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Assessing bone mineral density (BMD) and clinical correlations in elderly patients with hip fractures: A cross-sectional study

Dr. Nirbhay Virani, Dr. Shilpa Chudasama*, Dr. Kartiksinh Gohil
Department of Radiodiagnosis, Shri M. P. Shah Medical College, Jamnagar, Gujarat, India

Abstract

Background

Intertrochanteric fractures are common fragility fractures in the elderly and are strongly associated with osteoporosis. Dual-energy X-ray absorptiometry (DEXA) is the gold standard for bone mineral density (BMD) assessment; however, variation in BMD across skeletal sites may affect osteoporosis detection.

Objective

This study evaluated BMD at different skeletal sites in patients with intertrochanteric fractures and analysed the regional variation in bone mineral density which can enhance diagnostic precision, improve fracture risk assessment, and guide more effective measures for prevention and management in osteoporotic patients.

Methods

This observational study included patients with ≥ 50 years of age with radiologically confirmed intertrochanteric fractures meeting the inclusion criteria. Clinical and demographic data were recorded. BMD was measured using DEXA at the lumbar spine, femoral neck, and forearm at baseline and after the 6 months. T-scores were classified according to World Health Organization criteria. Statistical analysis was performed using Jamovi software.

Results

This study included 376 patients with intertrochanteric fractures meeting the inclusion criteria. Of these, 227 patients completed follow-up and were included in the final analysis. Study population predominantly comprised elderly patients with female preponderance. Osteoporosis was highly prevalent among patients with intertrochanteric fractures. Significant inter-site variation in BMD and T-scores was observed, with lower values commonly noted at the femoral neck. Multi-site DEXA assessment improved osteoporosis detection compared to single-site evaluation.

Conclusion

Osteoporosis is highly prevalent in patients with intertrochanteric fractures. Multi-site DEXA assessment improves diagnostic accuracy and may facilitate early intervention to reduce future fragility fractures.

Keywords: Bone mineral density, DEXA scan, intertrochanteric fracture, fragility fractures, osteoporosis, skeletal site comparison

Introduction

Osteoporosis is a systemic skeletal disorder characterized by decreased bone mass and deterioration of bone microarchitecture, leading to increased bone fragility and susceptibility to fractures [1]. It remains a major global health issue, especially in the aging population, contributing significantly to morbidity, mortality, and healthcare costs. The most common sites affected by osteoporotic fractures are the vertebral bodies, distal forearm, and proximal femur, particularly the intertrochanteric region of the hip. Among these, hip fractures are associated with the greatest burden of disability and mortality in the elderly population [2].

Dual-energy X-ray absorptiometry (DEXA) is the gold-standard imaging technique for assessing bone mineral density (BMD) and diagnosing osteoporosis and osteopenia. The DEXA scan quantifies BMD at specific skeletal sites commonly the lumbar spine, hip, and forearm and provides T-scores that categorize bone health status. However, the severity of bone loss may vary across skeletal regions due to differences in trabecular and cortical bone composition, mechanical loading, and local metabolic factors. Thus, evaluating multiple skeletal sites can provide a more comprehensive understanding of bone health and fracture risk [3, 4].

The intertrochanteric region of the femur is predominantly composed of trabecular bone, which is metabolically active and sensitive to systemic changes in bone turnover [5]. In contrast, the forearm and lumbar spine exhibit varying proportions of trabecular and cortical bone, which may influence their DEXA-measured BMD values. Therefore, studying the comparative severity of osteoporosis or osteopenia across these regions can provide insight into site-specific bone loss patterns and their correlation with fracture risk, particularly in patients presenting with intertrochanteric fractures [6, 7].

Previous studies have reported inconsistent findings regarding the relationship between lumbar spine, forearm, and hip BMD in predicting fracture susceptibility [8]. Some evidence suggests that lumbar spine BMD may not accurately reflect hip fracture risk due to degenerative changes, aortic calcifications, or artifacts in elderly patients, whereas forearm BMD may better correlate with overall cortical bone status [9]. Comparative analysis of BMD at these sites could help identify the most reliable predictor of bone fragility in patients with hip fractures [10].

This study aims to compare the severity of osteoporosis or osteopenia in the lumbar spine and forearm with that in the hip joint among patients suffering from intertrochanteric

fractures, using DEXA scan parameters. Understanding the regional variation in bone mineral density can enhance diagnostic precision, improve fracture risk assessment, and guide more effective site-specific prevention and management strategies in osteoporotic patients.

Materials and methods

This was cross-sectional, observational study in order to evaluate bone mineral density characteristics among patients presenting with intertrochanteric fractures. The study was conducted over an 18-month period within the Departments of Orthopaedics and Radiodiagnosis at tertiary care teaching hospital in Gujarat. Individuals aged 50 years and above with radiologically confirmed intertrochanteric fractures sustained without significant traumatic events were considered eligible. Patients having secondary causes of osteoporosis, such as hyperparathyroidism, chronic glucocorticoid therapy, renal osteodystrophy, or any metabolic bone disease were excluded. Patients unwilling to provide informed consent or with incomplete data were also omitted. A total of 376 patients who met the eligibility criteria were enrolled, and cohort of 227 completed the follow-up and considered for the statistical analysis.

Patients presenting to the Orthopaedics Department with suspected intertrochanteric fractures were clinically evaluated through history-taking, physical examination, and routine radiographs. Those meeting the inclusion criteria were subsequently enrolled into the study. After obtaining consent, detailed demographic and clinical information was collected, including age, sex, height, weight, comorbidities, medication history, and the mechanism and laterality of the fracture. These data were recorded in a structured case-record form.

Following initial evaluation, all enrolled patients were referred to the Radiodiagnosis Department for bone mineral density evaluation. Dual-energy X-ray absorptiometry (DEXA) scans were performed at three major skeletal sites: the lumbar spine, the non-dominant forearm, and the hip region. Scanning procedures followed standardized protocols recommended by the manufacturer to ensure reproducibility and accuracy. For each patient, T-scores were generated automatically by the DEXA system and were used to categorize bone mineral status as normal, osteopenic, or osteoporotic according to World Health Organization criteria. Throughout the process, the same equipment and technical personnel were used to minimize inter-observer variations. The primary independent variables of interest were the BMD values at each skeletal site, while the dependent outcome variable was the severity of osteoporosis or osteopenia. The participants were followed up for the repetition of same evaluation after 6 months of duration.

The principal tool used for measurement in the study was a dual-energy X-ray absorptiometry (DEXA) scanner, which is considered the gold standard for quantifying bone mineral density. The device utilized two X-ray beams of differing energies to measure bone absorption, allowing precise differentiation between bone and soft tissue components. All scans were performed by experienced radiology technicians trained in DEXA operation to reduce technical errors. The use of consistent tools and standardized procedures ensured reliability and reproducibility of the collected data.

This study was initiated only after obtaining formal approval from the Institutional Ethics Committee. All procedures adhered strictly to the ethical standards outlined in the Declaration of Helsinki. Prior to participation, every patient was informed about the purpose, procedures, benefits, and potential risks of the study in a language they clearly understood. Written informed consent was subsequently obtained from all participants.

All collected data were initially entered into Microsoft Excel, 2021 and subsequently analysed using Jamovi statistical software (version 2.3.28). Descriptive statistics were used to summarize the data. Continuous variables such as age, height, weight, body mass index (BMI), bone mineral density (BMD), and T-scores were expressed as mean ± standard deviation (SD). Categorical variables were presented as frequencies and percentages. The normality of continuous data was assessed using appropriate tests (e.g., Shapiro–Wilk test). As the majority of the BMD and T-score data were not normally distributed, non-parametric statistical methods were applied for inferential analysis. Inter-site comparison of T-scores across the lumbar spine, femoral neck, and forearm at baseline and follow-up was performed using the Friedman test. For pairwise comparisons between skeletal sites, Durbin–Conover post-hoc analysis was applied. Comparison of paired data (baseline versus 6-month follow-up) for T-scores and BMD values at each skeletal site was carried out using the Wilcoxon signed-rank test. To evaluate differences in the magnitude of change (ΔT-score) among the three skeletal sites, non-parametric repeated measures analysis was performed. A p-value < 0.05 was considered statistically significant for all analyses.

Results

A total of 376 patients with intertrochanteric fractures fulfilling the inclusion criteria were initially enrolled in the study. During follow-up, 149 patients were lost to follow-up, and the final analysis was performed on 227 patients who completed the 6-month follow-up period. Baseline Demographic and Clinical Characteristics are presented in table 1.

Table 1: Baseline demographic, anthropometric, lifestyle, and clinical characteristics of study participants (N = 227)

Variable	Category	n (%)
Gender	Male	103 (45.4)
	Female	124 (54.6)
Age group (years)	50–59	31 (13.7)
	60–69	56 (24.7)
	70–79	95 (41.9)
	80–89	36 (15.9)
	≥90	9 (4.0)

Residence	Rural	107 (47.1)
	Urban	120 (52.9)
Occupation	Farmer	94 (41.4)
	Homemaker	59 (26.0)
	Labourer	38 (16.7)
	Business	36 (15.9)
Sun exposure (>5 h/day)	Yes	130 (57.3)
	No	97 (42.7)
Sedentary lifestyle	Yes	118 (52.0)
	No	109 (48.0)
Smoking history	Yes	38 (16.7)
	No	189 (83.3)
Alcohol intake	Yes	27 (11.9)
	No	200 (88.1)
Concomitant medical illness	Yes	66 (29.1)
	No	161 (70.9)
Accidental trauma	Yes	10 (4.4)
	No	217 (95.6)
Anthropometric parameters (Mean ± SD)	Male height (cm)	159 ± 8.80
	Female height (cm)	149 ± 5.92
	Male weight (kg)	61.4 ± 8.91
	Female weight (kg)	56.2 ± 6.99
	Male BMI (kg/m²)	24.4 ± 3.38
	Female BMI (kg/m²)	25.2 ± 2.77

The study population showed a slight female predominance, with cohort is mainly constituted of the geriatric population. Most participants belonged to the seventh and eighth decades of life. Urban and rural populations were nearly equally represented.

Anthropometric assessment demonstrated higher mean height and body weight among males, whereas BMI values were comparable between genders. Farming was the predominant occupation among study participants. More than half of the patients reported adequate sunlight exposure; however, sedentary lifestyle was observed in a substantial proportion of the cohort.

Among evaluated clinical risk factors, smoking and alcohol intake were relatively less common, whereas nearly one-third of participants had associated medical comorbidities. Only a small proportion of patients reported antecedent accidental trauma prior to fracture. Baseline DEXA Characteristics and WHO Classification is represented in table 2.

Table 2: Baseline DEXA T-score characteristics and WHO classification across skeletal sites (N = 227)

Site	Mean ± SD	Normal N (%)	Osteopenia N (%)	Osteoporosis N (%)
Spine	−1.19 ± 1.43	112 (49.3)	51 (22.5)	64 (28.2)
Femoral neck	−5.31 ± 8.32	0 (0)	0 (0)	227 (100)
Forearm	−3.35 ± 2.17	130 (57.3)	21 (9.3)	76 (33.5)

Baseline DEXA assessment demonstrated substantial variation in bone mineral density across skeletal sites. The femoral neck exhibited markedly lower T-scores compared to the spine and forearm, indicating severe reduction in bone mineral density at this site.

According to WHO classification, osteoporosis was universally observed at The femoral neck, whereas the spine and forearm demonstrated mixed distributions of normal bone mineral density, osteopenia, and osteoporosis.

The forearm showed a comparatively greater proportion of normal bone mineral density than the spine. Longitudinal Changes in T-Scores and BMD Values is portrayed in table 3.

Table 3: Comparison of T-scores and BMD values between baseline and 6-month follow-up using Wilcoxon signed-rank test (N = 227)

Parameter	Baseline Mean ± SD	Follow-up Mean ± SD	Mean Difference	p value
T-score				
Spine	−1.19 ± 1.43	−0.92 ± 1.34	0.3	0.004
Femoral neck	−5.31 ± 8.32	−4.90 ± 8.50	0.6	<0.001
Forearm	−3.35 ± 2.17	−4.90 ± 8.50	0.8	<0.001
BMD (g/cm³)				
Spine	1.004 ± 0.1760	1.014 ± 0.1787	0.025	0.03
Femoral neck	0.623 ± 0.0737	0.641 ± 0.0791	0.024	<0.001
Forearm	0.599 ± 0.2751	0.652 ± 0.0918	0.061	<0.001

Comparison of baseline and 6-month follow-up measurements demonstrated statistically significant improvement in T-scores across all evaluated skeletal sites. Similar significant improvement was also observed in BMD values at the spine, femoral neck, and forearm. Among the evaluated regions, the greatest absolute improvement in BMD was observed at the forearm. Overall, follow-up analysis suggested measurable improvement in bone mineral density parameters over the study period. Inter-Site Comparison of T-Scores is shown in the table 4.

Table 4: Inter-site comparison of baseline, follow-up, and change in T-scores using Friedman test with Durbin–Conover post-hoc analysis (N = 227)

Comparison	Baseline T-score p value	Follow-up T-score p value	ΔT-score p value
Spine vs Femoral neck	<0.001	<0.001	0.972
Spine vs Forearm	<0.001	<0.001	0.727
Femoral neck vs Forearm	0.633	1	0.701

Inter-site comparison using Friedman test with Durbin–Conover post-hoc analysis demonstrated significant differences between spinal T-scores and those of both the femoral neck and forearm at baseline as well as follow-up evaluation. However, no statistically significant difference was observed between femoral neck and forearm T-scores either at baseline or at 6 months. Furthermore, comparison of ΔT-scores among skeletal sites did not reveal any significant inter-site variation in the magnitude of change over time.

Overall, the study demonstrated a high burden of reduced bone mineral density among patients with intertrochanteric fractures, particularly at the femoral neck. Significant longitudinal improvement in both T-score and BMD measurements was observed across all skeletal sites during follow-up.

Discussion

The present study evaluated 227 patients with intertrochanteric fractures who completed follow-up. The analysis focused on demographic characteristics, lifestyle and clinical risk factors, and radiological assessment of bone mineral density (BMD) using DEXA at multiple skeletal sites (spine, femoral neck, and forearm), along with follow-up changes over six months. These findings provide important insights into the burden of osteoporosis in patients with intertrochanteric fractures and underscore the relevance of DEXA in risk stratification and follow-up.

In the present study, the majority of patients belonged to the elderly age group. Previous studies have consistently demonstrated a sharp increase in hip fracture incidence with advancing age due to age-related bone loss, sarcopenia, and increased risk of falls. Lim et al. (2024) reported that the risk of hip fracture gets increases in older adults, reflecting progressive deterioration in bone strength and structural integrity [11]. Similarly, Schnell (2010) highlighted that approximately 90% of hip fractures occur in individuals above 65 years, emphasizing the strong correlation between aging and osteoporotic fractures [12].

The study demonstrated a female predominance (54.6%) compared to males (45.4%). This observation is in concordance with the well-documented higher prevalence of osteoporosis among postmenopausal women. Bergh (2020) reported that women account for approximately ~65% of osteoporotic fractures. Likewise, a recent meta-analysis by Salari et al. (2021) confirmed a significantly higher prevalence of osteoporosis among women globally [13, 14].

However, the relatively high proportion of male patients in this study suggests that osteoporosis in men, though under-recognized, is clinically significant. Anastasopoulou et al., 2021 have emphasized the growing burden of male osteoporosis, often associated with secondary causes such as smoking, alcohol use, and comorbidities [15].

The study demonstrated, Lower mean height and weight in females compared to males. Slightly higher mean BMI in females (25.2) than males (24.4). Gonnelli et al. (2014) reported that obesity may be associated with altered bone quality despite normal or increased BMD [16]. The findings of the present study support the concept that BMI alone is not a reliable predictor of fracture risk and highlight the importance of DEXA-based assessment.

Farming was the most common occupation with rural and semi-urban population predominance along with more than half of the patients having adequate sunlight exposure. Despite this, a high prevalence of osteoporosis was observed, indicating that, sunlight exposure alone may not ensure adequate vitamin D levels and nutritional deficiency, and aging impair vitamin D metabolism. Nowak (2021) emphasized that elderly individuals often have reduced cutaneous synthesis of vitamin D despite adequate sun exposure [17].

Baseline T-score analysis of study participants revealed that spinal mean T-score was −1.19 (osteogenic range), femoral neck's mean T-score was −5.31 (osteoporosis) and that of the forearm was −3.35 (osteoporosis). The most noteworthy finding is the universal presence of osteoporosis at the femoral neck (100%), which is clinically significant. This explains its vulnerability in osteoporotic fractures. This finding is consistent with studies by John et al. (2025), which demonstrated that hip fractures are strongly associated with low femoral neck BMD [18].

WHO Classification of site viz spine, forearm and femoral neck were 28.2%, 33.5% and 100% osteoporosis, respectively. This highlights site-specific variation in bone density and importance of multi-site DEXA evaluation. According to the ISCD (International Society for Clinical Densitometry, 2023) guidelines, femoral neck BMD is the most reliable predictor of hip fracture risk [19].

T-score showed significant improvement which was observed at all sites amongst spine ($p = 0.004$), femoral neck ($p < 0.001$), and forearm ($p < 0.001$). There was statistically significant improvement in BMD was noted at all sites amongst spine ($p = 0.03$), femoral neck ($p < 0.001$), and forearm ($p < 0.001$). The improvement in BMD suggests effective management (pharmacological or lifestyle intervention), bone remodelling and recovery over time. Tang et al. (2025) demonstrated that anti-osteoporotic therapies such as bisphosphonates and denosumab significantly improve BMD within 6–12 months [20].

Inter-site comparison of T-scores showed significant differences between spine vs femur neck, spine vs forearm, but not between femur neck vs forearm. This reflects different bone compositions (trabecular vs cortical) and site-specific rates of bone turnover. The lack of difference between femur and forearm suggests similar severity of cortical bone involvement. The results replicate the similar trend as shown in the study done by Azami et al., 2019 [21].

ΔT-score Analysis showed no significant difference in change in T-scores across sites. Which implies that the treatment effect is uniform across skeletal sites and suggests systemic improvement rather than localized change. The trend aligns with the study results observed by Vokes et al., 2005 [22]. This study reinforces the central role of DEXA in early diagnosis of osteoporosis, risk stratification, and monitoring treatment response. According to Kanis et al. (2015), DEXA remains the gold standard for osteoporosis diagnosis [23]. The findings emphasize mandatory DEXA screening in elderly fracture patients and importance of femoral neck evaluation.

Dual-energy X-ray absorptiometry (DEXA) remains the gold standard for the diagnosis of osteoporosis and assessment of fracture risk. The findings of the present study, demonstrating a high prevalence of osteoporosis, particularly at the femoral neck, strongly supports the need for routine multisite DEXA screening in elderly individuals, especially those above 60 to 65 years and those presenting with fragility fractures.

Limitation

The present study has few limitations that should be considered while interpreting the findings. The relatively small sample size and single centre recruitment limits the generalisability of the study results.

Conclusion

The study effectively achieves its stated aims and objectives by demonstrating that significant regional variations and discrepancies exist in BMD among the lumbar spine, forearm, and hip in patients with intertrochanteric fractures. These findings reinforce the importance of comprehensive, multi-site DEXA assessment in improving the evaluation and management of osteoporosis.

Declarations

Funding: No funding was received for this study.

Conflict of Interest (COI): The authors declare that there is no conflict of interest.

Ethical Approval: The study was conducted in accordance with institutional ethical standards. Consent was obtained from all individual participants included in the study.

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Data Availability Statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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