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Original Research Article

ASSOCIATION OF SERUM VITAMIN D LEVELS WITH OSTEOPOROSIS AND FRACTURE SITE COMMINUTION IN ELDERLY PATIENTS WITH HIP FRACTURES: A PROSPECTIVE STUDY

Sundeep Kumar[1], Ashok Kumar[2], Anubhav Chhabra[3], Anurag Chhabra[4], Abhishek Garg[3], Priyanka[5], Akash Ashiwal[1], Akshay Kumar[1], Ombir Singh Sihmar[1], Rohit Kadiyan[1], Yogesh Kumar[1], Naveen Kumar[1]

[1]Postgraduate, Department of Orthopaedics, MAMC Agroha, Hisar, Haryana, India
[2]Professor, Department of Orthopaedics, MAMC Agroha, Hisar, Haryana, India
[3]Assistant Professor, Department of Orthopaedics, MAMC Agroha, Hisar, Haryana, India
[4]Senior Professor & Head, Department of Orthopaedics, MAMC Agroha, Hisar, Haryana, India
[5]Senior Resident, JCD Vidyapeeth, Sirsa, Haryana, India

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Corresponding Author:
Dr. Ashok Kumar,
Professor, Department of Orthopaedics, MAMC Agroha, Hisar, Haryana, India.
Email: drashokbagotia@gmail.com

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ABSTRACT

Background: Hip fragility fractures are a major cause of morbidity and mortality among the elderly, primarily resulting from osteoporosis and minor trauma. Vitamin D plays a crucial role in bone health and its deficiency has been implicated in osteoporosis & fracture severity. This study aimed to assess serum vitamin D levels and their association with osteoporosis & fracture site comminution in elderly patients with hip fractures.

Materials and Methods: This prospective study was conducted at a tertiary care centre on 100 patients aged >60 years with hip fractures due to trivial trauma. Serum vitamin D levels were measured using an enzyme-linked fluorescent immunoassay (ELFA). Osteoporosis was classified using Singh's Index, and fracture site comminution was assessed by plain radiograph.

Results: Vitamin D deficiency (<20 ng/mL) was observed in 54% of patients, while 27% had insufficient levels (20–30 ng/mL). A significant association was found between vitamin D levels and Singh's Index ($p = 0.002$), as well as between vitamin D deficiency and fracture site comminution ($p \leq 0.001$).

Conclusion: Serum vitamin D deficiency was significantly associated with osteoporosis severity and fracture site comminution in elderly hip fracture patients. Singh's Index remains a useful tool for osteoporosis assessment in resource-limited settings. Early detection of osteoporosis and vitamin D deficiency is essential for timely intervention and fracture prevention.

Keywords: Hip fractures, osteoporosis, vitamin D deficiency, Singh's Index, fracture comminution, elderly patients.

INTRODUCTION

Hip fragility fractures are among the most serious complications of osteoporosis, contributing significantly to morbidity, mortality and healthcare burden among the elderly. Studies indicate that 12–20% of patients with hip fractures experience reduced life expectancy, with most excess mortality occurring within the first year post-fracture. The global incidence of hip fractures is projected to exceed 6 million annually by 2050, with women being twice as affected as men, primarily due to lower bone mineral density (BMD) and accelerated bone loss.[1,2] Bone mineral density (BMD) is the gold standard for diagnosing osteoporosis, providing precise and quantitative measurements. However, in resource-limited settings, Singh's Index, which evaluates the trabecular pattern on X-rays, serves as a cost-effective, accessible, and practical alternative. Vitamin D plays a critical role in bone metabolism by facilitating calcium absorption and maintaining skeletal homeostasis. Vitamin D deficiency is widely recognized as a risk factor for osteoporosis and increased fracture susceptibility. The present study evaluates serum vitamin D levels and their

association with osteoporosis & fracture site comminution in elderly patients with hip fractures.[3,4]

MATERIALS AND METHODS

This prospective observational study was conducted at Maharaja Agrasen Medical College, Agroha, Hisar, and included 100 elderly patients (aged >60 years) who presented with hip fractures resulting from low-energy (trivial) trauma. Ethical approval for the study was obtained from the Institutional Ethics Committee.

Inclusion criteria comprised patients with radiologically confirmed femoral neck or intertrochanteric fractures. Exclusion criteria included patients with systemic conditions such as chronic renal failure, chronic liver disease, or inflammatory bowel disease, pathological fractures unrelated to osteoporosis, recent vitamin D supplementation, current use of anti-osteoporotic medications, or long-term systemic corticosteroid therapy.

All participants underwent a thorough clinical evaluation, including assessment of pre-injury ambulation status, existing comorbidities, and the mechanism of injury. Radiological evaluation involved anteroposterior pelvic X-rays for fracture classification and Singh's Index grading (Grades 1–6), along with lateral view radiographs to assess the degree of comminution at the fracture site. Intertrochanteric fractures were further classified according to the Boyd and Griffin classification system, while femoral neck fractures were categorized using the Garden classification.

Serum vitamin D [25(OH)D] levels were measured in ng/mL using a two-step enzyme-linked fluorescent assay (ELFA) based on the sandwich principle, conducted on the BIOMÉRIEUX VIDAS fully automated analyzer. Radiographic findings and serum vitamin D levels were analyzed in relation to clinical parameters to assess their association with osteoporotic hip fractures resulting from trivial trauma.

Statistical Analysis: All the measurements and data were analyzed using standard statistical tools. The measurements were entered in Microsoft excel spreadsheet. Normally distributed variables were mentioned as means and standard deviation. Categorial variables were expressed as frequencies and percentages. For normally distributed data T-test was employed for analysis. Chi- square test was employed for categorial and ordinal data. Co-relation between variables was assessed by Spearman's coefficient. $P<0.05$ was considered statistically significant. Statistical software SPSS version 20.0 was employed for analysis

RESULTS

The mean age of the study population was 76.39 ± 10.03 years, with a slight male predominance (54%). Prior to injury, most patients (90%) were independently ambulatory without assistive devices. The predominant mechanism of injury due to trivial trauma was a slip and fall, accounting for 94% of cases. Comorbidities were present in 56% of patients, with chronic obstructive pulmonary disease (COPD) being the most common (23%), followed by hypertension (13%), diabetes mellitus (8%), and hypothyroidism (7%).

Radiographic evaluation revealed that intertrochanteric fractures were more prevalent (77%) than femoral neck fractures (23%). Among the intertrochanteric fractures, Boyd and Griffin Type II was the most frequent subtype (76.62%), while Garden Type IV was predominant (52.17%) among femoral neck fractures.

Osteoporotic changes were notable across the cohort. According to Singh's Index grading, 34% of patients were classified as Grade 2, 32% as Grade 3, and 32% as Grade 4. Fracture site comminution was observed in the majority of patients (71%). The mean serum vitamin D [25(OH)D] level was 21.25 ± 11.56 ng/mL, ranging from 8.10 to 86.70 ng/mL, with most patients classified as vitamin D deficient or insufficient.

Statistical analyses assessing the associations between vitamin D levels and demographic or clinical variables revealed no significant relationship with age ($p > 0.05$), gender ($p = 0.833$), or fracture type (intertrochanteric vs. femoral neck; $p = 0.254$).

A significant negative Spearman correlation was observed between vitamin D levels and Singh's Index ($\rho = –0.299$, $p = 0.002$), indicating that individuals with lower vitamin D levels tended to have lower Singh's Index grades, reflecting more advanced osteoporosis [Table 1].

Table 1: Association between vitamin D levels and Singh's index

Singh's Index Grade	Normal (30–100 ng/mL)	Insufficient (20–30 ng/mL)	Deficient (<20 ng/mL)	Total	Spearman correlation(ρ)	p-Value
Grade 1	0 (0.0%)	0 (0.0%)	1 (1.0%)	1 (1.0%)	–0.299	0.002
Grade 2	2 (2.0%)	9 (9.0%)	23 (23.0%)	34 (34.0%)		
Grade 3	4 (4.0%)	10 (10.0%)	18 (18.0%)	32 (32.0%)		
Grade 4	9 (9.0%)	11 (11.0%)	12 (12.0%)	32 (32.0%)		
Grade 5	0 (0.0%)	1 (1.0%)	0 (0.0%)	1 (1.0%)		
Grade 6	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)		
Total	15 (15.0%)	31 (31.0%)	54 (54.0%)	100		

Vitamin D levels were significantly lower in patients with fracture site comminution compared to those without, as shown by a Student's t-test ($p < 0.001$) [Table 2].

Table 2: Association Between Vitamin D Levels and Fracture Site Comminution

Comminution	N	Mean Vitamin D (ng/mL)	SD	SE Mean	t-test	df	p-Value
Yes	71	18.64	7.21	0.856	–3.750	98	<0.001
No	29	27.62	16.81	3.122			

However, a Chi-square test showed no statistically significant association between Singh's Index grades and fracture site comminution (p = 0.108), suggesting that the extent of comminution was not directly related to osteoporosis severity [Table 3].

Table 3: Association Between Singh's Index and Fracture Site Comminution

Singh's Index Grade	Comminution Present, n (%)	Comminution Absent, n (%)	Total, n	Chi-Square (p-value)
Grades 1–3	51 (76.1%)	16 (23.9%)	67	2.584 (0.108)
Grades 4–6	20 (60.6%)	13 (39.4%)	33	
Total	71 (71.0%)	29 (29.0%)	100	

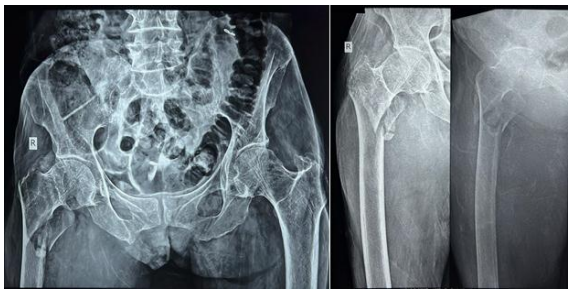

Figure 1: 75-year-old female with a Boyd and Griffin Type 4 comminuted intertrochanteric fracture, Singh's Index Grade 3, and serum vitamin D level of 14.6 ng/mL (deficient).

Figure 2: 78-year-old male patient with a Garden Type 4 femoral neck fracture, Singh's Index Grade 2, and serum vitamin D level of 10.6 ng/mL (deficient).

DISCUSSION

Among the elderly population, low-energy trauma such as a simple slip or fall that can lead to severe consequences, most notably fragility fractures of the hip. These injuries, often rooted in underlying osteoporosis, contribute significantly to long-term disability, reduced quality of life, and elevated mortality rates within the first year of occurrence. Extensive research, including work by Lips et al,[5] and Dhanwal et al,[6] has emphasized the critical influence of vitamin D deficiency and poor bone health in predisposing individuals to such fractures.

Vitamin D plays a critical role in bone health by facilitating calcium absorption and regulating bone metabolism. Deficiency in vitamin D leads to poor bone mineralization, decreased bone mass and an increased risk of fractures. Serum 25-hydroxy vitamin D [25(OH)D] is widely regarded as the most reliable marker for assessing vitamin D status. Although thresholds for sufficiency vary among guidelines, most experts agree that levels below 20 ng/mL indicate deficiency, while levels between 20 and 30 ng/mL represent insufficiency.

This investigation aimed to evaluate the association between serum vitamin D levels, Singh's Index (a radiological marker of osteoporosis), and the extent of fracture site comminution in elderly patients presenting with hip fractures resulting from trivial trauma. The findings were compared with those of previous international and Indian studies to assess consistency & clinical relevance.

The mean age of patients was 76.39 ± 10.03 years, consistent with previous research indicating that hip fractures predominantly affect individuals over 60 years of age. Although most literature reports a higher prevalence of hip fractures among females (e.g., Ramason et al., Dadra et al.),[7,8] a slight male predominance (54%) was observed in this cohort. This variation may reflect regional demographic differences or evolving trends within aging populations.

Many patients had common health problems such as diabetes, high blood pressure, COPD, and hypothyroidism. This is in line with studies by Niikura et al,[9] and Ingstad et al,[10] which showed that long-term illnesses and frailty can increase the risk of fractures. Almost all patients had fractures caused by simple falls, supporting the idea that low-energy injuries are the main cause of hip fractures in older adults, as also found by Skuladottir et al,[11] and Garg et al.[12]

Fracture distribution showed a predominance of intertrochanteric fractures (77%), which aligns with the findings of studies like Vellingiri et al,[13] and Skuladottir et al,[11] who also reported higher rates of intertrochanteric fractures in elderly cohorts. Singh's Index, used to estimate osteoporosis severity radiographically, showed most patients had Grade 2–4, indicating moderate to severe osteoporosis.

The mean vitamin D level among patients was 21.25 ± 11.56 ng/mL, placing it within the deficient-to-insufficient range. This finding aligns with studies by Browne et al,[14] Dadra et al,[8] and Skuladottir et al,[11] all of which reported widespread vitamin D deficiency in elderly patients with fractures.

When analyzing associations, there was no significant correlation found between vitamin D levels with patient age and gender ($p = 0.368$ and $p = 0.833$, respectively), which is similar to the results of De Jong et al,[15] and Vellingiri et al.[13] However, other studies like Lips et al,[5] and Metcalfe et al,[16] did find lower vitamin D levels in older adults and females, suggesting regional or lifestyle differences may influence these parameters.

The present study demonstrated a significant association between low serum Vitamin D levels and increased osteoporosis severity, as measured by Singh's Index ($p = 0.002$). This result is consistent with findings from De Jong et al,[15] and Garg et al,[12] both of which also reported a significant correlation between vitamin D deficiency and osteoporosis. The consistency of these outcomes across multiple studies strengthens the evidence that vitamin D deficiency may contribute to the progression and severity of osteoporosis.

Lower serum vitamin D levels are significantly associated with increased fracture comminution ($p \leq 0.001$), indicating a higher risk of complex fractures in deficient individuals. This finding aligns with Vellingiri et al,[13] who also reported a significant correlation ($p = 0.029$).

In contrast, no significant association was found between Singh's Index and fracture site comminution ($p = 0.108$). This aligns with results from Vellingiri et al,[13] and Metcalfe et al,[16] but differs from studies like Garg et al,[12] and Lips et al,[5] which reported that more severe osteoporosis increases the risk of comminuted fractures.

A comparison with previous studies shows that serum vitamin D levels had a strong association with both osteoporosis and fracture comminution in the present study. This finding is consistent with some earlier research, although the level of statistical significance varies across studies. However, the link between Singh's Index and fracture comminution remains unclear. While some studies reported a significant correlation, others including the present study did not find a meaningful association ($p = 0.108$). Despite these mixed results, Singh's Index continues to be a useful tool for assessing osteoporosis.

Strengths: The strength of the study is highlighted by its targeted focus on a well-defined elderly population experiencing hip fractures following low-energy trauma an increasingly prevalent and clinically significant condition. By simultaneously assessing serum vitamin D levels, Singh's Index, and fracture site comminution, the study offers a multidimensional understanding of the interplay between bone health and fracture complexity. Moreover, the use of established clinical and radiological markers enhances the study's validity and facilitates meaningful comparisons with findings from previous national and international research.

Limitations: This study is limited by a relatively small sample size and its single-center design, which may affect the generalizability of the results. The cross-sectional nature restricts causal interpretation between vitamin D levels, osteoporosis, and fracture severity. Additionally, important confounding factors such as nutrition, physical activity, and sun exposure were not extensively assessed.

CONCLUSION

Early diagnosis of osteoporosis through Singh's Index and Vitamin D screening is essential for identifying individuals susceptible to fractures. This provides the necessary impetus for timely intervention, facilitating appropriate supplementation and treatment strategies. Proactive management of osteoporosis can significantly reduce the risk of impending fractures and improve overall patient outcomes, ultimately enhancing quality of life.

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