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Is Severe Knee Osteoarthritis Associated with Intertrochanteric Rather Than Femoral Neck Hip Fractures?

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ABSTRACT

We have not identified any research in the literature that explores the severity of knee osteoarthritis in relation to the type of hip fracture. In our study, we examined the severity of knee osteoarthritis in patients with hip fractures affecting the intertrochanteric (Group 1) and femoral neck region (Group 2). In our study, patients over 50 years of age were analyzed and Kellgren-Lawrence classification was applied to bilateral knee radiographs. The correlation between the severity of knee osteoarthritis and the classification of hip fractures was analyzed, and subgroups were compared. The stages of knee osteoarthritis in Group 1 and Group 2; the stage of knee osteoarthritis on the hip fracture side and the healthy side were compared both between groups and within groups. 109 patients were evaluated in Group 1 and 74 patients in Group 2. The knee osteoarthritis grade of Group 1 patients was significantly more severe on both the fractured side (3.44 ± 0.81) and the healthy side (3.17 ± 0.91) in comparison to the fractured side (2.89 ± 1.00) ($p<0.01$) and the healthy side (2.88 ± 0.82) ($p=0.032$) of Group 2 patients. In Group 1, the severity of knee osteoarthritis on the fractured side was statistically substantially greater than on the healthy side ($p<0.01$). In Group 2, the comparison of knee osteoarthritis severity between the fractured and healthy sides revealed no statistically significant difference ($p=0.849$). Severe knee osteoarthritis was associated with a higher proportion of intertrochanteric hip fractures. Also, the hip on the same side as the knee with more advanced osteoarthritis is more likely to fracture.

Keywords: Intertrochanteric femur fracture, knee osteoarthritis, femoral neck fracture.

INTRODUCTION

Hip fractures are a significant cause of morbidity and mortality[1]. They include two main types of fractures; intracapsular (subcapital, cervical) and extracapsular (trochanteric, pertrochanteric and subtrochanteric) fractures[2].

The mean age of patients with hip fractures is roughly 80 years, with around 80% being female. The majority of hip fractures result from falls or stumbles[3]. Globally, the incidence of falls among persons aged 65 and older is roughly 28-35% annually, with fractures resulting from 10-15% of these incidents[4,5]. While many treatment methods are available for hip fractures, the main goal should be early mobility and restoration to the previous functional level[6].

Hip fractures can have a variety of causes, but more research is looking at how they relate to osteoarthritis (OA) in the knee. Knee osteoarthritis is significantly associated with aging and predominantly impacts individuals over 65 years of age[7].

The prevalence of falls and fractures increases with advancing age. While falls in the elderly result from various reasons, including age-related changes in sensory, motor, and cognitive functions, the correlation between falls and knee osteoarthritis remains an area of ongoing research[8]. Significant risk factors for falls in adults with knee and hip osteoarthritis include pain, muscle weakness, reduced joint proprioception, and poor balance[9]. A study revealed that prevalent knee pain correlates with an increased risk of falls and hip fractures; furthermore, increasing severity of knee pain is linked to an elevated risk of falls and hip fractures[10].

While numerous studies investigate the correlation between heightened fall tendency and hip fracture risk attributable to knee osteoarthritis, we have not identified

any research in the literature that investigates the severity of knee osteoarthritis in relation to the type of hip fracture.

The objective of our study is to examine the severity of knee osteoarthritis in patients with a history of hip fractures in the intertrochanteric femoral region and the femoral neck region. We hypothesized that severe knee osteoarthritis might be associated with intertrochanteric hip fracture type.

MATERIAL AND METHODS

In our retrospective study examined patients over the age of 50 who were hospitalized to our hospital due to a simple fall and subsequently diagnosed with a hip fracture between January 2019 and May 2024. Approval from the institutional review board was obtained for ethical considerations. In our study, we classified patients with intertrochanteric femur fractures as Group 1 and those with femoral neck fractures as Group 2.

The study consisted of patients with hip fractures identified on pelvic antero-posterior (AP) radiographs and those with knee radiographs. The bilateral knee radiographs of the study participants were assessed and classified. Radiographic evaluations were performed by a single experienced orthopedic surgeon.

The study comprised patients with primary medial compartment knee osteoarthritis. Conditions leading to secondary knee osteoarthritis, including trauma, congenital or developmental abnormalities, osteonecrosis, rheumatoid arthritis, septic arthritis, and Paget's disease of bone, were excluded from the study. The study included intertrochanteric (extracapsular) and femoral neck (intracapsular) fractures.

During patient evaluation, the Kellgren-Lawrence classification was employed for knee osteoarthritis, the Evans/Jensen classification for intertrochanteric fractures, and the Garden classification for femoral neck fractures[11,12]. The severity of knee osteoarthritis was classified into four stages: stage 1 (suspicious), stage 2 (minimal), stage 3 (moderate), and stage 4 (severe), based on the Kellgren Lawrence classification. The Evans/Jensen classification categorizes fractures into types 1 through 5 based on displacement, fragmentation extent, and stability. Type 1 and type 2 fractures were classified as stable, whereas type 3, type 4, and type 5 fractures were classified as unstable. Concurrent knee radiographs obtained in the emergency department were analyzed. The study comprised patients who had knee lateral radiographs, pelvic AP, and knee AP radiographs that met the requirements.

The relationship between the severity of knee osteoarthritis and the classification of hip fractures was analyzed, and subgroups were compared. Classifications of hip fractures and knee osteoarthritis were assessed and documented using standardized radiographs. The assessment of the images was conducted concurrently by two experienced orthopedic specialists.

The statistically analyzed data encompassed the relationship between the stage of knee osteoarthritis and the type of hip fracture in the patients. The knee OA stage in group 1 and group 2 was compared between the two groups. Furthermore, stages of fractured and unfractured knee osteoarthritis were compared within the groups.

Additional statistically analyzed data in groups 1 and 2 included the correlation between the degree of knee osteoarthritis and age, the association between hip fracture type and age, and the relationship between gender and hip fracture type.

The exclusion criteria included: patients with hip fractures lacking bilateral knee X-rays, patients who had previously received knee or hip prostheses on either side, those with a history of lower extremity surgery, hip fractures resulting from trauma other than a simple fall, patients unable to ambulate for any reason, and cases of knee osteoarthritis affecting the lateral compartment. Patients exhibiting pathological hip fracture images were excluded from the investigation. Subtrochanteric fractures were excluded from the study.

Statistical analyses were performed using IBM® SPSS® Statistics version 26.0. Continuous variables were expressed as mean ± standard deviation (minimum–maximum values), and categorical variables were presented as frequencies and percentages. Normality of continuous variables was assessed using the Shapiro–Wilk test. Homogeneity of variances was evaluated using Levene's test. Independent samples t-test was used to compare continuous variables between independent groups. When the assumption of equal variances was violated, Welch's correction was applied. Paired samples t-test was used for within group comparisons. The relationship between age and osteoarthritis severity was evaluated using Pearson correlation analysis. The association between gender and fracture type was analyzed using the Chi-square test. Although the Kellgren–Lawrence classification represents an ordinal scale, it was treated as a continuous variable due to the robustness of parametric tests in moderate

to large sample sizes. A p-value < 0.05 was considered statistically significant.

RESULTS

We analyzed the pelvis and knee radiographs of 183 patients from a cohort of 355 individuals with hip fractures who presented at our hospital and met the study criteria. Group 1 comprised 109 patients, while group 2 had 74 patients. The mean age was 78.67 ± 9.65 (range 53-96) in group 1 and 73.58 ± 10.5 (range 52-92) in group 2. There was a statistically significant difference ($p<0.05$) in the groups' mean ages (Table 1). Group 1 comprised 74 females and 35 males; Group 2 included 54 females and 20 males. No statistically significant difference in gender was seen between the groups ($p>0.05$) (Table I).

A statistically significant difference was seen when comparing the degree of osteoarthritis between the unfractured and fractured knees of Group 1 and Group 2. The severity of osteoarthritis in both the fractured side ($p<0.05$) and the unaffected side ($p<0.05$) knees of patients with intertrochanteric hip fractures was significantly greater than in those with femoral neck hip fractures (Table I).

A statistical comparison of osteoarthritis severity between the knees on the healthy side and the hip fracture side of patients with intertrochanteric hip fractures (group 1) revealed a significant difference ($p<0.05$). The degree of knee osteoarthritis on the hip fracture side was determined to be greater (Table II).

A statistical comparison of the severity of knee osteoarthritis on the fractured side of patients with femoral neck hip fractures (group 2) and the non-fractured knee (healthy side) revealed no significant difference ($p>0.05$). The severity of knee osteoarthritis was similar in both knees (Table II).

The calculation of partial correlation demonstrated that the significant difference in the severity of osteoarthritis between the fractured hip and the knee was independent of age. The difference in osteoarthritis severity between the intertrochanteric fracture and femoral neck fracture groups was found to be independent of age ($p<0.05$) ($r=0.22$).

Table I. —Basic data of hip fracture types and knee osteoarthritis classification.

		Intertrochanteric Femur Fracture Group 1 (n=109)	Femoral Neck Fracture Group 2 (n=74)	P
Age (years)		78.67 ± 9.65 (53-96)	73.58 ± 10.5 (52-92)	<0.05*
Gender	Female	74 (67.9%)	54 (73%)	>0.05**
	Male	35 (32.1%)	20 (27%)	
Severity of Knee Osteoarthritis (Kellgren Lawrence Classification)	Fractured Side	3.44 ± 0.81	2.89 ± 1.00	<0.05*
	Healthy Side	3.17 ± 0.91	2.88 ± 0.82	<0.05*

p: Statistical significance value, n: number of patients. Descriptive statistics were expressed as mean ± standard deviation (minimum-maximum values). All other categorical data were expressed as frequency (percentage) values. * Independent samples t-test was used for continuous variables; Welch correction was applied when the assumption of homogeneity of variance was violated. ** Chi-square test was used for categorical variables.

Table II. — Comparison of hip fracture types within the group, in terms of the degree of knee osteoarthritis, on the healthy and fractured sides.

	Severity of Knee Osteoarthritis (Kellgren Lawrence Classification)		
	Fractured Side	Healthy Side	p
Intertrochanteric Femur Fracture (n=109) Group 1	3.44 ± 0.81	3.17 ± 0.91	<0.05*
Femoral Neck Fracture (n=74) Group 2	2.89 ± 1.00	2.88 ± 0.82	>0.05*

p: Statistical significance value; n: number of patients. Descriptive statistics were expressed as mean ± standard deviation (minimum–maximum values). *Paired samples t-test.

The examination of the relation between the severity of osteoarthritis in the knee of the fractured side and age in both groups (groups 1 and 2) revealed a significant correlation ($p<0.05$) ($r=0.383$). The examination of the relationships between the severity of osteoarthritis in the knee of the healthy side and age in both groups (groups 1 and 2) revealed a significant correlation ($p<0.05$) ($r=0.304$).

According to the Evans/Jensen classification, intertrochanteric fracture patients are categorized into two groups: type 1 and type 2 fractures are classified as the stable group, while type 3, 4, and 5 fractures are designated as the unstable group. The stable group comprised 37 patients, while the unstable group included 72 patients.

A significant difference in the degree of osteoarthritis of the fractured side knees was seen between stable and unstable intertrochanteric fractures ($p<0.05$).

No statistically significant difference was observed in the osteoarthritis degree of the knees on the unfractured hip side between stable and unstable intertrochanteric fractures ($p>0.05$). As the severity of knee osteoarthritis escalates, the degree of fragmentation of the hip fracture increases, resulting in instability (Table III).

No statistically significant difference was observed in the intertrochanteric fracture patient group when comparing stable and unstable fractures with mean age ($p>0.05$).

Among patients with intertrochanteric fractures, the prevalence of knee osteoarthritis classified as type 4 according to the Kellgren Lawrence classification was 62.4% on the side of the hip fracture, compared to 47.7% in the contralateral healthy knee (Table IV).

In patients with femoral neck fractures, the severity of osteoarthritis in the knee on the same side as the hip fracture was classified as Kellgren Lawrence type 4 in 36.5% of cases, whereas the severity in the unaffected knee was classified as Kellgren Lawrence type 3 in 43.2% of cases (Table IV).

In our study, approximately 66% of the intertrochanteric femur fracture patients were classified as belonging to the unstable group according to the Evans/Jensen classification.

The fracture types among patients with femoral neck fractures were primarily Garden type 3 (37.8%) and Garden type 4 (40.5%) according to the Garden classification.

In our study, 16 patients among 355 who presented with hip fractures received knee prostheses. 4.5% of the hip fractures admitted to our hospital had a prior knee prosthesis. 16 patients were excluded from the study due to the presence of knee prostheses.

It was shown that patients with advanced knee osteoarthritis had a higher risk of intertrochanteric hip fractures than femoral neck fractures when our study's findings were analyzed. The possibility of hip fracture on the same side as the knee with more

Table III. — Comparison of stable and unstable groups in terms of degree of knee osteoarthritis in intertrochanteric fractures.

		Evans/Jensen Classification		p
		Stable (Type 1-2) (n=37)	Unstable (Type 3-4-5) (n=72)	
Severity of Knee Osteoarthritis (Kellgren Lawrence Classification)	Fractured Side	3.22 ± 0.947	3.56 ± 0.710	<0.05*
	Healthy Side	2.95 ± 1.026	3.28 ± 0.843	>0.05*

p: Statistical significance value; n: number of patients. Descriptive statistics were expressed as mean ± standard deviation (minimum–maximum values). *Independent samples t-test (Welch correction applied when equal variances were not assumed).

Table IV. — Data on hip fracture types according to Kellgren Lawrence classification.

Severity of Knee Osteoarthritis (Kellgren Lawrence Classification)	Intertrochanteric Femur Fracture Group 1		Femoral Neck Fracture Group 2	
	Fractured Side (n=109)	Healthy Side (n=109)	Fractured Side (n=74)	Healthy Side (n=74)
Grade 1	2 (1.8%)	4 (3.7%)	6 (8.1%)	3 (4.1%)
Grade 2	16 (14.7%)	26 (23.9%)	23 (31.1%)	21 (28.4%)
Grade 3	23 (21.1%)	27 (24.8%)	18 (24.3%)	32 (43.2%)
Grade 4	68 (62.4%)	52 (47.7%)	27 (36.5%)	18 (24.3%)

n: number of patients.

severe osteoarthritis was elevated. The severity of knee osteoarthritis on the fracture side in patients with unstable intertrochanteric hip fractures was observed to be greater than that in the stable group.

DISCUSSION

To our knowledge, our study is the sole investigation in the literature that discusses the correlation between the stage of knee osteoarthritis and the kind of hip fracture. Research exists on knee osteoarthritis and its association with fall susceptibility and hip fractures. This study investigates the stages of knee osteoarthritis and the types of hip fractures, along with subgroups based on hip fracture categories.

As the severity of knee osteoarthritis increases, the knee's mobility across all planes decreases, leading us to believe that the probability of an ipsilateral unstable intertrochanteric fracture will increase. The correlation between knee osteoarthritis and falls has been shown, although the underlying cause of falls attributable to knee osteoarthritis remains inadequately explained[9]. Our study does not establish a causal relationship between falls, and a biomechanical analysis of falls has not been performed. Therefore, the following mechanistic explanations are speculative. In patients with advanced knee osteoarthritis, restricted knee mobility, particularly difficulty with sudden movements such as standing, may be related to impaired energy transfer from the knee to the hip, leading to a fall and subsequent hip fracture.

Numerous research have examined the correlation between osteoarthritis and falls and fractures; nevertheless, the findings are inconsistent. This is due in part to the fact that OA has been defined in a variety of ways. Symptomatic knee osteoarthritis and radiographic knee osteoarthritis have been evaluated in multiple studies, showing an elevated risk of falls, recurrent falls, and particularly hip fractures[5,10,13]. A further problem is the absence of precise information regarding the fracture location and kind resulting from the fall. Our study assessed the correlation between knee osteoarthritis and hip fracture.

The risk of falling is significantly heightened by quadriceps muscle weakening, diminished proprioception, and heightened postural instability in knee osteoarthritis[10,14,15]. While we did not assess the risk of falls in this study, we believe we achieved a direct outcome concerning radiographic knee osteoarthritis and the kind of hip fracture.

In knee osteoarthritis, the success of obstacle avoidance is diminished[16]. Although most intertrochanteric hip fractures are associated with falls, we hypothesize that restricted mobility in advanced knee osteoarthritis may alter load transmission and rotational mechanics in the lower extremity, thereby contributing to intertrochanteric fracture patterns. However, this proposed mechanism is speculative and has not been biomechanically validated. A case report indicated that following a direct impact to the knee, a fracture in the ipsilateral hip occurred without any fracture in the knee, attributed to the passage of energy from the knee to the proximal femur[17]. We believe that biomechanical investigations might allow a more comprehensive examination of this clinical situation.

Our evaluation of all hip fractures in the data indicates that the existence of a 4.5% patient cohort who had knee prostheses supports our theory. This scenario is likely attributable to enhanced knee motion. However, due to the small number of cases and the lack of a control group, a definitive conclusion cannot be drawn about the potential effect of knee arthroplasty on the risk of hip fracture. The literature has a study suggesting that the incidence of hip fractures is elevated in patients who have had knee prostheses, in contrast to our findings[18]. The study indicated that the risk of hip fracture elevated during the initial year following knee prosthesis, although the risk aligned with that of the control group during the subsequent 10-year period[18]. A separate investigation indicated that the occurrence of hip fractures was infrequent in the initial year following knee prosthesis, similar to our findings[19]. We believe that research should be undertaken on hip fractures in people who have received knee prostheses to have a comprehensive understanding of this particular problem.

A large-scale study indicated that definitions of hip osteoarthritis correlate with falls but not with the risk of fractures[20]. A study indicated that the risk of hip fractures decreased in patients with hip osteoarthritis[21]. We presumed that hip osteoarthritis, which was not assessed in our investigation, would not influence the outcomes. The literature would benefit from studies assessing osteoarthritis in the knee and hip together and identifying the kind of hip fracture that occurs.

The results of our investigation correlate with existing literature; intertrochanteric femur fractures are observed 2-8 times more commonly in women than in males, and intertrochanteric fractures are more prevalent in the elderly compared to femoral neck fractures[22]. Contrary to the frequency reported as 35-40% in the literature, the unstable group in intertrochanteric fractures was found to be at

a higher rate in our study[23]. As the severity of knee osteoarthritis escalates, the instability of hip fractures correspondingly increases. A study by Liu et al. demonstrated a positive correlation between intertrochanteric fracture complexity and the severity of knee osteoarthritis[24].

The majority of hip fractures in the elderly are believed to occur due to a direct impact to the hip from falling on the side[25–28]. It is said that a fall by itself is ineffective and that if preventive reactions are not successful, the energy will be absorbed by the soft tissues around the hip, and the proximal femur receives more energy from the fall than the bone, hip fractures will result[27,29].

Multiple studies in the literature have failed to provide objective evidence elucidating the mechanism of hip fractures. We contend that the limitations of research documenting fractures resulting from direct impact during falls come from uncertainties in the anamnesis concerning the nature of the fall, the intensity of the impact, and the orientation of the knee. This ambiguity is believed to result from the fact that patients or independent witnesses to the fall are still processing the traumatic event and are hence unable to clearly identify the fall mechanism, and that this is questioned by biased researchers[17].

A study indicates that the primary cause of hip fractures is not solely the direct impact on the trochanter, but may also result from the force transmitted when the knee contacts the ground[30].

A study showed that the biomechanics of falls resulting in intertrochanteric fractures and femoral neck fractures were not different[31]. We believe that a potential reason for the differing fracture types among patients with similar fall patterns may be the varying stages of knee osteoarthritis.

Numerous factors have been identified as risk factors for intertrochanteric hip fractures, including osteoporosis, advanced age, multiple comorbidities, genetic predispositions, and physical inactivity[18,32,33]. Furthermore, when our findings is taken consideration, advanced knee osteoarthritis may also be included among the risk factors. The significance of protective clothes that mitigates hip impact during a fall has been notedmiche[34]. We believe that knee prosthesis applications should be included in research aimed at developing hip fracture prevention programs for patients with severe knee osteoarthritis. Further research is required to assess potential risk factors linked to hip fractures.

The severity of osteoporosis may also influence the type of fracture in the hip fracture mechanism. The correlation between osteoporosis and osteoarthritis is a complex and controversial matter. Numerous investigations have indicated an inverse correlation between osteoporosis and osteoarthritis[35,36]. A further study indicated no substantial difference in osteoporosis prevalence between individuals with knee osteoarthritis and healthy controls[37]. Although some studies indicate that osteoarthritis (OA) might have a preventive effect against osteoporosis, other research suggests that elevated bone mineral density (BMD) in OA may not reduce fracture risk[36,38]. A study indicated that patients with knee osteoarthritis reported elevated bone mineral density, however their risk of non-vertebral fractures was greater compared to those without knee osteoarthritis[39].

Our study indicates that the severity of knee osteoarthritis in people with intertrochanteric fractures is significantly greater than in those with femoral neck fractures. While our study did not assess BMD values, existing literature indicates that patients with intertrochanteric fractures have significantly reduced BMD compared to those with femoral neck fractures[32,40]. The research indicating that patients with knee osteoarthritis have lower femoral neck BMD T score values relative to the control group, this can be important in interpreting our findings[36].

The elevated fracture risk in people with osteoarthritis has been attributed to a heightened propensity for falls. A study has shown that the probability of hip fracture in knee OA may be more important than BMD T scores[36]. Researchers must recognize that elevated BMD in patients with OA may provide a misleading sense of security[20]. The potential confounding effect of osteoporosis on fracture type cannot be ignored. Therefore, the relationship between the severity of knee osteoarthritis and fracture type should be carefully examined.

Limitations: A comprehensive history and physical examination of the patients' knee osteoarthritis could not be conducted. The assessment of knee joint mobility was not possible. While patients with uncomplicated falls were assessed, their fall history was not thoroughly documented. Factors such as BMD, body mass index, muscle strength, and the use of walking aids were not evaluated. Kellgren-Lawrence staging was performed using non-weight-bearing knee radiographs due to fracture. Limb dominance, hand preference, and prefracture pain asymmetry were not evaluated in this study, and this may have affected the interpretation of the observed laterality differences. Radiographic grading was performed by a single observer, and inter-observer reliability was not assessed.

CONCLUSION

Severe knee osteoarthritis appears to be associated with an increased likelihood of intertrochanteric fractures rather than femoral neck fractures. This relationship warrants further prospective biomechanical validation.

REFERENCES

1. Gölge UH, Pazarci O, Kılınç S, et al. The treatment of intertrochanteric fractures comparison of PFN and hemiarthroplasty 3-year mortality study. Acta Orthop Belg 2016;82(3):508–515.
2. Mattisson L, Bojan A, Enocson A. Epidemiology, treatment and mortality of trochanteric and subtrochanteric hip fractures: data from the Swedish fracture register. BMC Musculoskelet Disord 2018;19(1):369; doi: 10.1186/s12891-018-2276-3.
3. Keene GS, Parker MJ, Pryor GA. Mortality and morbidity after hip fractures. BMJ 1993;307(6914):1248–50; doi: 10.1136/bmj.307.6914.1248.
4. Tinetti ME, Doucette J, Claus E, et al. Risk factors for serious injury during falls by older persons in the community. J Am Geriatr Soc 1995;43(11):1214–21; doi: 10.1111/j.1532-5415.1995.tb07396.x.
5. Cai G, Li X, Zhang Y, et al. Knee symptom but not radiographic knee osteoarthritis increases the risk of falls and fractures: results from the Osteoarthritis Initiative. Osteoarthritis Cartilage 2022;30(3):436–442; doi: 10.1016/j.joca.2021.11.015.
6. Polat M, Arslan A, Utkan A. External Fixation Versus Hemiartroplasty In Unstable Intertrochanteric Hip Fractures Of The Elderly. Acta Orthop Belg 2017;83(3):351–359.
7. Lespasio MJ, Piuzzi NS, Husni ME, et al. Knee Osteoarthritis: A Primer. Perm J 2017;21:16–183; doi: 10.7812/TPP/16-183.
8. Laurence BD, Michel L. The Fall in Older Adults: Physical and Cognitive Problems. Curr Aging Sci 2017;10(3):185–200; doi: 10.2174/1874609809666160630124552.
9. Zhang Y, Li X, Wang Y, et al. Association of knee and hip osteoarthritis with the risk of falls and fractures: a systematic review and meta-analysis. Arthritis Res Ther 2023;25(1):184; doi: 10.1186/s13075-023-03179-4.
10. Arden NK, Crozier S, Smith H, et al. Knee pain, knee osteoarthritis, and the risk of fracture. Arthritis Rheum 2006;55(4):610–5; doi: 10.1002/art.22088.
11. KELLGREN JH, LAWRENCE JS. Radiological assessment of osteo-arthrosis. Ann Rheum Dis 1957;16(4):494–502; doi: 10.1136/ard.16.4.494.
12. Mokawem M, Bobak P, Aderinto J. The management of pertrochanteric fractures of the hip. Orthop Trauma 2012;26(2):112–123; doi: 10.1016/j.mporth.2012.04.001.
13. Prieto-Alhambra D, Nogues X, Javaid MK, et al. An increased rate of falling leads to a rise in fracture risk in postmenopausal women with self-reported osteoarthritis: a prospective multinational cohort study (GLOW). Ann Rheum Dis 2013;72(6):911–7; doi: 10.1136/annrheumdis-2012-201451.
14. Sturnieks DL, Tiedemann A, Chapman K, et al. Physiological risk factors for falls in older people with lower limb arthritis. J Rheumatol 2004;31(11):2272–9.
15. Manlapaz DG, Sole G, Jayakaran P, et al. Risk Factors for Falls in Adults with Knee Osteoarthritis: A Systematic Review. PM R 2019;11(7):745–757; doi: 10.1002/pmrj.12066.
16. Pandya NK, Draganich LF, Mauer A, et al. Osteoarthritis of the knees increases the propensity to trip on an obstacle. Clin Orthop Relat Res 2005;(431):150–6; doi: 10.1097/01.blo.0000150316.97009.f2.
17. Kelly DW, Kelly BD. A novel diagnostic sign of hip fracture mechanism in ground level falls: two case reports and review of the literature. J Med Case Rep 2012;6:136; doi: 10.1186/1752-1947-6-136.
18. Vala CH, Kärrholm J, Kanis JA, et al. Risk for hip fracture before and after total knee replacement in Sweden. Osteoporos Int 2020;31(5):887–895; doi: 10.1007/s00198-019-05241-x.
19. Koh DTS, Chen JY, Yew AKS, et al. Functional outcome and quality of life in patients with hip fracture after total knee arthroplasty. J Orthop Surg (Hong Kong) 2019;27(2):2309499019852338; doi: 10.1177/2309499019852338.
20. Arden NK, Nevitt MC, Lane NE, et al. Osteoarthritis and risk of falls, rates of bone loss, and osteoporotic fractures. Study of Osteoporotic Fractures Research Group. Arthritis Rheum 1999;42(7):1378–85; doi: 10.1002/1529-0131(199907)42:7<1378::AID-ANR11>3.0.CO;2-I.
21. Chudyk AM, Ashe MC, Gorman E, et al. Risk of hip fracture with hip or knee osteoarthritis: a systematic review. Clin Rheumatol 2012;31(5):749–57; doi: 10.1007/s10067-012-1970-z.
22. Attum B, Pilson H. Intertrochanteric Femur Fracture. 2025.
23. Sidhu AS, Singh AP, Singh AP, et al. Total hip replacement as primary treatment of unstable intertrochanteric fractures in elderly patients. Int Orthop 2010;34(6):789–92; doi: 10.1007/s00264-009-0826-x.
24. Liu J, Wang Z, Zhang W, et al. Evaluating the Relationship between Intertrochanteric Fracture Complexity and Knee Osteoarthritis Severity in Elderly Patients: A Quantitative Analysis. Acta Orthop Belg 2025;91(2):187–193; doi: 10.52628/91.2.13925.
25. Schwartz A V, Kelsey JL, Sidney S, et al. Characteristics of falls and risk of hip fracture in elderly men. Osteoporos Int 1998;8(3):240–6; doi: 10.1007/s001980050060.
26. Aizen E, Dranker N, Swartzman R, et al. Risk factors and characteristics of falls resulting in hip fracture in the elderly. Isr Med Assoc J 2003;5(5):333–6.
27. Hayes WC, Myers ER, Morris JN, et al. Impact near the hip dominates fracture risk in elderly nursing home residents who fall. Calcif Tissue Int 1993;52(3):192–8; doi: 10.1007/BF00298717.
28. Parkkari J, Kannus P, Palvanen M, et al. Majority of hip fractures occur as a result of a fall and impact on the greater trochanter of the femur: a prospective controlled hip fracture study with 206 consecutive patients. Calcif Tissue Int 1999;65(3):183–7; doi: 10.1007/s002239900679.
29. Cummings SR, Nevitt MC. A hypothesis: the causes of hip fractures. J Gerontol 1989;44(4):M107-11; doi: 10.1093/geronj/44.4.m107.
30. YAMAMOTO S, TANAKA E, KUBOUCHI Y, et al. Biomechanical Evaluations of Hip Fracture Mechanism in Pedestrian Fall Accident. TRANSACTIONS OF THE JAPAN SOCIETY OF MECHANICAL ENGINEERS Series A 2006;72(723):1799–1807; doi: 10.1299/kikaia.72.1799.
31. Mautalen CA, Vega EM, Einhorn TA. Are the etiologies of cervical and trochanteric hip fractures different? Bone 1996;18(3 Suppl):133S-137S; doi: 10.1016/8756-3282(95)00490-4.
32. Kheirollahi H, Luo Y. Assessment of Hip Fracture Risk Using Cross-Section Strain Energy Determined by QCT-Based Finite Element Modeling. Biomed Res Int 2015;2015:413839; doi: 10.1155/2015/413839.
33. Dhanwal DK, Dennison EM, Harvey NC, et al. Epidemiology of hip fracture: Worldwide geographic variation. Indian J Orthop 2011;45(1):15–22; doi: 10.4103/0019-5413.73656.
34. Michelson JD, Myers A, Jinnah R, et al. Epidemiology of hip fractures among the elderly. Risk factors for fracture type. Clin Orthop Relat Res 1995;(311):129–35.
35. Dequeker J, Aerssens J, Luyten FP. Osteoarthritis and osteoporosis: clinical and research evidence of inverse relationship. Aging Clin Exp Res 2003;15(5):426–39; doi: 10.1007/BF03327364.

36. Kim BY, Kim H-A, Jung J-Y, et al. Clinical Impact of the Fracture Risk Assessment Tool on the Treatment Decision for Osteoporosis in Patients with Knee Osteoarthritis: A Multicenter Comparative Study of the Fracture Risk Assessment Tool and World Health Organization Criteria. J Clin Med 2019;8(7); doi: 10.3390/jcm8070918.
37. Sandini L, Arokoski JPA, Jurvelin JS, et al. Increased bone mineral content but not bone mineral density in the hip in surgically treated knee and hip osteoarthritis. J Rheumatol 2005;32(10):1951–7.
38. Jones G, Nguyen T, Sambrook PN, et al. Osteoarthritis, bone density, postural stability, and osteoporotic fractures: a population based study. J Rheumatol 1995;22(5):921–5.
39. Bergink AP, van der Klift M, Hofman A, et al. Osteoarthritis of the knee is associated with vertebral and nonvertebral fractures in the elderly: the Rotterdam Study. Arthritis Rheum 2003;49(5):648–57; doi: 10.1002/art.11380.
40. Vega E, Mautalen C, Gómez H, et al. Bone mineral density in patients with cervical and trochanteric fractures of the proximal femur. Osteoporos Int 1991;1(2):81–6; doi: 10.1007/BF01880448.