Research Article

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

Dr. Abdulmuttaleb Abduljabbar Fayyadh

F.I.C.M.S. (Family medicine) C.A.B.S. (Geriatric medicine) Consultant geriatrician

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ABSTRACT

Background: Type 2 diabetes mellitus is associated with various complications, including potential impacts on bone health. Although elderly patients with Type 2 diabetes mellitus may exhibit normal bone mineral density they are paradoxically at a higher risk for fractures. The underlying mechanisms remain multifactorial, involving glycaemic control, hormonal regulation, and nutrient deficiencies. **Objective:** To evaluate bone mineral density in elderly patients with Type 2 diabetes mellitus and investigate its relationship with glycaemic control, vitamin D levels, and calcium status.**Patients and Methods:** A prospective, cross-sectional study was conducted on 46 patients above 65 years of age in Merjan teaching hospital babil, Iraq, from May 2024 to May 2025. Data collected included demographics, HbA1c levels, serum vitamin D and calcium, and bone mineral density measured via DEXA scans at the spine and hips. **Results:** Osteoporosis was present in 54.3% of patients, with 34.8% of patients were classified as osteopenic. The majority of patients were females. A positive correlation was found between HbA1c and DEXA scan T-scores ($r = 0.313$, $p = 0.034$), patients with poor glycaemic 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 showed the highest site-specific prevalence of osteoporosis (41.3%).**Conclusions:** Osteoporosis is highly prevalent among elderly patients, particularly women. Poor glycemic control (high HbA1c) and increasing age are significantly associated with lower bone density. **Recommendation:** DEXA scans of multiple sites, especially the spine and hips, are essential for detecting osteoporosis in this population.

Introduction

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

Type 2 diabetes mellitus (T2DM) is a prevalent metabolic disorder characterized by insulin resistance and impaired insulin secretion. Beyond its well-established

*Corresponding author. Dr. Abdulmuttaleb Abduljabbar Fayyadh
E-mail address: abdulmuttalib0771@gmail.com

complications—such as cardiovascular disease, nephropathy, neuropathy, and retinopathy—T2DM significantly impacts 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]

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

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

Regular screening for BMD and fracture risk is essential for individuals with T2DM, particularly in 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 behind 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 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 be increased due to diabetic neuropathy, retinopathy, and other complications, further raising the risk of fractures. Thus, preventing falls through environmental modifications and strengthening exercises becomes an integral part of fracture prevention strategies. [8]

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

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

Patients and Method

Study Design: prospective, cross-sectional study

Study Setting and Duration

The research was carried out at Merjan teaching hospital Babil, Iraq, from May 2024 to May 2025**.** During this time, eligible patients visiting the geriatrics outpatient clinic were invited to participate.

Study Population and Sample Size

A total of 46 elderly patients with T2DM were enrolled 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.

Inclusion Criteria

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

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 that could interfere the results (e.g., advanced chronic kidney disease, malignancy).
4. Patients unable/unwilling to complete the study procedures.

Data Collection

Baseline Assessment and Questionnaire

A structured, paper-based questionnaire was prepared by the researcher was used to collect the data. Key information included:

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

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.

DXA Measurements

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

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

Results were recorded as T-scores, which compare the patient's BMD to that of healthy reference population. T-scores were interpreted according to 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.

Data Management and Analysis

Data analysis was done using IBM® Statistical Package for Social Sciences (SPSS) version 27 for Microsoft® Windows 11, results were presented in simple measures of frequency, percentage, mean, range and standard deviation and illustrated as tablets. A level of p- value less than 0.05 was considered statistically significant.

Results

The study included 46 elderly patients that underwent DEXA scan assessment of bone density, with the most represented age group of the sample was between 71-75 years, including 19 patients (41.3%). The overall mean age was 73.4 years, with a range from 65 to 87 years.
Most of the sample were females, 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

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

For Vitamin D, 25 patients, 54.3%, were found with levels below 20 ng/mL, while, 9 patients, 19.6%, had sufficient 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, and the values ranged from 8.1 to 59 ng/mL.

Ionized calcium levels, were showing that 5 patients, 10.9%, had low levels below 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 the range was between 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 scan across different sites. In the left hip, 13 patients, 28.3%, were found to have normal bone density (T score ≤ -1.0), while 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).

For the right hip 12 patients, 26.1%, had normal bone density, 15 patients, 32.6%, had osteopenia, and osteoporosis was present in 19 patients, 41.3%.

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

Overall, the total count across all sites showed that only 5 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 showing a positive and significant correlation with T scores, having 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 a p-value of 0.034.

Vitamin D and Calcium were inverse correlations with DEXA results, with coefficients of -0.057 and -0.080 respectively, and p-values of 0.705 and 0.597, 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 of 7.8, ranging from 7.3 to 8.4. Those with osteopenia had a slightly higher mean HbA1c of 7.9, ranging from 6.2 to 12.3. Patients diagnosed with osteoporosis had the highest mean HbA1c of 9.2, ranging from 6.6 to 14.4. as shown in figure 3.1.

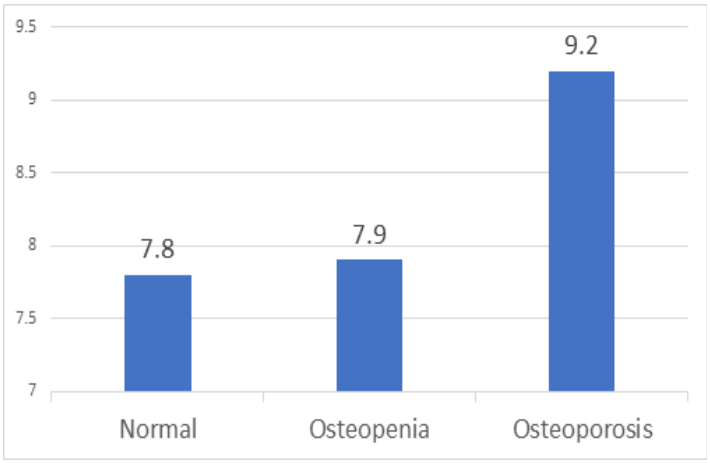

Figure 3.1.: Mean HbA1c results according to DEXA scan T-scores

Discussion

The currents study findings reveal 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 bone involves osteocalcin, a hormone produced by osteoblasts. However, it is still unclear whether osteocalcin simply indicates or actually 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, the condition was more commonly observed in female patients. [13]

The demographic profile of the participants is consistent with established risk factors for osteoporosis. The majority of 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 for 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 glycaemic 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 a total of 1480 diabetic patients that 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, 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) at both the spine and hip. [16]

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

The current study results show that vitamin D deficiency was present in more than half of the participants (54.3%), yet no statistically significant correlation was found between vitamin D levels and BMD (r = -0.057, p = 0.705). Similarly, ionized calcium levels did not show a significant relationship 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 more 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 like sun exposure, physical activity, or supplementation. **Cândido et al.** have similarly noted that while vitamin D deficiency is common in T2DM, it may not independently predict osteoporosis after adjustment for other variables. [18]

DEXA scan results varied by 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.** have shown similar findings, emphasizing the diagnostic value of multi-site bone density measurement 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]

Conclusion

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

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