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Research Article

The Validity of Plain Lumber Vertebral X-Rays in the Diagnosis of Osteoporosis – An Age Based Approach

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Abstract: ***Background*** Early diagnosis is the key for an 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. 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. This study assessed the validity of plain radiography indiagnosing osteoporosis in elderly women, 65 years and older, and compared them with those who are less than 65 years. ***Method*** Three hundred forty Sudanese women between the ages of 40 to 83 years were referred to orthopedic clinic in Best Care Hospital. These women were found to have features of osteopenia in lumber vertebrae plain radiography. The participants then categorized into two groups. Group A (n=202) are those who are younger than 65 years and group B (n=138) 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. ***Result:*** In group A, 51.4% 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

INTRODUCTION

Osteoporosis is a disease characterized by low bone mineral density and structural deterioration of bone tissue leading to bone fragility and increased risk of fragility fractures particularly of the hip, spine and wrist.

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(Seeman, E. 2003). 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

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measure bone density, but they can identify spine fractures(Albanese, C. V. *et al.*, 2011; Kanis, J. A. 2002). 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(Grigoryan, M. *et al.*, 2005).

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 (Fink, H. A. *et al.*, 2005). 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(Panda ,A. *et al.*,2014).

Objectives

General objective:

To assess the validity of plain radiography in diagnosing osteoporosis in elderly Sudanese women - an age based approach (with age groups less than 65 years or greater than 65 years) at Khartoum Locality-Sudan 2018.

Specific objectives:

- Evaluate the validity of lumbar X rays (AP and lateral) in the diagnosis of osteoporosis among women by adopting an age based approach (less than 65 years and greater than 65 years) age groups.
- Assess the usefulness of plain x rays in the diagnosis of different types of osteoporosis.
- Formulate a set of recommendations for the diagnosis of osteoporosis in primary health care facilities.

Materials and Methods

- **Study Design:** a retrospective, cross sectional, observational– hospital based study
- **Study Area:** The data was collected from orthopedic clinic in Best Care Hospital, Khartoum locality –Sudan.
- **Study Population:** All women presented with back pain in compliance with the criteria of the study population, attending the orthopedic clinic in Best Care Hospital were enrolled in this study.
- **Sampling:** probability sampling
- **Sample Size:** it is a hospital based study of 340 cases 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 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 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 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 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.

Ethical consideration:

Ethical approval for the current study was obtained from the Ethics Committee of Sudan Medical Specialization Board. All participants were enrolled in the study after signing a written informed consent.

RESULT

Participants:

In this study 340 Sudanese women met the inclusion criteria; The questionnaires were assigned and collected as primary data, then analyzed by using an analytical descriptive approach; Statistical Package for Social Sciences Software, version 21.0 (IBM SPSSInc., Chicago, IL) was used and Fisher's Exact test was applied to present the results. A P-value <0.05 was considered as statistically significant for differences in the validity of X rays as compared to QUS bone densitometry. The Participants (n= 340) age (40-83 years).

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 202 participants (59%), while those 65 years and old were 138 (41%). The participants in both groups have showed features of osteopenia in their plain lumbar vertebral X rays.

The age:

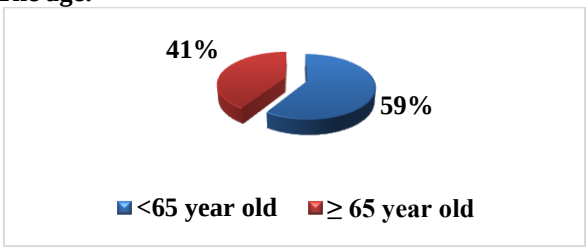

Fig.3.1: Pie-chart shows the age of study population in percentages

By QUS; in group A: 3 patients (1.5%) were found to have a normal bone mineral density (T score = > -1 SD), 95 patients (47.0%) were osteopenic (T score between -1 and -2.5 SD), while 104 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 126 patients (91.4%) were osteoporotic (T score = < -2.5 SD).

Table (3.1): The frequency and percentage of Osteopenea by x rays distribution according age of the study population:

Age group	Patients No.		
	Osteopenia	No- Osteopenia	Total
Group A	202 (100.0%)	0 (0%)	202 (59.4%)
Group B	138 (100.0%)	0 (0%)	138 (40.6%)
Total	**340 (100.0%)**	**0 (0%)**	**340 (100%)**

*group A; women of age <65 years, group B; women of age ≥ 65 years.

Table (3.2): The frequency and percentage of Osteoporosis by QUS distribution according to age of the study population:

Age group	Patients No.			Total
	Normal	Osteopenia	Osteoporosis	
Group A	3 (1.5%)	95 (47.0%)	104 (51.5%)	**202 (59.4%)**
Group B	6 (4.3%)	6 (4.3%)	126 (91.4%)	**138 (40.6%)**
Total	**9 (2.6%)**	**101 (29.7%)**	**230 (67.7%)**	**340 (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 (3.3): The P Value distribution according to age of the study groups

	No	X ray (Osteopenia)		QUS (Osteoporosis)		P value
		Yes	No	Yes	No	
Group A	202	202	0	104	98	0.000000006
Group B	138	138	0	126	12	0.49

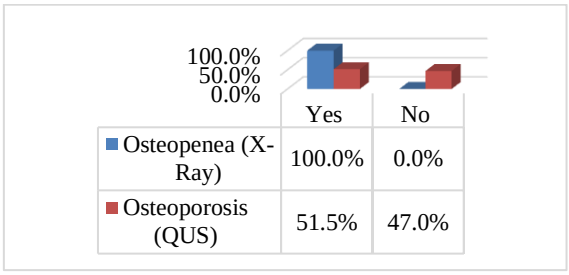

Fig.3.2: Histogram shows the distributions in percentages of group A according to their diagnosis (x rays/QUS)

- The difference between x ray and quantitative ultrasound bone densitometry among group A women was significant with P value (0.000000006)

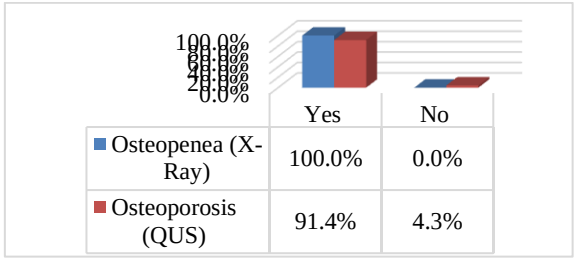

Fig.3.3: Histogram shows the distributions in percentages of group B according to their diagnosis (x rays/QUS)

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

DISCUSSION

This retrospective study tests 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* 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 (McCullagh, C. D. *et al.*, 2003), 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 (Scane, A. C. *et al.*,1994).

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(Masud, T. *et al.*,1996). 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 (Garton, M. J.*et al.*, 1994). 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 Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA has stated that; the total amount of bone lost during aging is determined by the difference between the amount of bone removed from the endocortical, trabecular and intracortical components of its inner endosteal envelope and formed beneath its outer periosteal envelope. 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 (Seeman, E. 2003), 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(Harris, W. H., & Heaney, R. P. 1969). 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 (Guglielmi, *et al.*, G.2018), 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 (Michel, B. A., *et al.*, 1995), their findings are very consistent with our study conclusion

and emphasizes on the socioeconomic context which is very crucial in our settings.

Mora S *et al* in their review in the endocrinology and metabolism had stated that amajor determinant of bone density in an older individual is her or his peak bone mass. 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(Mora, S., & Gilsanz ,V. 2003), this fact makes our age based approach valid and descent as we are investigating an ageing phenomenon.

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 (Resnick, N. M., & Greenspan, S. L.1989), 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 (Moldawer, M. 1955), 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. In the study of Epstein *et al*, the authors concluded that there was poor interobserver and intraobserver agreements, and this result should be appreciated in terms of standardization of radiologic criteria for the diagnosis of osteoporosis (Epstein, D. M., *et al.*, 1986), in other study conducted by Epseland *et al.*, (1998) 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.

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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