Comparison of Bone Mineral Densitometry at 2 Sites Versus 3 Sites in Patients Suspicious for Osteoporosis

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ABSTRACT

OBJECTIVES: In this study, we aim to evaluate the bone mineral density (BMD) results of 2 standard sites with 3 sites including wrist in diagnosing osteoporosis.

METHODS: We evaluated the BMD results of 1272 individuals referred for suspected osteoporosis between 2012 and 2015. Those individuals were included with BMD at lumbar spine, femur neck, and wrist. Bone mineral density was measured using a dual-energy X-ray absorptiometry (DXA) device. Bone mineral density and *T* score were measured for all 3 sites.

RESULTS: There was significant correlation between wrist *T* score with hip *T* score ($r = 0.606$, $P < .001$) and lumbar *T* score ($r = 0.527$, $P < .001$). With BMD of 2 sites, patients had osteopenia in 46.3% and osteoporosis in 23.7%, while by adding wrist T-BMD, subjects had osteopenia in 46.6% and osteoporosis in 33%. Between BMD at 2 sites and 3 sites, there was concordance in 81.9%, minor discordance in 17.6%, and major discordance in 0.5%.

CONCLUSIONS: We observed discordance between BMD measurements of 2 sites and 3 sites, with latter detecting more cases with osteoporosis. In fact, measurement of *T* scores of wrist along with lumbar and femur neck improves the diagnosis.

KEYWORDS: bone mineral densitometry, dual-energy X-ray absorptiometry, osteoporosis, concordance

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Introduction

Osteoporosis is the most common metabolic bone disease that causes an increased risk of fractures.[1] It is associated with increased rate and costs of hospital admission and medical treatment due to the osteoporotic fractures and its complications.[2–4] Low bone mineral density (BMD) is a risk factor of osteoporotic fracture.[5,6] Bone mineral density measurement of femoral neck and lumbar spine is the gold standard for evaluating osteoporosis,[7] with good accuracy and high precision.[8]

There is discordance in *T* score between the lumbar spine and hip in the reported literature,[9–12] so it is recommended that BMD at both sites should be measured and the lowest *T* score should be used for the diagnosis of osteoporosis.[13]

Hip, lumbar spine, and wrist are considered as the best areas for BMD assessment.[14] Fragility fractures at the femur or compression fractures in the lumbar spine or spondylosis with osteophyte formation would show falsely no osteoporosis in BMDs, which can predispose patients to fractures.[15,16] It is important to diagnose patients with osteoporosis at risk of fracture to initiate proper treatment and prevent these fractures.

Bone loss is not a homogeneous process in different parts of the skeleton.[17] Bone mineral density of peripheral sites including heel, wrist, metacarpals, and phalanges could also help identify patients at risk of fractures.[18,19] Different studies have stated that peripheral sites like wrist BMD could be a better representative of osteoporosis than central sites including lumbar spine and femoral neck.[18,20]

Due to the discordances between different sites and possible role for wrist BMD, we aim to compare the BMD results of 2 standard sites with wrist and 2 central sites.

Materials and Methods

In this retrospective study, 1272 individuals who underwent bone densitometry (BMD) for suspected osteoporosis between 2012 and 2015 were evaluated. Indications for BMD were old age in 272 subjects (24 men and 248 women), corticosteroid use for different rheumatologic or dermatologic diseases in 604 subjects (135 men and 469 women), and suspicious osteoporotic fractures in 396 subjects (54 men and 342 women). All examinations took place at the same institution. Patients with active hepatic disease, thyroid and parathyroid diseases (all patients with abnormal parathyroid hormone (PTH), calcium, and phosphorus levels were excluded), high erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP), patients with a history of bisphosphonate use at any time and raloxifene use of more than 2 years, use of teriparatide, history of any wrist or nonwrist fracture, severe degenerative joint disease (DJD) of the wrist due to the patient's complaint and

Table 1. Comparison of *T* scores between sex and menopausal state.

		FEMUR *T* SCORE	*P* VALUE	LUMBAR *T* SCORE	*P* VALUE	RADIUS *T* SCORE	*P* VALUE
Sex	Male (n = 213)	−0.99 ± 1.09	.01	−1.25 ± 1.47	.59	−1.80 ± 1.62	.02
	Female (n = 1059)	−1.23 ± 1.32		−1.31 ± 1.41		−1.54 ± 1.51	
Women	Premenopausal (n = 643)	−0.66 ± 1.01	<.001	−0.76 ± 1.16	<.001	−0.77 ± 1.00	<.001
	Menopause (n = 416)	−1.60 ± 1.36		−1.66 ± 1.44		−2.04 ± 1.58	

physical examination, connective-tissue disease with erosive decrement of the wrist, and clinical signs and symptoms of connective-tissue disease, secondary osteoporosis, and diabetes were excluded. Ethics committee of Ardabil University of Medical Sciences approved the study. Baseline variables including age, sex, and menopausal status were recorded for all patients.

Bone Mineral Density Measurements

BMD was measured by dual-energy X-ray absorptiometry (DXA; Hologic Inc., Marlborough, MA, USA) and by trained examiners. A single machine was used for the entire study. Measurement sites were femoral neck, lumbar spine (L1-L4), and wrist. Results are reported as g/cm^2 and presented as *T* score, after adjusting for age and weight. For lumbar spine (L-spine) BMD measurements, BMD was calculated excluding the affected vertebrae when specific vertebrae were not suitable for analysis because of compression fractures, degenerative changes, or any other reasons. The area of BMD (g/cm^2) was measured at the distal one-third radius of nondominant wrist. Trained technicians carried out all examinations and performed daily calibrations of the densitometers with equipment-specific phantoms.

Bone mineral density results were interpreted as osteoporosis (*T* score less than or equal to −2.5), osteopenia (*T* score between −1 and −2.5) and normal (*T* score higher than −1) according to the World Health Organization definition.[21] We calculated the BMD once using the femoral neck and lumbar spine and once including wrist to the measurement to evaluate the rate of osteoporosis with these 2 methods.

The results of 2 methods were compared in each patient and classified as having concordance (osteoporosis, osteopenia, or normal BMD at both sites), minor discordance (osteoporosis at one site and osteopenia at the other site or osteopenia at one site and normal at the other site), and major discordance (osteoporosis at one site and normal at the other site).

Statistical Analysis

Statistical analysis was performed using SPSS 17 (SPSS Inc., Chicago, IL, USA). Results were presented as means and standard deviations (SDs) or frequency and percent. Independent *t* test and chi-square test were used to compare results between groups. McNemar test was used to compare the effect between 2- and 3-site BMD measurement methods. The correlation between age and *T* scores of lumbar, femur, and radius was evaluated using Pearson correlation. *P* values <.05 were considered significant.

Results

Of 1272 subjects, 213 (16.7%) were men and 1059 (83.3%) were women. Subjects' mean age was 54.71 ± 11.86 years with the age range of 39-85 years. Among women, 643 (50.6%) attained menopause. *T* score of femoral neck, lumbar spine, and wrist were −1.19 ± 1.29, −1.30 ± 1.42, and −1.58 ± 1.53, respectively.

Significant negative correlations were found between age and *T* scores of hip ($r = -0.457$, $P < .001$), lumbar spine ($r = -0.346$, $P < .001$) and wrist ($r = -0.505$, $P < .001$) with the weakest correlation with lumbar *T* score. We also observed significant correlation between wrist *T* score with hip *T* score ($r = 0.606$, $P < .001$) and lumbar *T* score ($r = 0.527$, $P < .001$). According to Table 1, women had significantly lower *T* score in femoral neck and wrist; among women, there were significantly lower *T* scores of femur, lumbar, and radius in menopause women.

Among total study population, patients had normal BMD in 377 (29.6%) cases, osteopenia in 593 (46.3%) cases, and osteoporosis in 302 (23.7%) cases according to *T* scores of hip and lumbar spine. Adding radius *T* score to the above-mentioned *T* scores, results changed to normal BMD in 259 (20.4%) cases, osteopenia in 593 (46.6%) cases, and osteoporosis in 420 (33%) cases. Between BMD at 2 sites and 3 sites, there was concordance in 1042 (81.9%), minor discordance in 224 (17.6%), and major discordance in 6 (0.5%).

Minor and major discordance between 2 methods were 53 (24.9%) and 3 (1.4%) in men and 171 (16.1%) and 3 (0.3%) in women. Also, menopause and premenopause women had minor discordance in 116 (18%) and 55 (13.2%) and major discordance in 2 (0.3%) and 1 (0.2%).

Bone mineral density results in 2 methods are demonstrated between sex and menopause state in Table 2. Men and women were similar regarding BMD in 2 methods. In both methods, osteoporosis was significantly higher in menopause women compared with premenopause ones.

Table 2. BMD results in 2 methods are demonstrated between sex and menopause state.

		NORMAL	OSTEOPENIA	OSTEOPOROSIS	*P* VALUE
BMD of femur and lumbar					
Sex	Male	67 (31.5%)	99 (46.5%)	47 (22.1%)	.74
	Female	310 (29.3%)	494 (46.6%)	255 (24.1%)	
Women	Menopause	114 (17.7%)	301 (46.8%)	228 (35.5%)	<.001
	Premenopause	196 (47.1%)	193 (46.4%)	27 (6.5%)	
BMD by femur, lumbar, and wrist					
Sex	Male	32 (15%)	110 (51.6%)	71 (33.3%)	.08
	Female	227 (21.4%)	483 (45.6%)	349 (33%)	
Women	Menopause	77 (12%)	255 (39.7%)	311 (48.4%)	<.001
	Premenopause	150 (36.1%)	228 (54.8%)	39 (9.1%)	

Abbreviations: BMD, bone mineral density.

We divided BMD results in both methods and normal and abnormal BMD. Using McNemar analysis, BMD measurement using 3 sites had significantly diagnosed more cases with abnormal BMD compared with BMD of 2 sites.

Discussion

In this report, we evaluated the role of central BMD compared with peripheral BMD in diagnosing osteoporosis and observed higher rate of osteoporosis considering BMD of 3 sites compared with BMD of lumbar and femur neck. All 3 sites had lower BMD. We observed significantly lower *T* score in femur and radius in women compared with men and in menopause compared with premenopause women. We also find significant decrease in BMD in older age.

Previous studies have shown that osteoporosis is age-related and gender-specific with higher prevalence in women than men.[22] The effect of low estrogen, multiparity and prolonged lactation should also be considered as the cause for this difference.[23–25]

The correlation between different measurement sites has been reported previously. We observed significant correlation between radius *T* score with femur *T* score and lumbar *T* score, with the strongest correlation between radius and femur neck *T* score. However, Eftekhar-Sadat et al[18] in a study on menopause women reported poor correlation between wrist BMD with hip and lumbar BMD. The correlation between wrist and hip BMD in their study was also stronger than wrist and lumbar BMD, similar to our findings. These correlations have been reported in other studies as well.[26,27] However, the observed correlations between central and peripheral BMD were usually poor ranging between $r = 0.5$ and 0.65.[26]

It is possible that wrist BMD could increase the accuracy of BMD in diagnosing osteoporosis. The lower correlation between hip and wrist with lumbar BMD reported in the literature could be due to degenerative changes in lumbar spine, which reduces the osteoporosis prevalence of lumbar spine in comparison with other sites.[18]

Our patients had osteopenia and osteoporosis in the rate of 46.3% and 23.7%, respectively, using *T* scores of lumbar and femur neck, while adding *T* score of radius increased the osteoporosis rate to 33%. We observed concordance in 81.9%, minor discordance in 17.6%, and major discordance in 0.5% between *T* scores of 2 sites and 3 sites. Similar to our findings, Abdelmohsen[20] reported that in postmenopausal women, wrist BMD is lower than hip and lumbar BMD and that wrist BMD could show more cases with osteoporosis. Ilic Stojanovic et al[19] also indicated discordance in *T* scores at different skeletal sites.

Clinicians need to be aware of the possibility of discordance with BMD results and plan management strategies appropriately.[28–30] Minor discordance may not influence the therapeutic plan unless one site is normal and the other site is determined to have osteopenia. It will be more appropriate in such situations to consider other risk factors and plan the management accordingly. In the areas with higher risk of fracture, detecting osteoporosis would help for proper treatment to decrease and prevent the fracture. In our subjects, although the minor discordance was 17.6%, but the rate of major discordance was low; however, even detecting these cases of missed osteoporosis is necessary to provide an appropriate preventive and medical therapy to avoid the occurrence of a low-energy fracture. We also observed that men were more likely to show discordance in BMD at 2 and 3 sites, while women showed lower rate of discordance with higher discordance among menopause women.

Except for our results, no other studies have evaluated the discordance between 2 sites with 3 sites in BMD results. According to studies comparing results between hip and lumbar BMD or with peripheral BMD, different causes have proposed for this discordance such as physiologic, pathophysiologic

and anatomic causes, artifacts, and technical problems in measurement.[31] Studies have reported that weight-bearing bones such as hip and femur have higher BMD.[32] The degenerative changes in lumbar spine and vertebrae are considered as pathophysiologic discordance.[33,34] The measurement of different areas are considered as anatomical discordance, and having dense metals within the region of the interest as artifact discordance and device errors, technician variability and patients' movement are considered as technical discordance.[7] Older age, menopause, obesity, belated or premature menopause, and multiple pregnancies were also suggested as possible factor affecting diagnostic discordance.[9–12]

Overall, considering the possible discordance between *T* scores of different measured areas, it seems that measurement of central BMD along with peripheral BMD would increase the accuracy of our measurement.

Limitation

This is a single-center study, which could limit generalization to larger population. Gathering data from other centers would make the results more reliable. The age could be another limitation for generalizing these data, although the subjects were selected from a population of patients sent to an osteoporosis testing center because they were deemed by their physician to be at risk of osteoporosis. The age range of patients could be a limitation and cause for osteoporosis. However, the large sample size of the study population was the strength of our study.

Conclusions

In conclusion, there is discordance between BMD measurements of 2 sites and 3 sites, with latter detecting more cases with osteoporosis. In fact, measurement of *T* scores of wrist along with lumbar and femur neck improves the diagnosis.

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Author Contributions

Each author made significant individual contributions to this manuscript. AZa and AH drafted the manuscript. AZi, AH, and HA gathered clinical data. MI, AA, and AH evaluated the data from the statistical analysis. AZa, AH, AA, and HA performed the literature search, reviewed the manuscript, and contributed to the intellectual concept of the study.

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