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Evaluating the Relationship between Intertrochanteric Fracture Complexity and Knee Osteoarthritis Severity in Elderly Patients: A Quantitative Analysis

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Intertrochanteric fractures and knee osteoarthritis are prevalent among elderly patients; however, the relationship between the complexity of these fractures and the severity of knee osteoarthritis remains poorly understood. This study aimed to investigate the correlation between the complexity of intertrochanteric fractures and the severity of knee osteoarthritis in elderly patients. A total of 130 elderly patients with knee osteoarthritis, admitted between February 2021 and June 2023, were divided into a non-fracture group (77 patients) and a fracture group (53 patients). The fracture group was further stratified into a simple fracture subgroup (23 cases) and a complex fracture subgroup (30 cases). The Hospital for Special Surgery (HSS) score, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score, and Kellgren-Lawrence (K-L) grade were compared across the groups. Pearson correlation analysis was employed to assess the relationship between these variables and fracture complexity. Results revealed that the non-fracture group exhibited significantly higher HSS scores (64.88 ± 9.87 vs. 57.36 ± 10.08) and a greater proportion of mild K-L grade cases (80.52% vs. 20.75%) compared to the fracture group. Conversely, the fracture group demonstrated higher WOMAC scores (35.67 ± 8.19 vs. 43.22 ± 10.77) and a higher proportion of severe K-L grade cases (19.48% vs. 79.25%). Within the fracture group, the simple fracture subgroup had higher HSS scores (63.14 ± 9.27 vs. 55.43 ± 9.54) and lower WOMAC scores and severe K-L grade proportions compared to the complex fracture subgroup. HSS scores were negatively correlated with fracture occurrence (r = -0.351), while WOMAC scores and K-L grades were positively correlated with fracture complexity (r = 0.372, 0.592). These findings suggest a positive correlation between the complexity of intertrochanteric fractures and the severity of knee osteoarthritis, indicating that more severe osteoarthritis may be predictive of more complex fractures.

Keywords: P-Knee joint, Intertrochanteric fracture, Osteoarthritis, Elderly.

INTRODUCTION

Proximal humeral fractures (PHF) and distal radius fractures (DRF) are common and rank as the first and third most frequently encountered non-vertebral fractures[1,2]. Over the years, more and more patients in Western Europe have sought emergency care for upper extremity (UE) fractures after an accident[3,4]. With increasing age of the population and prevalence of osteoporosis, the incidence of fractures is expected to rise further[1,5,6].

Upper extremity fractures profoundly impact daily activities and functional status, often leading to physical deconditioning. Consequently, mortality following UE fractures tends to linearly increase in the initial post-fracture years, suggesting a modest impact[7,8].

Treatment for UE fractures are influenced by factors like fracture type, bone quality and patient-surgeon preferences[9,10]. There is limited consensus about the aftercare, the role of load bearing and performance guided rehabilitation after trauma regarding PHF and DRF, which is in line with recent literature[11].

One of the most pressing clinical questions is how early functional rehabilitation can be safely initiated[12-15]. Synergistic analysis of findings and broad implementation into medical guidelines is however hindered, because permissive load bearing (PLB) can be broadly interpreted and clear guidance is lacking[16].

For example the definition of allowed mobilization, and exercises used, as well as milestones for progression, and a comparison with a more conservative approach have not yet been delivered.

In light of these challenges, this study assesses the feasibility of implementing a well-defined performance guided rehabilitation protocol for UE fractures, i.e. the PERFormance guided fracture Rehabilitation Method (PERFoRM) protocol. PERFoRM aims to offer a fracture-and-patient guided structured framework, optimizing recovery and restoring activity and participation levels following upper extremity fractures.

METHODS

Study subjects

A total of 130 patients with knee osteoarthritis admitted to our hospital from February 2021 to June 2023 were selected, including 77 patients in the non-fracture group (n=77) and 53 patients in the fracture group (n=53). Non-fracture group: 48 males and 29 females; average age (78.21 ± 4.02) years; fracture group: 32 males and 21 females; average age (77.32 ± 3.45) years. The fracture group was further divided into a simple fracture group (n=23) and a complex fracture group (n=30) based on the complexity of the intertrochanteric fractures.

The HSS and WOMAC scores were assessed at the time of patient admission before any surgical intervention. These scores were recorded as baseline measurements to evaluate knee joint function prior to the potential impact of fracture-related factors. The data were obtained from the most recent clinical assessment prior to the occurrence of the fracture in the fracture group and at the time of hospital admission for the non-fracture group. This ensured a standardized comparison of knee function between groups.

Inclusion and exclusion criteria

Inclusion criteria: (1) Patients diagnosed with knee osteoarthritis7; (2) Patients who can strictly follow the doctor's instructions and receive treatment according to the physician's guidance; (3) Patients over 65 years old; (4) Patients with unilateral intertrochanteric fractures; (5) Patients who completed the relevant questionnaire; (6) Patients or their family members who signed the informed consent form for this study.

Exclusion criteria: (1) Patients with coagulation disorders; (2) Patients with knee joint trauma; (3) Patients who have undergone knee joint surgery; (4) Patients with malignant tumors; (5) Patients with knee joint damage or infection; (6) Patients who resist participating in the treatment study; (7) Patients with knee joint tumors, knee joint deformity, or congenital malformation; (8) Patients with incomplete medical records.

Grouping method

The complexity of intertrochanteric fractures was classified according to the AO classification[8], with simple fractures including type A1 and complex fractures including types A2 and A3.

Evaluation indicators

General data of the two groups, including age, BMI, gender, smoking history, drinking history, history of hypertension, history of diabetes, osteoporosis, and history of fractures.

HSS score: The knee joint function was evaluated using the Knee Society Hospital for Special Surgery (HSS) score[9], which includes pain (30 points), function (22 points), range of motion (18 points), stability (10 points), muscle strength (10 points), and knee flexion deformity (10 points). The total score is 100 points, and a higher score indicates better knee joint function and milder osteoarthritis.

WOMAC score: The severity of arthritis in patients was evaluated using the WOMAC scale[10], which consists of three aspects: joint pain, stiffness, and physical function. There are 24 questions in total, with a score of 0-4 for each question. A higher score indicates a more severe condition of the disease and more severe osteoarthritis.

K-L grade: Kellgren-Lawrence (K-L) grading was determined based on standard weight-bearing anterior-posterior knee X-rays. The radiographs were independently evaluated by two experienced orthopedic specialists who were blinded to the patients' clinical information. In cases of discrepancy, a third senior radiologist was consulted to reach a consensus. Interobserver agreement was assessed using Cohen's kappa coefficient (κ), ensuring consistency in K-L grading interpretation. According to the Kellgren-Law (K-L) grading[11], patients were divided into grades 0-4 (Table I).

We used HSS scores and other methods to evaluate the severity of knee joint, and analyzed the correlation between knee osteoarthritis and the occurrence of intertrochanteric fractures, as well as the complexity of fractures and the severity of knee joint.

Statistical analysis

SPSS 26.0 was used for analysis. Count data are expressed as [n(%)] and analyzed using chi-square

test. Normally distributed data are expressed as (X ± s) and analyzed using t-test. If data are not normally distributed, they are transformed for normal distribution analysis. P<0.05 indicates statistical significance.

RESULTS

General information

Comparison of general information between the two groups showed no significant differences (P>0.05) (Table II).

HSS scores and WOMAC scores of knee osteoarthritis

The non-fracture group had higher HSS scores and lower WOMAC scores compared to the fracture group, and the differences were statistically significant (P<0.05) (Table III).

K-L grading of knee osteoarthritis

The proportion of mild K-L grading in the non-fracture group was higher than that in the fracture group, and the proportion of severe K-L grading was lower than that in the fracture group, with statistically significant differences (P<0.05) (Table IV).

Correlation analysis between severity of knee osteoarthritis and occurrence of intertrochanteric fractures

As shown in Table V, correlation analysis found that age, BMI, gender, smoking history, alcohol consumption history, history of hypertension, history of diabetes, osteoporosis, and history of fractures had no significant correlation with the occurrence of intertrochanteric fractures (P>0.05). HSS scores were negatively correlated with the occurrence of intertrochanteric fractures (r=-0.351, p<0.001), while WOMAC scores and K-L grading were positively correlated with the occurrence of intertrochanteric fractures (r=0.372, 0.592, p<0.001). This indicates that HSS scores, WOMAC scores, and K-L grading are significantly correlated with the occurrence of intertrochanteric fractures in patients with knee osteoarthritis.

HSS scores, WOMAC scores, and K-L grading in patients with different complexity of intertrochanteric fractures

The HSS scores (63.14 ± 9.27 vs. 55.43 ± 9.54) and mild K-L grading (39.13% vs. 10.00%) were higher in the simple fracture group than in the complex fracture group, while the WOMAC scores (37.21 ± 9.75 vs. 44.28 ± 10.36) and severe K-L grading (60.87% vs. 90.00%) were lower in the simple fracture group than in the complex fracture group, with statistically significant differences (P<0.05) (Table VI).

Correlation analysis between severity of knee osteoarthritis and complexity of intertrochanteric fractures

As shown in Table VII, correlation analysis found that HSS scores (r=-0.382, P=0.005) were negatively correlated with the complexity of intertrochanteric fractures, while WOMAC scores (r=0.334, P=0.015) and K-L grading (r=0.345, P=0.011) were positively correlated with the complexity of intertrochanteric fractures. This indicates that HSS scores, WOMAC scores, and K-L grading are significantly correlated with the complexity of intertrochanteric fractures in patients with knee osteoarthritis. Similar results were found in the study by Lv et al.[12]

DISCUSSION

Intertrochanteric fractures are common types of fractures in the elderly lower limbs and are becoming a common problem in the global aging population. Currently, there are an average of 4.5 million new cases of intertrochanteric fractures worldwide every year, and the one-year mortality rate after surgery for many elderly intertrochanteric fracture patients is 19% to 33%13. Complications from intertrochanteric fractures, such as deep vein thrombosis, pulmonary infections, and loss of mobility, can be life-threatening, which is why these fractures are often referred to as the “last fracture” in elderly patients. Although many studies have been conducted on the risk factors for intertrochanteric fractures, such as age, anemia14, severe underlying diseases15, and hypoalbuminemia16, there are few studies on the correlation between knee osteoarthritis and intertrochanteric fractures. These two diseases have a significant impact on the elderly population, and exploring the relationship between them is of great significance. Given that the prevalence of knee osteoarthritis is expected to reach 40% in the elderly population in the coming years17,18, understanding its potential role in hip fractures is of significant clinical importance.

The thickness of articular cartilage diminishes with age, and the local tissue blood supply becomes inadequate, increasing the susceptibility to osteoporosis. This is particularly evident in patients with osteoarthritis, where ultrasound images reveal blurred or absent knee joint surfaces, rough cartilage,

Table I. — K-L grading criteria.

K-L Grade	Severity	Clinical Manifestations
0	Light	Normal
I	Light	There is a small amount of bony growths, resembling lips.
II	Light	The bony growths in the joints have increased, narrowing the gaps.
III	Heavy	The bony growths continue to develop into moderate or multiple states, narrowing the gaps and causing joint stiffness or even joint deformity in patients.
IV	Heavy	The bony growths become more severe, narrowing the gaps even further, causing more significant stiffness and deformity in the joints.

Table II. — Comparison of general information between the two groups.

Index	Non-fracture group (n=77)	Fracture group (n=53)	t	P
Age (years)	78.21 ± 4.02	77.32 ± 3.45	1.355	0.178
BMI (kg/m^2)	26.94 ± 2.67	26.58 ± 2.31	0.808	0.421
Gender (male/female)	48 (62.34%) / 29 (37.66%)	32 (60.38%) / 21 (39.62%)	0.002	0.966
Smoking history (yes/no)	37 (48.05%)	27 (50.94%)	0.021	0.884
Drinking history (yes/no)	32 (41.56%)	23 (43.40%)	0.001	0.978
Hypertension history (yes/no)	37 (48.05%)	22 (41.51%)	0.310	0.578
Diabetes history (yes/no)	37 (48.05%)	24 (45.28%)	0.017	0.895
Osteoporosis (yes/no)	44 (57.14%)	23 (43.40%)	1.857	0.173
Fracture history (yes/no)	29 (37.66%)	19 (35.85%)	0.001	0.980

Table III. — Comparison of HSS scores and WOMAC scores between the two groups of knee osteoarthritis.

Group	HSS scores	WOMAC scores
Non-fracture group	64.88 ± 9.87	35.67 ± 8.19
Fracture group	57.36 ± 10.08	43.22 ± 10.77
t	4.218	4.318
P	< 0.001	< 0.001

Table IV. — Comparison of K-L grading of knee osteoarthritis between the two groups.

Group	K-L grade	
	Light	Heavy
Non-fracture group	62 (80.52%)	15 (19.48%)
Fracture group	11 (20.75%)	42 (79.25%)
t	43.146	
P	< 0.001	

Table V. — Correlation analysis between various factors and occurrence of intertrochanteric fractures.

Factor	r	R2	P
Age (years)	-0.116	0.013	0.190
BMI (kg/m2)	-0.069	0.005	0.433
Gender (male/female)	-0.02	0	0.823
Smoking history (yes/no)	0.028	0.001	0.748
Drinking history (yes/no)	0.018	0	0.836
Hypertension history (yes/no)	-0.065	0.004	0.465
Diabetes history (yes/no)	-0.027	0.001	0.758
Osteoporosis (yes/no)	-0.135	0.018	0.125
Fracture history (yes/no)	-0.018	0	0.835
HSS score	-0.351	0.123	p < 0.001
WOMAC score	0.372	0.139	p < 0.001
K-L grade	0.592	0.350	p < 0.001

Table VI. — Comparison of HSS scores, WOMAC scores, and K-L grading between the two subgroups.

Group	HSS scores	WOMAC scores	K-L grade	
			Light	Heavy
Simple fracture group (n=23)	63.14 ± 9.27	37.21 ± 9.75	9 (39.13%)	14 (60.87%)
Complex fracture group (n=30)	55.43 ± 9.54	44.28 ± 10.36	3 (10.00%)	27 (90.00%)
t	2.964	2.547	4.754	
P	0.005	0.014	0.029	

Table VII. — Correlation analysis between various factors and complexity of intertrochanteric fractures.

Factor	r	R2	P
HSS scores	-0.382	0.146	0.005
WOMAC scores	0.334	0.111	0.015
K-L grade	0.345	0.119	0.011

and membranous cartilage wear, often accompanied by the formation of loose bodies. Radiographic findings typically include the development of osteophytes at the joint margins, narrowing of the joint space, and subchondral sclerosis and cyst formation. Relevant studies have identified a positive correlation between the severity of osteoarthritis and hip bone density, suggesting that the progression of osteoarthritis may exacerbate bone density loss in the hip region[19,20]. The bone density of patients with osteoarthritis is significantly higher than that of non-fracture population, and the increase in bone density is likely due to the formation of bone spurs, which leads to an increase in bone tissue turnover rate but a decrease in strength, resulting in osteoporosis of the knee joint. Knee osteoarthritis leads to bone loss and increased osteoporosis, which results in microstructure damage of trabecular bone. Even minor external forces can cause continuous interruption of bone[21], which is the main reason why elderly patients are prone to intertrochanteric fractures. In contrast, the fracture rate at the hip is low in patients with arthritis, which may be due to the significant reduction in the time and intensity of daily physical activity in patients with knee osteoarthritis. The results of this study showed that the HSS scores (64.88 ± 9.87 vs. 57.36 ± 10.08) and mild K-L grading (80.52% vs. 20.75%) were higher in the non-fracture group than in the fracture group, while the WOMAC scores (35.67 ± 8.19 vs. 43.22 ± 10.77) and severe K-L grading (19.48% vs. 79.25%) were lower in the non-fracture group than in the fracture group. This indicates that knee osteoarthritis may promote and affect the occurrence of intertrochanteric fractures. Similar results were found in the study by Lv et al.[12]. Additionally, due to the wear and tear of knee joint cartilage and the narrowing of joint space, patients with osteoarthritis are more likely to experience falls, slips, and twists in their daily lives, which can affect their basic daily living abilities. For patients with unilateral knee joint pain, the deviation of the center of gravity during walking can also disrupt body balance and increase the of falling. Patients with osteoarthritis, accompanied by factors such as muscle weakness, have more abnormal center of gravity and gait compared to non-fracture individuals. Whether it is the acute pain of arthritis or the chronic effects on muscle strength, joint mobility, cardiovascular, nervous system, and movement, there is a great possibility of falls and fractures.

There are many factors that can affect the complexity of intertrochanteric fractures, such as local bone weakness, local muscle weakness, poor compressive strength, and excessive bone loss[22]. If the skeletal muscles cannot fully absorb the energy caused by trauma during a fall, simple fractures can occur. In this study, the severity of knee osteoarthritis in the complex fracture group was significantly higher than that in the simple fracture group, and it was negatively correlated with HSS scores, and positively correlated with WOMAC scores and K-L grading. Similar conclusions were drawn in the study by Zhang et al.[23] In patients with knee osteoarthritis, as the disease worsens, the stability and bone quality of the joint decrease significantly. At the same time, with the wear of cartilage and the limitation of joint movement, joint pain intensifies, leading to muscle atrophy and reduced muscle strength, further reducing bone strength. When subjected to greater torsional force during a fall, the damage and complexity of the femur increase.

Knee osteoarthritis not only affects knee function but also induces gait abnormalities, which can lead to changes in hip biomechanics and contribute to fracture risk. Patients with knee osteoarthritis often develop

an increased knee varus moment, which alters weight distribution during ambulation[24]. This biomechanical shift leads to abnormal stress transmission to the hip, particularly at the intertrochanteric region. Additionally, knee osteoarthritis patients often experience muscle weakness, decreased proprioception, and altered gait patterns, which further increase fall risk and fracture susceptibility[25]. Beyond biomechanical alterations, knee osteoarthritis is also characterized by chronic systemic inflammation, which may negatively impact bone metabolism. Elevated levels of pro-inflammatory cytokines, such as IL-6 and TNF-α, are frequently observed in knee osteoarthritis patients and have been implicated in accelerated bone resorption[26]. These cytokines stimulate osteoclastic activity, reduce osteoblastic function, and contribute to cortical bone thinning and trabecular deterioration, increasing bone fragility.

Although this study has achieved certain results, there are still some limitations. For example, there were no significant differences in the comparison of general information between the two groups ($p>0.05$). However, epidemiological studies have shown that the incidence of intertrochanteric fractures varies among different ages and genders, with a higher incidence in women. Elderly women are more prone to intertrochanteric fractures, possibly due faster development of osteoporosis after menopause and more significant reduction in hip bone mass. Hypertension also has an impact on the circulatory function of the body. These factors did not show significant differences in this study, perhaps due to the small sample size. Low BMI individuals are more likely to experience physical weakness, malnutrition, and difficulties in absorbing calcium and vitamin D[27], but there was no significant difference in this study, which may be due to the high BMI and good physical condition of the study population. For smoking populations, harmful substances such as nicotine and nicotine in cigarettes can cause vasoconstriction and affect the blood supply to the fracture site, further affecting fracture healing. However, due to the small number of smokers in the study population, no significant difference was found statistically.

In conclusion, our study demonstrates that the severity of knee osteoarthritis is positively correlated with both the occurrence and complexity of intertrochanteric fractures in elderly patients. Patients with more severe knee osteoarthritis tend to exhibit a higher complexity of intertrochanteric fractures compared to those with milder or no osteoarthritis. While these findings suggest a potential association between knee osteoarthritis and fracture complexity, the cross-sectional nature of our study does not allow for causal inferences. Future longitudinal studies are needed to further explore the underlying mechanisms and potential causative relationships between these conditions.

Conflict of Interests: The authors declared no conflict of interest.

Authors' contributions: Jiaxing Liu and Zhen Wang: Conceptualization, methodology, writing original draft preparation. Wenqi Zhang: Investigation, software, statistical analysis. Qian Zhang: Reviewing and editing, funding acquisition, supervision. All authors read and approved the final manuscript.

Ethical Compliance: This study was approved by the ethics committee of The First Affiliated Hospital of Heilongjiang University of Chinese Medicine. Signed written informed consents were obtained from the patients and/or guardians.

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