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Evaluation of Bone Mineral Density among elderly Type II Diabetes Mellitus Patients in Babil 2025

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Abstract

Background: Type 2 diabetes mellitus (DM) is associated with various complications, including potential effects on bone health. Although elderly patients with Type 2 diabetes mellitus may exhibit normal bone mineral density, they are paradoxically at a higher risk of fractures. The underlying mechanisms remain multifactorial and involve glycemic control, hormonal regulation, and nutrient deficiencies.

Objective: To evaluate bone mineral density (BMD) in elderly patients with type 2 diabetes mellitus and investigate its relationship with glycemic control, vitamin D levels, and calcium status.

Patients and Methods: A prospective, cross-sectional study was conducted on 46 patients aged > 65 years at Merjan Teaching Hospital Babil, Iraq, between May 2024 and May 2025. Data collected included demographics, HbA1c levels, serum vitamin D and calcium levels, and bone mineral density measured via DEXA scans at the spine and hips.

Results: Osteoporosis was present in 54.3% of the patients, and 34.8% of the patients were classified as osteopenic. The majority of the patients were females. A positive correlation was found between HbA1c and DEXA T-scores ($r = 0.313$, $p = 0.034$), and patients with poor glycemic control (mean HbA1c = 9.2%) had a higher prevalence of osteoporosis. No significant correlations were found between bone mineral density (Dexa T-scores) and serum vitamin D ($r = -0.057$, $p = 0.705$) or calcium levels ($r = -0.080$, $p = 0.597$). The right hip had the highest site-specific prevalence of osteoporosis (41.3%).

Conclusions: Osteoporosis is highly prevalent among elderly patients, particularly women. Poor glycemic control (high HbA1c level) and increased age were significantly associated with lower bone density.

Recommendation: DEXA scans of multiple sites, particularly the spine and hips, are essential for detecting osteoporosis in this population.

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Ethical Compliance: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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Keywords: Type 2 diabetes mellitus, Bone mineral density, Osteoporosis, DEXA scan.

1. Introduction

Bone is a dynamic tissue that undergoes continuous remodeling involving the coordinated activity of osteoblasts and osteoclasts. In elderly patients with T2DM, this balance is disrupted, leading to alterations in the BMD and an increased risk of fractures. [1]

Type 2 diabetes mellitus (T2DM) is a prevalent metabolic disorder that is characterized by insulin resistance and impaired insulin secretion. In addition to its well-established complicationssuch as cardiovascular disease, nephropathy, neuropathy, and retinopathy, T2DM significantly affects bone health. [2]

Bone mineral density (BMD) and bone health are critical yet often overlooked aspects of managing type 2 diabetes mellitus. Although the relationship between T2DM and bone health is complex, it is clear that individuals with T2DM are at an increased risk of fractures due to a combination of factors, such as altered bone quality, the effects of hyperglycemia, insulin resistance, medication use, and microvascular complications. [3]

Currently, skeletal fragility is considered to be a complication of T2DM. These patients had an up to 3-fold increased in hip fracture risk. [4]

Dual-energy X-ray absorptiometry (DXA) is the primary tool used to evaluate BMD. DXA is a non-invasive imaging technique that measures the density of bones and provides a T-score that compares an individual's BMD to the average BMD of a healthy young adult of the same sex. A lower T-score indicates a lower BMD and an increased risk of fractures. [5]

Regular screening for BMD and fracture risk is essential for individuals with T2DM, particularly for those with additional risk factors. Management strategies that include tight glycemic control, appropriate supplementation of calcium and vitamin D, regular physical activity, weight management, and pharmacological interventions when needed can help mitigate the adverse effects of T2DM on bone health. [6]

Continued research into the mechanisms underlying diabetic bone disease will further aid in developing effective treatments and preventive measures to improve bone health in individuals with T2DM. The integration of advanced imaging technologies and better management of the underlying metabolic disturbances can enhance our ability to predict and address bone health issues in this growing patient population. [7]

In individuals with T2DM, the risk of falls may increase due to diabetic neuropathy, retinopathy, and other complications, further increasing the risk of fractures. Thus, preventing falls through environmental modifications and strengthening exercises is an integral part of fracture-prevention strategies. [8]

Additionally, fall prevention through education and fall risk assessments should be part of a comprehensive approach to minimize fracture risk in this population. [9]

Comprehensive fall prevention programs that include balance training, gait assessments, and the use of assistive devices (such as canes or walkers) can significantly reduce fall-related injuries in diabetic patients. Moreover, ensuring that home environments are free of tripping hazards and providing education on proper footwear can help mitigate the risk of falls. [10]

2.Patients and Method

2.1 Study Design: prospective, cross-sectional study

2.2 Study Setting and Duration

The research was conducted at Merjan Teaching Hospital Babil, Iraq, from May 2024 to May 2025**.** Eligible patients visiting the geriatric outpatient clinic were invited to participate.

2.3 Study Population and Sample Size

A total of 46 elderly patients with T2DM were enrolled in this study through convenience sampling. The initial

target sample size was estimated based on the availability of T2DM patients and the feasibility of conducting DXA scans within the specified timeframe.

2.3.1 Inclusion Criteria

1. Elderly patients (≥65 years) with a confirmed diagnosis of T2DM (based on the American Diabetes Association [ADA] criteria).
2. Ability to undergo DXA scanning.
3. Willingness to complete the study questionnaire and laboratory tests.

2.3.2 Exclusion Criteria

1. Other types of diabetes (Type 1 diabetes)
2. Known metabolic bone diseases (e.g., primary hyperparathyroidism, Paget's disease of bone) or long-term therapy affecting bone metabolism (e.g., chronic corticosteroids).
3. Significant comorbidities could interfere with the results (e.g., advanced chronic and malignancy).
4. Patients unable/unwilling to complete the study procedures.

2.4 Data Collection

2.4.1 Baseline Assessment and Questionnaire

The researcher prepared a structured, paper-based questionnaire to collect data. Key information included the following:

- **Demographics:** Age, and gender
- **Anthropometrics:** Height and weight (for Body Mass Index [BMI] calculation).

2.4.2 Laboratory Measurements

Blood samples were drawn and processed in the hospital laboratory according to standardized protocols. The following parameters were measured.

- Glycated Hemoglobin (HbA1c)
- Serum Calcium
- Serum Vitamin D.

2.4.3 DXA Measurements

BMD was assessed using dual-energy X-ray absorptiometry (DXA) under the guidance of a qualified radiology technician. Standard positioning protocols were used to measure the

- Left Hip
- Right Hip
- Lumbar Spine (vertebrae L1–L4)

The results were recorded as T-scores, which compared the patient's BMD to that of the healthy reference population. T-scores were interpreted according to the World Health Organization (WHO) criteria: [11]

- **Normal:** T-score ≤ -1.0
- **Osteopenia:** T-score -1.1-2.5
- **Osteoporosis:** T-score ≥ -2.5

All scans were reviewed by a radiologist experienced in DXA interpretation, and regular calibration checks were performed to maintain equipment accuracy.

2.5. Data Management and Analysis

Data analysis was performed using IBM® Statistical Package for Social Sciences (SPSS) version 27 for Microsoft® Windows 11, and the results are presented as simple measures of frequency, percentage, mean, range, and standard deviation and illustrated as tablets. Statistical significance was set at p- value less than 0.05.

3.Results

The study included 46 elderly patients who underwent DEXA scan assessment of bone density, with the most representative age group of the sample being between 71-75 years, including 19 patients (41.3%). The overall mean age was 73.4 years, range: 65–87 years).

Most of the sample was female, accounting for 45 patients (97.8%), while only one male was present 1 (2.2%). As shown in table 3.1.

Table 3.1.: Demographic characteristics of the study sample patients (n=46)

Variable	Frequency	Percent
Age (years)		
65-70	9	19.6
71-75	19	41.3
>75	18	39.1
Mean ± SD	73.4 ± 8.1	
Range	65-87	
Gender		
Male	1	2.2
Female	45	97.8

HbA1c levels were measured across the patients, with 44 (95.7%) showing levels greater than 6.5%, indicating poor glycemic control; the mean HbA1c level was 8.6%.

For Vitamin D, 25 patients (54.3%) had levels below 20 ng/mL, 9 patients (19.6%) had levels between 20 and 30 ng/mL, and 12 patients (26.1%) had normal levels exceeding 30 ng/mL. The mean Vitamin D level was 24.2 with a standard deviation of 13.7; the values ranged from 8.1 59 ng/mL.

Ionized calcium levels showed that five patients (10.9%) had low levels < 2.1 mmol/L. The majority (41 patients, 89.1%) had normal levels within the range of 2.1 to 2.9 mmol/L. The mean ionized calcium was 2.27 with a standard deviation of 0.2, and ranged from 1.87 and 2.86 mmol/L. as shown in table 3.2.

Table 3.2.: Laboratory measurements among the study sample patients (n=46)

Variable	Frequency	Percent
HbA1c (%)		
≤6.5	2	4.3
> 6.5	44	95.7
Mean ± SD	8.6 ± 1.9	
Range	6.2-14.4	
Vitamin D (ng/mL)		
Low (<20)	25	54.3
Sufficient (20-30)	9	19.6
Normal (>30)	12	26.1
Mean ± SD	24.2 ± 13.7	
Range	8.1-59	
Ionized Calcium (mmol/L)		
Low (<2.1)	5	10.9

Normal 2.1-2.9	41	89.1
Mean ± SD	2.27 ± 0.2	
Range	1.87 - 2.86	

Patients were sent for DEXA scans across different sites. In the left hip, 13 patients (28.3%) had normal bone density (T score ≤ -1.0), 21 patients (45.7%) were diagnosed with osteopenia (T-score 1.1-2.5), and 12 patients (26.1%) had osteoporosis (T-score ≥ -2.5).

In the right hip, 12 patients (26.1%) had normal bone density, 15 (32.6%) had osteopenia, and 19 (41.3%) had osteoporosis.

Spine measurements revealed that 12 patients (26.1%) had normal bone density, 19 (41.3%) had osteopenia, and 15 (32.6%) were diagnosed with osteoporosis.

Overall, the total count across all sites showed that only five patients (10.9%) had normal bone density, 16 patients (34.8%) had osteopenia, and 25 patients (54.3%) had osteoporosis. As shown in table 3.3.

Table 3.3.: DEXA scan results of the patients

Site	measurement	N	%
Left Hip	Normal	13	28.3
	Osteopenia	21	45.7
	Osteoporosis	12	26.1
Right Hip	Normal	12	26.1
	Osteopenia	15	32.6
	Osteoporosis	19	41.3
Spine	Normal	12	26.1
	Osteopenia	19	41.3
	Osteoporosis	15	32.6
Total	Normal	5	10.9
	Osteopenia	16	34.8
	Osteoporosis	25	54.3

Correlation analysis between DEXA scan results and other study variables showed that age was positively and significantly correlated with T-scores, with a coefficient of 0.411 and a significant p-value of 0.005.

HbA1c also showed a positive and significant correlation, with a coefficient of 0.313 and p-value of 0.034.

Vitamin D and Calcium levels were inversely correlated with the DEXA results, with coefficients of -0.057 and -0.080, respectively, and p-values of 0.705 and 0.597, respectively; these correlations were not statistically significant. As shown in table 3.4.

Table 3.4.: Correlation analysis between DEXA scan results and other study variables

Predictor	R	P-value	Comment
Age	0.411	0.005	Positive Significant
HbA1c	0.313	0.034	Positive Significant
Vitamin D	-.057-	0.705	Inverse Not Significant
Calcium	-.080-	0.597	Inverse Not Significant

Patients with normal bone density had a mean HbA1c level of 7.8, ranging from 7.3 8.4. Those with osteopenia had a slightly higher mean HbA1c level of 7.9, ranging from 6.2 12.3. Patients diagnosed with osteoporosis had the highest mean HbA1c level of 9.2, ranging from 6.6 14.4. as shown in figure 3.1.

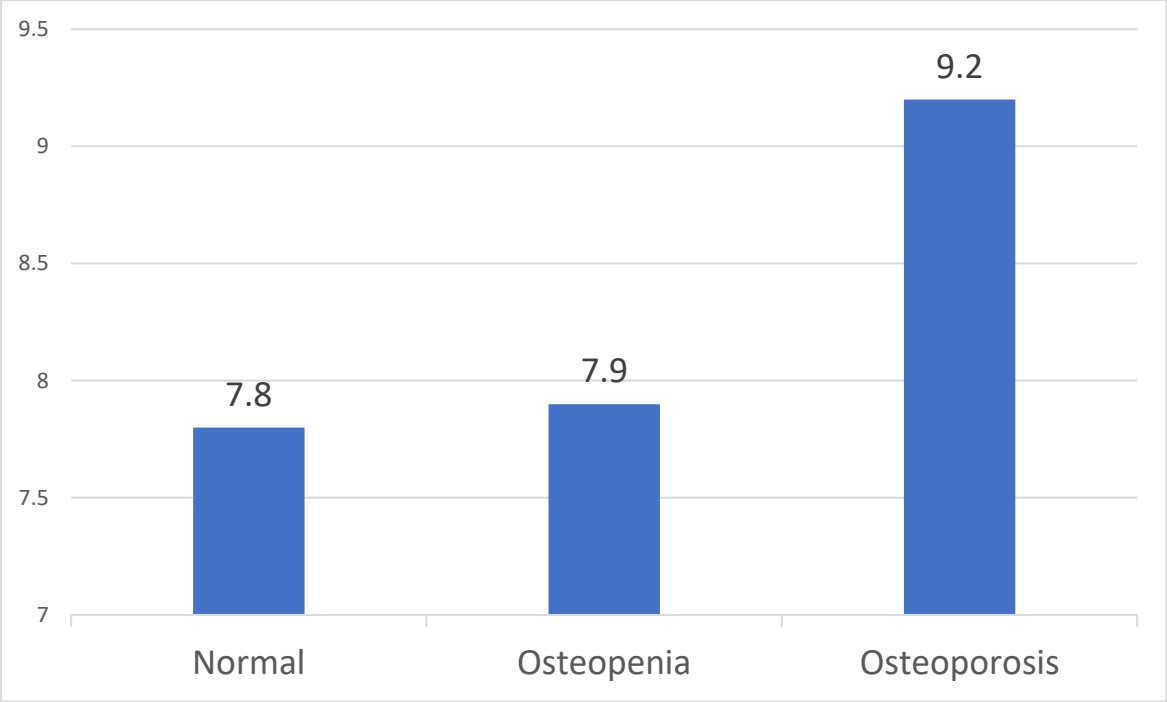

Figure 3.1.: Mean HbA1c results according to DEXA scan T-scores

4.

Discussion

The current study findings revealed a high prevalence of low bone density, with 54.3% of participants diagnosed with osteoporosis and an additional 34.8% with osteopenia. A study by **Sealand et al.** concluded that one possible connection between diabetes and the bone involves osteocalcin, a hormone produced by osteoblasts. However, it is still unclear whether osteocalcin simply indicates or influences the relationship between bone and glucose metabolism. [12]

Yuhao et al. study in China also found that the combined prevalence of osteoporosis among patients with type 2 diabetes mellitus (T2DM) was 37.8%. Interestingly, this condition is more commonly observed in female patients. [13]

The demographic profile of the participants was consistent with established risk factors for osteoporosis.

The majority of the patients were female (97.8%) and elderly, with a mean age of 77.4 years. This aligns with global and regional epidemiological patterns, where postmenopausal women constitute the most vulnerable group to osteoporosis due to estrogen deficiency, which accelerates bone resorption. Several studies, including those by **Strotmeyer et al.** and **Parizad et al.**, have reported similar trends, confirming that aging and female sex are critical determinants of low BMD in diabetic populations. [14,15]

One of the notable findings of the current study is the positive correlation between HbA1c and BMD ($r = 0.313$, $p = 0.034$). The presence of poor glycemic control, evidenced by a mean HbA1c of 8.6% and particularly elevated levels in patients with osteoporosis (mean 9.2%) further supports this link. This is in line with a study by **Linde et al.** on 1480 diabetic patients who had undergone a DXA scan and found that after adjusting for age, BMI, and sex, higher HbA1c levels were also linked to reduced BMD in the spine and hip. This suggests that blood glucose levels, as indicated by HbA1c levels, may serve as a useful predictor of lower BMD in individuals with diabetes. Their study also found that higher BMI and female sex were associated with lower bone mineral density (BMD) in both the spine and hips. [16]

Another study by **Gao et al.** on 152 postmenopausal females with T2DM and 326 postmenopausal females without T2DM found that HbA1c levels above 7.5% negatively influenced bone mineral density (BMD). However, they also found no clear association between HbA1c levels and the risk of developing osteoporosis. [17]

The current study results showed that vitamin D deficiency was present in more than half of the participants (54.3%); however, no statistically significant correlation was found between vitamin D levels and BMD ($r = -0.057$, $p = 0.705$). Similarly, ionized calcium levels were not significantly correlated with bone density ($r = -0.080$, $p = 0.597$). Although vitamin D and calcium are essential for bone metabolism, their isolated impact on BMD may be overshadowed in diabetic individuals by dominant metabolic factors, such as chronic inflammation, oxidative stress, and hormonal dysregulation. The lack of correlation in our data may also be due to the small sample size or the confounding influence of unmeasured variables, such as sun exposure, physical activity, or supplementation. **Cândido et al.** noted that while vitamin D deficiency is common in T2DM, it may not independently predict osteoporosis after adjustment for other variables. [18]

The DEXA scan results varied according to the anatomical site. The highest prevalence of osteoporosis was noted in the right hip (41.3%), followed by the spine (32.6%) and left hip (26.1%). These variations underscore the importance of site-specific assessment as certain areas may be more susceptible to bone loss based on weight-bearing function, cortical versus trabecular composition, and patient posture during imaging. A Study by **Rakic et al.** showed similar findings, emphasizing the diagnostic value of multisite bone density measurements in diabetic populations. [19]

The high prevalence of osteoporosis among elderly diabetic patients in this study supports the need for routine BMD screening, this is supported by the results from a pooled analysis by **Liu et al.** that included 21 studies involving 11,603 patients with type 2 diabetes mellitus (T2DM) and revealed a high prevalence of osteoporosis at 27.67% are therefore recommended routine screening. [20]

5. Conclusion

Osteoporosis is highly prevalent among elderly patients, particularly women. Poor glycemic control (high HbA1c level) and increased age were significantly associated with lower bone density. Vitamin D deficiency was common but was not significantly linked to bone density in this study. DEXA scans of multiple sites, particularly the spine and hips, are essential for detecting osteoporosis in this population.

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