

ASSOCIATION OF SERUM VITAMIN-D AND CALCIUM LEVELS WITH THE SEVERITY OF HIP FRAGILITY FRACTURES IN THE ELDERLY PATIENTS: A PROSPECTIVE STUDY

Anmol A Hublikar¹, Ashok R Nayak², Prashant B Kenganal³, Shreepad Kulkarni³, Rajkumar M Bagewadi³, Basavaraj M K¹, Syed Mohamad Faizan Razvi¹, Chetan A Rathod¹.

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Corresponding Author:

Dr. Rajkumar M Bagewadi,
Email: Savitiraj2010@gmail.com

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¹Junior Resident, Department of Orthopaedics, BLDE, Shri B M Patil Medical College Hospital & RC, Vijayapura, India.

²Professor, Department of Orthopaedics, BLDE, Shri B M Patil Medical College Hospital & RC, Vijayapura, India

³Assistant Professor, Department of Orthopaedics, BLDE, Shri B M Patil Medical College Hospital & RC, Vijayapura, India

Abstract

Background: Due to changes in bone mass, architecture, and material properties, older people with fragility fractures have markedly lower bone strength. These fractures result from low-energy injuries in elderly people. Hip fractures in elderly people result from low-energy injuries and have been linked to vitamin D insufficiency as a separate risk factor. It is also linked to poor muscle function, muscle weakness, an increased risk of falls, inadequate rehabilitation post-injury, and a higher chance of refracture in these patients. Understanding the links between vitamin D, serum calcium, and the severity of hip fractures can help to personalize preventative measures, enhance prognosis, plan treatment, and deliver differently tailored therapies. There have been no studies to see for an association of serum calcium and vitamin D with the severity of fragility hip fractures. Our study aims to analyze the baseline differences of calcium and vitamin D levels in patients with different types of hip fractures and their severity. **Objectives:** **a)** To determine the serum calcium levels and serum Vitamin-D levels in elderly patients having fragility hip fractures at B.L.D.E. (deemed to be university) Shri B. M. Patil Medical College, Hospital & research center, Vijayapura, Karnataka. **b)** To categorize hip fractures based on their type and further subclassify them based on their severity. **c)** To correlate the calcium and Vitamin-D levels in elderly patients with severity of fractures of hip which are further classified based on age and gender. **Materials and Methods:** A hospital-based descriptive prospective study was conducted among elderly patients (over 50 years of age) who presented with fragility fractures of the hip joint at the Emergency Trauma Care Center and OPD of the Orthopaedic Department at B.L.D.E. (deemed to be university) Shri B.M. Patil Medical College, Hospital, and Research Centre, Vijayapura, Karnataka. The study period was from January 1, 2021, to June 1, 2022. A total of 120 patients were included in the study. The patient's biographical information, injury date, and fracture type were recorded. The levels of serum calcium and vitamin D were measured and reported upon admission. **Data Management:** Version 23 of the Statistical Package for the Social Sciences (SPSS) was used to input, code, and analyze the data. The main findings were the levels of calcium and 25-hydroxycholecalciferol in the serum. The distribution of 25-hydroxycholecalciferol and calcium was summarized using means with standard deviations and the median with interquartile range (IQR). The Kruskal-Wallis and Mann-Whitney tests were conducted to determine if serum calcium and vitamin D levels correlated with specific patient features. The association between serum calcium and vitamin D levels and gender groups, different types of fractures, and the severity of fractures was examined using the chi-square test. **Results:** Out of 120 enrolled patients for the study, 37.5% were of the age group 60-69 years, with a male predominance of 56.7%. More men had deficient vitamin D levels than women. This study



showed that older individuals with hip fragility fractures frequently have hypovitaminosis D. 43.3% of the participants in the research showed vitamin D insufficiency. Only 12.5% of people had normal blood vitamin D levels, while 44.2% were vitamin D deficient. For 45.8% of the research subjects, the albumin-adjusted calcium levels were normal, but for 42.5% of them, calcium levels were low. The most common type of hip fracture was intertrochanteric femur fracture at 59.2%, followed by neck of femur fracture at 29.2%, and subtrochanteric femur fracture at 11.7%. Among intertrochanteric femur fractures, 25.8% belonged to Boyd and Griffin type 4 and 6.7% belonged to type 1. Among neck of femur fractures, 16.7% belonged to Garden's type 4 and 2.5% belonged to type 1. Among subtrochanteric femur fractures, 8.3% belonged to Russell-Taylor's type 1 and 3.3% belonged to type 2. Thus, the maximum percentage of patients with different hip fractures presented to us belonged to the more severe type of their respective fractures. There was a statistically significant difference seen for the intertrochanteric femur fracture, neck of femur fracture, and subtrochanteric femur fracture for the varying levels of serum calcium and vitamin D. 45.1% of intertrochanteric femur fracture and 54.3% of neck of femur fracture patients had hypocalcemia. 46.5% of intertrochanteric femur fracture and 57.1% of neck of femur fracture had vitamin D deficiency. There was a significant association of serum calcium and vitamin D levels with the severity of hip fractures. Among intertrochanteric femur fractures, all type 4 fractures had hypocalcemia (100%) and vitamin D insufficiency (100%). Among neck of femur fractures, almost all type 4 fractures had hypocalcemia (95%) and vitamin D deficiency (100%).

Conclusion: We concluded that the prevalence of vitamin D deficiency and insufficiency, as well as hypocalcemia, was high in this study. This was especially true when evaluated among different types of hip fractures and their severity. We could conclude that the more deficient the serum calcium levels and the more deficient/insufficient the serum vitamin D levels, the more severe the type of fracture. A weak statistically significant association was found between serum calcium and vitamin D levels with age and sex.

INTRODUCTION

Fragility fractures are fractures that develop in the absence of an evident trauma or as a result of trivial trauma, such as a fall while standing. Age increases the likelihood of sustaining a fragility fracture. Bone fragility is the ability of bone to fracture. The biomechanical definition requires a minimum of three components: strength, brittleness, and work to failure.^[1]

Reduction in periosteal bone formation, ongoing bone resorption across the basic multicellular unit (BMU) that causes remodeling of bone on its endosteal surface and an increased remodeling rate are the main factors affecting the cellular machinery which is responsible for achieving peak bone strength.^[2]

Fragility fractures around the hip joint are of great interest worldwide because they are linked to increased morbidity and mortality. Due to the high cost of post-injury care of untreated patients, they are the most commonly operated-on fracture of the proximal femur. They also have the highest postoperative death rate among surgically treated fragility fractures and are considered a significant health resource issue. A third of elderly patients with hip fractures die within the first year after the injury, and many of them are unable to return to their pre-fracture functional state.^[3]

According to several research, Vitamin-D deficiency prevalence ranges from 55% to 92% in patients with hip fractures and is reported to be higher in aged individuals in western nations with seasonal fluctuations. The risk of Vitamin-D deficiency is higher in elderly people due to risk factors include inadequate sun exposure, decreased Vitamin-D production in skin, dietary insufficiency, impaired absorptive capacity of the intestine, poor hydroxylation and absorption in the hepatic and renal system. A lack of Vitamin-D is linked to increased muscle weakness and discomfort, which reduces muscle strength, balance, and function. It is also linked to faster bone turn-over and an increased risk of falls leading to hip fractures among the elderly population. According to some writers, patients with hip fractures who are Vitamin-D deficient repair their fractures more slowly and have a greater death rate.^[4-6]

The serum levels of calcium and vitamin D in patients with fragility fractures of the hip have not been studied locally. The findings of this study will help orthopedic surgeons treat patients who present with fragility fractures of the hip based on the patient's serum vitamin D and calcium levels.

Case definition for fragility fractures of the hip

Fragility fracture: A fragility fracture is a pathological fracture that occurs from minimal trauma (e.g., a fall from a standing height) or no

identifiable trauma at all. It is both a sign and a symptom of osteoporosis.

Type of hip fracture:

- Fracture of the neck of the femur
- Intertrochanteric femur fracture
- Subtrochanteric femur fracture

Subclassifications (severity):

- Neck of the femur fracture: Garden classification (types 1, 2, 3, 4)
- Intertrochanteric femur fracture: Boyd and Griffin classification (types 1, 2, 3, 4)
- Subtrochanteric femur fracture: Russell-Taylor's classification (types 1, 2)

Serum Vitamin-D levels		
Vitamin-D deficiency:	≤20 ng/ml	(≤ 50 nmol/l)
Vitamin-D insufficiency:	21- 29 ng/ml	(52.5- 72.5 nmol/l)
Vitamin-D sufficiency:	≥ 30 ng/ml	(≥75 nmol/l)
Serum calcium levels		
Hypocalcemia:	< 8.5 mg/dl	(< 2.2 mmol/l)
Normocalcemia:	8.5- 10.2 mg/dl	(2.2 – 2.7 mmol/l)
Hypercalcemia:	> 10.2 mg/dl	(>2.7 mmol/l)

Figure 1: definition of variables

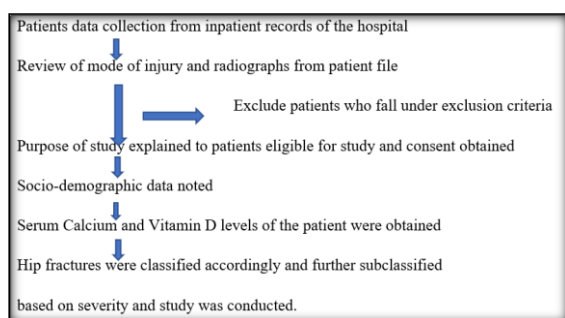


Figure 2: Data collection procedure

MATERIALS AND METHODS

The Advanced Trauma Center of our institute hosted a prospective observational study that ran from January 2021 to June 2022. The study was approved by the Ethics committee and consent was obtained from each participant. A total of 120 individuals with fragility fractures of the hip, of either gender and aged 50 years or above, were included in the study.

A fragility fracture is a pathological fracture that occurs from low-intensity trauma, such as a fall from a height that is lower than the individual's own height. The study only included proximal femur fractures with radiological proof, such as fracture neck of the femur (NOF), inter-trochanteric (IT) femur fractures and subtrochanteric (ST) femur fractures. Individuals who had a history of cancer, serious injury, or involvement of multiple bones and joints were excluded.

Each participant's clinical, biochemical, and radiological information was documented in a pre-written performa. Baseline fasting venous blood samples were taken to analyze several biochemical and hormonal factors. Serum calcium (normal range

8.5 - 10.2 mg/dl), inorganic phosphate (normal range 2.7 - 4.5 mg/dl), and albumin (normal range 3.4- 4.8 mg/dl) were measured by auto-analyzer (Roche Diagnostics, Modular P 800 Germany).

VITAMIN-D DEFICIENCY was defined as a level of less than or equal to 20ng/ml and more than 30ng/ml was considered Vitamin-D sufficient. The LIAISON® 25-OH Vitamin-D assay method was used to measure the levels of Vitamin-D in the serum. This is a quick, accurate, and precise automated chemiluminescent immunoassay (CLIA) technique.

Inclusion Criteria

- Hip fracture patients with age 50 or above and seen at BLDE.
- Patients who are willing to participate in the study.
- Intertrochanteric fracture of femur
- Subtrochanteric fracture of femur
- Neck of femur fracture

Exclusion Criteria

- Hip fracture patients aged less than 50 years
- Pathologic hip fractures
- High energy trauma
- Patients with metabolic disorders
- Patients who are currently taking anti-osteoporotic drugs
- Patients who are currently taking vitamin D and/or calcium

RESULTS

A total of 120 patients were enrolled in the study after meeting the inclusion criteria. Of these, 52 (43.3%) were female and 68 (56.7%) were male. The age distribution of patients with hip fractures was as follows:

- 40 (37.5%) were aged 60-69 years.
- 3 (2.5%) were aged over 90 years.

Of the 120 patients, 71 (59.2%) had an intertrochanteric femur fracture, 35 (29.2%) had a neck of femur fracture, and 14 (11.7%) had a subtrochanteric femur fracture.

Intertrochanteric femur fractures were further classified according to the fragmentation of the proximal femur and the displacement of the fracture fragments using the Boyd and Griffin classification. Of these, 31 (25.8%) patients belonged to type 4, and 8 (6.7%) to type 1.

Neck of femur fractures were classified according to the amount of displacement of the femoral head with respect to the femoral neck using the Garden classification. Of these, 20 (16.7%) patients belonged to type 4, and 3 (2.5%) to type 1.

Subtrochanteric femur fractures were classified according to the presence or absence of fracture involvement of the lesser trochanteric region (medial calcar) and the greater trochanteric region (piriformis fossa) using the Russell and Taylor classification. Of these, 10 (8.3%) patients belonged to type 1, and 4 (3.3%) to type 2.

Serum calcium levels were evaluated among the hip fractures. The mean calcium level in intertrochanteric femur fractures was 8.83 mg/dl (n=71) with a standard deviation of 0.956. The mean calcium level in neck of femur fractures was 8.71 mg/dl (n=35) with a standard deviation of 0.926. The mean calcium level in subtrochanteric femur fractures was 10.14 mg/dl (n=14) with a standard deviation of 0.949.

Serum vitamin D levels were also evaluated among the hip fractures. The mean vitamin D level in intertrochanteric femur fractures was 21.85 ng/dl (n=71) with a standard deviation of 4.662. The mean vitamin D level in neck of femur fractures was 21.03 ng/dl (n=35) with a standard deviation of 4.402. The mean vitamin D level in subtrochanteric femur fractures was 28.00 ng/dl (n=14) with a standard deviation of 3.595.

The association of serum calcium and serum vitamin D levels with the types of hip fragility fractures and their severity (subtypes) is shown in Table 1. The results showed that there was a statistically significant association between the two variables (p-value = 0.0001). This means that the more severe the type of hip fracture, the more deficient the serum calcium and vitamin D levels.

The correlation between serum calcium and serum vitamin D levels with hip fragility fractures and their severity (subtypes) is shown in Table 2. The results showed that there was a statistically significant correlation between the two variables (p-value = 0.0001). This means that there is a linear relationship between serum calcium and vitamin D levels and the severity of hip fractures.

Table 1: Correlation of Serum Calcium and Serum Vitamin-D with types of hip fractures and their severity (subtypes)

HIP FRACTURES	Number of patients	Mean Serum Calcium levels(mg/dl)	Mean serum Vitamin-D levels(ng/dl)	P Value
Intertrochanteric Femur Fracture (Boyd and Griffin)	71	8.83	21.85	0.001
Type-1	8	10.38	30.50	
Type-2	14	9.86	25.29	
Type-3	18	8.78	22.17	
Type-4	31	8.00	17.87	
Neck of femur fracture (Gardens)	35	8.71	21.03	0.001
Type-1	3	10.67	30.00	
Type-2	4	10.00	26.25	
Type-3	8	9.00	23.00	
Type-4	20	8.05	17.85	
Subtrochanteric femur fracture (Russell and Taylor's)	14	10.14	28.00	0.001
Type-1	10	10.60	29.80	
Type-2	4	9.00	23.50	

Table 2: Association of Serum Calcium and Serum Vitamin-D levels with types of hip fractures and their severity (subtypes)

Diagnosis	Serum Calcium (mg/dl)			Serum Vitamin-D(ng/dl)			Total	P value
	< 8.5	8.5 - 10.2	10.3+	<= 20	21 - 29	30 +		
Intertrochanteric femur fracture (Boyd and Griffin)	32 (45.1%)	34 (47.9%)	5 (7%)	33 (46.5%)	33(46.5%)	5 (7.0%)	71	0.0001
Type-1	0	3(37.5%)	5(62.5%)	0	3(37.55%)	5(62.5%)		
Type-2	1(7.1%)	13(92.9%)	0	1(7.1%)	13(92.6%)	0		
Type-3	0	18(100%)	0	1(5.6%)	17(92.9%)	0		
Type-4	31(100%)	0	0	31(100%)	0	0		
Neck of femur fracture (Gardens)	19 (54.3%)	14 (40%)	2 (5.7%)	20 (57.1%)	12(34.3%)	3 (8.6%)	35	0.0001
Type-1	0	1(33.3%)	2(66.7%)	0	0	3(100%)		
Type-2	0	4(100%)	0	0	4(100%)	0		
Type-3	0	8(100%)	0	0	8(100%)	0		
Type-4	19(95%)	1(5%)	0	20(100%)	0	0		
Subtrochanteric femur fracture (Russell and Taylor's)	0 (0%)	7 (50%)	7 (50%)	0 (0.0%)	7 (50.%)	7 (50%)	14	0.0001
Type-1	0	3(30%)	7(70%)	0	3(30%)	7(70%)		
Type-2	0	4(70%)	0	0	4(100%)	0		
Total	51 (42.5%)	55 (45.8%)	14 (11.7%)	53 (44.2%)	52(43.3%)	15(12%)	120	

DISCUSSION

Elderly patients frequently suffer from hip fragility fractures, which are brought on by minor trauma such falling from standing height or less. Some of the risk

factors influencing the onset of osteoporosis include calcium and Vitamin-D deficiency.^[7] Osteoporosis is linked to a higher risk of fragility fractures, which mostly affect the wrist, hip, and spine. According to reports, the lifetime risk of fragility fracture varies

between 33% and 44% for females and 20% to 27% for males.^[7-9]

Serum Vitamin-D and calcium levels

Out of the 120 patients who were enrolled in the study, 37.5% had hip fractures, and the majority of these men (56.7%) were in the 60-69 age range. Though there was no statistically significant difference, more men than women had low Vitamin-D levels. Our results diverged from those of studies conducted in Western and Asian regions. A Chinese study by Fu et al. found a link between postmenopausal women's hip fractures and low levels of blood 25-hydroxycholecalciferol.^[10] This study demonstrated that older patients with hip fragility fractures frequently have hypovitaminosis D. 43.3% of the people in the study were Vitamin-D deficient. Only 12.5% of people had normal serum Vitamin-D levels, whereas 44.2% were Vitamin-D deficient. Similar findings were made by Ramason et al,^[11] in Singapore, where Vitamin-D deficiency rates were 57.5%, Vitamin-D insufficiency rates were 34.5 percent, and normal serum Vitamin-D levels were 8%. The frequency of Vitamin-D deficiency among individuals with fragility fractures has been found to be quite high, ranging from 55% to 91.6% in other investigations. In contrast to studies in western nations and study by Ramason et al, this study revealed lower prevalence of Vitamin-D deficiency and insufficiency.^[11-13]

The levels of Vitamin-D and calcium in the elderly have been found to vary geographically and seasonally in previous research of a similar nature, with a higher frequency of Vitamin-D deficiency seen during the months of march till June due to lower cutaneous production in the winter months.^[13,14] It's conceivable that the lesser prevalence of vitamin deficiency can be attributed in this study to the fact that the participants were selected from Nairobi and its surroundings, where the climate is primarily sunny with few seasonal fluctuations. Additionally, it is possible to hypothesize that the discrepancies seen can be explained by the small sample size, lower mean population age and smaller percentage of women.

45.8% of research participants had normal albumin-adjusted calcium levels, while 42.5% had low levels. The findings were not at all surprising as the calcium levels are tightly regulated by parathyroid hormone and Vitamin-D, in spite of the fact that it is predicted that absorption of calcium declines with old age. The scope of this study did not allow for evaluation of other contributing factors, such as kidney illness, liver disease, hypoparathyroidism, and diet, which may have caused calcium shortage in 42.5% of the study group.^[15-17]

In a study conducted by Peng-Fei Li et al. (2016), they concluded that Patients with femoral neck fractures had a greater chance of restoring and conserving serum calcium than those with femoral intertrochanteric fractures. Femoral intertrochanteric fracture may be more likely in people with low blood calcium levels^[29].

Hip fracture pattern and among their severity

Intertrochanteric femur fractures made up 59.2% of all hip fractures, followed by neck of femur fractures at 29.2% and sub-trochanteric femur fractures at 11.7%. According to studies, the likelihood of developing an intertrochanteric fracture increases dramatically with age and is most frequently found in women.^[18-20] Intertrochanteric fractures are more frequent than other fracture patterns, according to studies conducted in different areas.^[21] In a retrospective study conducted in Tanzania, Tsabasvi et al. revealed that intertrochanteric fractures were the most prevalent type of fracture, accounting for 55.8% of cases, followed by neck of femur fractures, which were shown to be 28.5% more common.^[22]

Despite the fact that there were more women with fractures in this category, this study found no significant differences. Fox et al.earlier's study, which was similar, similarly found no variation in gender distribution.^[23]

25.8% of intertrochanteric femur fractures were Boyd and griffin type-4, while 6.7% were type-1. 16.7% of neck of femur fractures were of Gardens type-4, while 2.5% were of type-1. 8.3% of subtrochanteric femur fractures were Russell-Taylor's type-1, while 3.3% were type-2. Thus, a majority of the patients who came to us with various hip fractures belonged to the more severe variety of those fractures.

Correlation between Serum calcium and Vitamin-D levels with individual patient characteristics

There was no statistically significant correlation between age groups and serum calcium and Vitamin-D levels. It was seen that there was no statistically significant relationship between sex and the blood levels of calcium and Vitamin-D. Notably, statistically significant results were found for the different levels of serum calcium and Vitamin-D for the Intertrochanteric femur fracture, Neck of femur fracture, and Subtrochanteric femur fracture. Hypocalcemia was seen in 46.5% of Intertrochanteric femur fracture patients and Vitamin-D deficiency was present in 45.1% of Inter-trochanteric femur fracture patients and 54.3% of Neck of femur fracture patients.

In the past, research on osteoporosis and Vitamin-D levels examined the overall fracture risk. However, there has been debate among writers over the ideal serum 25(OH)D levels linked to an increased risk of fracture. Melhus et al. discovered in 2010 that a blood 25(OH)D level below 40nmol/l predicted an elevated fracture risk.^[24] According to a 2008 study by Cauley et al, the lowest risk of fracture was related with 25(OH) D levels between 60 and 70 nmol/l 4. In 2008, Van Schoolar discovered that the highest risk of fracture was associated with serum 25 (OH) D levels less than or equal to 30 nmol/l.^[25] The levels of Vitamin-D or serum calcium did not show a statistically significant correlation with patient age or gender.

There was significant association of serum calcium and Vitamin-D levels with severity of hip fractures, Among Intertrochanteric femur fractures all type-4

fractures had hypocalcemia (100%) & Vitamin-D Insufficiency (100%), Among Neck of femur fractures almost all type-4 fractures had hypocalcemia (95%) & Vitamin-D deficiency (100%).

In a study conducted by Larrosa M et al. (2012), they concluded that Although individuals with intracapsular and extracapsular hip fractures have similar blood Vitamin-D levels, there appears to be a stronger correlation between severe osteoporotic hip fractures and severe Vitamin-D deficit the more severe the shortage. A previous vitamin-D supplementation might prevent these fractures from becoming more severe.^[26]

In a study conducted by Hwang et al. (2020), they concluded that in aged individuals, an unstable intertrochanteric fracture is linked to low levels of calcium and vitamin D. An increase in the severity of intertrochanteric fractures might be prevented by maintaining appropriate amounts of calcium and vitamin D.^[27]

In a study conducted by Maheshwar Lakkireddy et al. (2019), they concluded that: There was a significant association between hypovitaminosis D, osteoporosis, and fracture site comminution. The comminution at the fracture site and high prevalence of Vitamin-D deficiency in patients presenting with hip fractures implicate the necessity for an effective supplementation and proper evaluation of Vitamin-D in elderly patients alongside anti-osteoporotic regimens for the appropriate management and effective prevention of osteoporotic hip fractures.^[28]

CONCLUSION

We conclude that the prevalence of vitamin D deficiency, insufficiency, and hypocalcemia was high in this study. This was especially true when evaluated among different types of hip fractures and their severity. We could conclude that the more deficient the serum calcium levels and the more deficient or insufficient the serum vitamin D levels, the more severe the type of fractures. There was a weak statistically significant association seen between serum calcium and vitamin D levels with the age and gender of patients.

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