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ORIGINAL RESEARCH ARTICLE

COMPARATIVE STUDIES OF BONE DENSITY BY QUANTITATIVE ULTRASOUND (QUS) WITH DUAL-ENERGY X-RAY ABSORPTIOMETRY (DEXA) SCAN

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ABSTRACT

Background: The aim of the study was to establish the correlation quantitative ultrasound (QUS) between and dual-energy X-ray absorptiometry (DEXA) and to assess the ability of QUS as a screening tool for osteoporosis.

Methods: The study was conducted on 115 patients. All the patients underwent QUS of radius using Sunlight MiniOmni bone sonometer and DEXA screening for measurement of bone mineral density (BMD) at lumbar spine, total left & femoral neck and radius.

Results: Significant correlations were observed between QUS and DEXA T score.

Conclusions: QUS is a sensitive screening tool to detect changes in the bone mass and risk of osteoporosis.

INTRODUCTION

Diabetes Osteoporosis, which literally means "porous bone", is a disease in which the density and quality of bone are reduced. The loss of bone occurs "silently" and progressively. Often there are no symptoms until the first fracture occurs.[1] It is the commonest metabolic bone disease in clinical practice and is a major public health problem as commonly it is underdiagnosed.[1] The term osteoporosis is used without a clear indication of its meaning. It may describe clinical end result that is fracture and the process that gives rise to it.[2]

Osteoporosis is defined as "a systemic skeletal disease characterized by low bone mass and micro-architectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fracture".[1,3] This definition indicates that measurement of bone mineral density (BMD) is a central component to diagnosis of the disease.[4]

Osteoporosis is one among the five non-communicable diseases of aging. The treatment costs are more expensive after diabetes, hyperlipidemia, hypertension and heart diseases. The incidence is increasing in developing countries as the longevity is increasing in these countries.[5]

The single best technique to measure BMD is dual energy x- ray absorptiometry (DEXA) scan which measures bone mineral density.[1] The limiting factors for use of DEXA, is availability and affordability in our country. On the other hand Quantitative Ultrasound (QUS) of bone to determine the BMD is a easy, inexpensive, portable and without radiation hazard risk. The aim of the study was to evaluate the accuracy of Quantitative Ultrasound with dual energy x- ray absorptiometry for osteoporosis.

METHODS

The study was undertaken in the Diabetes and Endocrinology Unit of National Academy of Medical Sciences, Bir Hospital after due receiving of clearance from Intuitional Review Board. The study was carried out from March 2014 to October 2014, and included 115 patients meeting the inclusion criteria (Age ≥ 65 years, post menopausal, vertebral deformity, primary hyperparathyroidism, glucocorticoid therapy > 5 mg/day of prednisone for > 3 months, chronic obstructive pulmonary disease of duration more than 1 years, chronic kidney disease stage 4-5, post hysterectomy of more than 5 yrs if hysterectomy done less than 45 of age, diabetes of more than 5 years duration and hypogonadism).

The diagnosis of osteoporosis was based on bone mineral density (BMD) measurements and is defined by the World Health Organisation (WHO)[4] as :

1. Normal: a value of BMD or bone mineral content (BMC) ≤ 1 standard deviation (SD) below the young adult average value

2. Osteopenia: a value of BMD or BMC >1 SD below the young adult average value but >2.5 SD above

3. Osteoporosis: a value of BMD or BMC ≥ 2.5 SD below the young adult average value

The data of each patient was recorded in pre-designed Performa which included detailed history regarding menstrual, bone and systemic disease and, drug intake. All the patients under went QUS of radius. Sunlight MiniOmni bone sonometer (BeamMed Ltd., Tel Aviv, and Israel) is specifically designed for assessing speed of sound (SOS) (m/s) of ultrasonic waves, which travel axially along the bones at a centre frequency of 1.25MHz using gel as a coupling agent between probe and skin. SOS was measured at distal one third radius point of the non dominant side of the subject, which was defined as the midpoint of the line between the elbow and the end of the middle finger. The device was calibrated before each data collection session using a verification phantom provided by the manufacturer. The T score was derived for each subject. Moreover, QUS measurements were repeated 3 times with repositioning after erasing the skin mark to calculate variability and average was taken. SOS T-scores were calculated according to the normative data derived from a sex- and age matched Asian population, provided by the manufacturer. All the QUS scans were carried out by a single investigator.

After that all the patients then underwent DEXA scan. Bone mineral density (BMD), which is expressed in grams per centimetre squared (g/cm2), was measured by DEXA technique. The instrument was calibrated daily using a spine phantom supplied by the manufacturer before the measurements. The subjects were then positioned and instructed to stay motionless throughout the scan. Each complete scan took approximately 15 minutes. BMD T-scores were calculated based on the database of normal age- and sex-matched Caucasian population delivered by the DXA manufacturer.

Statistical analysis

Data are presented as mean± standard deviation (SD) for numerical variables and frequency and percentage for categorical variables, unless otherwise stated. Cross tabulation between QUS and DEXA t score was done using chi square test. A receiver operating Characteristics (ROC) analysis was conducted and the area under the curve (AUC) was calculated to evaluate the potential of radial QUS to distinguish subjects with normal and low BMD as diagnosed by DEXA. The corresponding optimal cut-off value for the parameter of radial QUS for the classification of bone status was defined based on the sensitivity and specificity values obtained from the ROC curve. A P value less than 0.05 was considered statistically significant. Statistical analysis was conducted using Statistical Package for Social Sciences (SPSS) version 17.0 for Windows (SPSS Inc., Chicago, IL).

RESULTS

A total of 115 patients were included in this study. Their ages ranged from 26 to 87 years with a median of 60.17 years (SD = 11.948 years). Mean and standard deviation of measured variables are shown in Table 1 and Table 2. T score of QUS and DEXA were cross tabulated as shown in Table 3. ROC was derived and AUC calculated for QUS as shown in Figure 1.

Table 1: Baseline characteristic

Parameters (n=115)	Minimum(years)	Maximum(years)	Mean (years)	SD
Age (years)	26	87	60.17	11.948
Menarche (years)	11	17	13.65	1.515
Age at menopausal (years)	21	66	45.51	5.646
Duration of Menopausal (years)	1	38	12.32	9.334

The mean age of 60.17 years (SD 11.948) was seen. Mean age of menopausal was 45.51 (SD 5.646) and mean duration of menopausal 12.32 (SD 9.334) years.

Table 2: Baseline characteristic

Status	No. of patients	Percentage (%)
No microalbuminuria	116	55.8 %
Microalbuminuria	89	42.8 %
Clinical albuminuria	3	1.4 %

The diabetic patients who had microalbuminuria had significantly longer duration of disease and higher mean HbA1c levels compared to the patients without microalbuminuria. The two groups were not different in age, sex and medication use distribution [Table 3].

Table 3: Demographic variables and HbA1c of the patients expressed as mean ± SD or frequency or median (minimum- maximum) as appropriate based on microalbuminuria status

Parameters(n=115)	Gender	Number	Percentage	P value (DEXA)
Gender	Male	50	43.5	0.24
	Female	65	56.5	
Alcohol consumer	Male	20	45.5	.454
	Female	24	54.5	
Smoker	Male	28	52.8	.395
	Female	25	47.2	
Family history of osteoporosis	Male	13	37.1	.365
	Female	22	62.9	
Family history of fracture	Male	7	38.9	.273
	Female	11	61.1	

History of hysterectomy	Female	16	13.9	
History of Fracture	Male	9	37.5	.507
	Female	15	62.5	
Chronic renal failure	Male	8	34.8	.347
	Female	15	62.5	
Diabetes	Male	18	47.4	.554
	Female	20	52.6	
COPD	Male	9	45.0	0.14
	Female	11	55.0	
Rheumatic arthritis	Male	9	47.4	0.814
	Female	10	52.6	
On steroid	Male	7	33.3	0.036
	Female	14	66.7	
Hyperthyroidism	Male	2	40.0	0.437
	Female	3	60.0	

The study groups had Male 50 (43.5%) and Female 65 (56.5%). Patients who had taken steroid as defined in the inclusion criteria were found to be statistically significant.

Table 4: Correlation QUS with DEXA

QUS T Score	DEXA T Score							
	Radius		Left Femur		Right Femur		Spine	
	>-1	-1 to -2.5	>-1	-1 to -2.5	>-1	-1 to -2.5	>-1	-1 to -2.5
>-1	44	3	36	11	36	11	30	17
-1 to -2.5	20	11	22	9	21	10	21	10
<-2.5	10	27	13	24	16	21	13	24
P value	<0.001		<0.001		0.006		0.009	

When T score derived from QUS of radius and DEXA (4 sites) where compared, all the reading was found to be statistically significant.

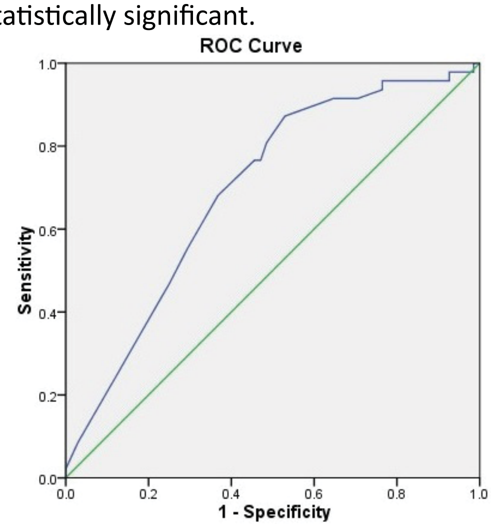

Figure 1 ROC curve for QUS T Score

ROC curve for predicting BMD using Radius bone BMD T-scores. AUC was 0.695 with p value <0.001 (95% Confidence Interval)

DISCUSSION

This study represents a contribution to the use of ultrasound as an adjuvant tool in diagnosis and monitoring of BMD. Ultrasound is a non-ionizing radiation requiring low cost instrumentation and suitable for in vivo bone structure characterization.[6]

The primary objective of the study was to evaluate the ability of QUS in the screening of osteopenia and osteoporosis in comparison to DXA in Nepalese population.

The QUS and DXA devices are based on two distinctly different technologies and measure two different parameters; SOS and BMD. QUS performs measurements of predominantly cortical bone. However, because the diagnosis of osteoporosis concerns assessment of fracture risk and not assessment of bone mass, there is, indeed, a basis for comparison.[7]

The risk of osteoporosis increases with age. Hui et al conducted a study on 521 women and found that increasing age was predictive of increased fracture risk.[8] A patients risk for fracture increases with age even at the same BMD or T Score.

Results from this study demonstrate significant correlation between t score of QUS and DEXA (Table 3).

CONCLUSION

QUS is a sensitive screening tool to detect changes in the bone mass and risk of osteoporosis.

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