Section: Miscellaneous

Original Research Article

COMPARATIVE ANALYSIS OF VITAMIN D STATUS IN PATIENTS WITH FEMORAL NECK AND INTERTROCHANTERIC FRACTURES: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Vitamin D deficiency is common among elderly patients with hip fractures and contributes to impaired bone mineralization, muscle weakness, and increased risk of falls. Whether serum vitamin D status differs between femoral neck and intertrochanteric fractures remains uncertain, particularly in the Indian population. The objective is to compare serum 25-hydroxyvitamin D [25(OH)D] levels between patients with femoral neck and intertrochanteric fractures and to evaluate the distribution of vitamin D deficiency in both fracture groups.

Materials and Methods: This study was a prospective observational research conducted in the Department of Orthopaedics at Autonomous State Medical College in Sultanpur, Uttar Pradesh. It included twenty-five patients who had proximal femoral fractures, specifically twelve patients with femoral neck fractures and thirteen patients with intertrochanteric fractures. The levels of serum 25-hydroxyvitamin D, also known as 25(OH)D, were assessed prior to starting treatment. These levels were then compared between the two groups using suitable statistical methods.

Results: The mean serum 25(OH)D level was significantly higher in patients with femoral neck fractures (16.44 ± 3.00 ng/mL) than in patients with intertrochanteric fractures (11.38 ± 2.07 ng/mL) ($p<0.001$). Vitamin D deficiency was highly prevalent in both groups, while severe deficiency was observed only among patients with intertrochanteric fractures.

Conclusion: Vitamin D deficiency is highly prevalent among patients with proximal femoral fractures. Patients with intertrochanteric fractures demonstrated significantly lower serum 25(OH)D concentrations than those with femoral neck fractures, suggesting poorer vitamin D status in this fracture pattern. Routine assessment and correction of vitamin D deficiency should be considered in elderly patients presenting with hip fractures.

Keywords: Vitamin D, 25-Hydroxyvitamin D, Femoral Neck Fracture, Intertrochanteric Fracture, Hip Fracture, Prospective Observational Study.

INTRODUCTION

Hip fractures are serious fragility injuries in older adults and are associated with loss of mobility, dependence, complications, and increased mortality.[1,2] Femoral neck and intertrochanteric fractures are the major patterns of proximal femoral fracture. Although grouped as one clinical entity, they differ in anatomical location, bone composition, biomechanics, patient characteristics, management, and outcome. Identifying modifiable metabolic abnormalities is relevant to acute management and secondary fracture prevention.[3-8]

Vitamin D is essential for calcium and phosphate homeostasis, bone mineralization, skeletal remodelling, and neuromuscular function. Serum

25-hydroxyvitamin D [25(OH)D] is accepted as the best indicator of vitamin D status [3]. Inadequate vitamin D may reduce intestinal calcium absorption and promote secondary hyperparathyroidism, increased bone turnover, cortical bone loss, and osteomalacia.[4] Associated muscle weakness and impaired balance may increase the likelihood of falls and fragility fractures.[9,10]

Vitamin D deficiency remains common in India despite abundant sunlight. Indian studies have reported a high prevalence of vitamin D deficiency and disturbed bone mineral metabolism [5,6]. Previous studies have demonstrated an association between low serum 25(OH)D concentrations, reduced bone mineral density, and fragility fractures.[7,8] These findings support routine assessment of metabolic bone health at hospital admission.

Although vitamin D deficiency has been extensively investigated in patients with osteoporosis and hip fractures, evidence comparing vitamin D status between femoral neck and intertrochanteric fractures remains limited.[12,15] Differences in age, bone architecture, nutritional status, renal function, and osteoporosis severity may contribute to variations between fracture patterns.[13,15] Therefore, direct comparison of pretreatment serum 25(OH)D concentrations between these two fracture groups may provide clinically useful information for fracture management and secondary prevention.

The present prospective observational study aims to compare serum 25(OH)D levels between patients with femoral neck and intertrochanteric fractures admitted to Autonomous State Medical College, Sultanpur, Uttar Pradesh. Secondary objectives are to compare vitamin D categories and associated biochemical parameters, including serum calcium, phosphorus, alkaline phosphatase, parathyroid hormone, creatinine, and estimated glomerular filtration rate, between the two fracture groups.

MATERIALS AND METHODS

Study design and setting: This prospective observational study was conducted in the Department of Orthopaedics at Autonomous State Medical College, Sultanpur, Uttar Pradesh, India, from November 2024 to July 2026. The study compared serum vitamin D status between patients with femoral neck fractures and those with intertrochanteric fractures. Twenty-five consecutive eligible patients were enrolled.

Inclusion criteria

- Age 50 years or older, irrespective of sex.
- Radiographically confirmed femoral neck or intertrochanteric fracture.
- Fracture caused by low-energy trauma, defind as a fall from standing height or lower.
- Admission to the study hospital during the study period.
- Availability of a pretreatment serum 25-hydroxyvitamin D [25(OH)D] measurement.
- Provision of written informed consent by the patient or legally authorised representative.

Exclusion criteria

- Hip fracture caused by high-energy trauma, including a road-traffic accident or fall from height.
- Pathological fracture secondary to malignancy or bone lesion.
- Periprosthetic, subtrochanteric, or isolated greater- or lesser-trochanteric fracture.
- Previous fracture or surgical procedure involving the same hip.
- Indeterminate fracture pattern radiographically.
- Therapeutic vitamin D supplementation during the preceding three months.
- Known primary hyperparathyroidism, advanced chronic liver disease, dialysis-dependent kidney disease, or severe intestinal malabsorption.
- Refusal to participate or unavailability of the primary biochemical measurement.

Clinical and radiographic assessment: Demographic and clinical information was recorded using a structured case-record form. Variables included age, sex, fracture side, mechanism of injury, time from injury to admission, comorbidities, previous fragility fractures, smoking and alcohol history, medication, and calcium or vitamin D supplementation. Anteroposterior pelvic and lateral hip radiographs were reviewed by the treating orthopaedic team. Fractures were categorised as femoral neck or intertrochanteric according to anatomical location. Group allocation was completed after radiographic confirmation.

Laboratory assessment: A venous blood sample was collected within 24 hours of hospital admission and before surgery or initiation of calcium or vitamin D supplementation whenever clinically feasible. Serum 25-hydroxyvitamin D [25(OH)D] was used as the primary indicator of vitamin D status and served as the primary comparative variable between the femoral neck and intertrochanteric fracture groups. Serum calcium, phosphorus, alkaline phosphatase, parathyroid hormone, creatinine, and estimated glomerular filtration rate were recorded as supporting biochemical parameters. All laboratory investigations were performed in the hospital's central laboratory following standard quality-control procedures. Serum 25-hydroxyvitamin D [25(OH)D] was estimated using the chemiluminescent immunoassay (CLIA) method in the central clinical laboratory of the institution following standard quality-control procedures.

Serum 25(OH)D below 10 ng/mL was operationally classified as severe deficiency, 10 to below 20 ng/mL as deficiency, 20 to below 30 ng/mL as insufficiency, and 30 ng/mL or higher as sufficient. The primary outcome was the between-group difference in serum 25(OH)D. Secondary outcomes

were the distribution of vitamin D categories and differences in the supporting biochemical parameters.

Statistical analysis: Data were entered in Microsoft Excel and analysed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, New York, USA). Continuous variables were checked for missing or implausible values. Distributional normality was assessed using the Shapiro–Wilk test and visual inspection of histograms. Normally distributed variables were presented as mean ± standard deviation and compared using Welch's independent-samples t-test. Non-normally distributed variables were presented as median with interquartile range and compared using the Mann–Whitney U test.

Categorical variables were summarised as frequencies and percentages. Fisher's exact test was used for group comparisons because of the small sample and expected cell counts. The difference in 25(OH)D between fracture groups was reported with a 95% confidence interval and a two-sided p-value. Statistical significance was defined as $p<0.05$. Because only 25 patients were included, the analysis was considered exploratory. Multivariable regression and extensive subgroup analysis were not performed to avoid model overfitting. Missing observations were not imputed; the available denominator was reported for each analysis.

Ethical considerations: The study was approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants before enrolment.

RESULTS

Study Selection: During the study period from November 2024 to July 2026, a total of 31 patients with proximal femoral fractures were assessed for eligibility. Six patients were excluded because they did not meet the predefined inclusion criteria or had incomplete biochemical investigations. The remaining 25 patients fulfilled all eligibility criteria and were included in the final analysis. Of these, 12 patients (48.0%) had femoral neck fractures, while 13 patients (52.0%) sustained intertrochanteric fractures. Complete demographic, clinical, radiographic, and biochemical data were available for all enrolled participants; therefore, no cases were excluded from the final statistical analysis.

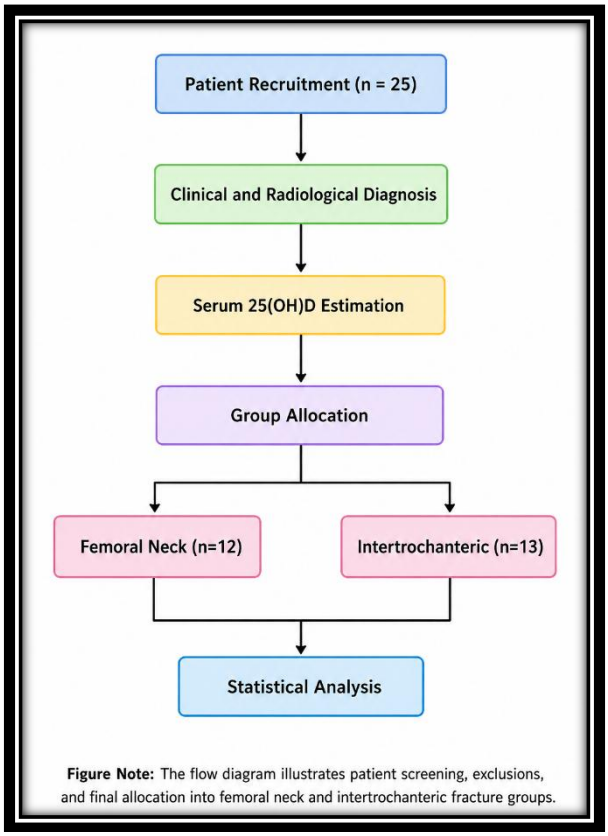

Figure 1: Study Workflow:

Baseline Demographic Characteristics: The baseline demographic characteristics of the study population are presented in [Table 1]. The mean age of patients with femoral neck fractures was 72.58 ± 6.05 years, whereas patients with intertrochanteric fractures had a mean age of 75.69 ± 5.65 years. Although the intertrochanteric fracture group was slightly older, the difference was not statistically significant (p=0.199). Female patients constituted the majority in both groups, accounting for 58.3% of femoral neck fractures and 69.2% of intertrochanteric fractures. The distribution of sex and fracture side was comparable between the two groups, indicating that the baseline demographic characteristics were well balanced.

Table 1: Baseline Demographic and Clinical Characteristics

Variable	Femoral Neck (n=12)	Intertrochanteric (n=13)	p-value
Age (years)	72.58 ± 6.05	75.69 ± 5.65	0.199
Male	5 (41.7%)	4 (30.8%)	0.688
Female	7 (58.3%)	9 (69.2%)	
Right-sided fracture	7 (58.3%)	8 (61.5%)	0.874
Left-sided fracture	5 (41.7%)	5 (38.5%)	

Table Note: Values are expressed as mean ± standard deviation or number (%). Continuous variables were compared using Welch's independent-samples t-test, whereas categorical variables were analysed using Fisher's exact test.

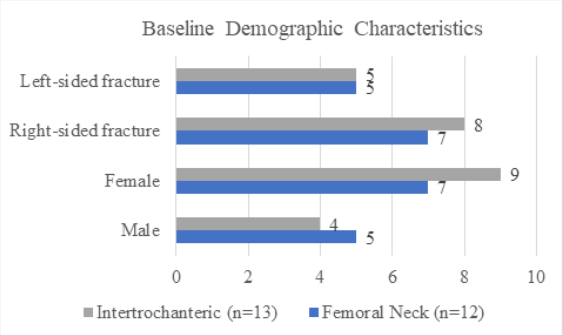

Figure 2. Baseline Demographic Characteristics of the Study Population

Figure Note: Female patients constituted the majority of the study population in both fracture groups.

Comparison of Serum Vitamin D Levels: Serum 25-hydroxyvitamin D [25(OH)D] concentrations were compared between the two fracture groups and are summarized in [Table 2]. Patients with femoral neck fractures had a mean serum vitamin D concentration of 16.44 ± 3.00 ng/mL, whereas those with intertrochanteric fractures had a significantly lower mean concentration of 11.38 ± 2.07 ng/mL. The mean difference between the groups was statistically significant (p<0.001), indicating poorer vitamin D status among patients with intertrochanteric fractures. The median serum vitamin D concentration also demonstrated a similar trend, confirming the consistency of the observed findings.

Table 2: Comparison of Serum Vitamin D Levels

Parameter	Femoral Neck (n=12)	Intertrochanteric (n=13)	p-value
Mean ± SD (ng/mL)	16.44 ± 3.00	11.38 ± 2.07	<0.001
Median (IQR), ng/mL	16.3 (14.2–18.8)	11.2 (9.8–12.8)	0.001
Range (ng/mL)	11.9–21.1	8.4–15.1	—

Table Note: Values are presented as mean ± standard deviation (SD) ormedian (interquartile range [IQR]). Serum 25-hydroxyvitamin D [25(OH)D] concentrations were measured before initiation of calcium or vitamin D supplementation. Welch's independent-samples t-test was used to compare normally distributed continuous variables, while the Mann–Whitney U test was used for non-normally distributed variables. A two-sided p value of <0.05 was considered statistically significant.

Distribution of Vitamin D Status: The distribution of vitamin D categories is shown in [Table 3]. Vitamin D inadequacy (serum 25(OH)D <30 ng/mL) was identified in all study participants. Among patients with femoral neck fractures, 83.3% had vitamin D deficiency, whereas 16.7% had vitamin D insufficiency. In contrast, severe vitamin D deficiency (<10 ng/mL) was observed exclusively in the intertrochanteric fracture group, affecting 30.8% of patients, while the remaining patients in this group were classified as vitamin D deficient. None of the participants in either group had sufficient vitamin D concentrations.

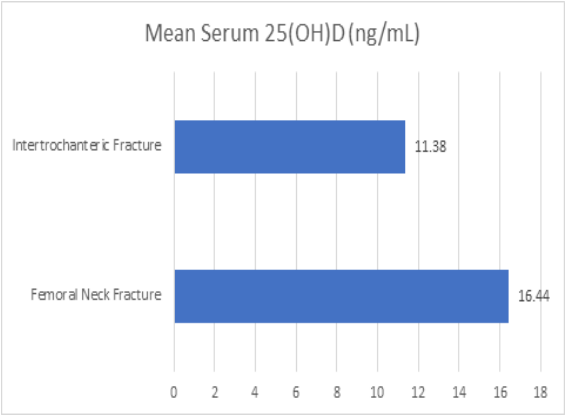

Figure 3: Mean Serum 25-Hydroxyvitamin D [25(OH)D] Levels in Femoral Neck and Intertrochanteric Fracture Groups.

Figure Note: Patients with intertrochanteric fractures had significantly lower mean serum 25-hydroxyvitamin D [25(OH)D] concentrations (11.38 ± 2.07 ng/mL) than patients with femoral neck fractures (16.44 ± 3.00 ng/mL; p<0.001).

Table 3: Distribution of Vitamin D Status

Vitamin D Category	Femoral Neck (n=12)	Intertrochanteric (n=13)	p-value
Severe deficiency (<10 ng/mL)	0 (0.0%)	4 (30.8%)	0.041
Deficiency (10–19.9 ng/mL)	10 (83.3%)	9 (69.2%)	
Insufficiency (20–29.9 ng/mL)	2 (16.7%)	0 (0.0%)	
Sufficiency (≥30 ng/mL)	0 (0.0%)	0 (0.0%)	

Table Note: Data are presented as number and percentage of patients in each fracture group.

Comparison of Biochemical Parameters:

The comparison of biochemical parameters between the two groups is presented in Table 4. Patients with intertrochanteric fractures demonstrated significantly lower serum calcium and phosphorus concentrations, while alkaline phosphatase, parathyroid hormone, and serum creatinine values were comparatively higher than those observed among patients with femoral neck fractures. These biochemical findings indicate a greater degree of disturbed bone metabolism in patients with intertrochanteric fractures.

Table 4: Comparison of Biochemical Parameters

Parameter	Femoral Neck	Intertrochanteric	p-value
Serum Calcium (mg/dL)	8.75 ± 0.21	8.45 ± 0.19	0.001
Serum Phosphorus (mg/dL)	3.19 ± 0.18	2.92 ± 0.16	<0.001
Alkaline Phosphatase (IU/L)	117.08 ± 8.41	143.54 ± 10.87	<0.001
Parathyroid Hormone (pg/mL)	53.08 ± 6.08	70.85 ± 8.32	<0.001
Serum Creatinine (mg/dL)	0.95 ± 0.10	1.09 ± 0.11	0.003

Table Note: Continuous variables are expressed as mean ± standard deviation. Statistical comparisons were performed using Welch's independent-samples t-test.

Summary of Major Findings: Overall, the present analysis demonstrated that vitamin D deficiency was highly prevalent among patients presenting with proximal femoral fractures. Patients with intertrochanteric fractures exhibited significantly lower serum vitamin D concentrations and less favourable biochemical profiles than patients with femoral neck fractures. Although demographic characteristics were comparable between the groups, the observed biochemical differences suggest that altered vitamin D status and bone metabolism may be more pronounced among patients with intertrochanteric fractures. These findings support the routine assessment of serum vitamin D levels in elderly patients presenting with hip fractures and highlight the potential importance of correcting vitamin D deficiency as part of comprehensive fracture management.

DISCUSSION

The present prospective observational study compared serum vitamin D status between patients with femoral neck fractures and intertrochanteric fractures. Overall, vitamin D deficiency was highly prevalent among patients with proximal femoral fractures. Patients with intertrochanteric fractures demonstrated lower serum 25(OH)D concentrations than those with femoral neck fractures. Differences in biochemical parameters also suggested greater disturbances in bone metabolism among patients with intertrochanteric fractures.

Vitamin D plays a fundamental role in calcium and phosphorus homeostasis, skeletal mineralization, and muscle function. Vitamin D deficiency promotes secondary hyperparathyroidism, increased bone turnover, osteoporosis, and fragility fractures.[4,9] In elderly individuals, muscle weakness and impaired balance further increase the risk of falls and hip fractures.[10]

The high prevalence of vitamin D deficiency observed in the present study is consistent with previous reports from India and other countries. Despite abundant sunlight, vitamin D deficiency remains common because of limited sun exposure, darker skin pigmentation, dietary inadequacy, and ageing [5,10]. Previous studies have also demonstrated an association between low vitamin D concentrations and poor bone mineral density among patients with fragility fractures.[7,8].

The lower vitamin D concentrations observed among patients with intertrochanteric fractures may be explained by the greater proportion of metabolically active trabecular bone in the intertrochanteric region. Nevertheless, fracture occurrence is multifactorial, and factors such as age, osteoporosis severity, nutritional status, renal function, and bone quality should also be considered.[12,15].

The biochemical findings observed in the present study are biologically plausible because prolonged vitamin D deficiency reduces calcium absorption and stimulates compensatory elevation of parathyroid hormone, resulting in increased bone turnover.[4,9] These mechanisms contribute to deterioration of skeletal health and increased susceptibility to fragility fractures.

Routine assessment of serum 25(OH)D at hospital admission may help identify previously unrecognized vitamin D deficiency. Early correction of vitamin D deficiency, together with calcium supplementation, osteoporosis treatment, and rehabilitation, may improve bone health and reduce the risk of future fractures.[13,16]

The present study has limitations because it was conducted at a single centre with a relatively small sample size. Larger multicentre prospective studies are needed to confirm these findings and determine whether correction of vitamin D deficiency improves fracture healing and long-term functional outcomes.[15,16]

Limitations: The present study has several limitations. First, it was conducted at a single tertiary care centre with a relatively small sample size, which may limit the generalizability of the findings. Second, the observational study design precludes establishing a causal relationship between vitamin D status and fracture type. Third, bone mineral density, dietary calcium intake, sunlight exposure, physical activity, and seasonal variation in vitamin D levels were not evaluated, all of which could have influenced the observed results. Larger multicentre prospective studies are required to validate these findings.

CONCLUSION

The present study demonstrated a high prevalence of vitamin D deficiency among patients with proximal femoral fractures. Patients with intertrochanteric fractures showed lower serum 25-hydroxyvitamin D [25(OH)D] levels than those with femoral neck fractures, suggesting a possible association between poorer vitamin D status and fracture pattern.

Routine assessment of vitamin D status in patients presenting with hip fractures may facilitate early identification and correction of deficiency as part of comprehensive osteoporosis management. Further large-scale multicentre prospective studies are required to confirm these findings and determine their clinical implications for fracture prevention and patient outcomes.

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