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THE VALIDITY OF PLAIN LUMBER VERTEBRAL X-RAYS IN DIAGNOSING OSTEOPOROSIS IN ELDERLY-AN AGE-BASED APPROACH

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Background: The diagnosis of osteoporosis relies on the quantitative assessment of BMD, which is currently considered the best predictor of osteoporotic fractures. Early diagnosis is the key for appropriate osteoporosis management. 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 assessed the validity of plain radiography in diagnosing osteoporosis in elderly women. **Methods:** A retrospective, cross-sectional, observational hospital-based study conducted at the Department of Ortho-Surgery, Patuakhali Medical College Hospital, Patuakhali, Bangladesh from June 2019 to July 2022. One hundred Seventy (170) female patients between the ages of 40 to 83 years were referred to the orthopedic department in PKMCH. 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 patients were included. The mean age of the participants was 63.5±6 years old with the minimum age was 40 years and the 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 (59.4%),

while those 65 years and old were 69 (40.6%). The participants in both groups have showed features of osteopenia in their plain lumbar vertebral X-rays. By QUS; in group A: 2 patients (1.9%) were found to have a normal bone mineral density (T score = >-1 SD), 47 patients (46.5%) were osteopenic (T score between -1 and -2.5 SD), while 52 patients (51.4%) were osteoporotic (T score = <-2.5 SD), in group B: 3 patients (4.3%) were found to have a normal bone mineral density (T score =>-1 SD), 3 patients (4.3%) were osteopenic (T score between -1 and -2.5 SD), while 63 patients (91.3%) were osteoporotic (T score =<-2.5 SD). Also when we performed Fisher's Exact test we found a significant difference 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.

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INTRODUCTION

In recent years the prevalence and awareness of osteoporosis are increasing and it has been estimated that 200 million 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. 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 [2]. 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 unit area (areal density), and both can be measured *in vivo* by densitometric techniques [3]. 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 the quantification of bone loss while morphometry provides an assessment of the presence of vertebral fractures. Bone biopsy may be indicated in specific situations. Conventional radiography is used for the qualitative and semi-quantitative evaluation of osteoporosis, and morphometry assesses the presence of fractures [4]. 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 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 [5]. A substantial amount of bone loss (30%) must occur before it can be detected on x-ray images. Variations in radiographic exposure factors, film development, and patients' soft tissue thickness can also make it difficult to diagnose early signs of osteoporosis. The main radiographic features of generalized osteoporosis are cortical thinning and increased radiolucency [6]. Moreover, all the X-ray-based methods provide a measure of BMD but this parameter can explain only 60%-80% of the variability in bone strength, and it has been demonstrated that other mechanical aspects of the bone (microarchitectural parameters, bone geometry and elastic properties, which cannot be assessed by densitometric techniques [5,7] are important in determining fracture risk [6,7,9]. 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.

MATERIALS AND METHODS

A retrospective, cross-sectional, the observational hospital-based study was conducted at the Department of Ortho-Surgery, Patuakhali Medical College Hospital, Patuakhali, Bangladesh from June 2019 to July 2022. One hundred Seventy (170) female patients between the ages of 40 to 83 years were referred to the orthopedic department in PKMCH. 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.

Inclusion Criteria:

- Women aged 40 years and above.
- Women with back pain of 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 QUS T 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 the average BMD of the young normal population. T score above -1 is normal, between -1 to -2.5 is osteopenic, and T score lower than -2.5 is osteoporotic which is an indication for risk of fractures.

Study variables: The dependent variables are the total QUS T score and radiography parameters of lumber vertebrae

and the independent variables are the women age less than 65 years or greater than 65 years.

Data management: Statistical analysis was performed using the 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.

RESULTS

Total 170 patients were included. The mean age of the participants was 63.5±6 years old with the minimum age was 40 years and the 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 (59.4%), while those 65 years and old were 69 (40.6%) (fig-1). The participants in both groups have shown features of osteopenia in their plain lumbar vertebral X-rays. By QUS; in group A: 2 patients (1.9%) were found to have a normal bone mineral density (T score = > -1 SD), 47 patients (46.5%) were osteopenic (T score between -1 and -2.5 SD), while 52 patients (51.4%) were osteoporotic (T score = <-2.5 SD), in group B: 3 patients (4.3%) were found to have a normal bone mineral density (T score = > -1 SD), 3 patients (4.3%) were osteopenic (T score between -1 and -2.5 SD), while 63 patients (91.3%) were osteoporotic (T score = < -2.5 SD). 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-1-3).

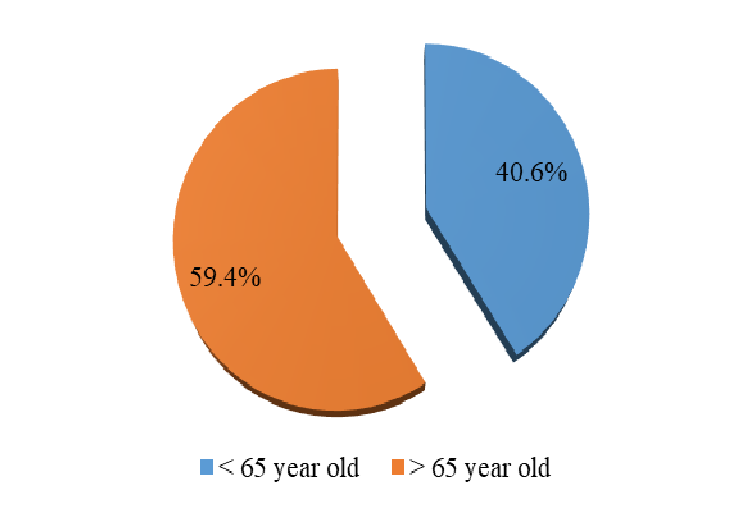

Fig-1: Pie-chart shows the age of study population in percentages.

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).

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

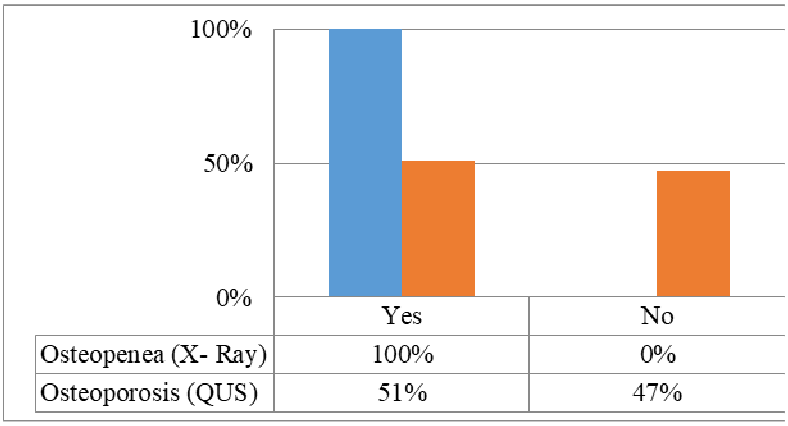

Fig-2: Histogram shows the distributions in percentages of group A according to their diagnosis (x rays/QUS). The difference between x ray and quantitative ultrasound bone densitometry among group A women was significant with P value (0.000000006) (Fig-2).

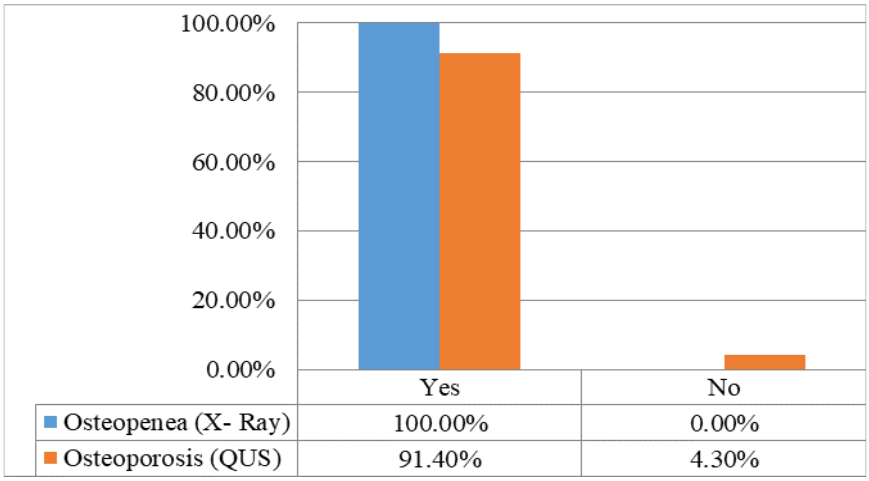

Fig-4: Histogram shows the distributions in percentages of group B according to their diagnosis (x rays/QUS).

The difference between x ray and quantitative ultrasound bone densitometry among group B women was not significant with P value 0.491 (Fig-3).

DISCUSSION

Accurate and early diagnosis of osteoporosis would result in better clinical management, in terms of prevention and adequate pharmacologic or surgical treatment. The currently available methods for bone densitometry are mainly based on the use of either X-rays, considered as the "gold standard" reference, or ultrasound. These techniques interact differently with bone tissues because of the different physical phenomena on which they are based [10]. Total of 170 patients were included. The questionnaires were assigned and collected as primary data, then analyzed by using an analytical descriptive approach. The mean age of the participants was 63.5±6 years old with the minimum age was 40 years and the 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 (59.4%), while those 65 years and old were 69 (40.6%). The X-ray absorption is mainly controlled by the amount of mineral in the bone tissue and so it does not provide information about organic composition or microstructure, which significantly contribute to the mechanical properties of bone that actually influences fracture risk assessment [11]. 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. McCullagh et al [11] have conducted a study to determine how reliable spinal radiographs were at detecting low bone density compared with Dual Energy X-Ray Absorptiometry (DXA). 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 [11], this conclusion supports the validity of X-rays in the diagnosis of osteoporosis, and in our study, we could reproduce the same results with a larger sample size, and more specification of age-related changes. By QUS; in group A: 2 patients (1.9%) were found to have a normal bone mineral density (T score =>-1 SD), 47 patients (46.5%) were osteopenic (T score between -1 and -2.5 SD), while 52 patients (51.4%) were osteoporotic (T score = <-2.5 SD), in group B: 3 patients (4.3%) were found to have a normal bone mineral density (T score =>-1 SD), 3 patients (4.3%) were osteopenic (T score between -1 and -2.5 SD), while 63 patients (91.3%) were osteoporotic (T score =<-2.5 SD). The study of Scane et al [12] 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 [12]. 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 [13]. This finding was supported by Garton et al, who assessed the BMD and spinal radiographs of normal

patients [14]. 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 [14]. 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 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 [2], 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 [15]. Bone mass loss in the area of 20-50% is necessary before osteopenia is detectable by traditional X ray methods Giuseppe Guglielmi et al [16] 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 help the radiologist in the diagnosis. Mora S et al in their review in endocrinology and metabolism stated that a major determinant of bone density in an older individual is her or his peak bone mass [17]. Although the attainment of peak bone mass begins in utero and is typically completed by the age of 40, the main contributor to this process is the amount of bone that is gained during adolescence [17], this fact makes our age-based approach valid and descent as we are investigating an ageing phenomenon. Resnick NM et al [18] had separately reviewed 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 [16,18], the amplitude of senile osteoporosis they recognized is comparable to our results; in our study we found that (91.3%) of the women aged 65 years and older were osteoporotic. The other important fact is that the interpretation of radiographs depends on many factors that include; film penetration, patient positioning, and inter/intraobserver variability. In the study of Epstein et al [19], the authors concluded that there were poor interobserver and intraobserver agreements, and this result should be appreciated in terms of standardization of radiologic criteria for the diagnosis of osteoporosis [19], in another study conducted by Epseland et al.[20] fair to excellent overall interobserver and intraobserver agreements were reported, making it valuable to consider the experience of the radiologist and/or the orthopedic surgeon who reviews the radiographs. The possibility of having a rapid, reliable, portable, non-ionizing, and space-saving device allows for performing osteoporosis screening, reducing waiting lists, and leaving the use of X-ray techniques only for a high-level investigation for specific pathologic definitions and some other therapeutic pathways.

CONCLUSION

The study concludes that plain radiography can provide a reliable method for the 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.

Conflict of Interest: None.

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