Vertebral body index and bone mineral density in women with spinal fractures

66 probands compared with controls

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The bone mineral density (BMD) was measured in 61 women with compression fractures of the spine and 66 normal pre-menopausal women. Radiographs of the lateral spine were also obtained and the vertebral body index (VBI) was measured in the region L2–L4. Women with spinal fractures had lower BMD and VBI values. Using both BMD and VBI, 3 regions of fracture risk were defined. All but 2 of the fracture patients were in the moderate- or high-risk region for fracture.

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One of the earliest methods for assessing spinal osteoporosis is by radiographic evaluation, usually based on a subjective decision which includes degree of biconcavity and changes in the end-plates of the vertebral body (Doyle et al. 1967). Vertebral morphometry has been used to define the extent of deformity of the vertebral bodies (Aloia et al. 1977, Gallagher et al. 1988, Minne et al. 1988). Changes in vertebral body height have also been used as an index of progressive bone loss. Woolf and Dixon (1988) defined the vertebral body index (VBI) as the ratio of the sum of the central vertebral body heights to the central disc heights. We have adopted this definition in our attempt to identify women at risk for osteoporotic compression fractures with the use of a radiographic parameter, in addition to bone mineral density (BMD) measurements.

Patients and methods

66 normal pre-menopausal women aged 40 (25–55) years and 61 women aged 72 (50–90) years with one or more spinal fractures were recruited for the study. Lateral radiographs of the spine were taken and any vertebra with a height difference of more than 15 percent were defined as fractured (Buchanan et al. 1988, Odvina et al. 1988). The extent of deformity of the vertebral bodies was classified as compression, single end-plate, double end-plate, wedge or a combination of any of the above (Table 1). Corner points of the second, third and fourth lumbar vertebrae (L2–L4) were selected, and measurements of the vertebral body index (VBI) and intervertebral disc heights were made, centered on the respective vertebra. The measurements were made with a millimeter rule to the nearest 0.5 mm. The VBI was calculated as the ratio of the sum of the central vertebral body heights to the central disc heights over L2–L4. The BMD of the spine, expressed as gHA/cm^2, was measured on a NOVO BMC Lab 22a bone densitometer equipped with a Gd-153 source. The whole lumbar spine was scanned and the BMD was determined from the region L2–L4.

Results

The normal pre-menopausal women had mean BMD and VBI values of 0.89 and 2.17, respectively, which were higher ($P < 0.05$) than the patients with spinal fractures (mean values 0.58 and 1.49). Most of the women had a fracture in the T12–L2 region. Patients with compressed vertebrae had the highest VBI and BMD values. There was no correlation between the different types of vertebral deformity and the BMD or VBI.

Table 1. Classification of vertebral fractures

Type of vertebral fracture	n	Age	VBI	BMD
Wedge	6	75	1.50	0.56
Single end-plate	8	66	1.53	0.55
Double end-plate	14	74	1.50	0.59
Compression	6	72	1.65	0.60
Combination	28	74	1.44	0.57

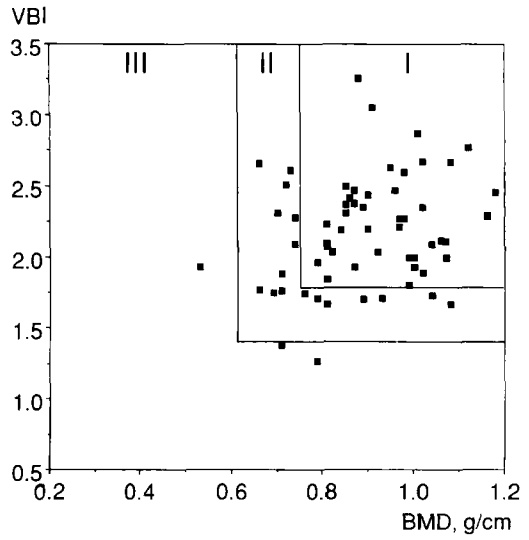

Figure 1. BMD and VBI values for normal pre-menopausal women (<55 years; ■). I > −1 SD, II −1 and −2 SD, and III < −2 SD.

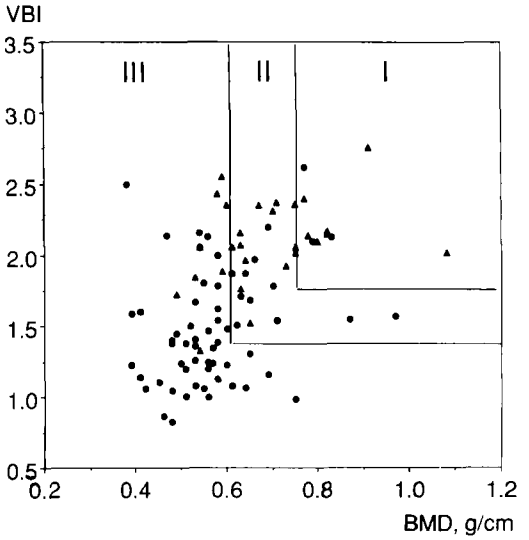

Figure 2. BMD and VBI values for normal post-menopausal women (▲) and patients with compression fractures (●).

Using the values for the normal pre-menopausal women, a graph of VBI against BMD was plotted (Figure 1). The graph was then divided into 3 regions. Region I represented the upper one standard deviation (1 SD) of the mean of the VBI and BMD of the normal women, region II between 1 and 2 standard deviations and region III exceeded 2 standard deviations. Region I was defined as the region in which there was no risk for fracture, while in region II, the risk for fracture was moderate. Region III was considered to be at high risk for fracture.

When the BMD and VBI values of the patients were plotted into these regions (Figure 2) 59 of the patients were in regions II and III, compared to only 43, if BMD measurements were considered alone. To further compare the discriminatory abilities of BMD alone and BMD/VBI measurements in identifying patients at risk for spinal fractures, receiver operating characteristic (ROC) curves were generated for the group with spinal fractures (Metz 1978). The ROC curve plots the true positive fraction against the false positive fraction. The measurement with the greatest area under the curve has the highest discriminatory ability.

Sensitivity (the number of true positive tests/number of patients with spinal fractures) was calculated as the fraction of patients with bone density measurements below the negative 2 SD of maximum bone density at age 35. The BMD value at this fracture threshold was 0.622 g/cm^2. The cut-off level for the VBI was defined as the negative one standard deviation of the mean VBI value of normal premenopausal women (1.78).

Figure 3 shows the ROC curve with regard to discrimination between BMD only and BMD/VBI measurements for patients with spinal fractures. The curve of BMD/VBI was above that for BMD measurements only, indicating the greater discriminative ability of using both BMD and VBI measurements in identifying patients who are at risk for spinal fractures.

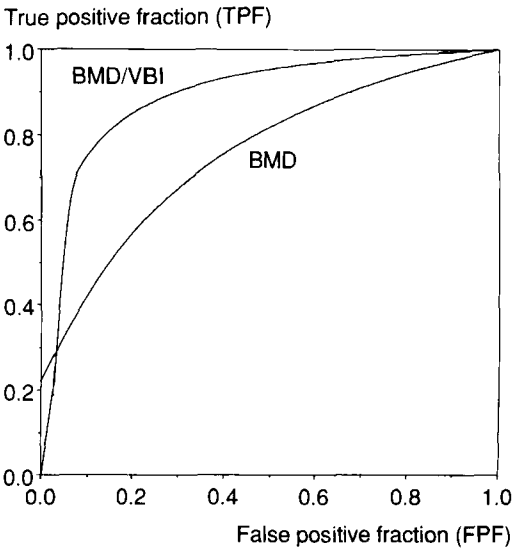

Figure 3. ROC curve for patients with spinal fractures.

Discussion

In recent years, dual photon absorptiometry (DPA) has been used to give a quantitative estimate of bone density in the lumbar spine and femoral neck. Although this method of measurement has been shown to be reliable, it also measures any other artifacts that may be present in the spine. Krolner et al. (1982), in a comparison of radiography, morphology and dual photon absorptiometry, found an over-estimate of the vertebral BMD when DPA was used in patients with osteophytes and severe aortic calcifications. Ross et al. (1987) observed an average increase of 5–11 percent in spine measurements for patients with similar artifacts. This would account for the increased BMD in some of the spinal fracture patients in our study. Undetected microfractures in the vertebral body and callus formation might also contribute to increased BMD values. The presence of aortic calcifications would also lead to falsely elevated values of BMD (Orwoll et al. 1990, Reid et al. 1991). Visualization of calcification and osteophytes on the scan image using the DPA is also difficult. In our analyses of the lumbar spine using the Novo BMC Lab 22a software, it was sometimes difficult to determine the separation of the intervertebral spaces, notably in the severely osteoporotic and the elderly patients. Drinka et al. (1992) studied 113 males with degenerative sclerosis and found that there was a significant increase in the lumbar spine BMD. The later techniques of bone density measurements by dual-energy X-ray absorptiometry (DXA) offer the option of lateral spine scans.

Kleerekoper and Nelson (1992) noted that in the assessment of spinal fractures, changes in the morphology of the vertebra alone do not necessarily suggest the occurrence of a fracture. We have shown that when we used a radiographic parameter, in addition to BMD measurements, the accuracy of diagnosis of subjects at risk for fracture improved. It is therefore important that both radiographic morphometry and bone density measurements be regarded as complementary rather than alternative methods in the evaluation of spinal osteoporosis.

References

Aloia J F, Vaswani A, Atkins H, Zanzi I, Ellis K, Cohn S H. Radiographic morphometry and osteopenia in spinal osteoporosis. J Nucl Med 1977; 18 (5): 425–31.

Buchanan J R, Myers C A, Greer R B. Determinants of atraumatic vertebral fracture rates in menopausal women: biologic vs mechanical factors. Metabolism 1988; 37 (4): 400–4.

Doyle F H, Gutteridge D H, Joplin G F, Fraser R. An assessment of radiological criteria used in the study of spinal osteoporosis. Br J Radiol 1967; 40 (472): 241–50.

Drinka P J, DeSmet A A, Bauwens S F, Rogot A. The effect of overlying calcification on lumbar bone densitometry. Calcif Tissue Int 1992; 50 (6): 507–10.

Gallagher J C, Hedlund L R, Stoner S, Meeger C. Vertebral morphometry: normative data. Bone Miner 1988; 4 (2): 189–96.

Kleerekoper M, Nelson D A. Vertebral fracture or vertebral deformity (editorial). Calcif Tissue Int 1992; 50 (1): 5–6.

Krolner B, Berthelsen B, Pors Nielsen S. Assessment of vertebral osteopenia. Comparison of spinal radiography and dual-photon absorptiometry. Acta Radiol (Diagn) (Stockh) 1982; 23 (5): 517–21.

Metz C E. Basic principles of ROC analysis. Semin Nucl Med 1978; 8 (4): 283–98.

Minne H W, Leidig G, Wuster C, Siromachkostov L, Baldauf G, Bickel R, Sauer P, Lojen M, Ziegler R. A newly developed spine deformity index (SDI) to quantitate vertebral crush fractures in patients with osteoporosis. Bone Miner 1988; 3 (4): 335–49.

Odvina C V, Wergerdal J E, Libanati C R, Schulz E E, Baylink D J. Relationship between trabecular vertebral body density and fractures: a quantitative definition of spinal osteoporosis. Metabolism 1988; 37 (3): 221–8.

Orwoll E S, Oviatt S K, Mann T. The impact of osteophytic and vascular calcifications on vertebral mineral density measurements in men. J Clin Endocrinol Metab 1990; 70 (4): 1202–7.

Reid I R, Evans M C, Ames R, Wattie D J. The influence of osteophytes and aortic calcification on spinal mineral density in postmenopausal women. J Clin Endocrinol Metab 1991; 72 (6): 1372–4.

Ross P D, Wasnich R D, Vogel J M. Magnitude of artifact errors in spine dual-photon absorptiometry measurements. Intern Symp Osteoporosis. Handbook of Abstracts, Abstr 158, 1987.

Woolf A D, Dixon A St J. Osteoporosis: A clinical guide. A clinical guide. Martin Dunitz, London 1988.