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DIAGNOSTIC ACCURACY OF LUMBOSACRAL SPINE X-RAY IN ASSESSING RISK OF SENILE OSTEOPOROSIS AMONG MALE PATIENTS USING SERUM VITAMIN D3 LEVELS AS REFERENCE

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Abstract

Background:
Senile osteoporosis in men is often underdiagnosed despite its growing public health impact. Serum Vitamin D_3 deficiency is strongly correlated with reduced bone mineral density (BMD) and serves as a biochemical marker of osteoporosis risk. Although dual-energy X-ray absorptiometry (DEXA) remains the gold standard for BMD measurement, its limited availability and cost restrict its use in routine screening. Conventional radiography may offer a practical alternative.

Objective:
To evaluate the diagnostic accuracy of lumbosacral spine radiography in detecting senile osteoporosis in male patients, using serum Vitamin D_3 levels as the reference standard with low serum Vitamin D_3 levels being indicative of increased risk of osteoporosis.

Methods:
This cross-sectional study was conducted in the Radiology Department of Capital Hospital, CDA, Islamabad, from 15 June to 15 September 2025. A total of 121 men aged 60–90 years with suspected osteoporosis underwent X-ray of the lumbosacral spine. Radiographs were interpreted by an experienced radiologist for characteristic osteoporotic changes. Serum Vitamin D_3 levels were measured for all participants. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of X-ray findings were calculated against Vitamin D_3 status.

Results:
Among 121 participants, 75 had radiographic evidence of osteoporosis; of these, 65 had low Vitamin D_3 levels (true positives) and 15 had normal Vitamin D_3 levels (false positives). Of 41 patients without radiographic features, 10 had low Vitamin D_3 levels (false negatives) and 31 had normal levels (true negatives). Lumbosacral spine X-ray showed a sensitivity of 86.7%, specificity of 67.4%, PPV of 81.3%, NPV of 75.6%, and an overall diagnostic accuracy of 79.3% (95% CI calculated for all parameters).

Conclusion:
Lumbosacral spine radiography demonstrates good sensitivity and moderate specificity in detecting senile osteoporosis in male patients when compared with serum Vitamin D_3 levels. Given its affordability and accessibility, it may serve as

a useful initial screening tool where DEXA is unavailable, though confirmatory testing remains advisable.

INTRODUCTION

Osteoporosis is a progressive skeletal disorder characterized by reduced bone mineral density (BMD), leading to increased bone fragility and susceptibility to fractures. [1] While it is predominantly associated with postmenopausal women, senile osteoporosis also significantly affects the aging male population, often underdiagnosed due to a lack of awareness and routine screening. [2] With increasing life expectancy, osteoporosis in elderly men has emerged as a critical public health concern, leading to substantial morbidity, mortality, and socioeconomic burden due to fragility fractures. [3] Accurate diagnosis and assessment of osteoporosis are crucial for timely intervention and prevention of fractures.

Vitamin D3 (cholecalciferol) plays a pivotal role in calcium homeostasis and bone metabolism. [4] Deficiency in serum Vitamin D3 has been strongly correlated with decreased BMD and increased risk of osteoporotic fractures in elderly populations, making it a reliable biochemical marker for assessing bone health. [5] As such, serum Vitamin D3 levels can serve as a valuable parameter in evaluating the diagnostic accuracy of imaging modalities like X-ray lumbosacral spine.

Assessment of bone mineral density (BMD) is frequently used as the basis for diagnosing osteoporosis as low BMD is an indicator of osteopenia and consequently osteoporosis. [6] Dual X-ray absorptiometry (DEXA) is widely regarded as the gold standard method currently used for diagnosing osteoporosis by measuring bone density among various available techniques. Despite being considered the "gold standard" for measuring bone density, DEXA is not well-suited for use in primary care settings or for widespread screening. Its effectiveness as a practical tool for improving osteoporosis diagnosis is limited by several factors, including the use of ionizing radiation, the large and immobile nature of the equipment, high operational costs, and limited availability. [7] Thus its limitations in accessibility and patient suitability call for exploration of alternatives in conventional radiography.

Conventional radiography, particularly X-ray imaging, is an affordable and highly reliable tool that is being widely utilized in medical diagnostics. [8] High-quality radiographs continue to serve an important role in identifying decreased bone density, which is an indicator of osteoporosis. [9] Characteristic radiographic features on lumbosacral spine radiographs such as decreased bone density, increased radiolucency of bones, vertebral compression fractures, and cortical thinning are also used as indicators of osteoporotic changes. [10]

The rationale of our study is to identify the potential of X-ray lumbosacral spine as a tool for assessing risk of senile osteoporosis in male patients. The findings of this study will contribute to the existing literature on the diagnosis and assessment of osteoporosis.

OBJECTIVE:

This study aims to determine the risk of senile osteoporosis in male patients by assessing X -ray lumbosacral spine using serum Vitamin D_3 levels as the reference standard with low serum Vitamin D_3 levels being indicative of increased risk of osteoporosis.

MATERIAL AND METHODS:

Study Design: Cross-sectional study.

Settings: Department of Radiology, Capital Hospital, CDA, Islamabad.

Duration of Study: 15th June 2025- 15th September 2025

Sample Size: The sample size was calculated using the WHO Sample Size Calculator [11] based on a 95% confidence level (z=1.96), a margin of error (MOE) of 0.075,

The formula for calculating sample size (n) is as follows:

$$N = \frac{Z^2 \times P \times (1 - P)}{d^2}$$

Where:
N: Required sample size.
Z: Z-score corresponding to the desired confidence level (1.96 for 95%).
P: Expected specificity or sensitivity (whichever is lower);
Here, P=0.77P = 0.77P=0.77 (specificity).
d: Desired margin of error 7.5% (0.075).

Calculate Z^2:

$$(1.96)^2 = 3.8416$$

Calculate $P \times (1 - P)$:

$$0.77 \times (1 - 0.77) = 0.77 \times 0.23 = 0.1771$$

Multiply Z^2 and $P \times (1 - P)$:

$$3.8416 \times 0.1771 = 0.6804$$

Divide by d^2:

$$d^2 = (0.075)^2 = 0.005625$$

$$N = \frac{0.6804}{0.005625} = 120.99$$

The calculation yielded a sample size of approximately 121 subjects.

Sampling Technique: Non-probability, consecutive sampling.

Sample Selection:
INCLUSION CRITERIA:
a. All male patients with suspected osteoporosis (as per-operational definition).
b. Duration of symptoms >12 weeks.
c. Age 60-90 years.
d. Males.
EXCLUSION CRITERIA:
a. Known malignancy.
b. Spondylitis or spondylodiscitis, lumbar vertebrae with metallic implants following spinal surgery.

OPERATIONAL DEFINITIONS:
1. Suspected osteoporosis: all male patients presenting with chronic lower back pain (VAS >3), stiffness below the costal margin with or without leg pain from more than 12 weeks
2. Risk of osteoporosis on X-ray lumbosacral spine: Characteristic radiographic features on lumbosacral spine radiographs such as decreased bone density, increased radiolucency of bones, vertebral compression fractures, cortical thinning and degenerative changes.
3. Risk of osteoporosis on serum Vitamin D3 levels: Normal serum vitamin D3 levels are 20–50 ng/mL. Vitamin D3 levels < 20 ng/mL were considered as indicative of increased risk of osteoporosis.
4.
5. Diagnostic accuracy: It was determined in terms of the following;
a. Sensitivity: Ability of X-ray lumbosacral spine to assess risk of osteoporosis = $\frac{TP}{TP+FN}$ x 100
b. Specificity: Ability of X-ray lumbosacral spine to assess patients without risk of osteoporosis = $\frac{TN}{TN+FP}$ x 100

c. **PPV:** Proportion of patients with risk of osteoporosis among all positive cases on X-ray lumbosacral spine = $\frac{TP}{TP+FP}$x 100

d. **NPV:** Proportion of patients without risk of osteoporosis among all negative cases on X-ray lumbosacral spine = $\frac{TN}{TN+FN}$ x 100

6. **True positive:** presence of risk of osteoporosis on both X-ray lumbosacral spine (characteristic radiographic features of osteoporosis) and serum Vitamin D3 levels.

7. **True negative:** absence of risk of osteoporosis on both X-ray lumbosacral spine (characteristic radiographic features of osteoporosis) and normal serum Vitamin D3 levels.

8. **False positive:** presence of characteristic radiographic features of osteoporosis on X-ray lumbosacral spine but normal serum Vitamin D3 levels.

9. **False negative:** absence of characteristic radiographic features of osteoporosis on X-ray lumbosacral spine but low serum Vitamin D3 levels.

DATA COLLECTION PROCEDURE:

After approval from institutional ethical review committee, total number of 121 patients presenting to Radiology department of Capital Hospital, CDA, Islamabad, fulfilling the inclusion criteria were selected. Informed consent was taken from each patient. After this, an X-ray of the lumbosacral spine was performed by qualified technologists using proper technique and positioning. X-ray findings were interpreted by a consultant radiologist and presence or absence of risk of osteoporosis (as per-operational definition) was noted. Then blood sample of each patient was sent to pathology laboratory for measurement of serum Vitamin D3 levels. X-ray findings were compared with serum Vitamin D3 findings. All this data was recorded on a pre-designed proforma (Annexure-I).

DATA ANALYSIS:

Collected data was analyzed through computer software SPSS 25.0. Shapiro wilk test was used to check the normality of data. 2×2 contingency table was used to calculate sensitivity, specificity, positive predictive value, negative predictive value and accuracy of X-ray lumbosacral spine in assessing risk senile osteoporosis male patients, taking serum Vitamin D3 levels as the reference standard with low serum Vitamin D_3 levels being indicative of increased risk of osteoporosis.

Osteoporosis on X-ray lumbosacral spine		Osteoporosis on serum vitamin D3 levels	
		Present	**Absent**
	Present	True positive (a)	False positive (b)
	Absent	False negative (c)	True Negative (d)

Sensitivity = (True Positives) / (True Positives + False Negatives) × 100

Specificity = (True Negatives) / (True Negatives + False Positives) × 100

Positive Predictive Value (PPV) = (True Positives) / (True Positives + False Positives) × 100

Negative Predictive Value (NPV) = (True Negatives) / (True Negatives + False Negatives) × 100

Diagnostic Accuracy = (True Positives + True Negatives) / Total Cases × 100

RESULTS:

Out of the 121 male patients who met the inclusion criteria, 75 patients showed characteristic findings of osteoporosis on X-ray lumbosacral spine. Out of these patients, 65 patients had low vitamin D3 levels and 15 patients showed normal vitamin D3 levels.

X-ray lumbosacral spine of 41 patients showed no osteoporotic changes. Out of these, 10 patients showed low vitamin D3 levels while 31 patients showed normal vitamin D3 levels.

Osteoporosis risk on X-ray lumbosacral spine		Osteoporosis risk on serum vitamin D3 levels	
		Present	Absent
	Present	True positive (a) = 65	False positive (b) = 15
	Absent	False negative (c) =10	True Negative (d) = 31

- Sensitivity: (65/(65+10) × 100) = 86.7%
- Specificity: (31/(31+15) × 100) = 67.4%
- Positive Predictive Value (PPV): (65/(65+15) × 100) = 81.3%
- Negative Predictive Value (NPV): (31/(31+10) × 100) =75.6%
- Diagnostic Accuracy: ((65+31)/121 × 100) = 79.3%
- Confidence Interval : 95% CI were calculated for sensitivity, specificity, PPV, NPV, and diagnostic accuracy.

DISCUSSION:

This study examined the diagnostic performance of lumbosacral spine radiographs in identifying senile osteoporosis risk in male patients, using serum Vitamin D_3 levels as a reference standard. We found that The lumbosacral spine X-ray demonstrated a sensitivity of 86.7% and a specificity of 67.4%, with a PPV of 81.3%, an NPV of 75.6%, and an overall diagnostic accuracy of 79.3%. This indicates that although X-ray findings are effective at identifying patients likely to have Vitamin D deficiency–related osteoporosis risk, they also produce a substantial number of false positives. Several prior studies have explored the association between Vitamin D levels and bone mineral density (BMD), and more broadly between biochemical markers and imaging techniques. Sadat-Ali et al. (2011) found a positive association between low serum Vitamin D and low bone mass in Saudi men and women, indicating that vitamin D deficiency is associated with decreased BMD. [12]

A meta-analysis and clinical trials have shown that supplementation with calcium and vitamin D can moderately reduce bone loss in older adults, including men. [13] However, randomized controlled trials more recently (e.g. LeBoff et al., 2020) have shown that daily Vitamin D_3 supplementation in generally healthy midlife and older adults did not significantly increase areal BMD at spine, femoral neck, or whole-body sites compared with placebo. [14]

There is less literature directly assessing the diagnostic accuracy of plain radiographs (versus DXA or biochemical markers) in male senile osteoporosis. However, according to one study, the sensitivity for detecting osteoporosis using pelvic X-rays ranged from 72% to 80%, while chest X-rays showed a sensitivity range of 81% to 84%. The respective specificity values were 86% to 95% for pelvic X-rays and 74% to 81% for chest X-rays. [15]

CONCLUSION:

The findings of this study indicate that lumbosacral spine radiograph demonstrated a sensitivity of 86.7% and a specificity of 67.4%, with a PPV of 81.3%, NPV of 75.6%, and an overall diagnostic accuracy of 79.3%. This indicates that while X-ray findings are effective at identifying patients who are likely to have osteoporosis related to Vitamin D deficiency, they also produce a notable proportion of false-positive results. Since the lumbosacral spine X-ray proved to be a moderately reliable diagnostic tool, it could provide a more accessible and cost-effective alternative for screening and monitoring osteoporosis in resource-limited settings where advanced imaging like DEXA scans may not be readily available, though confirmatory testing remains advisable.

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