures, management priorities include preservation of life, limb salvage, infection prevention, and restoration of extremity function.<sup>[11]</sup> The primary objective of surgical fixation in complex distal humerus fractures is anatomical reconstruction of the articular surface and stable fixation of the distal humerus to both the medial and lateral columns.<sup>[12]</sup> Because these injuries are both open and intra-articular, elbow range of motion is often significantly compromised. In the present study, all fractures were classified as type I3C according to the AO classification. Jupiter and Morrey reported that even relatively minor elbow trauma may result in joint stiffness due to capsular fibrosis.<sup>[13]</sup>

Despite the high rate of bone and soft-tissue complications associated with these open injuries, McKee et al.<sup>[14]</sup> reported generally favorable functional outcomes, including general health, limb-specific, surgeon-based, and radiological measures. In contrast, Min et al.<sup>[15]</sup> found that open distal humerus fractures were associated with poorer functional outcomes and reduced range of motion compared with closed fractures. Patients with open injuries also demonstrated a trend toward higher complication rates and longer times to union.

Given the relatively young age of these patients, functional expectations are typically high, which may influence postoperative satisfaction. Because we perform definitive joint reconstruction following temporary external fixation and initiate early mobilization, near-complete restoration of elbow range of motion can be achieved. In addition to fracture- and surgery-related factors, soft-tissue complications appear to play a critical role in functional recovery. In the present study,

peripheral nerve injury and heterotopic ossification were associated with significantly higher DASH scores, underscoring their negative impact on long-term upper-extremity function. These findings highlight the importance of meticulous intraoperative nerve exploration and protection, as well as consideration of strategies to minimize heterotopic ossification, particularly in young, high-demand patients requiring rapid functional recovery.

None of the patients in our series developed a major joint contracture. Gerardet et al.<sup>[6]</sup> reported satisfactory to excellent outcomes in up to 90% of intra-articular distal humerus fractures when anatomical reduction, stable fixation, and early initiation of active elbow motion were achieved.

MEPI scores did not differ significantly between groups. This finding suggests that, although callus preservation may facilitate biologically accelerated bone healing, this advantage was not reflected in elbow-specific performance outcomes within the available follow-up period. As the MEPI score is largely influenced by pain and range of motion, it may be less sensitive than the DASH score in detecting subtle functional impairment in young, high-demand patients.

The aim of this surgical technique is to achieve stable fixation by securing the plate to the callus at the fracture margins without extensive soft-tissue dissection, thereby preserving extra-articular callus. The articular surface is reconstructed using headless screws, followed by early postoperative mobilization once adequate pain control and wound stability are achieved.

In open distal humerus fractures, early definitive fixation is often challenging due to the increased risk of infection and soft-tissue complications. ORIF should be avoided in the presence of contamination or active infection at the fracture site.<sup>[16]</sup> Chapman and Mahoney reviewed the use of primary internal fixation in open fractures and reported high rates of bone and soft-tissue infection.<sup>[17]</sup>

Dragon et al.<sup>[18]</sup> compared damage-control surgery with early surgical treatment and found no significant differences in clinical outcomes or infection rates. In the present study, all cases were classified as Gustilo–Anderson type III open fractures and were considered contaminated, as they resulted from high-energy gunshot injuries. One patient developed a superficial infection, which was successfully treated with early debridement and appropriate antibiotic therapy, resulting in resolution of clinical signs and wound discharge. External fixation (EF) is another treatment method for open fractures. Kömürçü et al.<sup>[6]</sup> applied the Ilizarov technique to intra-articular distal humerus fractures caused by gunshot injuries in a series of 20 patients, reporting pin-site infections in three patients and deep infection in one. In a retrospective study of 18 patients, Mostafavi et al.<sup>[19]</sup> used a unilateral external fixator followed by a definitive treatment and reported pin-site infections in eight patients. They also noted that 70% of patients achieved good or excellent functional elbow scores. Because union tends to take longer in open fractures, complications such as pin-site infection and pin loosening may occur with external fixators, including the Ilizarov system. However, in our study, EF was used as a temporary rather than definitive treatment, and no pin-site infections were observed.

The concept of preserving extra-articular callus is biologically meaningful, as callus represents a highly vascular and metabolically active reparative tissue that provides osteogenic cells, cytokines, and an early scaffold for bridging the defect and promoting peripheral bone healing. Removal of this tissue may disrupt early biological continuity, create a secondary bone defect, and prolong the time required for cortical bridging. Previous studies on open fractures have primarily focused on the need for grafting in the presence of bone loss rather than on callus preservation. However, Min et al.<sup>[20]</sup> reported that staged fixation of open distal humerus fractures was associated with prolonged union times and occasional need for bone grafting. In contrast, our findings demonstrated shorter union times without grafting when callus was preserved, suggesting that, when extra-articular callus does not compromise reduction or joint congruency, it may serve as a biological enhancer of early fracture consolidation, particularly in high-energy periarticular injuries.

Open distal humerus fractures are typically caused by high-energy mechanisms and are often associated with additional musculoskeletal or systemic injuries. Brain trauma has been reported to accelerate fracture healing.<sup>[21]</sup> Following injury, the brain initiates complex cellular and molecular responses, including immune-inflammatory processes involving cyto-

kines, growth factors, and other biomolecules,<sup>[22]</sup> which may contribute to both local and/or systemic tissue repair, including bone healing. Yang et al.<sup>[23]</sup> demonstrated that brain injury accelerated fracture union and increased callus formation. In our series, nine patients had associated brain trauma; however, when patients were grouped based on the presence or absence of brain injury, no significant difference in union time was observed ( $p=0.08$ ).

Previous studies have shown that bone defects may occur in third-degree open tibial fractures and open hand injuries, where bone grafting may be required.<sup>[24,25]</sup> However, grafting may result in donor-site morbidity, as well as increased cost and risk of infection when allografts are used. Therefore, when the fracture does not involve the joint, we believe that preservation of callus tissue is important and may contribute to reduced union time. Min et al.<sup>[20]</sup> divided patients who underwent definitive treatment for open distal humerus fractures into two groups: primary and staged. The mean union time in the primary group was 23.4 weeks, compared with 25.7 weeks in the staged group. Three patients also required bone grafting due to bone loss. In our study, the mean union time was 21.1 weeks, despite no use of grafting. The shorter union time observed in our study compared with previous reports may be attributed to preservation of extra-articular callus during fixation, as well as reduced soft tissue dissection, both of which likely facilitate faster bone healing. Conversely, removal of callus tissue may lead to bone loss and defect formation, potentially resulting in delayed union.

### Limitations

This study has several limitations. First, its retrospective, single-center design limits the generalizability of the findings. Second, the small sample size reduces statistical power, particularly for subgroup analyses involving nerve injury and heterotopic ossification. Third, although predefined intraoperative criteria were applied, surgical decision-making inevitably involved some degree of surgeon judgment, which cannot be fully standardized. Finally, radiographic union was assessed using plain radiographs rather than CT, which may affect the precision of union-time assessment. Future prospective, multicenter studies are needed to validate the clinical utility of callus preservation and to establish standardized decision-making criteria.

### CONCLUSION

The findings of this study suggest that preservation of extra-articular callus during definitive fixation of high-energy distal humerus fractures may provide additional biological support without compromising anatomical reduction. In complex fire-arm-related injuries, this approach may help maintain column stability while preserving the biological environment necessary for fracture healing. From a clinical standpoint, avoiding unnecessary callus excision may represent a reasonable surgical strategy in selected cases. However, further studies with

larger cohorts and longer follow-up durations are required to confirm these findings.

**Ethics Committee Approval:** This study was approved by the Gülhane Training and Research Hospital Clinical Research Ethics Committee (Date: 25.11.2025, Decision No: 2025-555).

**Informed Consent:** Written informed consent was obtained.

**Peer-review:** Externally peer-reviewed.

**Authorship Contributions:** Concept: A.M.B., A.A.; Design: A.M.B., A.A.; Supervision: A.M.B., A.A.; Resource: A.M.B., A.A.; Materials: A.M.B., A.A.; Data collection and/or processing: A.M.B., A.A.; Analysis and/or interpretation: A.M.B., A.A.; Literature review: A.M.B., A.A.; Writing: A.M.B., A.A.; Critical review: A.M.B.

**Conflict of Interest:** None declared.

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ORİJİNAL ÇALIŞMA - ÖZ

## Ateşli silah yaralanmalarına bağlı distal humerus kırıklarında kallus korunması ve eksizyonunun klinik ve radyolojik sonuçları

**AMAÇ:** Distal humerusu içeren yüksek enerjili ateşli silah yaralanmaları sıklıkla belirgin parçalanma, ciddi yumuşak doku hasarı ve kontaminasyon ile sonuçlanır ve bu durum definitif fiksasyonu hem teknik hem de biyolojik açıdan zorlaştırır. Geçici stabilizasyon ile uygulanan evreli tedavi sürecinde, definitif fiksasyon öncesinde ekstraartiküler kallus oluşumu gelişebilir ve bu durum söz konusu dokunun korunması veya eksize edilmesine ilişkin cerrahi karar sürecini etkileyebilir. Bu çalışmanın amacı, ateşli silah yaralanmalarına bağlı yüksek enerjili distal humerus kırıklarında ekstraartiküler kallusun korunmasına dayalı fiksasyon stratejisinin klinik ve radyolojik sonuçlarını değerlendirmektir.

**GEREÇ VE YÖNTEM:** Bu retrospektif çalışmaya 2016–2024 yılları arasında yüksek enerjili ateşli silah yaralanmasına bağlı Gustilo–Anderson tip IIIA distal humerus kırığı nedeniyle tedavi edilen 21 erkek hasta dahil edildi. Tüm hastalarda definitif fiksasyon öncesinde geçici stabilizasyon uygulanmıştır. Hastalar intraoperatif olarak ekstraartiküler kallus dokusunun korunmasına (n=9) veya eksize edilmesine (n=12) göre iki gruba ayrılmıştır. Fonksiyonel sonuçlar Disabilities of the Arm, Shoulder and Hand (DASH) ve Mayo Elbow Performance Index (MEPI) skorları ile değerlendirilmiş, radyolojik kaynama süreleri kaydedilmiştir.

**BULGULAR:** Hastaların ortalama yaşı 28 yıl (22–43) idi. AO/OTA sınıflamasına göre kırıkların %81'i I3C3 tipindeydi. Beş hastada (%23.8) periferik sinir yaralanması, beş hastada (%23.8) heterotopik ossifikasyon saptandı. Gruplar arasında DASH, MEPI, eklem hareket açıklığı veya enfeksiyon oranları açısından anlamlı fark bulunmadı (tüm  $p>0.05$ ). Bununla birlikte kallusun korunduğu grupta kaynama süresi anlamlı olarak daha kısa bulundu ( $18.0\pm 3.1$  vs.  $23.5\pm 3.3$  hafta,  $p=0.004$ ). Periferik sinir yaralanması ( $p=0.043$ ) ve heterotopik ossifikasyon ( $p=0.025$ ) daha yüksek DASH skorları ile ilişkili bulunarak daha kötü fonksiyonel iyileşmeye işaret etti.

**SONUÇ:** Ekstraartiküler kallusun korunduğu fiksasyon yaklaşımı, yüksek enerjili ateşli silah yaralanmalarına bağlı distal humerus kırıklarının tedavisinde biyolojik avantaj sağlayabilir ve fonksiyonel sonuçları olumsuz etkilemeden daha erken kemik kaynamasına olanak tanıyabilir. Ekstraartiküler kallusun anatomik redüksiyonu engellemediği durumlarda, evreli hasar kontrolünden definitif fiksasyona uzanan tedavi stratejisinin bir parçası olarak yerinde korunması düşünülebilir.

**Anahtar sözcükler:** Ateşli silah yaralanması; distal humerus kırığı; kallus korunması.

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