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Anatomical evaluation of proximal femur fractures in trauma patients aged 65 or older admitted to the emergency department

Acil servise kabul edilen 65 yaş ve üzeri travma hastalarında proksimal femur kırıklarının anatomik değerlendirmesi

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Abstract

Purpose: This retrospective study aimed to assess the association between classification systems for proximal femur fractures and mid-term mortality in elderly patients, focusing on their clinical and anatomical aspects.

Materials and methods: Radiological images of patients aged 65 years and older who underwent surgical procedures for proximal femur fractures were reviewed. Various classification systems were applied, including Anatomical, Pipkin, Garden, Evans-Jensen, Seinsheimer, and AO/OTA classifications. Electronic hospital records provided patient data, and statistical analyses were performed.

Results: The study included 298 patients, and the mean age was 81.7±7.3 years, and 63.1% were female. Median length of stay in hospital 7 (1-63) days, 19.1% requiring intensive care, and a 13.8% mortality rate within 3 months. Patients were distributed based on anatomical classification, and the distribution of intracapsular and extracapsular fractures according to clinical classifications was detailed. The findings suggest that proximal femur fracture classification systems do not significantly influence mortality rates (p=0.787).

Conclusion: Anatomical classification systems may be favored for their simplicity and potential to establish a common language among healthcare professionals. This study provides valuable insights into proximal femur fractures in elderly patients, informing clinical practice.

Keywords: Anatomy, classification, femur, geriatric, hip fractures.

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Öz

Amaç: Bu retrospektif çalışma, proksimal femur kırıkları için sınıflandırma sistemleri ile yaşlı hastalarda orta vadeli mortalite arasındaki ilişkiyi değerlendirmeyi amaçlamıştır, odaklanılan nokta ise klinik ve anatomik yönleridir.

Gereç ve yöntem: Cerrahi işlem uygulanan proksimal femur kırıklı hastaların radyolojik görüntüleri incelendi. Anatomik, Pipkin, Garden, Evans-Jensen, Seinsheimer ve AO/OTA sınıflandırmaları olmak üzere çeşitli sınıflandırma sistemleri uygulandı. Elektronik hastane kayıtları hastaya ait verileri sağladı ve istatistiksel analizler yapıldı.

Bulgular: Çalışma, 298 hastayı içeriyordu ve ortalama yaş 81,7±7,3 yıl idi, %63,1'i kadındı. Hastanede kalış süresi, ortalama 7 (1-63) gün idi, %19,1'i yoğun bakım gerektiriyordu ve 3 ay içinde %13,8'lik bir mortalite oranı görüldü. Hastalar, anatomik sınıflandırmaya göre dağıtıldı ve klinik sınıflandırmalara göre intrakapsüler ve ekstrakapsüler kırıkların dağılımı detaylandırıldı. Bulgular, proksimal femur kırık sınıflandırma sistemlerinin mortalite oranlarını önemli ölçüde etkilemediğini öne sürmektedir (p=0,787).

Sonuç: Anatomik sınıflandırma sistemleri, basitliği ve sağlık profesyonelleri arasında ortak bir dil oluşturma potansiyeli nedeniyle tercih edilebilir. Bu çalışma, yaşlı hastalarda proksimal femur kırıkları hakkında değerli içgörüler sağlayarak klinik uygulamayı bilgilendirir.

Anahtar kelimeler: Anatomi, sınıflandırma, femur, geriatri, kalça kırıkları.

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Introduction

Hip fractures are one of the most prevalent types of fractures, predominantly afflicting the elderly demographic. A discernible escalation in hip fracture incidence is observed, concomitant with the aging global populace, and is principally attributed to pervasive osteoporosis. Projections delineate a significant amplification in both the incidence and the concomitant medical expenditures associated with hip fractures in the forthcoming decades [1, 2]. In the orchestration of strategic treatment paradigms for elderly individuals besieged with hip fractures, healthcare professionals customarily leverage established fracture classification systems. These classification frameworks wield a consequential influence, dictating the trajectory of treatment modalities and inherently impacting the prospective complications and therapeutic outcomes associated with the elected treatment strategies [3, 4].

Hip fractures are systematically categorized into two predominant groups, delineated based on their relational proximity to the capsular attachment: intracapsular and extracapsular fractures [5]. Intracapsular fractures, situated within the confines of the hip joint capsule, are subject to a multitude of classification paradigms. Prominent among these classification mechanisms are Garden's Classification, Pauwels' Classification, and the Arbeitsgemeinschaft für Osteosynthesefragen/ Orthopaedic Trauma Association (AO/OTA) Classification, each offering a nuanced approach to fracture assessment and categorization [6-8]. The Garden Classification is a system used to radiologically assess femoral neck fractures, categorizing them into four types based on the degree of fracture displacement. The Pauwels Classification, on the other hand, classifies femoral neck fractures according to the angle formed between the fracture line and the horizontal plane. Conversely, extracapsular hip fractures manifest externally to the hip joint capsule and encompass variations such as intertrochanteric and subtrochanteric fractures. These fractures are evaluated and classified utilizing a diverse array of mechanisms, with notable classifications including the Evans Classification, AO/OTA Classification, Jensen Classification, and Seinsheimer Classification. Each classification system provides a structured framework, facilitating a comprehensive and nuanced understanding of the fracture's anatomical and clinical intricacies [2, 9]. The Evans Classification categorizes fractures based on stability, assessing them according to the direction of fracture lines and the degree of displacement. The Jensen Classification evaluates intertrochanteric fractures based on stability and the extent of comminution. The Seinsheimer Classification grades fractures according to the degree and number of fragments, assessing the severity of the fracture. The AO/OTA Classification provides a detailed categorization of bone fractures based on anatomical and biomechanical principles.

Hip fractures are anatomically delineated based on the specific location and nature of the fracture within the hip joint, primarily bifurcating into intracapsular and extracapsular fractures. Extracapsular fractures manifest externally to the hip joint capsule and are further subclassified into intertrochanteric fractures, located between the greater and lesser trochanters, and subtrochanteric fractures, occurring below the lesser trochanter and extending into the femoral shaft [2, 5, 9]. Intracapsular fractures, on the other hand, are localized within the hip joint capsule. These fractures are further categorized into femoral neck fractures, which occur at the juncture of the femoral neck and head, and femoral head fractures, which involve the femoral head directly. Femoral head fractures are relatively rare, predominantly associated with high-energy traumatic incidents [3]. Femoral neck fractures can be classified into subcategories such as subcapital fractures, transcervical fractures, and basicervical fractures [10]. Basicervical fractures typically manifest proximal to or along the intertrochanteric line and are generally categorized as extracapsular, with their treatment protocols aligning closely with those of intertrochanteric fractures [11, 12].

Classification systems for hip fractures play a pivotal role in steering clinical decisions, influencing treatment strategies, forecasting potential complications, and outcomes associated with various fracture types. These systems facilitate informed decision-making regarding surgical interventions, implant selections, and the formulation of robust rehabilitation strategies tailored to individual patient needs [8, 13]. However, the diversity of classification systems and the varied nomenclature employed within clinical settings often breed confusion and ambiguity, complicating the communication and decision-making processes.

We advocate for the prioritization of anatomical classification systems, as they foster a unified language and enhance clarity among clinicians, thereby streamlining clinical communications and decision-making. In our study, we aimed to assess the efficacy of anatomical classification in predicting mortality outcomes for proximal femur fractures, juxtaposed against other prevalent classification methodologies utilized in clinical settings.

Materials and methods

A retrospective study was meticulously designed and conducted at a single center during the period from January 1, 2019 to December 31, 2020. This study primarily involved the meticulous examination of radiological images belonging to patients aged 65 years and above, who had endured proximal femoral fractures and subsequently underwent surgical procedures. Radiological images utilized in this study were diligently sourced from the Picture Archiving and Communication System (PACS). Ethical clearance for conducting this study was graciously accorded by the “Medical and Health Sciences Ethics Committee – 1” of Muğla Sıtkı Koçman University on May 15, 2023, bearing the reference number 220046-50. Given the retrospective nature of this study, the customary requirement for obtaining informed written consent from participants was judiciously waived.

The criteria for inclusion in this study were meticulously defined to ensure a focused and relevant participant selection. Eligible participants were required to be aged 65 years or older, with a documented history of experiencing a slip, fall, or trivial trauma, and must have undergone a surgical procedure. Additionally, a minimum of 3-months of follow-up data was necessitated for each participant. Exclusion criteria were also carefully delineated to maintain the study’s integrity. Participants who had encountered multiple traumas, those who opted not to receive treatment, and individuals whose radiological images were inaccessible through the PACS were systematically excluded from participation in the study.

Upon the successful identification of eligible participants, a comprehensive assessment of their radiological images was undertaken by expert Emergency Physicians, who conducted the evaluation with an unbiased approach, devoid of prior knowledge regarding the patients’ identities. A multifaceted classification strategy was employed, utilizing a diverse array of classification systems such as the Anatomical, Pipkin, Garden, Evans-Jensen, Seinsheimer, and AO/OTA classifications. In a concerted effort to garner a holistic understanding of the patients’ medical histories and current health statuses, electronic hospital records were meticulously reviewed. This review process aimed to collate essential information, including the patients’ age, gender, the necessity for admission to the Intensive Care Unit (ICU), the duration of their hospital stay, and the incidence of mortality within a 90-day period, encompassing all causative factors.

Statistical analysis

The distribution of the data was rigorously evaluated for normality utilizing the Kolmogorov-Smirnov test. Continuous variables were articulated through two distinctive methods to enhance the precision and clarity of the presentation. For data adhering to a normal distribution, values were depicted as means accompanied by their respective standard deviations (mean±SD). Conversely, for data not conforming to a normal distribution, values were presented as median (min-max). Categorical variables were meticulously represented, employing absolute values and their corresponding percentages to facilitate a comprehensive and nuanced understanding. Comparative analyses between groups were executed utilizing a Chi-square test, fostering a robust comparative evaluation. For all tests, $p<0.05$ (2 sided) was considered statistically significant. All analyses were performed using SPSS version 23.0 statistical software (SPSS, Inc, Chicago, IL).

Results

Over a two-year period, 64,890 patients presented to the ED trauma area, of which 19.955 were aged 65 and over. Among all patients, 1.152 were diagnosed with a femur fracture based on ICD codes. After excluding patients with multiple traumas, the number was reduced to 524. Further exclusions were made for those with a history of previous surgery, those who refused treatment at our hospital, and those who were not treated surgically, resulting in a study cohort of 326 patients. During the three-month mortality follow-up, data were successfully obtained for 304 patients, while direct radiographs were missing for 6 patients in the PACS system. Ultimately, the final analysis included data from 298 patients (Figure 1).

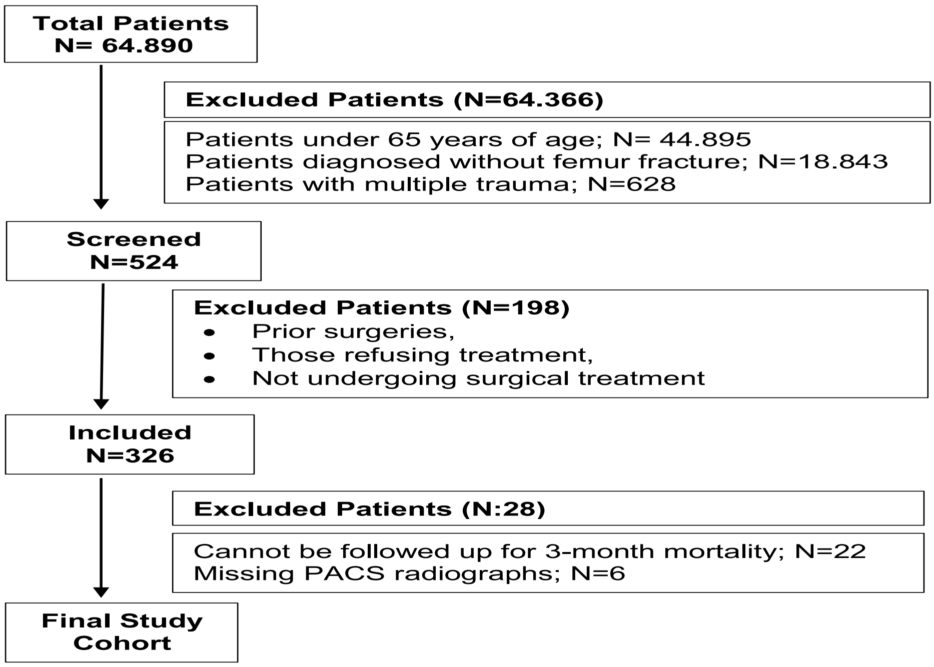

Figure 1. Flow chart

A comprehensive demographic analysis revealed that the participants' ages were distributed with a mean of 81.7±7.3 years, ranging broadly from 65 to 102 years, and a median age manifesting at 83 years. A notable predominance of females was observed within the study population, constituting 63.1% of the total participants, thereby highlighting a gender-based inclination in the occurrence of the fractures. An anatomical perspective of the fractures disclosed that 156 patients, representing 52.3% of the population, sustained fractures in their right femur. Conversely, the left femur was implicated in the fractures sustained by 142 patients, accounting for 47.7% of the participants, thus illustrating a relatively balanced distribution of fractures across the anatomical locations.

The hospitalization period exhibited variability among the patients, with the median duration of stay established at 7 (1-63) days. A segment of the patient population, constituting 19.1% (57 patients), necessitated admission into ICUs as part of their treatment protocol, underscoring the severity and complexity of their clinical presentations. In a pursuit to elucidate the mid-term mortality rates, a survival analysis spanning a 3-month period post-surgery was meticulously conducted. The findings from this analysis unveiled a mortality rate of 13.8%, representing 41 patients who unfortunately succumbed within the initial 3 months subsequent to their surgical procedures.

Table 1 meticulously delineates the distribution of patients who sustained proximal femur fractures, categorized based on anatomical classifications, and correlates these classifications with respective mortality rates. Moving on, Table 2 provides a comprehensive display of the distribution of patients who endured intracapsular fractures, with classifications articulated according to various established criteria such as the Pipkin, Garden, and AO/OTA classifications. Concluding this segment, Table 3 and Table 4 systematically presents the distribution of patients afflicted with extracapsular fractures, classified according to several recognized systems including the Evans-Jensen, Seinsheimer, and AO/OTA classifications.

Table 1. Patient distribution based on anatomical classification and mortality

	Intracapsular, n:100 (100.0)				Extracapsular, n:198 (100.0)		
	Femoral Head (n=2)	**Subcapital (n=12)**	**Transcervical (n=66)**	**Basocervical (n=20)**	**Interthoracanteric (n=185)**	**Subthoracanteric (n=13)**	***P* (test value)**
Survivor, n (%)	2 (2.0)	11 (91.7)	56 (84.8)	18 (90.0)	157 (84.9)	13 (100)	0.776 (2.470)[a]
Mortality, n (%)	0	1 (8.3)	10 (15.2)	2 (10.0)	28 (15.1)	0	
	Intracapsular, n:100 (100.0)				**Extracapsular, n:198 (100.0)**		***P* (test value)**
Survivor, n (%)	87 (87)				170 (85.9)		0.927 (0.008)[b]
Mortality, n (%)	13 (13.0)				28% (14.1)		

Data are expressed as count (n) and %. Abbreviations: AO/OTA, Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association
[a] Fisher-Freeman Halton test was used as Chi-square test result to comparise subgroups of femoral fractures in term of mortality
[b] Yates' corrected-Chi-square test was used for Chi-square test result to comparise intracapsular vs extracapsular fractures in term of mortality

Table 2. Distribution of intracapsular fracture patients according to clinical classifications and mortality numbers

-		AO/OTA classification	Survivor, n:87 (%)	Mortality, n:13 (%)
Pipkin classification	Pipkin 1	31-C1.1	0	0
		31-C1.2	0	0
		31-C1.3	0	0
	Pipkin 2	31-C2.1	0	0
	Pipkin 3	31-C2.2	1 (1.1)	0
	Pipkin 4	31-C2.3	3 (3.4)	0
Garden classification	Garden 1	31-B1.1	1 (1.1)	0
		31-B1.2	5 (5.8)	0
		31-B1.3	2 (2.3)	1 (7.7)
	Garden 2	31-B2.1	11 (12.7)	2 (15.4)
		31-B2.2	14 (16.1)	5 (38.5)
		31-B2.3	9 (10.3)	2 (15.4)
	Garden 3	31-B3	29 (33.3)	2 (15.4)
	Garden 4		12 (13.8)	1 (7.7)

Data are expressed as count (n) and %. AO/OTA, Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association

Table 3. Distribution and mortality numbers of patients with extracapsular fractures according to Evans-Jensen classification and OA/ATO classification

-		AO/OTA classification	Survivor, n:157 (%)	Mortality, n:28 (%)
Evans-Jensen classification	Type 1	31-A1.1	4 (2.5)	1 (3.6)
	Type 2	31-A1.2	25 (15.9)	1 (3.6)
	Type 3	31-A1.3	106 (67.5)	19 (67.8)
	Type 4	31-A2.1	6 (3.8)	1 (3.6)
		31-A2.2	6 (3.8)	1 (3.6)
		31-A2.3	1 (0.7)	1 (3.6)
		31-A3.1	1 (0.7)	0
	Type 5	31-A3.2	3 (1.9)	4 (14.2)
		31-A3.3	5 (3.1)	0

Data are expressed as count (n) and %. AO/OTA, Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association

Table 4. Distribution and mortality numbers of patients with extracapsular fractures according to Seinsheimer classification and OA/ATO classification

-		AO/OTA classification	Survivor, n:16 (%)	Mortality, n:4 (%)
Seinsheimer classification	Type 1	-	1 (6.25)	0
	Type 2		6 (37.5)	0
	Type 3		5 (31.25)	0
	Type 4		1 (6.25)	0
	Type 5	31-A3.2	3 (18.75)	4 (100)

Data are expressed as count (n) and %. AO/OTA, Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association

Discussion

In our research, we conducted an in-depth analysis of proximal femur fractures, a prevalent medical concern, particularly among the elderly population. We examined these fractures from a multifaceted perspective, considering both their anatomical characteristics and clinical attributes. Our specific focus was on understanding the relationship between these factors and mid-term mortality rates. This detailed investigation revealed an intriguing insight: the classification systems we meticulously examined did not demonstrate a significant advantage over one another. This finding highlights the importance of revisiting the approaches used in clinical settings and potentially shifting the emphasis towards a more cohesive and streamlined method for classifying proximal femur fractures.

In 2018, the AO Foundation and the OTA collaborated to establish a comprehensive classification system. This system was meticulously designed to offer a standardized and logically structured approach for categorizing and documenting bone fractures and dislocations, commonly referred to as the AO/OTA classification [14]. Notably, this classification system employs a sophisticated and highly specific methodology, rendering it particularly well-suited for academic and research purposes [15]. However, it is worth noting that our analysis did not reveal any substantial advantages in terms of mortality. Therefore, it may be more practical to consider utilizing existing clinical or anatomical classifications instead of this particular system.

The femur, known as the body's strongest bone, derives its strength from its unique anatomical features. However, its proximal region, consisting of the neck and trochanteric part, is particularly vulnerable. Proximal femur fractures are predominantly observed in this area and are associated with severe morbidity and mortality. In the 1990s, reports indicated that approximately 1.3 million patients worldwide suffered from femur fractures annually. However, projections suggest a significant increase, ranging from 7.3 to 21.3 million cases by 2050. Notably, a substantial portion of those affected by proximal femur fractures consists of elderly patients [16]. A comprehensive investigation into the factors contributing to frailty in the elderly has highlighted several key elements, including undesirable weight loss, diminished grip strength, self-reported burnout, reduced walking speed, and low levels of physical activity [17]. Furthermore, factors such as alterations in the femoral neck angle and age-related osteoporosis are believed to substantially contribute to the prevalence of these fractures, resulting in a higher incidence of femur fractures [8, 18]. Our research aligns with existing literature, focusing on the elderly population. Our patient demographics closely mirror the characteristics described in the literature, with a higher representation of females, and an equitable distribution of fracture types.

Fractures affecting the femur can be anatomically classified as intracapsular and possess the potential to disrupt blood supply to the femoral head, potentially leading to avascular necrosis after traumatic events. For intracapsular fractures, the Pipkin classification is employed. In Pipkin types 1 and 2, the fracture is associated with the foveal line, and clinical recommendations encompass a conservative approach or surgical intervention following closed reduction. However, in the case of Pipkin types 3 and 4, there is not only a femoral head fracture but also concomitant femoral neck and acetabulum fractures. In these complex scenarios, the blood supply to the femoral head is compromised, necessitating immediate surgical intervention [19]. Within intracapsular fractures, femoral neck fractures can be further subdivided into subcapital, transcervical, and basicervical fractures. These subdivisions are often managed according to the Garden classification. Garden 1 fractures denote non-displaced and stable fractures, typically amenable to conservative management. In contrast, Garden 2 fractures, although not distinctly categorized, are often associated with impaired blood supply. Garden 3 and 4 fractures are characterized by a complete separation of the femoral neck. Garden 2, 3 and 4 fractures necessitate surgical treatment [20]. In summary, the clinical management of these intricate fractures requires meticulous classification and a tailored approach to ensure optimal patient outcomes.

Extracapsular fractures of the femur are subdivided into intertrochanteric and subtrochanteric categories, primarily based on their location relative to the trochanter.

Among these, intertrochanteric fractures are frequently classified using the Evans/Jensen classification system, which comprises five distinct types. Each type reflects various fracture characteristics, including displacement, angulation, comminution, involvement of the greater trochanter, participation of the lesser trochanter, and oblique extension. Notably, except for Type 1, which designates a stable fracture, all other types necessitate surgical intervention. On the other hand, subtrochanteric fractures are often categorized according to the Seinsheimer classification system. This system designates Type 1 as a nondisplaced fracture, whereas Types 2, 3, and 4 represent transverse, oblique, and comminuted fractures, respectively. Type 5 is characterized by a fracture extending into the trochanteric region [21]. Importantly, it's worth noting that this classification system lacks an equivalent representation within the AO/OTA classification.

In a study focused on classification systems, it was determined that there were no significant variations in terms of the effectiveness of all the classification systems considered [22]. When deciding on a classification system, it's advisable to choose systems that facilitate effective communication among clinicians. Furthermore, an ideal classification system should aid in diagnosing the patient, devising a treatment plan, and predicting the likely outcome. With this perspective in mind, it might be worth considering the adoption of an anatomical classification system that is more user-friendly for clinicians, such as the academically established AO/OTA classification system.

The risk of death following a hip fracture in older individuals is significantly elevated, with mortality rates being 5 to 8 times higher than those in the general population [23]. Various studies have reported differing mortality statistics for proximal femur fractures, with annual mortality rates ranging from 14% to 36% [24]. In a research effort that investigated annual mortality based on the anatomical location of the fracture, mortality rates were found to be 26.8% for intracapsular fractures, 28.2% for intertrochanteric fractures, and 24.2% for subtrochanteric fractures. Interestingly, the study did not identify any significant differences in mortality rates based on the location of the fracture [25]. In another study examining short-term mortality, the 30-day mortality rates were reported as 6.5% for intertrochanteric fractures, 17.2% for subtrochanteric fractures, and 7.5% for intracapsular fractures. Similar to the previous study, no significant disparities in mortality rates were observed among different fracture locations. According to the results of the study, patient comorbidities and clinical frailty scores were identified as significant determinants of mortality [26]. In our own study, we focused on mid-term mortality, and the mortality rates for intracapsular (13%) and extracapsular (14.1%) fractures were consistent with findings in the existing literature. Furthermore, our study, like others, did not establish a significant association between the location of the fracture and mortality (p=0.787).

While the findings from our research have broad applicability, there are certain limitations to consider. Our study was conducted at a single center, which may affect the generalizability of the results. Additionally, as it was a retrospective study, there were challenges in accurately identifying and retrieving patient data from their medical records. Only patients who underwent surgical procedures were included, and patients with stable fractures were excluded since they did not require surgery. This exclusion limits our ability to accurately determine the prevalence of lower-level patients in the classifications. Furthermore, our sample size and exclusion criteria may have limited our ability to predict patient mortality outcomes accurately. This represents another constraint in our study. To address these limitations, future research conducted prospectively, involving multiple medical centers, is expected to yield more extensive and thorough results.

In conclusion, individuals afflicted with proximal femur fractures, confronted with a notable 3-month mortality rate of 13.8%, represent a patient cohort marked by a substantially heightened mortality risk. Although various classification methodologies exist for the evaluation of the clinical attributes of these patients, none of these systems manifest a discernible superiority in prognosticating mortality outcomes. Among the accessible classification systems, the adoption of anatomical classification may be preferable due to its straightforwardness and its capacity to engender a standardized lexicon among healthcare practitioners.

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