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Association Between Radiographic Knee Osteoarthritis, Pre-Fracture Mobility, and Hip Fracture Patterns in Older Adult Patients: A Retrospective Cohort Study

Authors' Contribution:

Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ABCEF **Süleyman Kaan Öner** 
BCDF **Enes Alptekin Canlı** 
CF **Turan Cihan Dülgeroğlu** 
AD **Sabit Numan Kuyubaşı** 
BE **Süleyman Kozlu** 
BCD **Recep Berk Üren** 

Department of Orthopedics and Traumatology, Faculty of Medicine,
Kutahya Health Sciences University, Kutahya, Türkiye

Corresponding Author: Enes Alptekin Canlı, Department of Orthopedics and Traumatology, Kutahya Health Sciences University Kutahya City Hospital, Eviyya Celebi Mah., Tavsanli Yolu Cd., 43040 Merkez/Kutahya, Türkiye, Phone: +90 5056154568, e-mail: drenesacanlı@gmail.com
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Background: Hip fracture morphology in older adults is influenced not only by bone mineral density but also by biomechanical and functional factors. Knee osteoarthritis (KOA) can alter lower-limb alignment, load distribution, and gait patterns, potentially affecting the type of hip fracture sustained. This study aimed to evaluate the association between radiographic KOA and hip fracture type while accounting for osteoporosis and pre-fracture mobility.

Material/Methods: This single-center retrospective cohort study included patients aged ≥ 65 years admitted with low-energy hip fractures between January 2018 and December 2023. Radiographic KOA was assessed using Kellgren-Lawrence classification, defined as grade ≥ 2 . Osteoporosis was evaluated using dual-energy X-ray absorptiometry within 1 year before fracture. Pre-fracture mobility was assessed using the Parker Mobility Score, categorized as high (7-9), moderate (4-6), or low (0-3). Hip fractures were classified as femoral neck or intertrochanteric. Multivariable logistic regression identified predictors of intertrochanteric fracture.

Results: Ninety-two patients (mean age 79.1 ± 7.8 years; 67.4% female) were included. Intertrochanteric fractures occurred in 55 patients (59.8%). KOA was present in 56 patients (60.9%), and osteoporosis in 64 (69.6%). Intertrochanteric fractures were more common in patients with KOA (71.4% vs 41.7%, $P=0.006$). Low mobility was also associated with higher rates (79.4% vs 54.8% vs 40.7%, $P=0.007$). KOA (OR 2.87; 95% CI, 1.18-6.99; $P=0.020$) and low mobility (OR 3.41; 95% CI, 1.42-8.19; $P=0.006$) were independent predictors, whereas osteoporosis was not.

Conclusions: KOA and reduced mobility were found to be independently associated with intertrochanteric fracture patterns, underscoring the role of biomechanical and functional factors beyond bone density.

Keywords: Hip Fractures • Mobility Limitation • Orthopedics • Osteoporosis • Retrospective Studies

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Introduction

Hip fractures are a leading cause of morbidity, mortality, and functional decline in the older adult population worldwide [1,2]. Although osteoporosis is a well-established risk factor, bone mineral density alone does not fully explain the occurrence and pattern of hip fractures [3]. Increasing evidence suggests that functional status and lower extremity biomechanics also play an important role in fracture mechanisms.

Knee osteoarthritis (KOA) is highly prevalent among older adults and is associated with pain, malalignment, and impaired proprioception, leading to altered gait and balance [4,5]. These biomechanical changes can influence fall dynamics and load transmission to the proximal femur; however, the relationship between KOA and hip fracture type remains insufficiently explored.

Pre-fracture mobility is another key determinant of fall characteristics and fracture outcomes. Reduced mobility reflects frailty and musculoskeletal degeneration and has been associated with increased fall risk and worse outcomes following hip fracture [6]. Importantly, impaired mobility may confound or mediate the relationship between knee pathology and hip fracture pattern.

Despite the frequent coexistence of KOA, impaired mobility, and osteoporosis in older adult patients with hip fractures, few studies have evaluated these factors simultaneously using validated assessment tools. Therefore, the aim of this study was to investigate the association between radiographic KOA and hip fracture type while adjusting for osteoporosis and pre-fracture mobility. We hypothesized that KOA and reduced pre-fracture mobility would be independently associated with intertrochanteric fracture patterns.

Material and Methods

Study Design and Ethics Approval

This study was designed as a single-center, retrospective observational cohort study. Institutional ethics committee approval was obtained prior to data collection (approval No: 2026/02-29). The study was conducted in accordance with the Declaration of Helsinki. Due to the retrospective nature of the study, informed consent was waived.

Study Population

Consecutive patients aged 65 years and older who were admitted with a low-energy hip fracture between January 2018 and December 2023 were screened for eligibility.

The inclusion criteria were as follows: age 65 years or older; low-energy hip fracture resulting from a fall from standing height or less; radiographically confirmed femoral neck or intertrochanteric fracture; availability of bilateral knee radiographs; availability of dual-energy X-ray absorptiometry (DXA) performed within 1 year prior to fracture; and complete clinical and radiographic records.

The exclusion criteria were as follows: high-energy trauma; pathological fractures; periprosthetic fractures; previous hip or knee arthroplasty; inflammatory arthritis (eg, rheumatoid arthritis); post-traumatic knee osteoarthritis; and neurological disorders affecting gait or balance (eg, stroke with residual deficit, Parkinson disease).

A total of 192 patients met the initial eligibility criteria. Of these, 100 patients were excluded due to missing imaging data, primarily the absence of bilateral knee radiographs and/or DXA measurements within 1 year prior to fracture. The final study cohort therefore consisted of 92 patients.

To assess potential selection bias, baseline demographic characteristics (age and sex) of included and excluded patients were compared when available. Missing imaging data were related to the retrospective nature of the study and variability in pre-fracture imaging availability rather than predefined clinical exclusion criteria. However, the randomness of missing data could not be definitively confirmed.

Hip Fracture Classification

Hip fractures were classified using standard anteroposterior pelvic radiographs obtained at admission as femoral neck fractures (intracapsular fractures proximal to the intertrochanteric line) or intertrochanteric fractures (extracapsular fractures between the greater and lesser trochanters). Fracture classification was independently performed by 2 senior orthopedic surgeons blinded to knee osteoarthritis and osteoporosis status, with discrepancies resolved by consensus.

Radiographic Assessment of KOA

Knee osteoarthritis severity was evaluated on anteroposterior knee radiographs using the Kellgren-Lawrence (KL) classification system. KOA was defined as a KL grade of 2 or higher, while patients with KL grades 0 or 1 were classified as the non-KOA group. Interobserver reliability for KL grading was excellent, with an intraclass correlation coefficient (ICC) of 0.82. A KL grade of 2 or higher was selected to represent definite radiographic KOA, consistent with prior epidemiological and biomechanical studies. Laterality of KOA relative to the fracture side (ipsilateral, contralateral, or bilateral) was recorded but not included in the multivariable analysis due to limited subgroup sizes.

Assessment of Osteoporosis

Osteoporosis status was assessed exclusively using DXA. Only patients with available DXA measurements obtained within 1 year prior to the index fracture were included in the analysis. DXA scans of the lumbar spine (L1-L4) and proximal femur (femoral neck and/or total hip) were reviewed. Bone mineral density values were classified according to World Health Organization criteria. For statistical analysis, patients were dichotomized into osteoporotic (T-score ≤ -2.5) and non-osteoporotic (T-score > -2.5) groups.

Pre-Fracture Mobility Assessment

Pre-fracture mobility was assessed using the Parker Mobility Score (PMS), which evaluates walking ability indoors, outdoors, and during shopping or social activities. Each domain is scored from 0 to 3, yielding a total score of 0 to 9. Pre-fracture mobility status was determined based on functional capacity during the 2 weeks preceding the fracture, obtained retrospectively from standardized medical records and, when necessary, from structured interviews conducted by the treating orthopedic team. Patients were categorized as having high (7-9), moderate (4-6), or low (0-3) mobility.

Clinical and Demographic Data

Age, sex, body mass index (BMI), fracture side, pre-fracture mobility category, Charlson Comorbidity Index, KOA status, and osteoporosis status were recorded.

Outcome Measures

The primary outcome was the association between KOA and hip fracture type after adjustment for osteoporosis and pre-fracture mobility. Secondary outcomes included the relationship between osteoporosis and fracture pattern, the association between pre-fracture mobility and fracture type, and identification of independent predictors of intertrochanteric fracture.

Statistical Analysis

Statistical analyses were performed using SPSS software (version 26.0, IBM Corp, Armonk, NY, USA). Normality was assessed using the Shapiro-Wilk test. Continuous variables were compared using the *t* test or Mann-Whitney U test, and categorical variables were analyzed using the chi-square or Fisher exact test, as appropriate. A multivariable logistic regression model was constructed including age, sex, BMI, KOA (KL ≥ 2), osteoporosis status, and pre-fracture mobility category. Variables were selected based on clinical relevance and prior literature. Results were reported as odds ratios with 95% confidence intervals. Statistical significance was set at $P < 0.05$. The number of outcome events per variable met commonly

recommended thresholds for multivariable logistic regression analysis. Multicollinearity among independent variables was assessed using variance inflation factors, with values less than 5 considered indicative of acceptable collinearity. Model calibration was evaluated using the Hosmer-Lemeshow goodness-of-fit test. Model discrimination was assessed using the area under the receiver operating characteristic curve (AUC).

Reporting Standards

This study was conducted and reported in accordance with the STROBE guidelines for observational studies.

Results

Patient Characteristics

A total of 92 patients were included in the final analysis, consisting of 62 women (67.4%) and 30 men (32.6%), with a mean age of 79.1 ± 7.8 years. Intertrochanteric fractures were identified in 55 patients (59.8%), while femoral neck fractures were identified in 37 patients (40.2%).

Radiographic KOA, defined as KL grade ≥ 2 , was present in 56 patients (60.9%). Osteoporosis based on DXA criteria (T-score ≤ -2.5) was detected in 64 patients (69.6%). Pre-fracture mobility assessment using the PMS revealed low mobility (PMS 0-3) in 34 patients (37.0%), moderate mobility (PMS 4-6) in 31 patients (33.7%), and high mobility (PMS 7-9) in 27 patients (29.3%). Baseline demographic and clinical characteristics are summarized in **Table 1**.

A comparison of included and excluded patients is presented in **Table 2**. There were no statistically significant differences between the 2 groups in terms of age and sex distribution ($P > 0.05$ for both), suggesting that the excluded patients were broadly comparable to the study cohort based on available demographic variables.

Association Between KOA and Hip Fracture Type

Intertrochanteric fractures were significantly more frequent in patients with radiographic KOA (KL ≥ 2) compared with those without KOA (KL < 2) (71.4% vs 41.7%, $P = 0.006$). In contrast, femoral neck fractures were more commonly observed in patients without KOA. The distribution of fracture types according to KOA status is presented in **Table 3**.

Osteoporosis and Hip Fracture Pattern

All included patients had available DXA measurements obtained within 1 year prior to fracture. Intertrochanteric fractures were

Table 1. Baseline demographic and clinical characteristics of the study population (n=92).

Variable	Value
Age (years), mean±SD	79.1±7.8
Female sex, n (%)	62 (67.4)
Body mass index (kg/m ²), mean±SD	26.3±4.1
Fracture type, n (%)	
– Femoral neck	37 (40.2)
– Intertrochanteric	55 (59.8)
Knee osteoarthritis (KL ≥2), n (%)	56 (60.9)
Osteoporosis (DXA), n (%)	64 (69.6)
Pre-fracture Parker Mobility Score category, n (%)	
– High (7-9)	27 (29.3)
– Moderate (4-6)	31 (33.7)
– Low (0-3)	34 (37.0)
Charlson Comorbidity Index, mean±SD	5.2±1.4

Abbreviations: KL, Kellgren-Lawrence; DXA, dual-energy X-ray absorptiometry. Values are presented as mean±standard deviation or number (percentage), as appropriate.

Table 2. Comparison of included and excluded patients.

Variable	Included (n=92)	Excluded (n=100)	P value
Age (years), mean±SD	79.1±7.8	78.4±8.1	0.512
Female sex, n (%)	62 (67.4%)	65 (65.0%)	0.728

Values are presented as mean±standard deviation or number (percentage). P values were calculated using the t test for continuous variables and chi-square test for categorical variables.

Table 3. Relationship between radiographic knee osteoarthritis (KOA) and hip fracture type.

KOA status	Femoral neck, n (%)	Intertrochanteric, n (%)	P value
KOA (KL ≥2), n=56	16 (28.6)	40 (71.4)	
No KOA (KL <2), n=36	21 (58.3)	15 (41.7)	0.006

P values were calculated using the chi-square test.

Table 4. Association between Parker Mobility Score category and hip fracture type.

PMS category	Femoral neck	Intertrochanteric	P value
High (7-9), n=27	16 (59.3%)	11 (40.7%)	
Moderate (4-6), n=31	14 (45.2%)	17 (54.8%)	
Low (0-3), n=34	7 (20.6%)	27 (79.4%)	0.007

PMS, Parker Mobility Score. P values were calculated using the chi-square test.

more frequently observed in patients with osteoporosis than in those without osteoporosis (65.6% vs 45.8%); however, this difference did not reach statistical significance (P=0.081).

Pre-Fracture Mobility and Hip Fracture Type

A significant association was observed between pre-fracture mobility and fracture pattern. Patients with low pre-fracture mobility (PMS 0-3) exhibited a markedly higher rate of intertrochanteric fractures compared with those with moderate and high mobility (79.4% vs 54.8% vs 40.7%; P=0.007), as shown in **Table 4**.

Multivariable Logistic Regression Analysis

A multivariable logistic regression analysis was performed to identify independent predictors of intertrochanteric fracture after multivariable adjustment for age, sex, BMI, osteoporosis status, and pre-fracture mobility. Radiographic KOA (KL ≥2) (OR 2.87; 95% CI, 1.18-6.99; P=0.020) and low pre-fracture mobility (PMS 0-3) (OR 3.41; 95% CI, 1.42-8.19; P=0.006) emerged as independent predictors of intertrochanteric fracture. Osteoporosis did not remain a significant predictor in the adjusted model. Results of the regression analysis are summarized in **Table 5**. The Hosmer-Lemeshow goodness-of-fit test indicated adequate model calibration (P=0.64). The model

Table 5. Multivariable logistic regression analysis for predictors of intertrochanteric fracture.

Variable	β	SE	OR	95% CI	P value
Age (per 1-year increase)	0.039	0.025	1.04	0.99-1.09	0.112
Female sex (vs male)	0.322	0.436	1.38	0.58-3.27	0.462
Body mass index (kg/m ²)	0.058	0.040	1.06	0.98-1.15	0.148
Osteoporosis (yes vs no)	0.482	0.404	1.62	0.71-3.69	0.252
KOA (KL ≥ 2 vs < 2)	1.054	0.452	2.87	1.18-6.99	0.020
Low mobility (PMS 0-3 vs ≥ 4)	1.227	0.438	3.41	1.42-8.19	0.006

Abbreviations: KOA, knee osteoarthritis; OR, odds ratio; SE, standard error; KL, Kellgren-Lawrence; PMS, Parker Mobility Score.

demonstrated acceptable discrimination with an AUC of 0.74 (95% CI, 0.64-0.84).

Discussion

The present study demonstrates that radiographic KOA (KL grade ≥ 2) and reduced pre-fracture mobility are independently associated with intertrochanteric hip fracture patterns in older adult patients, even after adjustment for osteoporosis and demographic factors. These findings indicate that hip fracture morphology cannot be explained solely by bone mineral density and underscore the importance of functional and biomechanical contributors in fracture mechanisms.

Hip fractures remain a major cause of morbidity and mortality in the aging population and have traditionally been attributed to osteoporosis and low-energy trauma [7-9]. However, accumulating evidence suggests that bone mineral density alone does not adequately explain differences in fracture patterns or fracture morphology [10-12]. In line with these observations, osteoporosis was highly prevalent in our cohort but did not emerge as an independent predictor of fracture type after multivariable adjustment.

Radiographic KOA was present in approximately 61% of patients in our study, consistent with epidemiological reports indicating a high coexistence of knee osteoarthritis and hip fractures in older adults [13,14]. Importantly, patients with KOA exhibited a significantly higher proportion of intertrochanteric fractures, and KOA independently increased the odds of this fracture pattern by nearly 3-fold. This finding suggests that knee joint degeneration may influence hip fracture morphology beyond its association with age or reduced bone density.

Several biomechanical mechanisms may explain this relationship. KOA is associated with reduced knee flexion during gait, altered coronal plane alignment, and impaired shock absorption [15-17]. These alterations can limit the ability to dissipate

impact forces during a fall, resulting in increased load transmission to the extracapsular region of the proximal femur. Experimental and finite element studies have demonstrated that fall direction, joint positioning, and load distribution substantially influence stress concentrations within the proximal femur, favoring intertrochanteric fracture patterns under specific mechanical conditions [18,19].

Pre-fracture mobility emerged as the strongest independent predictor of intertrochanteric fracture in our cohort. Patients with low PMS had more than a 3-fold increased risk of sustaining intertrochanteric fractures. Reduced mobility reflects a complex interaction of frailty, sarcopenia, neuromuscular impairment, and joint degeneration, all of which can adversely affect balance and protective responses during falls [20,21].

Reduced pre-fracture mobility also represents a long-term functional trajectory rather than an acute deterioration. Longitudinal studies have shown that functional decline often precedes major adverse health events, including fractures, and serves as a marker of cumulative vulnerability in older adults [22]. This concept supports our findings that low mobility is not merely a consequence of aging but a critical contributor to fall biomechanics and fracture morphology.

The combined presence of KOA and reduced mobility may represent a functional-structural double burden, in which joint degeneration and frailty synergistically increase susceptibility to intertrochanteric fractures. Similar concepts have been proposed in studies examining the relationship between gait abnormalities, balance impairment, and fracture risk in older adult populations [23,24]. Our results extend these observations by demonstrating their relevance to fracture pattern, not merely fracture occurrence.

Although osteoporosis remains a key determinant of hip fracture risk, its lack of independent association with fracture pattern in our adjusted model aligns with previous work suggesting that mechanical loading conditions during falls play a

dominant role in determining fracture configuration [12,19,23]. These findings reinforce the notion that effective fracture prevention strategies should integrate functional assessment and biomechanical considerations alongside bone health evaluation.

From a clinical perspective, recognition of KOA and mobility impairment may help identify patients at higher risk for intertrochanteric fractures, which are often associated with greater surgical complexity and postoperative morbidity [24]. Epidemiological data further indicate that hip fractures continue to impose a substantial healthcare burden despite advances in osteoporosis management, likely reflecting population aging and progressive functional decline [25]. Addressing joint pathology, mobility limitation, and fall risk in addition to bone density may therefore be essential for comprehensive fracture prevention.

The prevalence of osteoporosis in the present cohort (69.6%) is in close agreement with previously reported rates in older adult patients with hip fractures, which have consistently ranged between 60% and 80% in large epidemiological and clinical studies. This concordance supports the representativeness of the study population and suggests that the lack of an independent association between osteoporosis and fracture pattern in the multivariable analysis is unlikely to be attributable to selection bias [2,3].

Several limitations should be acknowledged. The retrospective design limits causal inference, and pre-fracture mobility assessment relied partly on retrospective reporting, which may introduce recall bias. In addition, although osteoporosis status was assessed using DXA obtained within 1 year prior to fracture, bone mineral density may still vary over time and may not perfectly reflect skeletal status at the exact moment of injury. Nevertheless, the PMS is a validated and widely accepted tool in hip fracture research [6].

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An additional limitation of this study is the potential for selection bias arising from the exclusion of a substantial proportion of eligible patients due to missing imaging data (100 out of 192 patients, approximately 52%). Although no statistically significant differences were observed between included and excluded patients in terms of age and sex, the possibility of non-random missingness cannot be entirely excluded. Patients with complete imaging data may represent a more thoroughly evaluated subgroup, which could introduce systematic differences compared with the broader population. Therefore, the findings of this study should be interpreted with caution, particularly regarding their external validity and generalizability to all older adult patients with hip fractures.

Conclusions

Radiographic knee osteoarthritis and low pre-fracture mobility were independently associated with intertrochanteric fracture patterns in older adult patients. These findings suggest that functional and biomechanical factors should be considered alongside bone mineral density when evaluating hip fracture patterns and risk.

Ethics Approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Kutahya Health Sciences University (Date: February 9, 2026, No: 2026/02-29).

Informed Consent

Due to the retrospective nature of the study, informed consent was waived by the ethics committee.

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