Original Article

Major and Minor Discordance in Dual-Energy X-Ray Absorptiometry Diagnosis of Osteoporosis – A Cross-Sectional, Population-Based, Observational Study in Indian Women

Tulika Singh[1], Adarsh Ghosh[1,2], Niranjan Khandelwal[1], Veenu Singla[1], Madhu Gupta[3]

[1]Department of Radiodiagnosis and Imaging, Postgraduate Institute of Medical Education and Research, Chandigarh, [2]Department of Radio Diagnosis, AIIMS, New Delhi, [3]Department of Community Medicine, School of Public Health, Postgraduate Institute of Medical Education and Research, Chandigarh, India

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ABSTRACT

Objective: The study objective was to evaluate the presence of major and minor discordance in the diagnosis of osteoporosis in a population-based screening program of Indian women using hip and spine dual-energy X-ray absorptiometry (DEXA). **Methods:** In this institutional review board-approved study, a population-based screening program was offered to women aged > 40 using a mobile van model. A total of 5708 women underwent DEXA between May 2012 and May 2016 as a population-based, opt-in screening program offered to women as an outreach program. Bone mineral density (BMD) was measured at the hip and spine, which was used to derive T-scores and to determine the prevalence of discordance. **Results:** The densitometry scores were concordant in 42.50% of the cases, with abnormal bone mineral density, whereas in 54.15% of cases, there was minor discordance and major discordance in 3.35% of cases. Body mass index, weight, age, and postmenopausal status of the patient were important predictors of the presence of discordance. **Conclusions:** Clinicians and epidemiologists should be prepared for at least five out of every ten women screened to have discordance of the T scores at the two anatomical sites scanned. If there is discordance of BMD in underweight persons or in those with low body mass index, then causes other than physiological discordance should be considered, which may be further evaluated.

KEYWORDS: *Bone mineral density, discordance, dual-energy X-ray absorptiometry, osteoporosis*

INTRODUCTION

Osteoporosis accounted for more than nine million fractures worldwide in 2000.[1] Besides advanced age, previous low-trauma fractures, low body weight, excess alcohol intake or cigarette smoking, and low bone mineral density (BMD) remain significant risk factors for osteoporotic fractures.[2]

The fracture risk assessment tool introduced by the 2008 WHO task force predicts the 10-year risk of osteoporotic fracture based on various clinical risk factors and BMD information.[3] Several different methods such as quantitative computed tomography (QCT), peripheral dual X-ray absorptiometry (DXA), radiograph absorptiometry, and peripheral QCT are used to determine BMD. Of these, DXA is the most commonly used and validated method used in the determination of BMD.[4]

There is no single best site for measuring BMD. BMD at the hip, spine, and distal forearm is measured. In case of discordant readings, the BMD is determined by the lowest score at any of these sites.[5,6]

Discordance is defined as the discrepancy in the BMD measurements at two sites, with minor discordance

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Address for correspondence: Dr. Tulika Singh, Department of Radiodiagnosis and Imaging, Postgraduate Institute of Medical Education and Research, Sector 12, Chandigarh - 160 012, India.
E-mail: tulikardx@gmail.com

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indicating osteopenia at one site and normal or osteoporotic BMD at another, whereas major discordance indicating normal bone density at one site and osteoporosis at another.[7]

In this study, we describe the site-wise prevalence of minor and major discordance and associated epidemiological features and also determine the statistically significant risk factors for the same in a North Indian, opt-in, screening-based population.

Methods

The study was conducted under the Women's Health Out-Reach Programme, called Asha Jyoti, in our institute with a retrospective analysis of the data collected between May 2012 and May 2016. The program is an opt-in type of screening program where all women above the age of 40 years were invited for the screening of BMD and screening mammogram, with the screening being offered on a mobile van in one rural and two urban locations. The screened women filled a self-administered questionnaire available in both Hindi and English, with the questions being administered by a field worker in case of illiterate persons. Demographic, socioeconomic, and health-related data were obtained. The weight and the standing height of the patient were recorded before the DXA scan.

The patients were scanned using Hologic Discovery A Qdr Series, Hologic Inc. USA, 250 Campus Drive, Malborough, MA 01752, USA. using a switched-pulse, dual-energy, X-ray source with kVp of 100/140 having a linear X-ray fan beam, a motorized table, and c arm. The BMD precision was <0.1%. The scan time and exposure for the lumbar spine and the proximal femur were 30 s and 0.07 mGy each, respectively. The standard vendor guidelines for the conduct of the test were followed. The same technician had carried out all the examinations. Daily calibration was carried out, and automatic, continuous calibration using Hologic's patented Automatic Internal Reference System (Hologic Discovery A Qdr Series, Hologic Inc. USA, 250 Campus Drive, Malborough, MA 01752, USA) was also done. The Indian normative data were used to characterize patients having osteoporosis when the T score was <2.5, or osteopenia when the T score varied in between 1 and 2.5 standard deviation (SD). Minor discordance was defined as osteopenia at one site and osteoporosis or normal bone density at the other, whereas major discordance was defined as osteoporosis discrepancy at two sites.

Statistical analysis

The data were coded and entered in IBM SPSS Statistics for Windows, IBM Corp. Released 2015, Version 23.0. Armonk, NY: IBM Corp. The mean and SD were obtained for all the descriptive data, while frequency distribution was obtained for the nominal and ordinal data. The sample population was split into subgroups of normal BMD, osteopenia, and osteoporosis and was further characterized as having minor major or no discordance.

ANOVA was used to compare the effects of various quantitative risk factors in the sample population across different levels of discordance, while Kruskal–Wallis H-test was used for ordinal and nominal risk factors. Post hoc tests using Bonferroni correction was applied for group wise comparison of risk factors found to be significant after the ANOVA or Kruskal–Wallis H-test.

Results

A total of 5708 patients were evaluated using our women's imaging outreach program. Their characteristics are summarized in Table 1.

Among the screened women, 0.3% and 0.2% of the women had a history of smoking and alcohol intake, respectively. Nearly 51.2% of the screened women had attained menopause, whereas 69.9% of those having achieved menopause at 45–50 years of age. Only 25.7% of the women had used any form of contraceptive previously, whereas only 5.1% of these had used oral contraceptive pills. Almost 47% of the population had heard about osteoporosis, whereas only 12.4% of them had some knowledge about the symptoms of osteoporosis. Very few of the screened patients acknowledged having signs of osteoporosis such as decrease in height (3.8%), persistent low back pain (11.5%), and spinal deformities (0.2%).

Nearly 89.3% of our population were from urban area, with 25% of the population being graduate and higher. Overall 71.9% of the population identified themselves

Table 1: The demographic details of the screening population included in our study

Attributes of the screening population	Mean±SD
Age of the screened woman (years)	50.35±8.74
The number of family members	4.92±1.85
Per capita income (INR)	10610.95±25741.87
Age at menarche (years)	14.01±1.26
Age at marriage (years)	21.25±2.93
Number of children	2.40±0.93
Age at first childbirth (years)	22.55±3.67
Weight of the patient (kg)	66.15±11.06
Height of the patient (cm)	156.01±5.33
Body mass index (kg/m^2)	27.23±4.68

SD: Standard deviation

as Hindus, while 93% of the screened sample were vegetarians.

A total of 1983 (34.7%) women had no osteoporosis, whereas 2614 (45.8%) had osteopenia and 1111 (19.5%) had osteoporosis. Thirty-eight women (3.4%) had osteoporosis at the hip only, whereas 87 (7.8%) women had osteoporosis at the spine only.

Of the women having osteopenia and osteoporosis, there was no discordance in the hip and spine T scores in 1583 (42.5%) women, whereas 2017 (54.1%) had minor discordance and 125 (3.4%) had major discordance. The distribution of the discordances using WHO diagnostic criteria is presented in Table 2. There was a statistically significant difference between groups with no discordance, minor discordance, and major discordance for body mass index as determined by one-way ANOVA (F (2, 3722) = 16.66, $P < 0.0001$), body weight (F (2, 3722) = 20.73, $P < 0.0001$), and age of the woman (F (2, 3722) = 23.7, $P < 0.0001$), whereas there was no statistical difference between the groups for the height, age at menarche, age at first childbirth, age at marriage, and per capita income. Bonferroni *post hoc* test revealed a group-wise difference in the above-described parameters and is presented in Table 3.

Kruskal–Wallis H-test showed that there was a statistically significant difference in the three groups of no discordance, minor discordance, and major discordance with the menopausal status of the women, $\chi^2 = 40.254$, $P < 0.0001$. *Post hoc* Mann–Whitney U-test with Bonferroni correction showed the group-wise difference, which is summarized in Table 4. No statistically significant group-wise difference was found in the age of onset of menopause.

Discussion

In our study sample of patients with osteoporosis or osteopenia, 42.5% had no discordance, whereas 54.1% had discordance by one T-score WHO class and 3.4% were discordant by two T-score WHO class, with age, weight, body mass index, and postmenopausal status being statistically associated with minor and major discordance. These findings are comparable to those described by other studies conducted in the Caucasian population. The strength of our study was that it was an opt-in screening program, whereby women above the age of 40 opted to be screened for osteoporosis, against a hospital-based model where patients had been screened for osteoporosis on the basis of clinical history. The results of our study are tabulated and compared against those of other studies in Table 5.

Table 2: The prevalence (*n*) of minor and major discordance as per site (using WHO definition) in our sample population

Discordance	BMD	Anatomical site	*n* (%)
No discordance (*n*=1583)	Osteopenia	Spine osteopenia and hip osteopenia	1233 (33.10)
	Osteoporosis	Spine osteoporosis and hip osteoporosis	350 (9.40)
Minor discordance (*n*=2017)	Osteopenia (*n*=1381)	Spine normal and hip osteopenia	546 (14.66)
		Spine osteopenia and hip normal	835 (22.42)
	Osteoporosis (*n*=636)	Spine osteopenia and hip osteoporosis	174 (4.67)
		Spine osteoporosis and hip osteopenia	462 (12.40)
Major discordance (*n*=125)	Osteoporosis	Spine normal and hip osteoporosis	38 (1.02)
		Spine osteoporosis and hip normal	87 (2.34)
Total			3725 (100.00)

BMD: Bone mineral density

Table 3: Variation in the body mass index, weight and age in the screened population according to extent of BMD discordance

	Group	Mean±SD	Group	Mean±SD	*P*
Body mass index (kg/m^2)	No discordance	26.38±4.61	Minor discordance	27.15±4.50	<0.0001
	No discordance	26.38±4.61	Major discordance	27.96±4.51	0.001
	Minor discordance	27.15±4.50	Major discordance	27.96±4.51	0.164
Weight of the patient (kg)	No discordance	63.67±10.63	Minor discordance	65.86±10	<0.0001
	No discordance	63.67±10.63	Major discordance	66.86±10.61	0.004
	Minor discordance	65.86±10	Major discordance	66.86±10.61	0.93
Age of the patient (years)	No discordance	53.11±9.27	Minor discordance	51.37±8.87	<0.0001
	No discordance	53.11±9.27	Major discordance	55.34±9.83	0.025
	Minor discordance	51.37±8.87	Major discordance	55.34±9.83	<0.0001

SD: Standard deviation

Table 4: The difference in post-menopausal status of the screened population having no, minor or major discordance in bone mineral density measurements

Discrepancy in the bone mineral density measurements at two sites	Percentage of post-menopausal women (Expressed as a per cent of total no of women in the group)	Discrepancy in the bone mineral density measurements at two sites	Percentage of post-menopausal women (Expressed as a per cent of total no of women in the group)	*P* value
No discordance	64.20%	Minor discordance	54.90%	<.0001
No discordance	64.20%	Minor discordance	69.60%	0.118
Minor discordance	54.90%	Minor discordance	69.60%	<.0001

Table 5: Comparison of the prevalence of minor, major discordance as observed in other studies and that found in our study

	Prevalence of concordance and minor and major discordance in previous studies			
	N	Concordance (%)	Minor discordance (%)	Major discordance (%)
Woodson[8]	5051	56.00	39.00	5.00
Moayyeri *et al*.[9]	4188	58.30	38.90	2.70
Mounach *et al*.[10]	3479	53.90	41.60	4.40
Our study (Cases with osteopenia and osteoporosis only)	3725	42.50	54.15	3.35

Similarly, those having no discordance had statistically significant lower body mass index and body mass (26.38 ± 4.61 kg/m^2 and 63.67 ± 10.63 kg, respectively) as compared to those with minor (27.15 ± 4.50 kg/m^2 and 65.86 ± 10 kg, respectively) or major discordance (27.96 ± 4.51 kg/m^2 and 66.86 ± 10.61 kg, respectively), however there was no statistically significant difference between those having minor or major discordance for both body mass index or body mass.

Reduced BMD at the lumbar spine was more prevalent compared to that at the hip in cases with both major and minor discordance. Several possible explanations are presented for the same[8] – The multiple thick trabeculae in the femoral heads get re-enforced in early osteoporosis because the axis of body weight is transmitted through them. Thus, the bone loss appears to be greater in the lumbar spine as compared to the femoral heads where the thicker trabeculae result in greater bone mineral density.[11]

The proportion of cortical and cancellous bones might also have an effect on the BMD; the cancellous bone has a higher rate of bone turnover and is lost earlier compared to cortical bone – thus the presence of higher cancellous bone in the spine might account for earlier loss of bone matrix in early osteopenia and more significant discrepancy in late osteoporosis.[12] Diseases which affect bone mineralization such as rheumatoid arthritis and liver diseases also affect the spine because of the earlier bone turnover as described.[13]

Five different causes of discordance have been discussed in literature.[8] Bone is a dynamic structure and is remodeled according to the external and internal mechanical stresses it is subjected to, thus in physiological discordance, the difference in the degree of weight-bearing might be responsible for the discordance between the dominant and nondominant hip and between the hip and the spine. Additionally, the spine and the hip reach BMD of the peak levels of BMD at different times – thus the spine which reaches the peak earlier compared to the hips starts the decline earlier too, and this might explain why patients of higher age were at a higher risk of having major discordance (55.34 ± 9.83 years), while paradoxically the average age of having minor discordance (51.37 ± 8.87 years) was less than those having no discordance (53.11 ± 9.27 years).

Any pathological process which causes sclerosis such as osteoarthritic spurs of the underlying bones, or of the surrounding tissue such as atherosclerotic plaques, would give a fallaciously high BMD when it is included in the DXA field of interest.[14,15]

The variability of the bone architecture between various sites would result in anatomic discordance while radiodense objects in the field of view would result in artifactual discordance because of more significant attenuation of the X-rays. Experimental errors, observer errors, and movement-related artifacts result in technical discordance.[16]

Limitations

The screening program was an opt-in type of program. Its cross-sectional design limits our study. The bias associated with such a type of screen is inherent to our study also.

Conclusion

Clinicians and epidemiologists should be prepared for at least five out of every ten women screened

to have discordance of the T-scores at the two anatomical sites scanned. If there is discordance of BMD in underweight persons or in those with low body mass index, then causes other than physiological discordance should be considered which may require further evaluation.

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Conflicts of interest

There are no conflicts of interest.

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