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Diagnosis of Osteoporosis of Plain Lumber Vertebral X-Rays Through X-Ray an Age Based Techniques

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Abstract
Background: *The diagnosis of osteoporosis relies on the quantitative assessment of BMD, which is currently considered the best predictor of osteoporotic fractures. Dual-energy X-ray absorptiometry (DXA) is the current standard method to assess bone mineral density (BMD). However, access to this method may be limited. In the other hand, x-ray is inexpensive, easy to perform and widely available method. Although common, osteoporosis can be clinically silent, and without prevention and screening, the costs of osteoporotic fracture–related morbidity and mortality will burden healthcare systems especially in developing countries.* ***Objective:*** *To assess the diagnosis of osteoporosis of plain lumber vertebral x-rays through x-ray an age based techniques.* ***Methods:*** *One hundred seventy women between the ages of 40 to 83 years were referred to Orthopedic Dept., 250 Bed General Hospital, Kishoreganj, Bangladesh from January to December 2022. These women were found to have features of osteopenia in lumber vertebrae plain radiography. The participants then categorized into two groups. Group A (n=101) are those who are younger than 65 years and group B (n=69) are those who are 65 years and older. The two groups underwent a quantitative ultrasound bone densitometry. Correlations between plain radiography parameters and QUS were calculated. Osteoporosis was diagnosed by QUS T-score ≤ –2.5 at the lumber vertebra.* ***Results:*** *Total 170 women met the inclusion criteria. The mean age of the participants was 63.5± 6 years old with the minimum age was 40 years and maximum age was 83 years. The most common population aged more than 63 years old, group A who are less than 65 years of age were 101 participants (59%), while those 65 years and old were 69 (41%). The participants in both groups have showed features of osteopenia in their plain lumbar vertebral X rays. In group A, 51.5% were found to have a T-score equal or less than (-2.5) on QUS compared with 92.7% in group B who were found to have osteoporosis by QUS. Also when we performed Fisher's Exact test we found a significant differences in the validity of X rays as compared to QUS bone densitometry between the two groups, in Group A the difference between X ray and quantitative ultrasound bone densitometry was significant (p = 0.000000006 at p > 0.05), and was not significant in Group B (p = 0.491 at p > 0.05).* ***Conclusion:*** *Plain radiography can provide reliable method for diagnosis of osteoporosis in women with a higher risk for fragility fractures (≥65 years) especially in primary healthcare and sittings with limited resources.*

Keywords: *Radiography, Bone Mineral Density (BMD), Osteoporosis.*

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I. Introduction

In recent years the prevalence and the awareness of osteoporosis are increasing and it has been estimated that 200 millions of individuals suffer from osteoporosis worldwide. Nevertheless, about 75% of these people represent undiagnosed cases and do not receive appropriate treatment. According to the World Health Organization (WHO), osteoporosis is "a systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissue with a consequent increase in bone fragility and susceptibility to fracture" [1]. The diagnosis of osteoporosis relies on the quantitative assessment of BMD, which is currently considered the best predictor of osteoporotic fractures. Dual-energy X-ray absorptiometry (DXA) is the current standard method to assess bone mineral density (BMD). However, access to this method may be limited. In the other hand, x-ray is inexpensive, easy to perform and widely available method. Classically, plain x-ray has been considered less valuable in diagnosing osteoporosis. However, the validity of plain radiography has never been compared between different age groups. Fractures resulting from osteoporosis lead to high rates of morbidity and mortality, reduce quality of life and are responsible for a sharp increase in healthcare costs [2-4]. As a consequence, with the gradual increase in life expectancy in developed countries, osteoporosis and consequent

fragility fractures represent a major health problem in elderly women (older than 50 years) which will become a predominant portion in the next decades [2]. The socio-economic demand for the management of osteoporotic patients will also increase in the next years [5]: it would be both useful and necessary to adopt a preventive approach to the problem in postmenopausal women with the aim to stop or at least slow down the disease progression [2,6]. Over the past 25 years, many non-invasive methods (like conventional Single Photon Absorptiometry (SPA), Single-Energy-X-ray Absorptiometry (SXA) and Dual Photon Absorptiometry (DPA) for osteoporosis diagnosis have been developed, they rely on the attenuation of ionizing radiation to quantify BMD at different skeletal sites and the traditional X-rays can't measure bone density, but they can identify spine fractures [6,7]. Bone biopsy may be indicated in specific situations. Conventional radiography is used for the qualitative and semi quantitative evaluation of osteoporosis, morphometry assesses the presence of fractures [8]. Conventional radiography is useful, both alone and in conjunction with CT or MRI, when detecting complications of osteopenia (e.g., fractures), for the differential diagnosis of osteopenia, or for follow-up examinations in specific clinical settings, such as progression of soft tissue calcifications, or signs of secondary hyperparathyroidism and osteoporosis. It is relatively insensitive to the detection of early disease, though [9].

II. Materials and Methods

A retrospective, cross sectional, observational– hospital based study was carried out at Orthopedic Dept., 250 Bed General Hospital, Kishoreganj, Bangladesh from January to December 2022. One hundred seventy women included in our study and age range of 40 to 83 years. These women were found to have features of osteopenia in lumber vertebrae plain radiography. The participants then categorized into two groups. Group A (n=101) are those who are younger than 65 years and group B (n=69) are those who are 65 years and older. The two groups underwent aquantitative ultrasound bone densitometry. Correlations between plain radiography parameters and QUS were calculated. Osteoporosis was diagnosed by QUS T-score ≤ –2.5 at the lumber vertebra. It is a hospital based study that fulfilled the Inclusion/Exclusion criteria.

Inclusion Criteria:

- Women aged 40 years and above.
- Women with back pain more than 4 weeks of duration, not relieved by usual medications and exercises.

Exclusion criteria:

- Female gender less than 40 years old.
- Known to have any form of secondary osteoporosis.
- Pathologic or traumatic lumbar vertebral fracture.
- Any lumbar vertebral (inflammatory, neoplastic, pyogenic) pathology.

Data collection method and tools: Patients presented with back pain in compliance with the criteria of the study, population was selected. Informed consent was taken from the patients who agree to be part of the study. At the orthopedic clinic a standard questionnaire (contains patient gender & age), plain radiography and QUST score examination were done. Plain AP and lateral radiographs from the first lumbar vertebra down to the sacrum; which commented on the presence of osteopenia or osteoporosis in the absence of any vertebral fracture. The BMD was measured in all patients using QUS, it was obtained from the calcaneus. The QUS was expressed as a T score, which is the standard deviation (SD) in BMD. The T score is the most significant parameter for the assessment of osteoporosis, which compares BMD of the subject with average BMD of young normal population. T score above -1 is normal, between -1 to -2.5 is osteopenic, and T score lower than -2.5 are osteoporotic which is an indication for risk of fractures.

Data management: Statistical analysis was performed using SPSS software program (version 21.0 for Windows XP, SPSS, Chicago, Illinois). The normally distributed variables are expressed as mean and SD. For comparison of age groups, X rays and QUS T score, cross-tabulation was performed with Fisher's Exact test and analysis of variance as appropriate. The level of significance was set at P value <0.05.

III. Results

Total 170 women met the inclusion criteria. The mean age of the participants was 63.5± 6 years old with the minimum age was 40 years and maximum age was 83 years. The most common population aged more than 63 years old, group A who are less than 65 years of age were 101 participants (59%), while those 65 years and old were 69 (41%). The participants in both groups have showed features of osteopenia in their plain lumbar vertebral X rays.

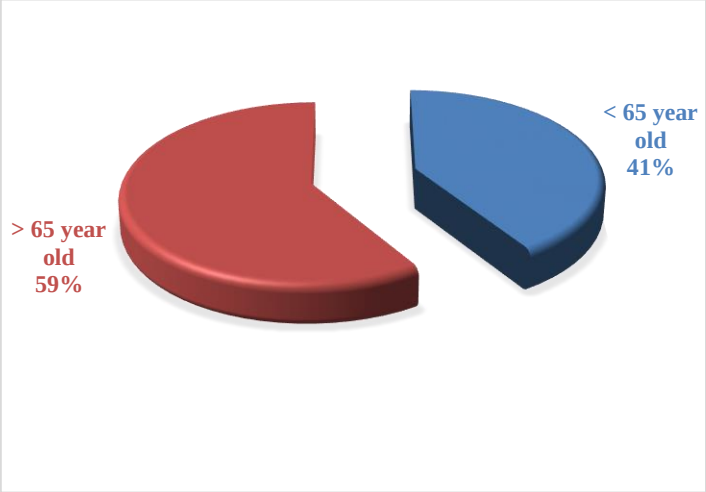


Fig-1: Pie-chart shows the age of study population in percentages.

By QUS; in group A: 3 patients (1.5%) were found to have a normal bone mineral density (T score = > -1 SD), 65 patients (47.0%) were osteopenic (T score between -1 and -2.5 SD), while 33 patients (51.5%) were osteoporotic (T score = < -2.5 SD), in group B: 6 patients (4.3%) were found to have a normal bone mineral density (T score = > -1 SD), 6 patients (4.3%) were osteopenic (T score between -1 and -2.5 SD), while 57 patients (91.4%) were osteoporotic (T score = < -2.5 SD).

Table-1: The frequency and percentage of Osteopenea by x rays distribution according age of the study population (N=170)

Age group	**Patients No.**		
	Osteopenia	**No- Osteopenia**	**Total**
Group A	101 (100.0%)	0 (0%)	101 (59.4%)
Group B	69(100.0%)	0 (0%)	69(40.6%)
Total	170 (100.0%)	0 (0%)	170 (100%)

*group A; women of age

Table-2: The frequency and percentage of Osteoporosis by QUS distribution according to age of the study population (N=170)

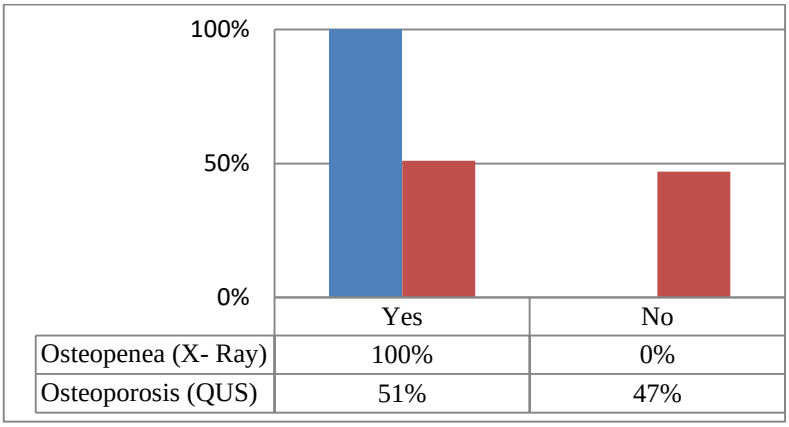
Age group	**Patients No.**			**Total**
	Normal	**Osteopenia**	**Osteoporosis**	
Group A	2(1.9%)	47 (46.6%)	52 (51.5%)	101(59.4%)
Group B	3 (4.3%)	3 (4.3%)	63(91.3%)	69 (40.6%)
Total	5 (2.9%)	50 (29.4%)	115 (67.6%)	170(100.0%)

*group A; women with age <65 years, group B; women with age ≥ 65 year, normal; score average (+1 or -1), osteopenia; score average (-1 to -2.5), osteoporosis; score average (≤-2.5)

Results were processed by Fisher's Exact test; in group A: the difference between the results yielded by plain X rays and QUS was significant (0.000000006 at p – value = 0.05), while in group B the difference is not significant (0.49 at p – value = 0.05)

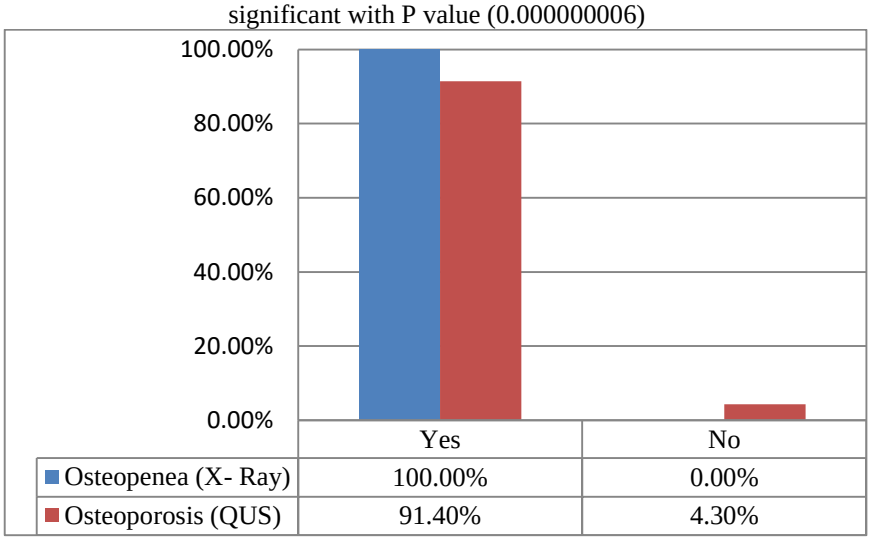
Table-3: The P Value distribution according to age of the study groups (N=170)

	No	**X ray (Osteopenia)**		**QUS (Osteoporosis)**		**P value**
		Yes	**No**	**Yes**	**No**	
Group A	101	101	0	54	47	0.000000006
Group B	69	69	0	63	6	0.49



	Yes	No
Osteopenea (X- Ray)	100%	0%
Osteoporosis (QUS)	51%	47%

Fig-2: Histogram shows the distributions in percentages of group A according to their diagnosis (x rays/QUS). The difference between x ray and quantitative ultrasound bone densitometry among group A women was significant with P value (0.000000006)



	Yes	No
Osteopenea (X- Ray)	100.00%	0.00%
Osteoporosis (QUS)	91.40%	4.30%

Fig-3: Histogram shows the distributions in percentages of group B according to their diagnosis (x rays/QUS).

The difference between x ray and quantitative ultrasound bone densitometry among group B women was not significant with P value 0.491.

IV. Discussion

The diagnosis of osteoporosis relies on the quantitative assessment of BMD, which is currently considered the best predictor of osteoporotic fractures. The BMD value is the amount of bone mass per unit volume (volumetric density), or per unit area (areal density), and both can be measured in vivo by densitometric techniques [9]. Over the past 25 years, many non-invasive methods for osteoporosis diagnosis have been developed that rely on the attenuation of ionizing radiation to quantify BMD at different skeletal sites. Among the most commonly used X-ray based methods, quantitative computed tomography (QCT) and DXA allow quantification of bone loss while morphometry provides assessment of the presence of vertebral fractures. Total 170 women met the inclusion criteria. The mean age of the participants was 63.5± 6 years old with the minimum age was 40 years and maximum age was 83 years. The most common population aged more than 63 years old, group A who are less than 65 years of age were 101 participants (59%), while those 65 years and old were 69 (41%). The participants in both groups have showed features of osteopenia in their plain lumbar vertebral X rays. The capacity of plain lumbar vertebral X rays in the diagnosis of osteoporosis, by comparing the radiologic features on the X ray films to the T-score measured by QUS by adopting an age based approach, lumbar X rays in patients who are 65 years and older could yield a comparable results to the standard QUS test of bone density (P-value = 0.491 at $p > 0.05$), but for patients who are younger than 65 years the plain X rays failed to demonstrate comparable results (P-value = 0.000000006 at $p > 0.05$), these results may indicate that X rays can be a beneficial screening and / or diagnostic modality for osteoporosis in the elder population along with the other clinical features. C. D. Mc Cullagh et al have conducted a study to determine how reliable spinal radiographs were at detecting low bone density compared with Dual Energy X ray Absorptiometry (DXA) [9]. They retrospectively measured the Bone Mineral Density (BMD) at the spine in 130 patients with a radiological diagnosis of osteopenia or osteoporosis in the absence of vertebral fractures. They concluded that a radiological report of low bone density

is a strong predictor of osteopenia or osteoporosis [9], this conclusion supports the validity of X rays in the diagnosis of osteoporosis, and in our study we could reproduce the same results with larger sample size, and more specification of age related changes. The study of Scane et al showed that only 66.7% of women with apparent osteopenia on spine x-ray without vertebral deformation had a bone density below the normal range for young women, this result may again make it inappropriate to relay on X rays alone for the diagnosis of osteoporosis [10]. Masud et al, assessed osteopenia in spine radiographs and BMD as measured by DXA in 818 patients concluded that radiologic features of osteopenia may reflect a low BMD, and the absence of these features make it very unlikely to have a significantly low BMD [10]. This finding was supported by Garton et al, who assessed the BMD and spinal radiographs of normal patients. Their sample comprised more men than women (107 versus 93), which does not correspond to the true referral patterns for osteoporosis. However, they concluded that the diagnosis of osteoporosis should not depend only on radiological features or 38.1 % of patients with osteoporosis would have been missed [11]. On the other hand, 44.7% of the patients with a radiological diagnosis of osteoporosis will possibly receive treatment for osteoporosis when they had osteopenia or a normal bone density. The diversity in these results will potentially raise questions about the validity of X rays as a fair diagnostic tool in osteoporosis, and may necessitate considering a different approach for its validation. The type of osteoporosis and extent of bone damage should be appreciated as important factors in the selection of the diagnostic modality, Seeman, Ego in his review for the European Endosteal bone loss is determined by the remodeling rate (number of basic multicellular units, BMUs) and the negative balance in each BMU. Bone loss accelerates in women at menopause because remodeling intensity increases and BMU balance becomes more negative as estrogen deficiency reduces osteoblast lifespan and increases osteoclast lifespan. The high remodeling rate also reduces the mineral content of bone tissue. The negative BMU balance results in trabecular thinning, disappearance and loss of connectivity, cortical thinning and increased intracortical porosity [12], owing to these facts the X ray is capable of detecting changes in cortical thickness which take place later in the senility as it detects pathology only after 30% of bone has been lost [13,14]. Bone mass loss in the area of 20-50% is necessary before osteopenia is detectable by traditional X ray methods Giuseppe Guglielmi et al in their recent review have highlighted that; the detection of insufficiency fractures has been challenging in the past years, but has improved for the diffusion of vertebral morphometry, which can be applied on both conventional and DXA images, vertebral morphometry uses a semi-quantitative method to characterize vertebral fractures which helps the radiologist in the diagnosis. The increased risk of future bone fractures, in course of osteoporosis, does not only depend on BMD, but also on the "quality" of bone: this characteristic is determined by several factors, such as the number and thickness of bone trabeculae and their micro-architectural organization [15], this again raises the need for a qualitative method for the assessment of osteoporosis and the prediction of future vertebral fractures. Michel B et al had reviewed the usefulness of the plain radiographs in estimating lumbar bone density; they have concluded that plain radiography is proving to be a simple, low-cost, low-risk, technique for determination of BMD in primary health care centers in the developing countries and for use as a screening tool for osteoporosis [16], their findings are very consistent with our study conclusion and emphasizes on the socioeconomic context which is very crucial in our settings. Resnick NM et al and Boonen S et al had separately reviewed the senile osteoporosis as a different entity from perimenopausal osteoporosis; they concluded that the occurrence of senile osteoporosis in elderly women is quite common, the diagnosis may be suggested clinically, but a radiologic confirmation is essential [17], the amplitude of senile osteoporosis they recognized is comparable to our results; in our study we found that (91.4%) of the women aged 65 years and older were osteoporotic. Moldawer M in a very old paper dating half a century back have recognized that the lumbar x rays in a typical case of osteoporosis will show radiolucency of the bone, usually affecting the bodies of spinal vertebrae giving a "cod fish" appearance due to the involvement and thinning of both the trabecular and cortical bone [18], after this very long time with all the new advances in diagnostic technology, the need for this qualitative descriptive method is still there. The other important fact is that the interpretation of radiographs depends on many factors that include; film penetration, patient positioning and inter/ intra observer variability.

V. Conclusion

The study concludes that plain radiography can provide a reliable method for diagnosis of osteoporosis in women with a higher risk for fragility fractures (≥65 years), this conclusion is supported by the scientific bases of bone resorption patterns is senile osteoporosis; where more cortical thinning takes place. The results of this study are best discussed in primary healthcare and settings with limited resources, where a quick, cheap and reliable diagnostic modality is needed to address osteoporosis which is a nation threatening health condition.

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