Comparison of Bone Density of Distal Radius With Hip and Spine Using DXA

Leila Amiri[1], Azita Kheiltash[2], Shafieh Movassaghi[1], Maryam Moghaddassi[1], and Leila Seddigh[2]

[1] *Rheumatology Research Center (RRC), Tehran University of Medical Sciences, Tehran, Iran*

[2] *Department of Community Medicine, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran*

Received: 08 Jun. 2016; Revised: 09 Jul. 2016, Accepted: 15 Nov. 2016

Abstract- Osteoporosis diagnosis is usually based on examination of the hip bone and vertebrae density; however, the radius bone has gained attention recently in terms of feasibility and accessibility as it is done by portable devices with proper precision. This study aims to compare hip and spine density with radius, knowing whether radius may be an appropriate alternative for osteoporosis diagnosis. 120 females who were referred to one Densitometry Center checked their skeletal status using a hologic unit for densitometry of spine, femoral neck, and one-third radius. The patients were divided into three groups of healthy, osteopenic and osteoporotic based on WHO's protocol. Concordance analysis was done to investigate the degree of similarity of diagnosis. In the study, there were 40, 41, and 39 individuals with normal, osteopenic, and osteoporotic bone densities, respectively which obtained from hip bone or vertebrae using the T-score criterion T-score of radius bone density has a direct linear relationship with these result. Osteoporosis diagnosis can be made based on radius densitometry.

Acta Med Iran 2017;55(2):92-96.

Keywords: Bone densitometry; Radius; Hip; Spine; DXA

Introduction

Osteoporosis is an increasing fundamental problem of public health across the world. According to WHO guideline, it is defined as a systemic disease with low bone mass and hence increased the risk of bone fragility. WHO reports that more than 75 million people in the United States, Europe, and Japan are suffering from the disease, and 8.9 million of them experience a fracture. Therefore, early diagnosis and prevention of the disease progression are necessary for health maintenance, improvement of living standard, and independence in the elderly population (1).

According to WHO, *osteoporosis* is defined as reduced bone density as 2.5 standard deviations (SD) from the average values for bone density among young and normal individuals of a society (*T-score≤-2.5*); and *osteopenia* as reduced bone density between 1 and 2.5 SD less than mean bone density among young and normal individuals of a society (*-2.5<T-score<-1*). WHO defined the density equal or higher than -1 SD of mean as *normal* (2).

At present, due to the high rates of mortality and morbidity of hip fracture and the high costs they impose on societies, prevention from hip fracture has highly gained attentions. Therefore, BMD screening of hip bone is recommended by WHO (3-4). Osteoporosis is usually diagnosed through examination of hip bone and vertebrae, and the radius bone can be used in case of impossibility to examine central bones (5).

Since an early diagnosis and prevention of osteoporosis may prevent high costs as well as fractures of hip and other parts of the skeleton, this study aims to examine density of bones in three sites, comparing consistency of hip and spine results with that of radius, and knowing whether radius may be an appropriate predictor for osteoporosis diagnosis. It is more convenient to make measurements of radius area which is not affected by the artifacts that may exist in areas such as spine (*i.e.* deformity and aortic calcification) (6).

The research project is part of a dissertation conducted under the supervision of Tehran University of Medical Sciences Academics and the dissertation registration no: 9011160005. All dissertations have received official approval from Tehran University of Medical Sciences ethics committee.

Corresponding Author: A. Kheiltash
Department of Community Medicine, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran
Tel: +98 21 64053216, Fax: +98 21 88952357, E-mail address: kheiltash@tums.ac.ir

Materials and Methods

This cross-sectional study examined 120 females who were referred to Shahid Shourideh Densitometry Center in 2013 in Tehran to check their skeletal status as recommended by their physicians by bone densitometry. They are included in the study in consecutive order. All patients signed informed consent forms. Besides, as it was a dissertation project the ethical approval was granted by the ethical committee of the university.

Their hip, femur, and radius bone densitometry documents are available in this center. Almost all menopausal women were referred for evaluation of the effect of menopause on their bone status. However, the underlying reasons for nonmenopausal referral for investigation were not written in their BMD reports. A Hologic unit was used for densitometry of the patients in the spine, femoral neck, and one-third radius. The MRI of three places has been done on each patient in one day.

In order to analyze the data, the patients were then divided into three groups of *healthy*, *osteopenic* and *osteoporotic* as WHO's protocol. The variable named "final result" is based on the lowest scored obtained from hip bone or vertebrae using the T-score criterion which is in agreement with WHO's clinical guideline. For concordance analysis, degrees of concordance were divided into three subgroups of major discordance, minor discordance, and concordance. Based on the categorization, *major* discordance means that one of the results indicates osteoporosis and the other shows normal result. *Minor* discordance means that one group is normal and the other is osteopenic and/, or one group is osteopenic, and the other is osteoporotic. Concordance means that the two groups are identical. Finally, data analysis was done by calculating mean, frequency and Pearson correlation coefficient using SPSS software version 11.5.

Results

Bone densitometry was performed in this study in three bone sites (hip, vertebrae, and radius). Seventy-eight women (65%) were menopause. Mean age of the participants and onset age of menopause among menopausal females were 53.7 and 47.5 years, respectively. Table 1 shows specifications of the participants.

Table 1. Characteristics of participants

		Mean	Min	Max
Age(year)		53.7	25	86
Age of menopause		47.5	34	57
Height (cm)		157.0	138	173
Weight (Kg)		68.7	39	110
BMI		27.8	17.4	44.1
Menopause	**(Y)**		78(65%)*	
	(N)		43(35%)	

*Number (frequency %)

According to WHO's clinical guideline, the result of bone densitometry is based on the lowest scored obtained from hip bone or vertebrae using the T-score criterion. (in our study we called it "final result) With respect to this standard for diagnosis, in the study, there were 40, 41, and 39 individuals with normal, osteopenic, and osteoporotic bone densities, respectively (Table 2).

Table 2. Classification of T-scores according to the WHO Criteria

Group	FN	LS	R	Final result
	N (%)	N (%)	N (%)	N (%)
Normal (T>=-1)	67(55.8)	47(39.2)	35(29.2)	40(33.3)
Osteopenic (-2.5<T<-1)	41(34.2)	39(32.5)	51(42.5)	41(34.2)
Osteoporotic (T=<-2.5)	12(10)	34(28.3)	34(28.30	39(32.5)
Total number		120		

FN: T score of hip (femur neck), LS: lumbar spine, R: 1/3 radius, Final result: considered as lowest T score of FN or LS

Correlation analysis was performed between radial bone density and the final result based on T-score for all participants, menopausal females, and non-menopausal females. The results showed a statistically significant correlation in all subgroups (Table 3).

Table 3. Correlation of radius density and Final result (T-score) in three subgroup

	r[b]
All cases[a]	0.689(**)
Menopause	.0.616(**)
Menopause<=65[c]	0.573(**)
Menopause 65<	0.738(**)
Non menopause	0.719(**)

a: Menopause and non-menopause, b: Pearson correlation
c: Age group ** significant at the 0.01 level

T score of radial bone density has a direct linear relationship with the final result which is illustrated by scatter plot (Figure 1).

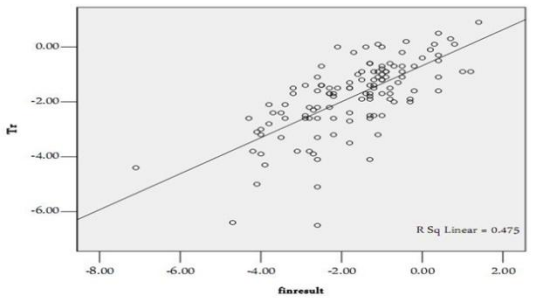

Figure 1. Scatter plot showing correlation between radius (Tr) and the end result (finresult) based on T-Score. (r= 0.689) with significance level <0.001

T score concordance between the radius and final result for all the individuals and menopausal females was examined after grouping T scores of the radius and final result based on WHO's clinical guideline into three groups of normal, osteopenic, and osteoporotic. Table 4 shows the frequency of individuals in each group. This analysis was performed for all the participants and menopausal group. Frequencies of major and minor discordance in the groups consisting of all the participants and menopausal females are almost equal. The frequency of concordance for all the individuals and menopausal females is far beyond discordance. That is, the frequency of concordance in the group consisting of all participants is 58%, and discordance with respect to minor and major is 42%. For the menopausal females, these rates are respectively 59% and 40.5% (Table 4).

Table 4. Distribution of diagnostic discordances using WHO criteria

	All cases(n=120)		Menopause cases(n=78)	
	No.	**(%)**	**No.**	**(%)**
		Major T-score discordance		
Radius osteoporosis, normal final result	1	2(2%)	1	2(2.5%)
Radius normal, osteoporosis final result	1		1	
		Minor T-score discordance		
Radius osteoporosis, osteopenia final result	9		6	
Radius osteopenia, normal final result	15	48(40%)	7	30(38%)
Radius normal, osteopenia final result	10		6	
Radius osteopenia, osteoporosis final result	14		11	
		T-score concordance		
Radius and Final result normal	24		7	
Radius and Final result osteopenia	22	70(58%)	17	46(59%)
Radius and Final result osteoporosis	24		22	

Moreover, regarding upgrading when using radius density for diagnosis, radius density in almost 20% of patients show lower density than the final result. That is, 9 subjects were reclassified as osteoporotic based on a scan of the radius when scans of the femur and spine suggested they were only osteopenic, and 15 patients were reclassified as osteopenic when scans of the femur and spine suggested they were normal (Table 4).

Discussion

This study specified that radius density has a statistically significant linear correlation with the result of hip or spine density i.e. final result on which the osteoporosis diagnosis based. This was seen in all the menopausal and non-menopausal subgroups and the whole participants.

The study of Rajesh Patel conducted in England showed that instead of hip and spine, only radius densitometry results could be used for osteoporosis diagnosis; however, it might have a different threshold limit value (TLV). It means that the diagnostic application of forearm densitometry with a lower threshold of about -2.1 instead of -2.5 has value as much as the ones of central densitometry (hip and spine) (7). Moreover, they found correlation coefficients (Z-scores) of 0.56 for forearm vs. spine, 0.58 for forearm vs. femoral neck (7). Which is almost in accordance with our finding regarding correlation coefficients between the radius and final result (r=0.689). Besides, Clowes *et al.*, found that distal forearm BMD from DXA had a 98% sensitivity and 72% specificity for total hip T-score in the osteoporotic range, with r=0.686 and AUC 0.896(15).

Patel study in London (2006) discussed the effect of osteoporosis risk factors on forearm densitometry whose effects on the density of central bones (hip and spine) have already been proved. The study showed that forearm bone density was reduced clearly in the females who had a history of non-traumatic fracture, a family history of osteoporosis, BMI<20, or a diagnosis of osteopenia based on radiography, and with increasing risk factors, Z-Score declines progressively in the individuals. Therefore, the influence of the risk factors effective on low forearm bone density is similar to hip and spine (8). As a result, it is expected to obtain equivalent results from radius densitometry and hip and spine densitometry. Similarly, in the current study with regard to upstaging, only 20% of patients' results upstaged after revealing the radius bone densitometry results, while nearly 60% of patients' densitometry classification did not change.

This study examined the concordance of densitometry performed on spine or hip (based on them we have final results) and radius among *osteoporotic*, *osteopenic*, and healthy groups. The frequency of concordance in the whole group and in the menopausal females was about 60%, followed by minor discordance as about 38%, and major discordance with the lowest frequency (about 2%) in both groups. Some earlier studies discussed discordance among lumbar spine and hip. In one study the rate of concordance, minor discordance, and major discordance were 53.9, 41.6, and 4.4 percent, respectively (9). Other studies also obtained similar results (10-12). It is noticed that major discordance is not a common finding and this percentage was also low in our study. In other words, as the lowest value related to hip or spine is a diagnostic criterion for diagnosing osteoporosis (to obtain the final result), frequency rates of different concordances between two measurements of hip and spine that were evaluated in other studies are similar to the different concordance of the radius with the final result. As concordance and minor discordance have the highest frequency rates, radius densitometry can also be used as an osteoporosis diagnostic criterion.

On the other hand, in Japan, a study discussed and compared densitometry of spine and peripheral bones (radius). The study results indicate that although spine densitometry is affected by some confounding factors such as degenerative and hypertrophic changes, its accuracy for monitoring exceeds radius densitometry (13).

Miller *et al.*, studied peripheral bones densitometry, which predicts fracture in the same bone and/or other sites in the future (14). The results of this study indicate that radius bone density may be a suitable alternative for diagnosis of osteoporosis as compared with central bones. In fact, it confirms that an osteoporosis diagnosis can be made based on only radius density.

Besides, the study has some limitations. First, the sample size compared to some other studies, particularly in menopausal women was low. Second, the sample collection was not multicentric which could help to determine the predictors more precisely. Third, according to previous studies, weight, BMI and age have strong correlation with BMD values (16), so it would be better to check concordance in these subgroups. The last but not the least, not every woman could remember the exact date of her menopause so; calculation of its

duration until undergoing densitometry is subjected to error.

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