# Association of Serum Vitamin D and Calcium Levels With the Severity of Intertrochanteric Fractures in the Elderly: A Retrospective Study

**Seok-Min Hwang**
Seoul Red Cross Hospital https://orcid.org/0000-0002-8594-5745
**Suk-Hyun Hwang**
Seoul Red Cross Hospital
**Yeon-Ho Kim** ( nextverup@gmail.com )
https://orcid.org/0000-0002-5175-0018

**Research article**

**Keywords:** Hip fracture, Vitamin D, Calcium, Elderly

**Posted Date:** June 16th, 2020

**DOI:** https://doi.org/10.21203/rs.3.rs-34943/v1

## Abstract

**Background**: Femur intertrochanteric fractures can be classified into stable and unstable fractures according to their severity. Postoperative complications and mortality were more common in patients with unstable intertrochanteric fractures. However, there has been little effort to evaluate the risk factors of the two fracture types. This study aimed to identify the possible differences in demographic and clinical characteristics of older patients with different types of intertrochanteric fractures.

**Methods**: The medical records of patients aged ≥60 years who presented with intertrochanteric fractures from June 2018 to March 2020 were retrospectively reviewed. Fifty-seven patients were enrolled and divided into two groups according to severity: stable (21 patients) and unstable (36 patients). Demographic data, body mass index (BMI), ambulatory ability prior to fracture, pre-fracture residence, season at fracture, bone mineral density (BMD), and serum 25-hydroxyvitamin D [25(OH)D], osteocalcin, and calcium levels were compared between the two groups. Additionally, we analyzed the correlation among variables.

**Results**: The stable group had significantly higher serum 25(OH)D and calcium levels than the unstable group ($p = 0.010$, $p = 0.019$). There were no statistically significant differences ($p > 0.05$) in age, sex, height, weight, BMI, ambulatory ability prior to fracture, pre-fracture residence, season at fracture, BMD, and serum osteocalcin level between the two groups. In addition, serum 25(OH)D and calcium levels were not correlated with any of the variables in all patients.

**Conclusion**: Low vitamin D and calcium levels are associated with unstable intertrochanteric fracture in elderly patients. Maintaining adequate vitamin D and calcium levels could avoid an increase in the severity of intertrochanteric fractures.

## Background

Hip fracture is one of the most common osteoporotic fractures, and its frequency is increasing as it progresses to an aging society [1, 2]. Femoral intertrochanteric fractures account for approximately half of all hip fractures in the elderly [2]. The mortality and morbidity in patients with intertrochanteric fractures are significantly higher than in those with femoral neck fractures, and this is most likely due to older age and the corresponding fragile physical conditions of patients who experience intertrochanteric fractures [3]. Only about 50% of patients can be expected to regain their preinjury function, while the other half becomes more dependent in some manner [4]. Mortality within 1 year after femoral intertrochanteric fractures is reported to be high, ranging from 11–27% [5–7]. Several studies compared patients with intertrochanteric fracture and those with neck fracture of the hip. Intertrochanteric fractures are associated with a more severe and generalized bone loss, especially of the trabecular component, as shown by bone mineral density (BMD) measurement at the spine and proximal femur [8, 9]. On histomorphometric evaluation, patients with trochanteric fracture have lower trabecular bone volume, trabecular surface density, and mean wall thickness [10].

Intertrochanteric fractures can be classified into stable and unstable according to their severity. The characteristics of unstable fractures include reverse obliquity, loss of posterior medial buttress, lateral wall comminution, and subtrochanteric extension [11]. These difficult patterns are associated with longer operative time, increased need for open reduction, hardware failure, head cutout, varus malunion, and nonunion [12, 13]. Medical complications such as myocardial infarction, pneumonia, and urinary tract infections frequent occur after surgery of patients with unstable intertrochanteric fractures [4]. Mortality after surgical fixation was higher in patients with more unstable fracture patterns, because unstable fractures are associated with increasing age and functional dependence [4, 12, 14].

Although unstable intertrochanteric fractures have a variety of complications and poor prognosis, it remains unclear whether the risk factors for fracture vary by severity of intertrochanteric fracture. It is important to determine whether the interactions between variables differ by type of intertrochanteric fracture and which risk factors can be used in clinical practice. Understanding the relationships between stable and unstable fractures can help in personalizing preventive measures, improving prognosis, planning of treatment, and providing differentially targeted interventions. From this, we aimed to evaluate the possible differences in demographic and clinical characteristics of older patients with different types of intertrochanteric fractures. Additionally, we analyzed the correlation among these variables.

## Methods

# Study design and population

We conducted a single-center, retrospective cross-sectional study. Patients aged 60 years or older who were diagnosed with femur intertrochanteric fracture in our hospital from June 2018 to March 2020 were selected. We retrospectively reviewed the patients' medical records. Patients (1) with intertrochanteric fractures due to high-energy trauma, such as vehicular accidents or falls from a height of > 2 m; (2) with pathological fractures; (3) who had previous hip surgery or trauma on either ipsilateral or contralateral hip; and (4) were currently taking anti-osteoporotic drugs or vitamin D and/or calcium or had a past history of taking such drugs were excluded from the study. Fractures were defined according to the Orthopedic Trauma Association (OTA) classification, and were categorized into two groups: the stable group, which included A1.1 through A2.1, and the unstable group, which included A2.2 through A3.3 [15]. The patients were divided into two groups according to this classification: stable group and unstable group.

# Data collection

The following demographic and clinical outcomes data were obtained from the electronic medical records: age, sex, height, weight, body mass index (BMI), ambulatory ability prior to fracture, pre-fracture residence, season at fracture, BMD and serum 25-hydroxyvitamin D [25(OH)D], osteocalcin, and calcium levels. Body height and weight were measured, and BMI was calculated using the standard formula. The ambulatory ability prior to fracture was assessed according

to the Koval's classification (grade I: independent community ambulator, grade II: community ambulator with cane, grade III: community ambulator with walker/crutches, grade IV: independent household ambulator, grade V: household ambulator with cane, grade VI: household ambulator with walker/crutches, and grade VII: nonfunctional ambulator) [16]. Pre-fracture residence was classified as living in the community (community) and residing in aged care facilities (nursing home). Seasons during the occurrence of fracture were divided into spring (March, April, and May), summer (June, July, and August), fall (September, October, and November), and winter (December, January, and February). BMD (in $g/cm^2$) was measured by performing a dual-energy X-ray absorptiometry (DXA) (Discovery W; Hologic Inc., Marlborough, MA, USA) in the femoral neck, trochanteric region, intertrochanter region, Ward's triangle region, and the total hip region of the contralateral proximal femur. However, the Ward's triangle region of the hip should not be used for this study, because this site overestimates osteoporosis [17]. BMD measurements were routinely obtained not later than 1 week following fracture.

For biochemical measurements, patients' blood samples were obtained after an overnight fast of at least 8 hours, and their serum 25(OH)D, osteocalcin, and calcium levels were measured. Serum 25(OH)D was measured by performing a chemiluminescence immunoassay method using the UniCel DxI 800 (Beckman Coulter Diagnostics, CA, USA). Serum osteocalcin was measured by performing an electrochemiluminescence immunoassay method using the N-MID osteocalcin kit (Roche Diagnostics, Mannheim, Germany). Serum calcium was measured by the O-cresolphthalein method using the 7180 Clinical Analyzer (Hitachi Ltd., Tokyo, Japan). Vitamin D status was classified as follows: normal vitamin D status (serum 25(OH)D level ≥ 30 ng/mL) and low serum vitamin D levels, which can be further subcategorized into insufficiency (20–30 ng/mL) and deficiency (< 20 ng/mL) [18].

## Statistical analysis

Continuous variables were expressed as means ± standard deviation and categorical variables as percentages. The normality of the data was assessed using the Shapiro-Wilk test. In order to verify the differences between groups of variables, categorical variables (sex, ambulatory ability prior to fracture, pre-fracture residence, and season at fracture) were analyzed using chi-square test, while continuous variables (weight, height, BMI, BMD, and serum calcium levels) were analyzed using an independent sample t-test. Because of the uneven distribution of the data for age, serum vitamin D, and osteocalcin, the Mann-Whitney U test was performed. In order to evaluate the correlation among variables, a Spearman correlation analysis was performed. Statistical analyses were performed using IBM SPSS software, version 25.0 (SPSS Inc. Chicago, IL, USA) for Windows. For all analyses, the level of significance was set at $p < 0.05$.

# Results

## Patient characteristics

A total of 68 patients with femoral intertrochanteric fractures were identified. Of them, 57 patients were included in the study. Eight patients with previous hip fractures and three who were taking anti-osteoporotic drugs or vitamin D were excluded. The mean age of these patients was 81.93 years (range, 60–95 years), and 41 (71.9%) were women. According to the OTA classification, 21 patients comprised the stable group (A1.1–A2.1), while 36 comprised the unstable group (A2.2–A3.3). Approximately 57.9% of the patients showed vitamin D deficiency, 26.3% showed insufficiency, and 15.8% showed normal vitamin D levels.

## Differences between the stable group and unstable group

The patients in the unstable group (82.72 ± 9.76 years) were slightly older than those in the stable group (80.57 ± 9.35 years), but this difference was not statistically significant ($p = 0.328$) (Table 1). The female-to-male ratio was similar between the two groups ($p = 0.585$). No statistically significant differences were observed in both groups in terms of height, weight, BMI, ambulatory ability prior to fracture, pre-fracture residence, and season at fracture ($p > 0.05$). Compared with patients with stable fractures, those with unstable fractures had lower BMD in the femoral neck, trochanteric region, intertrochanter region, and total hip region, but this difference was not statistically significant ($p > 0.05$). The mean serum 25(OH)D and calcium levels were 27.01 ± 15.75 ng/mL and 8.48 ± 0.45 mg/dL in the stable group and 17.52 ± 8.65 ng/mL and 8.19 ± 0.43 mg/dL in the unstable group. The stable group had significantly higher serum 25(OH)D and calcium levels than the unstable group ($p = 0.010$, $p = 0.019$). In the stable group, 38.1% of the patients had a vitamin D deficiency and 28.6% had a vitamin D insufficiency (Table 2). In the unstable group, 69.4% of the patients had a vitamin D deficiency, while 25.0% had a vitamin D insufficiency. More patients in the unstable group had low vitamin D status ($p = 0.012$). However, there were no statistically significant differences in serum osteocalcin level between the two groups ($p = 0.914$).

Table 1
Difference of variables between the stable group and unstable group

| Variable | | Total (n = 57) | Stable (n = 21) | Unstable (n = 36) | *p* value |
|---|---|---|---|---|---|
| Age (years) | | 81.93 ± 9.58 | 80.57 ± 9.35 | 82.72 ± 9.76 | 0.328 |
| Sex, n (%) | Female | 41(71.9) | 16(76.2) | 25(69.4) | 0.585 |
| | Male | 16(28.1) | 5(23.8) | 11(30.6) | |
| Height (cm) | | 155.02 ± 9.07 | 155.84 ± 7.58 | 154.54 ± 9.91 | 0.608 |
| Weight (kg) | | 51.89 ± 12.00 | 55.37 ± 13.19 | 49.86 ± 10.93 | 0.095 |
| BMI | | 21.50 ± 4.40 | 22.69 ± 4.79 | 20.81 ± 4.07 | 0.121 |
| Ambulatory ability prior to fracture, n (%) | 1 | 23(40.4) | 9(42.9) | 14(38.9) | 0.823 |
| | 2 | 13(22.8) | 6(28.6) | 7(19.4) | |
| | 3 | 5(8.8) | 2(9.5) | 3(8.3) | |
| | 5 | 8(14.0) | 2(9.5) | 6(16.7) | |
| | 6 | 8(14.0) | 2(9.5) | 6(16.7) | |
| Pre-fracture residence, n (%) | Community | 37(64.9) | 15(71.4) | 22(61.1) | 0.431 |
| | Nursing home | 20(35.1) | 6(28.6) | 14(38.9) | |
| Season of fracture, n (%) | Spring | 10(17.5) | 2(9.5) | 8(22.2) | 0.544 |
| | Summer | 19(33.3) | 9(42.9) | 10(27.8) | |
| | Fall | 14(24.6) | 5(23.8) | 9(25.0) | |
| | Winter | 14(24.6) | 5(23.8) | 9(25.0) | |
| Neck BMD (g/cm$^2$) | | −3.18 ± 0.85 | −2.99 ± 0.54 | −3.29 ± 0.97 | 0.137 |
| Trochanteric BMD (g/cm$^2$) | | −2.14 ± 0.89 | −1.92 ± 0.88 | −2.26 ± 0.87 | 0.161 |
| Intertrochanter BMD (g/cm$^2$) | | −2.35 ± 0.95 | −2.14 ± 0.69 | −2.48 ± 1.07 | 0.157 |
| Total BMD (g/cm$^2$) | | −2.38 ± 0.91 | −2.12 ± 0.64 | −2.53 ± 1.01 | 0.064 |
| 25(OH)D (ng/mL) | | 21.02 ± 12.52 | 27.01 ± 15.75 | 17.52 ± 8.65 | 0.010* |
| Osteocalcin (ng/mL) | | 19.32 ± 11.59 | 20.05 ± 14.02 | 18.89 ± 10.10 | 0.914 |
| Calcium (mg/dL) | | 8.29 ± 0.46 | 8.48 ± 0.45 | 8.19 ± 0.43 | 0.019* |
| Results are presented as mean ± standard deviation or n (%). The *p* values represent the differences between stable and unstable group. | | | | | |
| *BMI*: body mass index, *BMD*: bone mineral density, *25(OH)D*: 25-hydroxyvitamin D | | | | | |
| *$p < 0.05$ indicates statistical significance. | | | | | |

Table 2
Distribution of vitamin D level according to the severity of fractures

| | Total group (n = 57) | Stable group (n = 21) | Unstable group (n = 36) | *p* value |
|---|---|---|---|---|
| Normal | 9 (15.8%) | 7 (33.3%) | 2 (5.6%) | 0.012* |
| Insufficiency | 15 (26.3%) | 6 (28.6%) | 9 (25.0%) | |
| Deficiency | 33 (57.9%) | 8 (38.1%) | 25 (69.4%) | |
| The *p* values represent the differences between stable and unstable group. | | | | |
| *$p < 0.05$ indicates statistical significance. | | | | |

## Correlation between variables

These analyses revealed similarities and differences between variables associated with the type of intertrochanteric fractures (Table 3). In all patients, age showed a significant positive correlation with the ambulatory ability prior to fracture ($r = 0.337$, $p = 0.010$) and a significant negative correlation with height ($r = -0.310$, $p = 0.019$), weight ($r = -0.310$, $p = 0.019$), neck BMD ($r = -0.049$, $p < 0.001$), trochanteric BMD ($r = -0.359$, $p = 0.006$), intertrochanter BMD ($r = -0.456$, $p < 0.001$), and total BMD ($r = -0.476$, $p < 0.001$). Sex, which were coded 1 for male and 0 for female, showed a significant positive correlation with height ($r =$

0.688, $p < 0.001$) and neck BMD ($r = 0.336$, $p = 0.011$). Men have higher height and neck BMD than women. Height was significantly positively correlated with weight ($r = 0.460$, $p < 0.001$), neck BMD ($r = 0.370$, $p = 0.005$), intertrochanter BMD ($r = 0.418$, $p = 0.001$), and total BMD ($r = 0.385$, $p = 0.003$). Weight was significantly positively correlated with BMI ($r = 0.822$, $p < 0.001$), neck BMD ($r = 0.455$, $p < 0.001$), intertrochanter BMD ($r = 0.371$, $p = 0.004$), and total BMD ($r = 0.408$, $p = 0.002$). Weight was significantly inversely correlated with fracture in spring ($r = -0.315$, $p = 0.017$). The ambulatory ability prior to fracture was significantly inversely correlated with neck BMD ($r = -0.316$, $p = 0.017$). The worse the ambulatory ability prior to fracture, the lower the neck BMD. Pre-fracture residence, which were coded as community = 0 and nursing home = 1, showed a significant negative correlation with height ($r = -0.360$, $p = 0.006$). Height was relatively low in patients living in nursing homes. Neck BMD, trochanteric BMD, intertrochanter BMD, and total BMD showed a significant positive correlation with each other ($p < 0.001$). However, serum 25(OH)D and calcium levels were not correlated with any of the variables in the total group ($p > 0.05$).

Table 3
Correlation matrix for variables in total group

| Variable | Sex | Height | Weight | BMI | Ambulatory ability | Pre-Fx residence | Spring | Summer | Fall | Winter | Neck BMD | TC BMD | I E |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | −0.191 | −0.310* | −0.310* | −0.150 | 0.337* | 0.154 | 0.042 | 0.059 | −0.027 | −0.074 | −0.490# | −0.359# | - |
| Sex | - | 0.688# | 0.260 | −0.151 | −0.180 | −0.214 | 0.020 | −0.028 | −0.084 | 0.097 | 0.336* | 0.045 | C |
| Height | - | - | 0.460# | −0.073 | −0.207 | −0.360# | −0.196 | 0.038 | 0.043 | 0.088 | 0.370# | 0.193 | C |
| Weight | - | - | - | 0.822# | −0.050 | 0.003 | −0.315* | 0.166 | 0.142 | −0.046 | 0.455# | 0.227 | C |
| BMI | - | - | - | - | 0.076 | 0.249 | −0.203 | 0.255 | 0.059 | −0.159 | 0.296* | 0.159 | C |
| Ambulatory ability | - | - | - | - | - | 0.249 | 0.214 | −0.022 | −0.259 | 0.094 | −0.316* | −0.178 | - |
| Pre-Fx residence | - | - | - | - | - | - | 0.144 | −0.052 | 0.007 | −0.078 | 0.004 | 0.011 | - |
| Spring | - | - | - | - | - | - | - | −0.326* | −0.263* | −0.263* | −0.239 | −0.095 | - |
| Summer | - | - | - | - | - | - | - | - | −0.403# | −0.403# | 0.099 | −0.116 | C |
| Fall | - | - | - | - | - | - | - | - | - | −0.326* | 0.148 | 0.218 | C |
| Winter | - | - | - | - | - | - | - | - | - | - | −0.045 | −0.007 | C |
| Neck BMD | - | - | - | - | - | - | - | - | - | - | - | 0.724# | C |
| TC BMD | - | - | - | - | - | - | - | - | - | - | - | - | C |
| ITC BMD | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Total BMD | - | - | - | - | - | - | - | | - | - | - | - | - |
| 25(OH)D | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Osteocalcin | - | - | - | - | - | - | - | - | - | - | - | - | - |

*BMI*: body mass index, *Fx*: fracture, *TC*: trochanteric, *ITC*: intertrochanter, *BMD*: bone mineral density, *25(OH)D*: 25-hydroxyvitamin D

#$p < 0.01$ and *$p < 0.05$ indicate statistical significance.

## Discussion

Because unstable intertrochanteric fractures of the hip have a greater bony injury, technically they are much more challenging than stable fractures [4]. Unstable fractures have greater potential to displace or result in nonunion [19]. Typically closed reduction required for fixation of intertrochanteric fractures, but open reduction seems to be necessary for complex fracture patterns [12]. Medical complications after operation of unstable intertrochanteric fractures frequently occur. The most common complications are myocardial infarction, pneumonia, and urinary tract infections [4]. Mortality rate after surgical fixation is higher in patients with more unstable fracture patterns [12, 14]. Functional outcomes may also vary based on the severity of hip fracture. Functional independence is worse in patients with unstable intertrochanteric fractures than in those with stable fracture [20]. Thus, unstable fractures are recognized as difficult problem for both surgeons and elderly patients. Hence, we investigated which variable determines the severity of the fracture when intertrochanteric fractures occur.

Previous studies have examined the relationship between BMD and hip fracture severity. Cauley et al. found that patients with more stable fractures (intra- and extracapsular) had a mean lower hip BMD than those with unstable fractures [21]. They assumed that this could be because the lower the BMD, the weaker the mechanical forces that are needed to cause the hip fracture, thus leading to less displacement and more stable fractures. Spencer et al. reported that there was no difference in BMD measured with DXA between stable and unstable hip fractures [22]. Our results showed that patients with unstable fractures had lower BMD in all regions than those with stable fractures. However, this difference was not statistically significant ($p > 0.05$). Another study evaluated the relationship between vitamin D and the severity of hip fracture. Larrosa et al. reported an association between vitamin D level and the severity of osteoporotic

hip fractures (femur neck and intertrochanteric fractures) [23]. The authors concluded that the largest vitamin D deficiency was associated with a more severe type of hip fracture. However, serum calcium levels were not different between less severe fracture and more severe fracture. The present study reported that serum 25(OH)D levels as well as serum calcium levels were significantly different between the stable group and unstable group. The patients with unstable fractures had significantly lower serum vitamin D and calcium levels. Correspondingly, more patients were categorized as having low vitamin D levels in the unstable group. In the stable group, 28.6% of the patients had vitamin D insufficiency, while 38.1% had vitamin D deficiency. In the unstable group, 25.0% of the patients had vitamin D insufficiency, while 69.4% had vitamin D deficiency. Irving et al. studied the relationship between BMI and stability of intertrochanteric fracture [24]. They reported that unstable intertrochanteric fracture were found more frequently in obese patients (BMI > 30) than in those who were not obese, but this difference did not reach statistical significance. Another retrospective study by Chen et al. investigated the factors affecting the stability of intertrochanteric fractures in elderly patients [25]. They concluded that the stability of intertrochanteric fractures cannot be predicted by patient's age, gender, body weight, body height, and BMI. The results of the present study demonstrate that BMI was slightly higher in the stable group than in the unstable group, but there was no statistically significant difference.

Vitamin D status has been associated with the development and maintenance of mineralized bone and muscle function [26]. The insufficiency of vitamin D increases the secretion of parathyroid hormone to promote bone resorption, resulting in osteopenia and osteoporosis [27]. In addition, vitamin D deficiency weakens muscle strength, increases the risk of falls, and consequently increases the risk of fracture [28, 29]. Vitamin D is necessary for the regulation of calcium and phosphate in the human body, and decreased levels can alter the bone mineralization process. There is a high prevalence of vitamin D deficiency in patients with osteoporosis, and low vitamin D is associated with a reduction in bone strength and increased fracture risk [30]. Meanwhile, higher levels of 25(OH)D and vitamin D supplementation may increase hip bone strength via effects on femur geometry, including the cortical thickness, cortical volume, cross-sectional area, and cross-sectional moment of inertia [31, 32]. Calcium is also a substantial component of bone. Calcium plays an important role in bone mass and bone strength [33]. Low calcium intake increases the parathyroid hormone secretion and bone resorption, thus increasing bone turnover, bone loss, and risk of fractures [34]. In addition, calcium is plays an essential role in the muscle physiology and skeletal–muscle interaction. Hence, adequate calcium levels are important for both the bones and muscles [35]. In the present study, the higher severity of fracture in patients with low vitamin D and calcium levels is a result of the combined effects of vitamin D and calcium on both bones and muscle metabolism. This relationship and its pathophysiology can be further explored in larger, dedicated trials in the future. Currently, it remains unclear how vitamin D and calcium could have influenced the severity of fracture.

The association of vitamin D, calcium, and BMD has been studied over the past decades, but the presence of a correlation between vitamin D, calcium, and BMD remains controversial. In a study conducted in southern California among community-dwelling postmenopausal older women, 25(OH)D levels were positively and independently associated with BMD, while PTH levels were negatively and independently associated with BMD [36]. A Dutch population-based study showed that all BMD values were higher in the higher serum 25(OH)D groups than in the lowest serum 25(OH)D group, although this was only significant for the total hip, femoral trochanter, and total body bone mineral content [37]. A Saudi study showed no significant correlation between vitamin D and spine or total femoral BMD in a community-based population [38]. Japanese study found that there is positive association between serum 25(OH) D and BMD of the femoral neck, but no association was found between serum 25(OH) D and BMD of the lumber spine in home-dwelling postmenopausal women [39]. A Chinese population-based study did not find a significant correlation between 25 (OH) D and calcaneus BMD in middle-aged and elderly individuals [40]. Liu et al. studied the association between serum calcium, 25(OH)D, and lumbar BMD using a large-scale database from National Health and Nutrition Examination Survey in the United States [41]. They indicated that serum calcium negatively correlated with lumbar BMD, and serum 25(OH)D positively correlated with lumbar BMD in older adults. A Mendelian randomization study conducted by Cerani et al. revealed that increased serum calcium levels was not associated with increased estimated BMD derived from heel ultrasound or a reduced risk of fractures in individuals with normal calcium levels [42]. Therefore, the causes of these different results may be the heterogeneity of the studies, including study design, study size, and differences in participant selection, such as age, gender, and race/ethnicity. Nevertheless, our results supported that there is no significant correlation between 25(OH)D, calcium level, and femoral BMD in elderly patients with intertrochanteric fracture.

There are several limitations to our analysis. First, an independent interpretation of the radiographs to classify the fractures was not provided. The classification of the fracture type and severity could have been affected by interobserver variability, although experienced orthopaedic surgeons were asked to examine the images. Second, the number of study participants was relatively small to allow a definite conclusion. Therefore, additional large-scale, prospective studies are warranted to supplement and further validate our results. Third, there was a possibility of inadequate assessment of the facts such as injury mechanism, history of anti-osteoporosis treatment, previous trauma, and other secondary osteoporosis causes, because the review was limited to medical records. For example, if a patient has cognitive impairment due to old age, the wrong information might be recorded.

## Conclusion

We believe that the lower severity of intertrochanteric fractures is important for elderly populations, allowing them to return to higher functional activities and reducing the overall morbidity and mortality. The analysis of demographic and clinical characteristics in a series of patients with femur intertrochanteric fracture has shown that low vitamin D and calcium levels are associated with unstable fracture. The present study can have clinical implications that vitamin D and calcium levels may play an important role in predicting the severity of intertrochanteric fractures. In this respect, maintaining adequate vitamin D and calcium levels in the elderly could avoid a higher severity of intertrochanteric fractures.

## Abbreviations

25(OH)D
25-hydroxyvitamin D
BMD
bone mineral density

BMI
body mass index
DXA
dual-energy X-ray absorptiometry
OTA
Orthopedic Trauma Association

## Declarations

# Ethics approval and consent to participate

This study was approved by the Institutional Review Board (IRB) of Public Institutional Bioethics Committee. Because this study was the retrospective analysis, the requirement for obtaining an informed consent was waived.

### Consent for publication

Not applicable.

### Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

### Competing interests

The authors declare that they have no competing interests

# Funding

The authors declare that they did not receive any funding.

# Authors' contributions

SMH and YHK designed the study. SHH collected the subject data. SMH, SHH, and YHK performed the data analysis and interpreted the results. SMH and YHK contributed to the review and editing of the manuscript and revising it critically. All authors were involved in writing the manuscript. All authors read and approved the final submitted manuscript.

# Acknowledgments

Not applicable.

## References

1. Hagino H, Yamamoto K, Ohshiro H, Nakamura T, Kishimoto H, Nose T. Changing incidence of hip, distal radius, and proximal humerus fractures in Tottori Prefecture, Japan. Bone. 1999;24:265–70. doi:10.1016/S8756-3282(98)00175-6.
2. Richmond J, Aharonoff GB, Zuckerman JD, Koval KJ. Mortality risk after hip fracture. J Orthop Trauma. 2003;17:53–6. doi:10.1097/00005131-200301000-00008.
3. 10.1016/8756-3282(95)00381-9
Kannus P, Parkkari J, Sievanen H, Heinonen A, Vuori I, Jarvinen M. Epidemiology of hip fractures. Bone. 1996;18:57 s-63 s. doi:10.1016/8756-3282(95)00381-9.
4. Lindskog DM, Baumgaertner MR. Unstable intertrochanteric hip fractures in the elderly. J Am Acad Orthop Surg. 2004;12:179–90. doi:10.5435/00124635-200405000-00006.
5. Barton TM, Gleeson R, Topliss C, Greenwood R, Harries WJ, Chesser TJ. A comparison of the long gamma nail with the sliding hip screw for the treatment of AO/OTA 31-A2 fractures of the proximal part of the femur: a prospective randomized trial. J Bone Joint Surg Am. 2010;92:792–8. doi:10.2106/JBJS.I.00508.
6. Schipper IB, Steyerberg EW, Castelein RM, van der Heijden FH, den Hoed PT, Kerver AJ, et al. Treatment of unstable trochanteric fractures. Randomised comparison of the gamma nail and the proximal femoral nail. J Bone Joint Surg Br. 2004;86:86–94. doi:10.1302/0301-620X.86B1.14455.
7. Haidukewych GJ, Israel TA, Berry DJ. Reverse obliquity fractures of the intertrochanteric region of the femur. J Bone Joint Surg Am. 2001;83:643–50. doi:10.2106/00004623-200205000-00028.
8. Vega E, Mautalen C, Gomez H, Garrido A, Melo L, Sahores AO. Bone mineral density in patients with cervical and trochanteric fractures of the proximal femur. Osteoporos Int. 1991;1:81–6. doi:10.1007/BF01880448.

9. Greenspan SL, Myers ER, Maitland LA, Kido TH, Krasnow MB, Hayes WC. Trochanteric bone mineral density is associated with type of hip fracture in the elderly. J Bone Miner Res. 1994;9:1889–94. doi:10.1002/jbmr.5650091208.
10. Uitewaal PJ, Lips P, Netelenbos JC. An analysis of bone structure in patients with hip fracture. Bone Min. 1987;3:63–73.
11. Babhulkar S. Unstable trochanteric fractures: issues and avoiding pitfalls. Injury. 2017;48:803–18. doi:10.1016/j.injury.2017.02.022.
12. Diaz VJ, Canizares AC, Martin IA, Peinado MA, Doussoux PC. Predictive variables of open reduction in intertrochanteric fracture nailing: a report of 210 cases. Injury. 2016;47:51-5. doi:10.1016/S0020-1383(16)30606-4.
13. Suckel AA, Dietz K, Wuelker N, Helwig P. Evaluation of complications of three different types of proximal extra-articular femur fractures: differences in complications, age, sex and surviving rates. Int Orthop. 2007;31:689–95. doi:10.1007/s00264-006-0250-4.
14. Chehade MJ, Carbone T, Awward D, Taylor A, Wildenauer C, Ramasamy B, et al. The influence of fracture stability on early patient mortality and reoperation after pertrochanteric and intertrochanteric hip fractures. J Orthop Trauma. 2015;29:538–43. doi:10.1097/BOT.0000000000000359.
15. Sonawane DV. Classifications of Intertrochanteric fractures and their clinical importance. Trauma Int. 2015;1:7–11.
16. Koval KJ, Aharonoff GB, Rosenberg AD, Bernstein RL, Zuckerman JD. Functional outcome after hip fracture. Effect of general versus regional anesthesia. Clin Orthop Relat Res. 1998;348:37–41.
17. Fogelman I, Blake GM. Different approaches to bone densitometry, continuing education. J Nucl Med. 2000;41:2015–25.
18. Rosen CJ. Clinical practice. Vitamin D insufficiency. N Engl J Med. 2011;364:248–54. doi:10.1056/NEJMcp1009570.
19. Lichtblau S. The unstable intertrochanteric hip fracture. Orthopedics. 2008;31:792–7. doi:10.3928/01477447-20080801-15.
20. Cornwall R, Gilbert MS, Koval KJ, Strauss E, Siu AL. Functional outcomes and mortality vary among different types of hip fractures: a function of patient characteristics. Clin Orthop Relat Res. 2004;425:64–71. doi:10.1097/01.blo.0000132406.37763.b3.
21. Cauley JA, Lui L, Genant HK, Salamone L, Browner W, Fink HA, et al. Study of osteoporotic fractures research and group. Risk factors for severity and type of the hip fracture. J Bone Miner Res. 2009;24:943–55. doi:10.1359/jbmr.081246.
22. Spencer SJ, Blyth MJ, Lovell F, Holt G. Does bone mineral density affect hip fracture severity? Orthopedics. 2012;35:e945-9. doi:10.3928/01477447-20120525-34.
23. Larrosa M, Gomez A, Casado E, Moreno M, Vázquez I, Orellana C, et al. Hypovitaminosis D as a risk factor of hip fracture severity. Osteoporos Int. 2012;23:607–14. doi:10.1007/s00198-011-1588-z.
24. Irving D, Hinkley J, Marquart M. The relationship between BMI and stability of intertrochanteric fracture following low-energy falls. A retrospective cohort study. Geriatr Orthop Surg Rehabil. 2019. doi:10.1177/2151459319857555.
25. Chen PH, Wu CC, Chen WJ. Factors affect stability of intertrochanteric fractures when elderly patients fall. Biomed J. 2016;39:67–71. doi:10.1016/j.bj.2015.08.007.
26. Dusso AS, Brown AJ, Slatopolsky E. Vitamin D. Am. J Physiol Renal Physiol. 2005;289:F8–28. doi:10.1152/ajprenal.00336.2004.
27. Holick MF, Siris ES, Binkley N, Beard MK, Khan A, Katzer JT, et al. Prevalence of vitamin D inadequacy among postmenopausal North American women receiving osteoporosis therapy. J Clin Endocrinol Metab. 2005;90:3215–24. doi:10.1210/jc.2004-2364.
28. Bischoff-Ferrari HA, Dawson-Hughes B, Willett WC, Staehelin HB, Bazemore MG, Zee RY, et al. Effect of Vitamin D on falls: a meta-analysis. JAMA. 2004;291:1999–2006. doi:10.1001/jama.291.16.1999.
29. Visser M, Deeg DJ, Lips P. Low vitamin D and high parathyroid hormone levels as determinants of loss of muscle strength and muscle mass (sarcopenia): the longitudinal aging study Amsterdam. J Clin Endocrinol Metab. 2003;88:5766–72. doi:10.1210/jc.2003-030604.
30. Holick MF. Optimal vitamin D status for the prevention and treatment of osteoporosis. Drugs Aging. 2007;24:1017–29. doi:10.2165/00002512-200724120-00005.
31. Hwang S, Choi HS, Kim KM, Rhee Y, Lim SK. Associations between serum 25-hydroxyvitamin D and bone mineral density and proximal femur geometry in Koreans: the Korean National Health and Nutrition Examination Survey (KNHANES) 2008–2009. Osteoporos Int. 2015;26:163–71. doi:10.1007/s00198-014-2877-0.
32. Martin EN, Haney EM, Shannon J, Cauley JA, Ensrud KE, Keaveny TM, et al. Femoral volumetric bone density, geometry, and strength in relation to 25-hydroxy vitamin D in older men. J Bone Miner Res. 2015;30:562–9. doi:10.1002/jbmr.2360.
33. Balk EM, Adam GP, Langberg VN, Earley A, Clark P, Ebeling PR, et al. Global dietary calcium intake among adults: a systematic review. Osteoporos Int. 2017;28:3315–24. doi:10.1007/s00198-017-4230-x.
34. Zhu K, Prince RL. Calcium and bone. Clin Biochem. 2012;45:936–42. doi:10.1016/j.clinbiochem.2012.05.006.
35. Chiodini I, Bolland MJ. Calcium supplementation in osteoporosis: useful or harmful? Eur J Endocrinol. 2018;178:D13–25. doi:10.1530/EJE-18-0113.
36. von Muhlen DG, Greendale GA, Garland CF, Wan L, Barrett-Connor E. Vitamin D. parathyroid hormone levels and bone mineral density in community-dwelling older women: the rancho bernardo study. Osteoporos Int. 2005;16:1721–6. doi:10.1007/s00198-005-1910-8.
37. Kuchuk NO, Pluijm SM, van Schoor NM, Looman CW, Smit JH, Lips P. Relationships of serum 25-hydroxyvitamin D to bone mineral density and serum parathyroid hormone and markers of bone turnover in older persons. J Clin Endocrinol Metab. 2009;94:1244–50. doi:10.1210/jc.2008-1832.
38. Alkhenizan A, Mahmoud A, Hussain A, Gabr A, Alsoghayer S, Eldali A. The Relationship between 25 (OH) D levels (Vitamin D) and Bone Mineral Density (BMD) in a Saudi population in a community-based setting. PLoS One. 2017;12:e0169122. doi:10.1371/journal.pone.0169122.
39. Nakamura K, Tsugawa N, Saito T, Ishikawa M, Tsuchiya Y, Hyodo K, et al. Vitamin D status, bone mass, and bone metabolism in home-dwelling postmenopausal Japanese women: Yokogoshi study. Bone. 2008;42:271–7. doi:10.1016/j.bone.2007.09.056.

40. Zhen D, Liu L, Guan C, Zhao N, Tang X. High prevalence of vitamin D deficiency among middle-aged and elderly individuals in northwestern China: its relationship to osteoporosis and lifestyle factors. Bone. 2015;71:1–6. doi:10.1016/j.bone.2014.09.024.
41. Liu M, Yao X, Zhu Z. Associations between serum calcium, 25(OH)D level and bone mineral density in older adults. J Orthop Surg Res. 2019;14:458. doi:10.1186/s13018-019-1517-y.
42. Cerani A, Zhou S, Forgetta V, Morris JA, Trajanoska K, Rivadeneira F, et al. Genetic predisposition to increased serum calcium, bone mineral density, and fracture risk in individuals with normal calcium levels: mendelian randomisation study. BMJ. 2019;366:l4410. doi:10.1136/bmj.l4410.