ASSESSMENT OF OSTEOPOROSIS IN TYPE 2 DIABETES PATIENTS BY OSTA AND FRAX

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ABSTRACT

Objective: We investigated the accuracy of OSTA and FRAX scorning tools (without BMD measurements) in identifying osteoporosis among Type 2 diabetes patients.

Methodology: This study was performed at the Department of Diabetes and Endocrinology, Lady Reading Hospital Peshawar, and included 174 T2DM patients aged 45-65 of both genders who had "Dual-Energy X-ray Absorptiometry" (DEXA) scan.

Results: Osteoporosis was detected in 28.6% of lumbar spine measurements and 22.3% of femoral neck measurements. Researchers identified a strong negative correlation between bone mineral density (BMD) and FRAX score for both "Major Osteoporotic Fractures" (MOF) and "Hip Fractures" (HF) at skeletal sites examined ($p < 0.001$). The OSTA score demonstrated a positive correlation with BMD at the lumbar spine ($p = 0.002$) and femoral neck ($p < 0.001$). When assessing predictive performance, area under the curve (AUC) values were 0.83 (95% CI, 0.7-0.9) for FRAX-MOF, 0.87 (95% CI, 0.8-0.9) for FRAX-HF, and 0.61 (95% CI, 0.5-0.7) for OSTA.

Conclusion: Both FRAX and OSTA are effective tools for osteoporosis screening in individuals with T2DM. Their implementation, particularly in resource-constrained healthcare environments, may facilitate early detection and management of osteoporosis, ultimately reduce fracture risk and improve patient outcomes. Further research with larger cohorts is recommended to establish their broader applicability and optimize their integration into routine clinical practice.

Keywords: OSTA, FRAX, Osteoporosis, DEXA, Pakistan

INTRODUCTION

Osteoporosis represents a considerable skeletal affliction characterized by an impaired bone architecture, notably diminished bone density, and an increased susceptibility to fractures. The International Osteoporosis Foundation (IOF) indicates that approximately 33% of women and 20% of men aged 50 years or older are at risk of sustaining fractures as a consequence of osteoporosis (1). Women are at an elevated risk of developing osteoporotic conditions due to hormonal fluctuations that occur post-menopause, which accelerates the process of bone density reduction (2). These statistics underscore the importance of early awareness, prompt identification, and proactive measures to mitigate this issue, such as lifestyle modifications and appropriate treatments aimed at reducing the likelihood of bone fractures.

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Healthcare professionals can ascertain the presence of osteoporosis by evaluating bone density through a specialized radiographic examination known as a DEXA scan, which focuses on the hip and lumbar region (3). While DEXA scans are crucial for accurate diagnosis, their high cost and requirement for specialized equipment limit their widespread availability (2). A comprehensive systematic review and meta-analysis found that approximately 23.1 % of women worldwide have osteoporosis (4). In Pakistan, the lack of a national database constitutes a considerable obstacle to comprehending the true prevalence of osteoporosis. Existing research suggests that osteoporosis impacts between 5% and 17% of premenopausal women and 20% to 49.3% of postmenopausal women (5).

Type 2 diabetes mellitus (T2DM) serves as a significant risk factor for osteoporosis, elevating the chances of fractures due to increased bone fragility. The relationship between type 2 diabetes and osteoporosis is complex and warrants further exploration (6). Research conducted in mainland China revealed that 37.85% of diabetic individuals also suffer from osteoporosis, with a greater prevalence among women and the elderly (7). Although T2DM patients often show normal or slightly raised Bone Mineral Density (BMD), they face a heightened risk of bone fractures, indicating that bone quality may be more critical than quantity. Contributing factors to this issue include reduced bone turnover, changes in bone microstructure, the buildup of advanced

glycation end-products (AGEs), increased fatty tissue in the marrow, and the release of inflammatory substances. Patients with T2DM are particularly vulnerable to fractures in areas such as the hip, wrists, and feet, with risk escalating alongside the duration of the disease, insulin usage, and poor glycemic management. This relationship between T2DM and osteoporosis highlights the necessity for focused prevention strategies, especially for women and older adults (7). Furthermore, the "Fracture Risk Assessment" (FRAX) and the "Osteoporosis Self-assessment Tool for Asians" (OSTA) are increasingly acknowledged as crucial tools for evaluating the risk of osteoporosis, particularly in environments where advanced diagnostic options are either scarce or expensive. These instruments provide a practical and cost-efficient method for identifying individuals at greater risk of developing osteoporosis. FRAX is a highly effective algorithm that accurately estimates the probability of severe fractures over a decade, making it essential for determining suitable treatment. In contrast, OSTA assesses osteoporosis risk in postmenopausal women across Asia by using age and weight and requires local validation before being put into clinical practice (8). This study analyzed the effectiveness of the OSTA and FRAX tools in identifying osteoporosis in patients with type 2 diabetes, using DEXA scans as the benchmark.

MATERIALS AND METHODS

This cross-sectional study was conducted at the Department of Diabetes and Endocrinology, Lady Reading Hospital, Peshawar, from July 2022 to January 2023. A total of 174 patients diagnosed with type 2 diabetes mellitus (T2DM), aged between 45 and 65 years, were recruited, using non-probability consecutive sampling technique. Sample size was calculated using calculator.net software (9). Written informed consent was obtained from all participants, and the study was approved by the Ethics Committee of Khyber Medical University, Peshawar. Exclusion criteria included patients with type 1 diabetes mellitus, Cushing's syndrome, rheumatoid arthritis, chronic steroid use, hyperparathyroidism, hypoparathyroidism, Paget's disease, renal osteodystrophy, osteomalacia, osteogenesis imperfecta, prior organ transplantation, current anti-osteoporotic treatment, malignant tumors, and significant hepatic or renal impairment.

Data collected included demographic and clinical variables such as age, body weight, BMI, smoking and alcohol consumption, history of previous fractures, and parental hip fractures. Bone mineral density (BMD) measurements were obtained at the femoral neck and lumbar spine (L1–L4) using dual-energy X-ray absorptiometry (DXA) with a Discovery Hologic DXA® system (USA), performed by a certified operator.

Osteoporosis was diagnosed based on World Health Organization (WHO) criteria, defined by a T-score of ≤ –2.5 SD at the lumbar spine, femoral neck, or any skeletal site. The Osteoporosis Self-Assessment Tool for Asians (OSTA) index was calculated using the original 2001 formula based on age and weight. Additionally, the FRAX® tool was employed to estimate the 10-year probability of major osteoporotic fracture (MOF) and hip fracture (HF), using clinical risk factors with or without BMD inputs. The OSTA score was calculated using the established 2001 formula incorporating patient weight and age (OSTA Score = 0.2 x [body weight kg – Age Years] (10). A lower (more negative) score indicates high risk of osteoporosis.

Data were analyzed using IBM SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Pearson's or Spearman's correlation coefficients were applied depending on the normality of data distribution. The diagnostic performance of the FRAX and OSTA tools in predicting osteoporosis was assessed using receiver operating characteristic (ROC) curve analysis, with predictive accuracy quantified by the area under the curve (AUC). A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 174 patients with type 2 diabetes mellitus were included in the study. The mean age of the participants was 55 ± 5 years, with a female predominance (59.2%). Other demographic and clinical characteristics are presented in Table 1.

Table 1. Demographic and Baseline Characteristics

Age (yrs)	55 ± 5
Gender (Female)	103 (59.2)
Weight (Kg)	72 ±14
Height (cm)	161 ±8
BMI (Kg/m2)	27.9 ±5.5
Systolic blood pressure (mmHg)	136 ±14
HbA1c (%)	11.2 ±1.7
Smoking	28 (16.1)
Alcohol consumption	4 (2.3)
Fracture history	48 (27.6)
Hip fracture (parents)	72 (41.4)
Medical History	
Insulin	125 (71.8)
Biguanides	171 (98.3)
DPP-4 Inhibitors	128 (73.6)
SGLT2 Inhibitors	35 (20.1)
Sulphonyl urea	148 (85.1)
Thiazolidinedione	7 (4.0)
Antiepileptics	6 (3.4)
PPIs	58 (33.3)
SSRIs	13 (7.4)

The diagnostic performance of FRAX and OSTA for identifying osteoporosis was evaluated using receiver operating characteristic (ROC) curve analysis. The predictive accuracy was quantified by the area under the ROC curve (AUC). Table 2 classifies AUC values according to their diagnostic interpretation.

Table 2: **Interpretation of AUC Values**

AUC Range	Predictive Values
1.0	Perfect
0.9-1.0	High
0.7-0.9	Moderate
0.5-0.7	Less
< 0.5	Non-predictive

According to the World Health Organization (WHO) criteria, osteoporosis prevalence varied depending on the skeletal site evaluated via DEXA. Osteoporosis was observed in 21.8% of participants at the lumbar spine, 13.2% at the femoral neck, and 29.3% when the worst reading across all measured sites was considered. These data are summarized in Table 3.

Table 3. DEXA Scan–Based Classification of BMD

Site	Normal, n (%)	Osteopenia, n (%)	Osteoporosis, n (%)
Lumbar Spine	65 (37.4%)	68 (39.1%)	38 (21.8%)
Femoral Neck	69 (39.7%)	81 (46.6%)	23 (13.2%)
Worst at any Site	45 (25.9%)	81 (46.6%)	51 (29.3%)

Mean BMD values were 0.91 ± 0.17 g/cm² at the lumbar spine and 0.72 ± 0.16 g/cm² at the femoral neck.

Correlation analysis demonstrated a statistically significant inverse relationship between DEXA-derived BMD and both FRAX-MOF and FRAX-HF scores, confirming that fracture risk increases as bone density declines. The strength of association was greater at the femoral neck.

- FRAX-MOF vs. BMD: r = – 0.51 ($p < 0.001$) at the lumbar spine; r = –0.67 ($p < 0.001$) at the femoral neck.
- FRAX-HF vs. BMD: r = –0.51 ($p < 0.001$) at the lumbar spine; r = –0.87 ($p < 0.001$) at the femoral neck.
- OSTA vs. BMD: r = 0.22 ($p = 0.002$) at the lumbar spine; r = 0.37 ($p < 0.001$) at the femoral neck.

Descriptive statistics of FRAX and OSTA are shown in Table 4.

Table 4. Summary of Screening Tool Scores

Tool	Mean ± SD
OSTA	3.17 (2.90)
FRAX-MOF (%)	6.02 ±6.87
FRAX-HF (%)	1.30 ±2.35

Receiver operating characteristic (ROC) curve analysis was used to determine the discriminatory power of each screening tool in predicting osteoporosis. All three tools exhibited predictive value with AUC values exceeding the 0.5 threshold (Figure 1). The FRAX-HF score demonstrated the highest diagnostic accuracy, followed by FRAX-MOF. The OSTA index, while predictive, showed lower discriminative capacity.

- **FRAX-HF**: AUC = 0.87 (95% CI: 0.80–0.90)
- **FRAX-MOF**: AUC = 0.83 (95% CI: 0.70–0.90)
- **OSTA**: AUC = 0.61 (95% CI: 0.50–0.70)

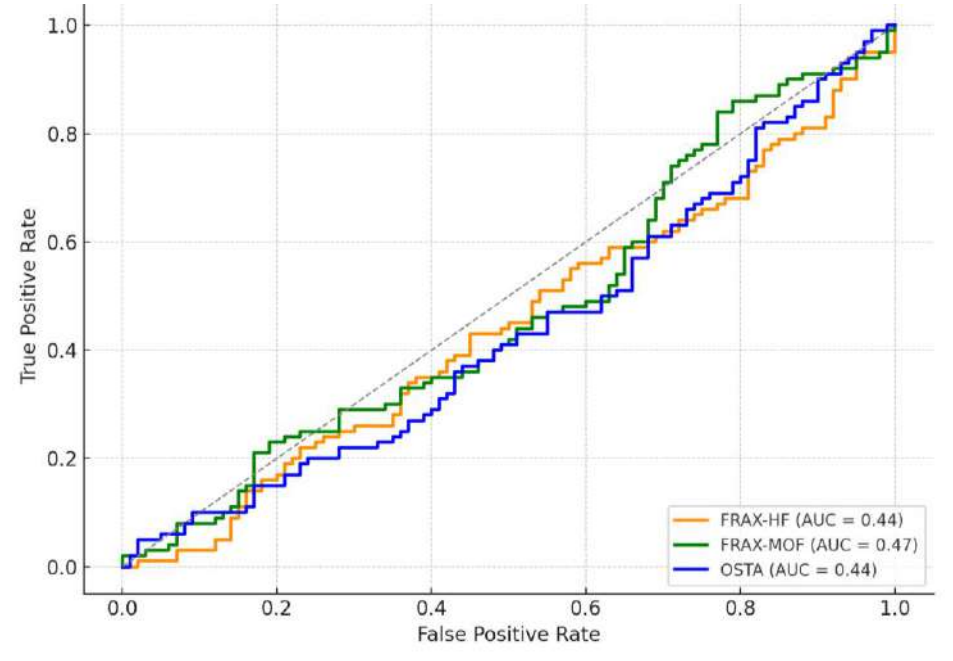

Figure 1 presents the ROC curves for all three screening tools.

DISCUSSION

Our study demonstrated a significant prevalence of osteoporosis among individuals with type 2 diabetes mellitus (T2DM), alongside a strong association between bone mineral density (BMD) and the fracture risk assessment tools FRAX and OSTA. Both instruments effectively identified individuals with T-scores ≤ –2.5 at various skeletal sites, indicating their diagnostic utility in osteoporosis screening.

It is well-established that therapeutic interventions aimed at fracture prevention often result in modest improvements in BMD. Therefore, early identification of individuals at risk through densitometry changes and the prompt initiation of anti-osteoporotic therapy are essential strategies in mitigating fracture risk [11]. Previous studies have documented a positive association between T2DM and reduced bone health, including increased fracture risk and lower BMD [12]. The primary objective of this study was to evaluate the comparative effectiveness of the OSTA and FRAX tools in predicting osteoporosis among patients with T2DM—a population at heightened risk but frequently under-screened.

With the aging global population and increasing life expectancy, osteoporosis is anticipated to become a major public health challenge. The associated complications, particularly fragility fractures, impose a significant burden on healthcare systems, often leading to functional disability, diminished quality of life, and increased mortality among older adults. Given these implications, proactive screening and prevention strategies are paramount [13–15]. Identification of at-risk individuals facilitates timely lifestyle modification, nutritional optimization, and initiation of pharmacologic therapy to attenuate bone loss and reduce fracture risk. Screening tools such as FRAX and DEXA remain integral to this process, offering a cost-effective and clinically efficient approach for risk stratification [16].

FRAX and OSTA are particularly advantageous in resource-limited settings such as Pakistan, where access to advanced imaging modalities like dual-energy X-ray absorptiometry (DEXA) may be limited. These tools provide practical alternatives for preliminary osteoporosis risk assessment and help prioritize patients who may benefit most from further diagnostic evaluation. The adoption of such screening tools can potentially reduce the clinical and economic burden of osteoporosis by promoting early detection and intervention [17].

The findings of our study support the clinical utility of both FRAX and OSTA in detecting osteoporosis in patients with T2DM. These tools may significantly enhance early identification strategies and improve treatment outcomes in this at-risk population. Importantly, both tools demonstrated the ability to identify individuals with low BMD, thus enabling targeted use of DEXA scanning and more efficient allocation of healthcare resources [18]. Furthermore, in regions where DEXA scanning is unavailable or impractical, these tools may serve as viable alternatives for osteoporosis screening [19].

Although the clinical performance of FRAX and OSTA has been evaluated in previous studies, this is among the first to assess their comparative effectiveness specifically within a T2DM cohort. Our analysis revealed that FRAX exhibited superior discriminatory performance compared to OSTA in identifying individuals with osteoporosis, indicating its greater reliability for clinical application in this population. These findings underscore the potential role of FRAX as a more effective and practical tool for routine osteoporosis screening in patients with T2DM [20,21].

Despite its strengths, our study is not without limitations. The relatively small sample size restricts the generalizability of our findings. Additionally, the cross-sectional nature of the study precludes causal inferences. Nonetheless, the results provide valuable insights into the utility of FRAX and OSTA in clinical decision-making and highlight the need for larger population-based studies to validate and expand upon these findings.

CONCLUSION

In conclusion, FRAX and OSTA are effective tools for osteoporosis screening in individuals with T2DM. Their implementation, particularly in resource-constrained healthcare environments, may facilitate early detection and management of osteoporosis, ultimately reduce fracture risk and improve patient outcomes. Further research with larger cohorts is recommended to establish their broader applicability and optimize their integration into routine clinical practice.

Authors Contribution

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