PERFORMANCE OF BONE MINERAL DENSITY AT ULTRADISTAL RADIUS IN DIAGNOSIS OF OSTEOPOROSIS AT AXIAL SKELETAL SITES

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ABSTRACT

Background: Bone mineral density (BMD) measurement at the forearm has some advantages over at the axial skeletal sites due to lower radiation dose, lower cost, more patient's comfort, faster scan time and not interfered by abnormal calcification or degenerative change of the spines. Performance of the forearm BMD in the diagnosis of osteoporosis at the axial skeleton in the northeastern Thai women has not been reported.

Objective: The study was aimed to determine the performance of the ultradistal radial BMD in the diagnosis of osteoporosis at the lumbar spines and proximal femur in terms of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and likelihood ratio for positive and negative test.

Design: Retrospective, descriptive study

Setting: Srinagarind Hospital, Faculty of Medicine, Khon Kaen University

Study methods: Results of 592 BMD measurements simultaneously performed at all three skeletal sites including lumbar spines, proximal femur and ultradistal radius from May 1998 to August 2000 of all consecutive women were retrospectively reviewed and classified as non-osteoporosis and osteoporosis according to WHO cirteria. The BMD of the lumbar spines and proximal femur was used to be the standard to determine the diagnostic performance of BMD at the ultradistal radius.

Results: High sensitivity of the ultradistal radial BMD for the diagnosis of osteoporosis at the femoral neck and trochanteric regions, 82.9% and 82.5% respectively, was found but the sensitivity for L_{2-4} was only 37.5%. Specificity and NPV for the lumbar spines and proximal femoral regions were very high, whereas the likelihood ratio for the positive test for the proximal femoral region was better than that for the lumbar spine region.

Conclusion: The ultradistal radial BMD measurement is a promising method as a screening for the diagnosis of osteoporosis at the proximal femur but it is of limitation when applied for the lumbar spines.

Key words: BMD, Ultradistal radius, Osteoporosis, Diagnostic performance

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INTRODUCTION

Over the past decade, osteoporotic fractures have come to be recognized as one of the most serious problems in public health.[1,2] The growing awareness of the impact of osteoporosis on the elderly and postmenopausal population and the development of new treatment modalities have led to a rapid increase in the demand for bone densitometry services.[3] It has been accepted that dual-energy X-ray absorptiometry (DEXA) is the most appropriate technique for bone mineral density (BMD) measurement because of its high accuracy, high precision and low radiation exposure.[4-6] The common sites of BMD measurement are those at high risk of fracture including lumbar spines, hip and forearm. However, the study at the forearm has some advantages over at the axial skeletal sites, such as lower radiation dose, lower cost, more patient's comfort and faster scan time. Moreover, it is not affected by abnormal calcification or degenerative change as in the antero-posterior spinal BMD measurement.[7] Although high correlation between the forearm BMD and the axial BMD, both lumbar spines and proximal femur, have been reported,[8-9] few studies regarding performance of the forearm BMD in the diagnosis of osteoporosis at the axial skeleton have been reported. [10-12]

One of the forearm regions commonly measured for BMD is the ultradistal radius. It is located approximately between 10-mm to 25-mm proximal to the level of the tip of ulnar styloid process[13] and is the area that has high trabecular to cortical bone ratio, of about 60%: 40%, comparable to the vertebral body and has been recognized a sensitive area in the detection of alteration of bone mass.[14]

We, therefore, conduct this study to determine the performance of the ultradistal radial BMD in the diagnosis of osteoporosis at the lumbar spines and proximal femur according to the World Health Organization (WHO) criteria in terms of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and likelihood ratio for positive and negative test.

MATERIALS AND METHODS

The studied population was women who were referred for BMD measurement at the Division of Nuclear Medicine, Department of Radiology, Srinagarind Hospital, Faculty of Medicine, Khon Kaen University from May 1998 to August 2000. Their medical records and results of BMD measurement were retrospectively reviewed. The inclusion criterion was women who had the BMD measurement at all three parts of the skeleton-lumbar spines, proximal femur and ultradistal radius. The exclusion criterion was those who had the history of fracture.

The recorded data included age, weight, height, body mass index (BMI) and BMD with T-score at these various sites including antero-posterior lumbar spines (L_1, L_2, L_3, L_4, L_{2-4}), femoral neck, Ward's triangle, trochanteric region, total proximal part of the non-dominant femur and ultradistal part of the non-dominant radius.

The BMD was measured using DEXA technique of EXPERT-XL bone densitometer of Lunar Corp, USA, by the standardized well-trained technician. Quality control of the instrument was undertaken daily, using the standard phantom with automatic software program by technicians under the supervision of an experienced nuclear medicine physician. Precision error of each site of measurement was about 1-2%. The BMD of all sites was classified as non-osteoporosis or osteoporosis for further analysis. T-score of the studied subject was calculated using the BMD database from the

normal Japanese population. The T-score > –2.5, as normal or osteopenia according to WHO criteria, was classified as non-osteoporosis, whereas the T-score ≤ –2.5 was classified as osteoporosis. BMD of the axial skeletal sites, as non-osteoporosis or osteoporosis, was then used to be the standard to determine the diagnostic performance of BMD of the ultradistal radius.

The tabulated data were edited and analyzed using SPSS program for Windows, version 9.0. Sensitivity, specificity, PPV, NPV, likelihood ratio for positive and negative test of the axial BMD determined by the ultradistal radial BMD were shown. The continuous data including age, weight, height, BMI and BMD were reported as mean ± standard deviation (SD). The prevalence of osteoporosis and all diagnostic performance parameters were shown as percentage or ratio. This study was approved by the Ethics Committee of Faculty of Medicine, Khon Kaen University.

RESULTS

Of all subjects referred for BMD measurement during the studied period, 477 cases meeting our criteria were recruited. Almost all subjects were from the northeast of Thailand. Two hundred and sixty cases (55.5%) were sent from the Menopause Clinic, Srinagarind Hospital, for baseline BMD measurement, to find evidence of low bone mass or osteoporosis, or to follow-up BMD after a period of hormone replacement therapy, and 217 cases (45.5%) were sent from various other units in order to find the evidence of osteopenia or osteoporosis. From all 477 cases, 71 were studied for 2 times and 22 were studied for 3 times, resulting in overall 592 studies enrolled for analysis.

Baseline characteristics of subjects were shown in Table 1. Using T-score ≤ –2.5, the prevalence of osteoporosis for each skeletal site was demonstrated (Table 2). The prevalence of osteoporosis at the ultradistal radius was higher than that of various regions of the proximal femur and the lumbar spines except at L_1. It was also noted that the prevalence of osteoporosis at the femoral and trochanteric region was very low, 2.2% and 1.4% respectively,

The diagnostic performance parameters in the diagnosis of osteoporosis at various regions of the lumbar spines and proximal femur determined by the ultradistal radial BMD were shown in Table 3 and 4 respectively. Very high specificity and NPV of the ultradistal radial BMD in the diagnosis of osteoporosis at the lumbar spines and proximal femoral regions were observed. Sensitivity of the ultradistal radial BMD in the diagnosis of osteoporosis at the proximal femoral regions was high, while sensitivity for the diagnosis at the lumbar regions was relatively compromised. Low PPV for the diagnosis at the lumbar spines and proximal femur was observed, more prominent at the femoral neck, trochanteric region and total proximal femur. The likelihood ratio for the positive test was highest at the trochanteric region and was lowest at the L_{2-4} spines.

Table 1. Baseline characteristics of the subjects (N=477 cases, 592 studies).

Characteristics	Value
Age (y)	
mean ± SD	52.1 ± 8.5
range	28 - 88
Weight (g)	
mean ± SD	57.4 ± 8.4
range	37 - 85
Height (cm)	
mean ± SD	154.9 ±+ 5.6
range	133 - 175
BMI (kg/m^2)	
mean ± SD	23.9 ± 3.4
range	16.2 - 38.4
BMD (g/cm^2)	
mean ± SD	
L_1	0.908 ± 0.178
L_2	1.004 ± 0.184
L_3	1.086 ± 0.183
L_4	1.091 ± 0.182
L_{2-4}	1.063 ± 0.171
Femoral neck	0.874 ± 0.136
Ward's triangle	0.721 ± 0.153
Trochanteric region	0.749 ± 0.125
Total proximal femur	0.945 ± 0.136
Ultradistal radius	0.319 ± 0.059

Table 2. Prevalence of osteoporosis in each skeletal site diagnosed by using T-score ≤ -2.5 SD criteria (N=592 studies)

Skeletal sites	Prevalence	
	N	(%)
L_1	125	21.1
L_2	89	15.0
L_3	40	6.8
L_4	45	7.6
L_{2-4}	64	10.8
Femoral neck	13	2.2
Ward's triangle	80	13.5
Trochanteric region	8	1.4
Total proximal femur	10	1.7
Ultradistal radius	108	18.2

Table 3. Performance of ultradistal radial BMD in the diagnosis of osteoporosis at various regions of the lumbar spines.

	Lumbar spines				
	L_1	L_2	L_3	L_4	L_{2-4}
Ultradistal radius					
Sensitivity (%)	42.4	50.6	55.0	55.6	37.5
Specificity (%)	88.0	87.3	84.2	84.6	83.9
PPV (%)	48.6	41.3	20.2	22.9	22.0
NPV (%)	85.1	90.9	96.3	95.9	91.7
Likelihood ratio +	3.5	4.0	3.5	3.6	2.3
Likelihood ratio -	0.7	0.6	0.5	0.5	0.7

Table 4. Performance of ultradistal radial BMD in the diagnosis of osteoporosis at various regions of the proximal femur.

	Proximal femur			
	Neck	Ward's	Trochanter	Total
Ultradistal radius				
Sensitivity (%)	76.9	58.8	87.5	80.0
Specificity (%)	82.9	87.9	82.5	82.6
PPV (%)	9.2	43.1	6.4	7.3
NPV (%)	99.4	93.2	99.8	99.6
Likelihood ratio +	4.5	4.9	5.0	4.6
Likelihood ratio -	0.3	0.5	0.2	0.2

DISCUSSION

Although osteoporosis is described conceptually as 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,[15] it may not occur at all skeletal sites at the same time, of the same severity and in the same individual. Using WHO criteria as a T-score of $\leq$ -2.5, we found a wide variety of prevalence of osteoporosis in the three skeletal sites studied, varying from 1.4% at the trochanteric region to 21.1% at L_1. These findings corresponded to those of a recent large study from Japan, which reported a fivefold difference among the prevalence of osteoporosis at different skeletal sites with lower prevalence at the hip as compared with that at the lumbar spines and distal one-third of the radius.[16] Variations in the prevalence of osteoporosis with skeletal sites of BMD measurement have been reported in the literature.[17-18] This showed that using a unique T-score of $\leq$ -2.5 might not be appropriate to be applied to different sites in the diagnosis of osteoporosis. Recently, the WHO diagnostic guidelines were updated and were clearly stated that the diagnosis of osteoporosis by T-score $\leq$ -2.5 was applicable only to measurements at the hip and possibly the spine.[19]

From our findings regarding the diagnostic performance of the ultradistal radial BMD, because of high sensitivity for the femoral neck and trochanteric regions, 76.9% and 87.5% respectively, the ultradistal radial BMD measurement could be the method in the screening for evidence of osteoporosis at these two common sites of fracture. Moreover, it also provided very low false positive rate owing to high specificity in these two regions. Very low PPV for the diagnosis of osteoporosis at the femoral neck and trochanteric regions was observed, 9.2% for the femoral neck and 6.4% for the trochanteric region and could be resulted from very low incidence of osteoporosis in these regions, 2.2% and 1.4% respectively. Thus if we apply this in the higher prevalence population such as in the elderly or high risk individuals, the PPV would be higher than that in this study. The likelihood ratio of positive test for the femoral neck was 4.5 which is fair and for the trochanteric region was 5.0 which was rather good. It means that the ratio of probability between those being osteoporotic and those being non-osteoporotic in the positive-test individuals is acceptable.

For the diagnosis at the lumbar spines, although providing very high specificity and NPV, the ultradistal radial BMD seemed too compromised to be used as a screening test because of too low sensitivity, especially at the L_{2-4}. In addition, the likelihood ratio for positive test for the lumbar spines was not good as that at the proximal femoral regions.

Regarding other previous study in Thai population, Trivitayaratana W et al.[10] reported the accuracy of BMD at distal 1/10 of radii in the identification of non-forearm osteoporosis in Thais and found high NPV, varying from 71.43% to 96.88%, in the diagnosis of osteoporosis at the lumbar spines, hip, femoral neck and Ward's triangle.[19] These figures were comparable to those in our study. However, sensitivity and PPV from their study were clearly higher than those in our study, whereas specificity was somewhat lower. The difference in PPV could be attributed to the prevalence of osteoporosis in the studied population. Since their studied population was recruited from the elderly club which certainly had a higher prevalence of the disease than that in our studied population, which was mostly from the Menopausal Clinic. Moreover, they used the distal 1/10 radius region, not the ultradistal radius, in identifying non-forearm osteoporosis, whereas we chose the ultradistal radius because of, unlike the distal 1/10, its availability in the software of our instrument. Although these two regions are close proximity, they have different onsets and rates of trabecular and cortical bone losses. Diagnostic discrepancies between these two closely related forearm sites of BMD measurement, distal and ultradistal, were recently reported in Bulgarian population by Boyanov M and were found to be more pronounced after the age of 60.[18]

However, our study had some drawbacks. T-scores used in the study were calculated from the Japanese BMD database, which might not be suitable for the diagnosis of osteoporosis in the northeastern Thai women. In addition, since most of our studied population came from the Menopause Clinic, the prevalence or pretest probability of osteoporosis therefore might not be the same as that in the general population. Accordingly, the diagnostic performance obtained might not be the same.

In conclusion, the ultradistal radial BMD measurement is a promising method as a screening for the diagnosis of osteoporosis at the proximal femur but it is of limitation when applied for the lumbar spines. Further studies should be carried out on the basis of population-based, especially focussing at the proximal femoral region and it will be better if the northeast Thai BMD database or Thai BMD database was used in stead of the Japanese database.

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