Original Article

Cukurova Anestezi ve Cerrahi Bilimler Dergisi

Etiology, AO/OTA Classification, and Clinical Distribution of Adult Distal Humerus Fractures at a Tertiary Trauma Center

Melih Civan[1*], *Olgun Burak Borucu*[1], *Cihangir Mete Kızılgedik*[1], *Çağatay Tekin*[1], *Melih Çağrı Elçi*[1], *Mehmet Ali Talmaç*[1]

[1] Department of Orthopedics and Traumatology, Başakşehir Çam ve Sakura City Hospital, Istanbul, Türkiye
***Correspondence:** Melih Civan; melihcivan@gmail.com
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Abstract

Objective: Distal humerus fractures occur across a heterogeneous injury spectrum, ranging from low-energy fragility injuries to complex fractures caused by high-energy trauma. Studies examining the epidemiological characteristics or institutional presentation patterns of these fractures remain limited. This study aimed to describe the demographic characteristics, injury mechanisms, and fracture morphology of adult distal humerus fractures treated at a tertiary trauma center. **Methods:** This retrospective observational cohort study included adult patients treated for distal humerus fractures between January 2021 and December 2025. Demographic characteristics, injury mechanisms, AO/OTA classification, open fracture status, and the presence of polytrauma were evaluated. Associations between categorical variables were analyzed using the Pearson chi-square test or Fisher–Freeman–Halton exact test, as appropriate. Age distributions across the main fracture types were compared using the Kruskal–Wallis test. **Results:** A total of 115 patients, including 49 women and 66 men, were included. The mean age was 45.3 ± 19.8 years. Of the injuries, 47.8% were high-energy, 40.9% were low-energy, and 11.3% were moderate-energy. AO/OTA type C fractures accounted for 72.2% of all fractures. Open fractures occurred in 38.2% of high-energy injuries, while the polytrauma rate in this group was 40.0%. Low-energy injuries were more frequent among women, whereas high-energy injuries were more common among men ($p<0.001$). No significant age difference was found among the main AO/OTA fracture types ($p=0.940$). **Conclusion:** Adult distal humerus fractures treated at a tertiary trauma center demonstrated a heterogeneous distribution characterized by substantial contributions from high-energy trauma, AO/OTA type C fractures, open injuries, and polytrauma. The findings indicate that the institutional case profile differed from that reported in fragility fracture–predominant series.

Keywords: distal humerus fracture; AO/OTA classification; high-energy trauma; epidemiology

1. Introduction

Distal humerus fractures comprise a heterogeneous group of injuries that may occur across a broad age spectrum and under markedly different clinical circumstances. In

younger patients, these fractures are more commonly associated with high-energy trauma, including motor vehicle accidents, falls from height, gunshot injuries, and complex musculoskeletal trauma. In contrast, fractures in older adults may occur after lower-energy mechanisms and may be influenced by reduced bone quality, comorbidity burden, and fragility-related factors.[1-3] This wide clinical spectrum is reflected not only in patient age and injury mechanism but also in fracture morphology, associated injuries, open fracture status, and the urgency and complexity of initial management.

Most published studies on distal humerus fractures have focused on operative techniques, implant selection, surgical exposures, complications, union, and functional and radiological outcomes. Although these studies have contributed substantially to treatment decision-making, they often represent selected surgical cohorts and may not fully describe the overall institutional burden or clinical spectrum of distal humerus fractures. In particular, there is limited information regarding the relationship between age, trauma energy, AO/OTA fracture morphology, open fracture status, and polytrauma in unselected tertiary-care cohorts that include both operative and nonoperative cases.

The institution where the study was conducted is a fully equipped tertiary city hospital that began providing clinical services on 21 May 2020. Since its opening, the orthopedic training clinic has progressively expanded its surgical capacity, multidisciplinary trauma coordination, and management of complex and referred trauma cases. This evolving institutional setting provided an opportunity to examine the spectrum of distal humerus fractures encountered in a contemporary tertiary trauma center, rather than focusing solely on treatment-specific subgroups.

Accordingly, the present study was designed to characterize the demographic and injury-related profile of all patients presenting with distal humerus fractures to our institution. We aimed to describe the temporal distribution of cases, patient age, injury mechanisms, trauma energy levels, AO/OTA fracture patterns, open fracture status, polytrauma, and initial treatment characteristics. By evaluating these variables together, we sought to provide an institutional overview of distal humerus fractures as a heterogeneous injury spectrum and to explore how fracture morphology and associated injury burden vary across different patient and trauma profiles.

2. Materials and Methods

This retrospective observational cohort study was conducted at a fully-equipped hospital in Istanbul, Türkiye. The study included patients older than 17 years old and treated for distal humerus fractures between 1 January 2021, and 31 December 2025. Ethical approval was obtained from the institutional ethics committee before data collection and analysis [App. No: 29.07.2026-332]. Because of the retrospective design and use of anonymized clinical data, the requirement for informed consent was waived.

All operative and nonoperative cases having distal humerus fracture evaluated and managed by the orthopedic surgery clinic during the study period were eligible for inclusion. Patients were excluded when the available clinical or radiological records did not permit confirmation of the distal humerus fracture diagnosis. Data were retrospectively collected from institutional clinical and radiological records, and follow-up documentation.

The following variables were recorded: age at presentation or treatment, injury mechanism, status of polytrauma, status of open fracture, AO/OTA fracture classification, initial treatment, details of surgical treatment and fixation method when applicable, status and mortality of follow-up. Because the primary objective was to describe the institutional and injury-pattern spectrum of distal humerus fractures, treatment-related variables were recorded only as indicators of initial management. Surgical technique, implant-specific

outcomes, functional recovery, union, complications, and revision outcomes were not evaluated in the present study.

The documented injury mechanism was categorized into clinically relevant groups, including falls on the same level, falls from height, falls down stairs, bicycle-related falls, traffic accidents involving vehicle occupants or pedestrians, sports-related injuries, assaults, gun-shot injuries and other mechanisms. Energy of the injury was classified as low, moderate, or high energy according to the documented trauma mechanism. Low energy injuries primarily included falls on the same level and comparable mechanisms. Moderate-energy injuries included selected sports-related or bicycle-related mechanisms, falls from stairs. High-energy injuries included falls from height, motor vehicle-related trauma and gunshot injuries involving substantial kinetic force. (Table 1)

Fractures were classified according to the AO/OTA classification system based on the available preoperative imaging, including plain radiographs and, when available, computed tomography scans. Imaging was reviewed by two authors (MC and ÇT), both orthopedic surgeons experienced in trauma surgery.[4-6] The final AO/OTA classification was determined by consensus, with involvement of the senior author (MAT) in cases of disagreement. Fractures were recorded both as detailed AO/OTA subtypes and as the aggregated main classes (types A, B, and C). For the primary comparative analyses, fracture subtypes were grouped into the main AO/OTA classes because several individual subgroups contained small numbers of patients. Open fractures were recorded as present or absent according to the initial clinical documentation. Polytrauma was recorded when the patient had clinically relevant injuries involving more than one anatomical region or organ system in addition to the distal humerus fracture.

Initial treatment was classified as nonoperative treatment, operative treatment, or definitive external fixation. Detailed surgical technique-related variables, including fixation construct, surgical approach related parameters, were not included in the present analysis. Follow-up duration was calculated from the date of treatment to the final recorded follow-up visit or last documented clinical contact. Follow-up of at least 12 months was recorded separately. Mortality during the available follow-up period was documented when identifiable. Patients without subsequent clinical follow-up after initial treatment or discharge were classified as lost to follow-up. The distribution of follow-up availability and loss to follow-up was evaluated according to year of treatment.

The study was primarily descriptive. Comparative analyses were performed on an exploratory basis to examine clinically relevant associations between injury characteristics, markers of trauma severity, fracture pattern, and initial treatment strategy. These comparisons were intended to complement the descriptive findings rather than to test a prespecified causal hypothesis.

Statistical analyses were performed using IBM SPSS Statistics Version 29 (IBM Corp., Armonk, NY, USA). Continuous variables were assessed for distributional characteristics using visual inspection of histograms and normality tests. Normally distributed continuous variables were presented as mean ± standard deviation, whereas non-normally distributed variables were presented as median with interquartile range and range. Categorical variables were summarized as frequencies and percentages. Comparisons of age across AO/OTA main fracture classes were performed using the Kruskal–Wallis test because age distributions were non-normal within the fracture groups. When the overall comparison was significant, pairwise Mann–Whitney U tests were used. Associations between categorical injury characteristics, including energy level, polytrauma, open fracture status, and treatment category, were evaluated using chi-square or Fisher–Freeman–Halton exact tests as appropriate.

3. Results

3.1. Baseline demographics, injury profile and annual case distribution

A total of 115 adult patients with distal humerus fractures were included in the final analysis. The cohort consisted of 49 women (42.6%) and 66 men (57.4%), corresponding to a female-to-male ratio of 0.74:1. The mean age was 45.3 ± 19.8 years, with a range of 18–90 years.

The mean annual number of cases was 23.0 ± 7.1, with a range of 15–34 cases per year. The annual distribution of distal humerus fractures is presented in Figure 1, and the age distribution of the study population is presented in Figure 2.

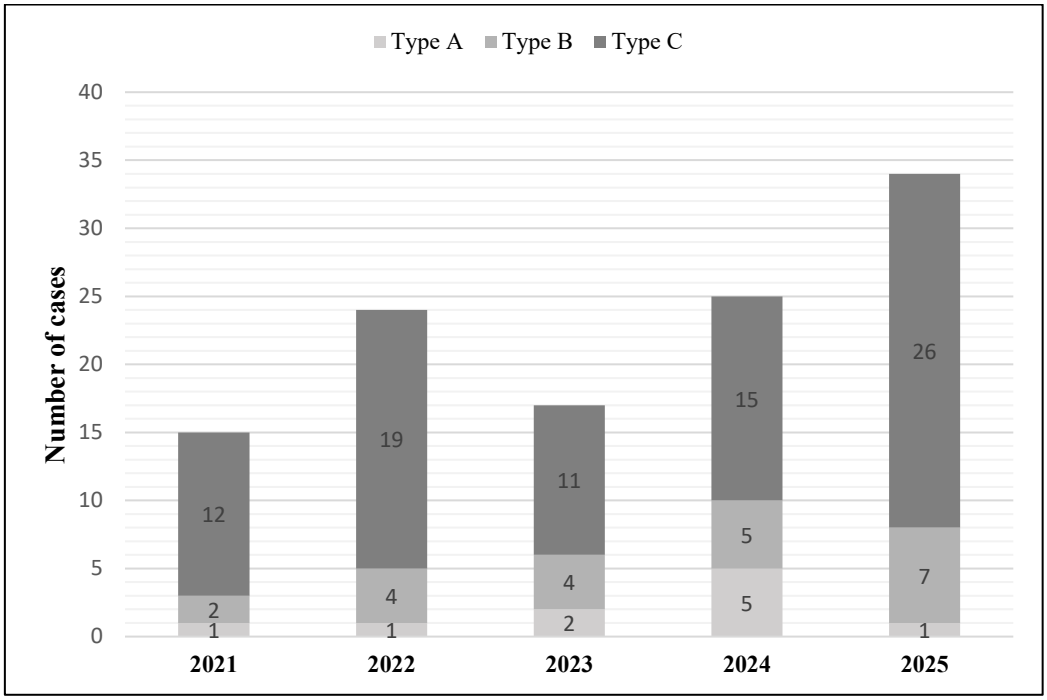

Figure 1: Graphic shows annual distrubution of the distal humerus fractures

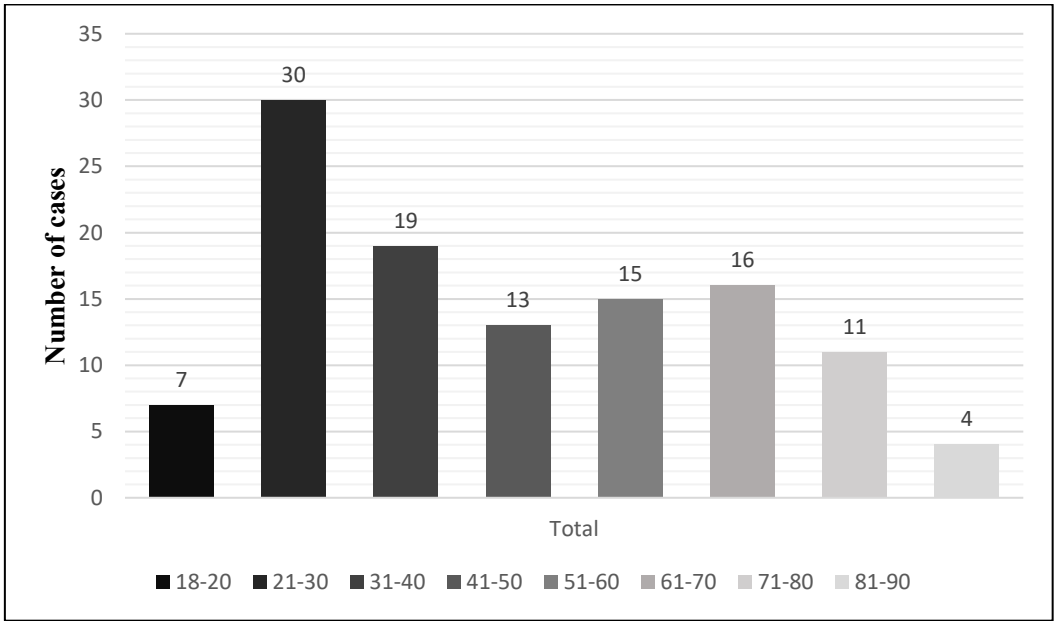

Figure 2: Graphic shows age distrubution of the study cohort

Ground-level falls were the most common injury mechanism, accounting for 47 cases (40.9%), followed by falls from height in 27 patients (23.5%), motorcycle accidents in 11 (9.6%), and motorized road traffic injuries including both vehicle occumants and pedestrians injured in collisions in 11(9.6%). High-energy trauma was the most frequent energy category and was recorded in 55 patients (47.8%), whereas 47 patients (40.9%) sustained low-energy injuries and 13 (11.3%) sustained moderate-energy injuries.

Polytrauma and open fractures were each identified in 22 patients (19.1%). AO/OTA type C fractures constituted the predominant fracture pattern, occurring in 83 patients (72.2%), followed by type B fractures in 22 (19.1%) and type A fractures in 10 (8.7%). Initial management was operative in 110 patients (95.7%), nonoperative in 3 patients (2.6%), and definitive external fixation in 2 patients (1.7%). The demographic, injury-related, fracture-related, treatment, and follow-up characteristics of the cohort are summarized in Table 1.

Table 1: Baseline demographic and injury characteristics of the study cohort

Variables	***Overal Cohort, n=115***
Age, years, mean ± SD	45.3 ± 19.8
Age range, years	18-90
Injury mechanism	
Ground-level fall (low energy)	47 (40.9)
Fall from height (high energy)	27 (23.5)
Motorcycle accident (high energy)	11 (9.6)
Motorized road traffic injury (high energy)	11 (9.6)
Gunshot injury (high energy)	4 (3.5)
Fall from stairs (moderate energy)	3 (2.6)
Sports related injury (moderate energy)	3 (2.6)
Bicycle related fall (moderate energy)	2 (1.7)
Assault (moderate energy)	2 (1.7)
Fall from a tractor (moderate energy)	1 (0.9)
Fall during horse riding (moderate energy)	1 (0.9)
Physiotherapy related injury (moderate energy)	1 (0.9)
Crush Injury (high energy)	1 (0.9)
Fall inside elevator (high energy)	1 (0.9)
Trauma energy level	
Low energy	47 (40.9)
Moderate energy	13 (11.3)
High energy	55 (47.8)
Polytrauma	22 (19.1)
Open Fracture	22 (19.1)
AO/OTA main fracture class	
Type A (median=48,5, IQR=52,0, min-max=21-81)	10 (8.7)
Type B (median=36,0, IQR=34,0, min-max=21-86)	22 (19.1)
Type C (median=45,0, IQR=31,0, min-max=18-90)	83 (72.2)
Initial treatment	
Nonoperative treatment	3 (2.6)
Operative treatment	110 (95.7)
Definitive external fixation	2 (1.7)

Values are presented as n (%) unless otherwise indicated. SD, standard deviation; IQR, interquartile range;

3.2. Age distribution according to AO fracture subtype

Age distribution according to AO/OTA fracture main classes and subtypes is presented in Table 2. When fractures were grouped into the main AO/OTA classes, patient age did not differ significantly across fracture classes (Kruskal–Wallis H=0.124, df=2, p=0.940). The median age was 48.5 years for AO/OTA type A fractures, 36 years for type B fractures, and 45 years for type C fractures.

Table 2: Age distribution across AO/OTA distal humerus fracture main classes and subtypes

AO/OTA Class	*n*	*Age, years, median* (IQR)*	*Range*
Group A	10	48.5 (57)	21-81
13A1	1	21	21
13A2	5	66 (27)	21-81
13A3	4	35.5 (28,25)	22-78
Group B	22	36 (34)	21-86
13B1	10	44 (26,5)	23-68
13B2	2	47	26-68
13B3	10	31 (36)	21-86
Group C	83	45 (31)	18-90
13C1	24	56.5 (34,75)	18-82
13C2	31	40 (23)	19-90
13C3	28	40.5 (28,5)	18-80

**Age is presented as median (interquartile range) and range because of non-normal distributions and small sample sizes in several AO/OTA subgroups.*

3.3. Associations Between Trauma, Injury Characteristics and Treatment

Polytrauma was significantly associated with injury energy level (Pearson χ^2=29.677, df=2, p<0.001). No polytrauma cases were observed among patients with low- or moderate-energy injuries, whereas 22 of 55 patients with high-energy injuries had polytrauma (40 %).

Injury energy level was also significantly associated with open fracture status (Pearson χ^2=25.121, df=2, p<0.001). No open fractures occurred among low-energy injuries. Open fractures were observed in 1 of 13 moderate-energy injuries (7.7%) and 21 of 55 high-energy injuries (38.2%).

Operative treatment was used in 90 of 93 closed fractures (96.8%) and in 20 of 22 open fractures (90.9%), while definitive external fixation was used only in open fractures (2/22, 9.1%).

3.4. Associations Between Gender and Fracture/Injury Characteristics

No statistically significant association was found between gender and AO/OTA main fracture class (Pearson χ^2=2.063, df=2, p=0.356).Although AO type B fractures appeared to be more frequent among female patients than among male patients, this difference did not reach statistical significance. Low-energy injuries were substantially more frequent among women, whereas high-energy injuries were more frequent among men. (Pearson χ^2=18.528, df=2, p<0.001). Open fracture status also differed significantly according to gender (Pearson χ^2=6.638, df=1, p=0.010). The proportion of open fractures was higher among male patients than among female patients (27.7% vs. 8.0%). In contrast, polytrauma status did not differ significantly according to gender (Pearson χ^2=1.295, df=1, p=0.255). Although the proportion of polytrauma was numerically higher among male patients, this difference was not statistically significant.

Table 3: Associations Between Gender and Fracture/Injury Characteristics

	Male, n=66	*Female, n=49*	*Total, n=115*	*p value**
AO/OTA Class				***0.356***
AO Class A	5, 7.6%	5, 10.2%	10	
AO Class B	10, 15.2%	12, 24.5%	22	
AO Class C	51, 77.3%	32, 65.3%	83	
Injury Energy Level				***<0.001***
Low Energy	16, 24.2%	31, 63.3%	47	
Moderate Energy	11, 16.7%	2, 4.1%	13	
High Energy	39, 59.1%	16, 32.7%	55	
Open Fracture Status				***0.010***
Open Fracture	18, 27.3%	4, 8.2%	22	
Closed Fracture	48, 72.7%	45, 91.8%	93	
Polytrauma Status				***0.255***
Polytrauma	15, 22.7%	7, 14.3%	22	
Not Polytrauma	51, 77.3%	42, 85.7%	93	

**Values are presented as n (%). P values for comparisons between gender and AO/OTA class, injury energy level, open fracture status, and polytrauma status were calculated using Pearson chi-square test.*

3.5. Analysis of Treatment and Follow-Up Achievements

Initial treatment was predominantly operative. Of the 115 patients, 110 (95.7%) were managed operatively, 3 (2.6%) were managed nonsurgically (Figure 3), and 2 (1.7%) underwent definitive external fixation. Both cases of definitive external fixation was gunshot injuries. (Figure 4)



Figure 3: One-year follow-up radiographs of the left elbow of a 45-year-old woman. *The patient had previously undergone surgery for an intracranial tumor and had residual hemiplegia with limited functional demand. Owing to her comorbidities, the fracture was managed nonoperatively. The extra-articular AO/OTA type A fracture healed with delayed union. Passive elbow range of motion was preserved.*

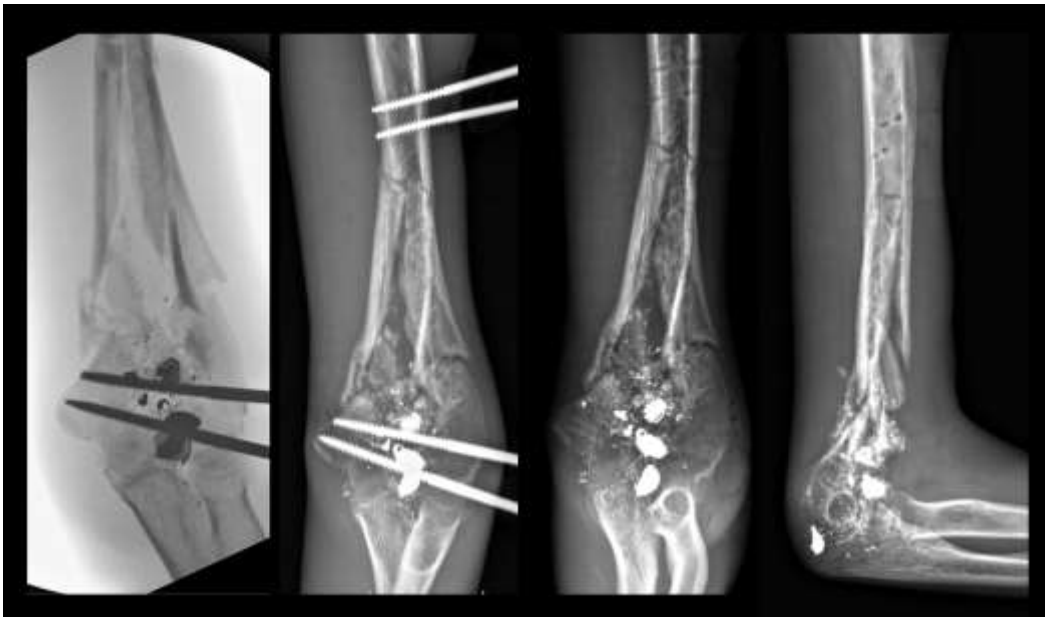

Figure 4: A case treated with definitive external fixation. *Marked metaphyseal comminution and associated soft-tissue injury necessitated external fixation as the initial treatment. The external fixator was subsequently maintained as the definitive method of fracture fixation for 6 months. From left to right: intraoperative fluoroscopic image, postoperative anteroposterior radiograph, and anteroposterior and lateral radiographs obtained after removal of the external fixator.*

At least 12 months of follow-up was available for 72 patients (62.6%). Among patients with at least 12 months of follow-up, the median follow-up duration was 731.5 days (IQR, 575,25; range, 366–1740 days). Follow-up duration was not normally distributed according to the Shapiro–Wilk test ($p<0.001$). Among the 43 patients who did not have at least 12 months of follow-up, 11 were still under active clinical follow-up but had not yet reached the 12-month threshold at the time of the study, 26 were lost to follow-up or had unknown follow-up status, 2 died before hospital discharge, and 4 died within 3 months after discharge. Thus, 72 of the 115 patients (62.6%) had follow-up data available for at least 12 months, while the remaining 43 patients were excluded from the 12-month follow-up analysis for the reasons summarized in Table 4.

Table 4. Follow-up Status of the Study Cohort

Follow-up Status	*n*	%
≥12 months follow-up available	72	62.6
Under active follow-up but not yet reaching 12 months at the time of study	11	9.6
Lost to follow-up / unknown status	26	22.6
Death Before Discharge	2	1.7
Death within 3 months after discharge	4	3.5
Total	115	100
FU duration if FU ≥12 months, days, median (IQR)	731.5 (575.3)	
Follow-up duration range, days	366–1740	

Patients in the "under active follow-up <12 months" category were still being followed clinically but had not yet completed 12 months of follow-up at the time of the study.

4. Discussion

The principal finding of this study was that adult distal humerus fractures treated at a contemporary tertiary trauma center demonstrated a broad and heterogeneous clinical

spectrum, with a substantial contribution from high-energy trauma, complex articular fracture morphology, open injuries, and associated polytrauma. Unlike population-based studies in which distal humerus fractures are frequently characterized as low-energy fragility injuries affecting predominantly older women, the present cohort included a relatively young population, showed a male predominance, and contained a high proportion of high-energy injuries.[1] These findings suggest that the clinical profile of distal humerus fractures encountered at a major metropolitan referral center may differ considerably from that reported in national registries and elderly population-based cohorts.[2]

Distal humerus fractures are uncommon in comparison with other major osteoporotic fractures, but they remain clinically important because of the complex anatomy of the elbow, the frequent involvement of the articular surface, and the technical difficulty of restoring stable fixation and functional motion. Their clinical presentation extends from low-energy extra-articular fractures in older patients with compromised bone quality to severely comminuted, open, and intra-articular injuries associated with high-energy trauma in younger patients.[3] Accordingly, distal humerus fractures should not be considered a uniform injury entity. The present findings support viewing them as a spectrum in which patient characteristics, trauma energy, fracture morphology, soft-tissue injury, and associated systemic trauma collectively determine the initial management burden.

The mean age of the cohort was 45.3 years, and men constituted the majority of patients. The female-to-male ratio was 0.74:1. This distribution differs from registry-based reports demonstrating a clear female predominance, particularly in older age groups. Bergdahl et al., for example, reported a female-to-male ratio of approximately 2.55:1 among patients with distal humerus fractures.[4] The difference between that cohort and the present series may primarily reflect differences in population structure, referral patterns, and the institutional role of the study center.

Population-based and national registry studies capture fractures occurring across an entire geographical population and therefore include a large proportion of elderly patients with low-energy injuries. In contrast, the present institution functions as a tertiary trauma and referral center within a large metropolitan region and manages a substantial volume of high-energy trauma. This setting is likely to increase the relative representation of younger patients, men, open fractures, polytrauma, and complex fracture patterns.[5] Therefore, the male predominance observed in the present study should not necessarily be interpreted as contradicting the established epidemiology of fragility-related distal humerus fractures. Rather, it illustrates how the case mix of a tertiary trauma center may differ from the distribution observed in the general population.

Palvanen et al. demonstrated that the incidence of low-trauma distal humerus fractures among older Finnish women increased markedly over several decades before subsequently stabilizing or declining.[1, 6] Their findings emphasize the relationship between distal humerus fractures, aging, osteoporosis, and demographic change. However, that study was restricted to older women with low-trauma fractures and therefore represents only one part of the wider distal humerus fracture spectrum. The present cohort complements such population-based data by demonstrating the substantial burden created by high-energy and complex injuries in a tertiary-care environment.

Ground-level falls accounted for 40.9% of the injuries in the present study, confirming that low-energy mechanisms remain an important cause of distal humerus fractures. Nevertheless, high-energy trauma constituted 47.8% of the cohort and was therefore slightly more frequent than low-energy trauma. Falls from height, motorized road traffic injuries, motorcycle accidents, and gunshot injuries collectively contributed substantially to the institutional case volume. This distribution explains, at least in part, the relatively young age of the cohort and the greater representation of male patients.

The association between gender and trauma energy further supports this interpretation. Low-energy injuries were more frequent among women, whereas high-energy injuries were significantly more frequent among men. Thus, the overall gender distribution of the cohort appears to reflect differences in trauma exposure rather than a direct gender-specific predisposition to a particular fracture morphology. Consistent with this observation, no statistically significant association was found between gender and AO/OTA main fracture class.

AO/OTA type C fractures represented 72.2% of all fractures and were therefore the dominant fracture pattern in the cohort. This finding is clinically relevant because type C fractures involve the articular surface and are generally associated with greater technical complexity, more demanding reconstruction, and a higher risk of stiffness, fixation failure, nonunion, and post-traumatic arthrosis than simpler extra-articular patterns.[7, 8]

The predominance of type C fractures differs from some registry-based series in which type A fractures were reported as the most frequent main fracture class.[4] This difference may again be related to referral characteristics. Less complex extra-articular fractures may be managed in secondary-care institutions, whereas comminuted intra-articular fractures are more likely to be transferred to tertiary centers with specialized trauma expertise. In addition, the high proportion of high-energy injuries in the present cohort may have contributed to the predominance of type C morphology.

Although type C fractures are often discussed in the context of elderly patients with osteoporosis and poor bone quality, they are not limited to the fragility-fracture population. High-energy trauma in younger patients may also produce severe articular comminution and metaphyseal fragmentation. The absence of a statistically significant difference in age among AO/OTA type A, B, and C fractures in the present study supports this point. Median age was similar across the main fracture classes, and age alone did not appear to predict the principal AO/OTA morphology. Fracture complexity should therefore be interpreted in relation to both trauma energy and bone quality rather than being attributed exclusively to advanced age.

Open fractures were identified in 19.1% of the cohort, a rate approximately twice that reported in the distal humerus subgroup of the registry series cited above, in which 16 of 167 fractures were open, corresponding to 9.6%.[4] The relatively high open-fracture rate in the present study is compatible with its tertiary trauma-center setting and the substantial contribution of high-energy mechanisms.[9]

A strong relationship was observed between trauma energy and open fracture status. No open fractures occurred following low-energy injuries. In contrast, open fractures were observed in 7.7% of moderate-energy injuries and 38.2% of high-energy injuries. This progressive increase demonstrates that trauma energy provides clinically meaningful information regarding soft-tissue injury severity and supports the internal clinical validity of the energy classification used in the study.

Polytrauma was present in 19.1% of patients and occurred exclusively in the high-energy group. Overall, 40.0% of patients with high-energy injuries had polytrauma, whereas no polytrauma cases were recorded following low- or moderate-energy mechanisms. This finding highlights an important distinction between low-energy fragility-type fractures and high-energy distal humerus injuries. In the latter group, treatment priorities may be determined not only by the elbow fracture but also by associated cranial, thoracic, abdominal, pelvic, spinal, or additional extremity injuries and by the patient's overall physiological condition.

Therefore, a distal humerus fracture sustained through a high-energy mechanism should prompt careful evaluation for associated injuries, even when the elbow lesion is the most clinically apparent musculoskeletal injury. In this setting, the fracture may serve as a marker of broader trauma severity rather than an isolated orthopedic problem.

The overwhelming majority of patients underwent operative treatment, reflecting the high prevalence of displaced, intra-articular, and complex fractures in the cohort.[10] Only a small number of patients were treated nonoperatively, generally because of substantial comorbidity, neurological impairment, limited functional demand, or other patient-specific considerations.[11] This distribution is consistent with contemporary treatment principles, according to which operative fixation is generally preferred for displaced distal humerus fractures in medically suitable adults.

Definitive external fixation was used only in open fractures and was reserved for highly selected cases with severe comminution and soft-tissue compromise.[12, 13] Both definitively externally fixed injuries were caused by gunshot trauma. This observation illustrates that external fixation was not used as a routine alternative to internal fixation but as a salvage or definitive stabilization method when conventional reconstruction was limited by bone loss, contamination, comminution, or soft-tissue injury.

Because the present study was designed to characterize clinical distribution rather than treatment outcomes, no conclusions can be drawn regarding the relative effectiveness of internal fixation, external fixation, or nonoperative treatment. Surgical exposure, implant configuration, olecranon osteotomy, union, complications, revision surgery, range of motion, and patient-reported outcomes were intentionally outside the scope of the analysis. These questions require a separate outcome-focused study with standardized follow-up.

At least 12 months of follow-up was available for 72 patients, corresponding to 62.6% of the cohort. Among these patients, the median follow-up duration was 731.5 days, indicating more than two years of observation for the typical patient who remained under clinical surveillance. Nevertheless, follow-up availability was heterogeneous. Eleven patients were still under active follow-up but had not yet reached 12 months at the time of analysis, 26 were lost to follow-up or had unknown follow-up status, and six patients died during the early follow-up period.

This pattern is not unexpected in a large tertiary trauma-center cohort. Patients may be referred from distant regions, return to local institutions after definitive treatment, or discontinue follow-up once early recovery is achieved. Nevertheless, the proportion of patients without complete long-term follow-up limits the ability to evaluate late complications and functional outcomes. For this reason, the present study appropriately focuses on demographic characteristics, injury patterns, and initial management rather than long-term therapeutic success.

The present study does not provide population incidence estimates because it was based on a single institution and did not use a defined population denominator. It should therefore be considered an institutional clinical-distribution study rather than a formal epidemiological investigation. Nevertheless, institutional studies remain valuable because they describe the actual trauma burden encountered by treating surgeons and may reveal injury patterns that are underrepresented in population-based datasets.

The findings indicate that a tertiary metropolitan trauma center may encounter a distinctly different distal humerus fracture profile from that described in elderly registry cohorts. In this environment, surgeons should anticipate a substantial number of younger patients, high-energy injuries, open fractures, polytrauma, and AO/OTA type C fractures. These cases require not only expertise in elbow reconstruction but also multidisciplinary trauma management, soft-tissue assessment, staged treatment planning, and access to alternative fixation strategies.

The principal strength of this study is the inclusion of the full spectrum of adult distal humerus fractures managed at the institution, including operative, nonoperative, open, closed, isolated, and polytrauma cases. Unlike studies limited to a specific surgical

technique or implant, the present analysis provides a broader overview of institutional case distribution.

Several limitations should be acknowledged. First, the retrospective and single-center design limits generalizability. Second, the absence of a population denominator precludes calculation of incidence. Third, the tertiary referral nature of the institution may have produced selection toward more complex injuries. Fourth, trauma energy was classified retrospectively according to documented injury mechanism and may therefore be subject to misclassification. Fifth, some AO/OTA subgroups contained small numbers of patients, limiting subtype-specific statistical comparisons. Sixth, incomplete follow-up prevented reliable assessment of long-term functional and radiological outcomes. Finally, bone mineral density, osteoporosis diagnosis, frailty, and detailed comorbidity indices were not systematically available and could not be incorporated into the comparison of low- and high-energy injury patterns.

5. Conclusion

Adult distal humerus fractures treated at a tertiary trauma center represented a heterogeneous injury spectrum rather than a predominantly elderly fragility-fracture population. High-energy trauma was common, male patients predominated, and open fractures and polytrauma occurred at clinically relevant rates. AO/OTA type C fractures constituted the majority of injuries, while age did not differ significantly among the main AO/OTA fracture classes. These findings demonstrate that the institutional burden of distal humerus fractures is influenced by referral patterns and trauma-center characteristics in this study. Population-based fragility-fracture data and tertiary-center trauma cohorts should therefore be regarded as complementary rather than directly interchangeable descriptions of distal humerus fracture epidemiology.

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Data Availability: All data will be provided by the authors upon request.

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