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Discordance in lumbar bone mineral density measurements by quantitative computed tomography and dual-energy X-ray absorptiometry in postmenopausal women: a prospective comparative study

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received funding from the Scientific Research Start Plan of Shunde Hospital, Southern Medical University (SRSP2021007).

**Ethical Review Committee Statement**

This study was performed in accordance with the ethical standards in the 1964 Declaration of Helsinki. This study was carried out in accordance with relevant regulations of the US Health Insurance Portability and Accountability Act (HIPAA). Details that might disclose the identity of the subjects under study have been omitted. Ethical approval was obtained from the Institutional Review Board of Shunde Hospital of Southern Medical University (LWLS202207003).

**Acknowledgements**

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**Color Agreement**

The authors know the fees to produce figures in color in *The Spine Journal*, and wish all figures to run in color.

**Abstract**

**Background Context**

Level-specific lumbar bone mineral density (BMD) evaluation of a single vertebral body can provide useful surgical planning and osteoporosis management information. Previous comparative studies have primarily focused on detecting spinal osteoporosis but not at specific levels.
Purpose
To compare the detection rate of lumbar osteoporosis between quantitative computed tomography (QCT) and dual-energy X-ray absorptiometry (DXA); to explore and analyze the distribution models of QCT-derived BMD and DXA T-score at the specific levels; and to evaluate the diagnostic accuracy of level-specific BMD thresholds for the prediction of osteoporotic vertebral compression fracture (OVCF) in postmenopausal women.

Study Design/Setting
A comparative analysis of prospectively collected data comparing QCT-derived BMD with DXA T-score.

Patient Sample
A total of 296 postmenopausal women who were referred to the spine service of a single academic institution were enrolled.

Outcome Measures
QCT-derived BMD and DXA T-score at specific levels, with or without osteoporotic vertebral compression fracture.

Methods: Postmenopausal women who underwent QCT and DXA within a week of admission from May 2019 to June 2022 were enrolled. The diagnostic criteria for osteoporosis recommended by the World Health Organization and the American College of Radiology were used for lumbar osteoporotic diagnosis. To evaluate differences in lumbar BMD measurements at specific levels, a threshold of T score = -2.5 and QCT-derived BMD = 80 mg/cm³ were used to categorize level-specific lumbar BMD into low and high BMD. Disagreements in BMD categorization between DXA and QCT were classified as a minor or
major discordance based on the definition by Woodson. Data between QCT and DXA were visualized in a stacked bar plot and analyzed. Correlations between DXA and QCT at the specific levels were evaluated using Pearson’s linear correlation and scatter plots. Curve fitting of BMD distribution, receiver operating characteristic (ROC) and area under the curve (AUC) for each single vertebral level was performed.

**Results:** Of the 296 patients, QCT diagnosed 61.1% as osteoporosis, 30.4% as osteopenia and 8.4% as normal. For those screened with DXA, 54.1% of the patients had osteoporosis, 29.4% had osteopenia and 16.6% had normal BMD. Diagnoses were concordant for 194 (65.5%) patients. Of the other 102 discordant patients, 5 (1.7%) were major and 97 (32.8%) were minor. Significant correlations in level-specific BMD between DXA and QCT were observed ($p < 0.001$), with Pearson’s correlation coefficients ranging from 0.662 to 0.728. The correlation strength was in the order of $L1 > L2 > L3 > L4$. The low BMD detection rate for QCT was significantly higher than that for DXA at the L3 and L4 levels (65% vs. 47.9% and 68.1% vs 43.7, respectively, $p < 0.001$).

Patients with OVCF showed significantly lower QCT-derived BMD (47.2 mg/cm$^3$ versus 83.2 mg/cm$^3$, $p < 0.001$) and T-score (-3.39 versus -1.98, $p < 0.001$) than those without OVCF. Among these patients, 82.8% (101/122) were diagnosed with osteoporosis by QCT measurement, while only 74.6% (91/122) were diagnosed by DXA. For discrimination between patients with and without OVCF, QCT-derived BMD showed better diagnosed performance (AUC range from 0.769 to 0.801) than DXA T-score (AUC range from 0.696 to 0.753).
Conclusion: QCT provided a more accurate evaluation of lumbar osteoporosis than DXA. The QCT-derived BMD measurements at a specific lumbar level have a high diagnostic performance for OVCF.

Keywords: specific level, lumbar osteoporosis, quantitative computed tomography, QCT, dual X-ray absorptiometry, DXA, bone mineral density

Introduction

Osteoporosis is a metabolic disease that is characterized by low bone mass and microarchitectural deterioration, predisposing patients to fragility and fracture. More than half of postmenopausal women undergoing spine surgery have osteoporosis.\(^1\) Although bone strength is multifactorial, bone mineral density (BMD) plays a prominent role and is the most widely used parameter that can be readily measured in clinical practice.\(^2\)

The well-established gold standard for measuring area BMD is dual X-ray absorptiometry (DXA), which includes both cortical and trabecular bone. However, aortic calcifications, severe bone spur formation, sclerosis, obesity and scoliosis can render DXA inaccurate.\(^3\)\(^5\) Quantitative computed tomography (QCT) overcomes several shortcomings of DXA and allows for the quantification of the volumetric BMD of trabecular bone, which is expressed as g/cm\(^3\). QCT has consequently been increasingly applied to clinical research.

Implant loosening due to loss of fixation at the screw-bone interface is one of the most common instrumentation-related complications seen in osteoporotic patients who undergo pedicle screw fixation.\(^6\)\(^8\) As trabecular bone is the main contributor to the strength of the screw-bone interface in the vertebral body, it is of greater clinical value to focus on trabecular
BMD than that of the entire vertebral body. Trabecular BMD of a single vertebral body can provide useful surgical planning information, as preoperative BMD at a specific level can help to predict the benefits of cement augmentation. Regional QCT-derived BMD was confirmed to predict the strength of pedicle screw fixation, as well as cage subsidence following lumbar interbody fusion. However, previous comparative studies comparing DXA and QCT have primarily focused on osteoporosis detection and clinical application, not level-specific vertebral BMD measurement. Significant differences in osteoporosis detection rates have been observed between the bones of different parts of the body, emphasizing the need for level-specific information for those who are about to undergo spinal surgery.

The objectives of this study were to 1) compare the detection rate of lumbar osteoporosis between QCT and DXA and 2) compare the distribution models of DXA T-score and QCT-derived BMD at specific levels and evaluate the diagnostic accuracy of level-specific BMD thresholds for the prediction of osteoporotic vertebral compression fracture (OVCF) in postmenopausal women.

**Materials and Methods**

**Patients**

This study was approved by the local institutional review board (IRB) and conducted in accordance with the Declaration of Helsinki. A total of 296 postmenopausal women who were referred to the spine service of a single academic institution from May 2019 to June 2022 agreed to participate in this study. The demographic information was recorded at admission,
including age, height, weight, body mass index, smoking status, disease information, primary diagnosis, comorbidities, and medications. All patients had to complete QCT and DXA, as well as serological indicators within a week of their admission, and could not undergo any surgery or receive any anti-osteoporotic treatment during this time, including previous treatment with anti-osteoporotic medication (bisphosphonates, strontium ranelate, teriparatide, denosumab and selective estrogen receptor modulators), but not calcium and vitamin D. The exclusion criteria were as follows: (1) systemic metabolic bone disease, including hypoparathyroidism, hyperparathyroidism, rickets, Paget’s disease, etc.; (3) history of spinal instrumentation surgery; (4) spinal tumors; (5) spinal infection; and (6) severe spinal deformity. A total of 993 level-specific vertebral BMD measurements from 296 patients were included in the final analysis.

**BMD measurements**

DXA scans were performed using GE Lunar DXA (GE Lunar Prodigy and DPX Brovo DXA scanners, GE Healthcare, WI, USA) according to the manufacturer’s standard protocol. BMD (in g/cm²) was assessed at L1 to L4 by a well-trained radiologist to ensure scan quality. The scanner was calibrated daily using a phantom supplied by the manufacturer, and daily quality assurance and quality control were performed as recommended by the DXA manufactures; the coefficient of variation during the period was < 1%. The short-term in vivo precision of lumbar areal BMD for 20 subjects, expressed as the coefficient of variation, was ≤ 0.65%.

Lumbar QCT images were obtained using an Aquilion 64-slice CT scanner (Toshiba Medical System Inc., Tokyo, Japan) with the Mindways QCT pro system (Mindways Software Inc., Austin, TX). Benefiting from the greater stability X-ray output by modern CT scanners, an
asynchronous technique that allowed for scanning of the calibration phantom at a different time from the scanning individual was employed for QCT examination. Following the manufacturer’s protocols, standard QCT measurements were utilized to evaluate BMD at the L1-L4 vertebrae. An elliptical region of interest (ROI) was outlined on the interior space of each vertebral body on an axial CT image and adjusted to exclude anterior cortical bone and the posterior basal vertebral vein (Figure 1). Special attention was given to maximizing the ROI while avoiding bone islands or sclerotic regions. Lumbar levels with a large bone island or sclerotic regions that did not allow for adequate ROI were excluded from the analysis. The methods used to highlight ROIs have been described in previously published articles. Asynchronous QCT measurements were calibrated using a Model 4 calibration phantom (Mindways Software Inc., Austin, TX) for quality assurance. Details on this procedure have been described elsewhere. The short-term in vivo precision of lumbar QCT measurements for 20 subjects was 2.9 mg/cm³. Both DXA and QCT were evaluated by the same experienced radiologist who was blinded to the study.

**Diagnostic category based on BMD measurements**

The diagnostic criteria for osteoporosis recommended by the World Health Organization (WHO) in 1994 were used to establish the diagnosis of osteoporosis based on the DXA T-score (normal, -1.0 or above; osteopenia, between -1.0 and -2.5; osteoporosis, -2.5 or below). The revised thresholds at the L1-L2 levels introduced in 2018 were used for lumbar osteoporotic diagnosis (normal, BMD > 120 mg/cm³; osteopenia, 80 mg/cm³ ≤ BMD ≤ 120 mg/cm³; osteoporosis, BMD < 80 mg/cm³). Table 1 lists the six possible disagreements in BMD categorization between DXA and QCT classified as a minor or major discordance based
on the definition by Woodson. To evaluate the difference in lumbar BMD measurements at the specific levels, a threshold of T score = -2.5 and QCT-derived BMD = 80 mg/cm³ were used to categorize level-specific lumbar BMD into low and high BMD.

**Statistical analysis**

Continuous variables are expressed as the mean ± standard deviation, and categorical variables are expressed as frequencies and percentages. The Kolmogorov–Smirnov test was used to test for data normality. Baseline characteristics between patients with and without osteoporosis were evaluated using one-way ANOVA followed by LSD tests for multiple comparisons. On the basis of univariate analysis, multivariate logistic regression was used to analyze the associations between risk factors and osteoporosis, and the odds ratio (OR) and 95% confidence interval (CI) of osteoporosis were calculated. Nonnormal data between QCT and DXA were visualized in a stacked bar plot and analyzed using the Wilcoxon rank-sum and Wilcoxon signed-rank tests. Correlations between DXA and QCT at the specific levels were evaluated using Pearson’s linear correlation and scatter plots. Curve fitting of BMD distribution was performed using a nonlinear least-squares curve-fitting program with a Gaussian product function. Receiver operating characteristic (ROC) analysis was performed to estimate the diagnostic performance for OVCF by DXA and QCT. From the ROC curve, the corresponding area under the curve (AUC) for each single vertebral level was calculated. Statistical analysis was performed using the SPSS statistics software package (version 25.0, SPSS Inc., Chicago, IL, USA). Statistical significance was set as p < 0.05.
Results

A total of 296 consecutive patients with available DXA and QCT imaging of the lumbar spine were included in this analysis. Their mean age was 66.9 ± 10.2 years, and their mean BMI was 24.1 ± 3.8 kg/m². Lumbar disc herniation was the most common cause for spinal surgery among patients, followed by osteoporotic vertebral compression fracture. The characteristics of the study population, including comorbidity, time since menopause, smoking status, creatinine clearance, serum vitamin D and PTH, are shown in Table 2.

Discordance in osteoporosis diagnoses by QCT and DXA

Of the 296 patients, QCT diagnosed 61.1% as osteoporosis, 30.4% as osteopenia and 8.4% as normal. For those screened with DXA, 54.1% of the patients had osteoporosis, 29.4% had osteopenia and 16.6% had normal BMD. A comparison of baseline characteristics between the subgroups of patients with osteoporosis versus those without osteoporosis is shown in Table 2.

Diagnoses were concordant for 194 (65.5%) patients. Of the other 102 discordant patients, 5 (1.7%) were major and 97 (32.8%) were minor. A total of 49 (16.6%) patients met the criteria for osteoporosis via QCT but osteopenia or normal by DXA, while 28 (8.4%) were diagnosed as osteoporosis by DXA but not by QCT. Details of the diagnostic discordance of DXA and QCT measurements are presented in Table 3.

On the basis of univariate analysis, multivariate logistic regression was used to analyze the associations between risk factors and osteoporosis detected by QCT or DXA. The results revealed that age and alkaline phosphatase were independent risk factors for osteoporosis.
when evaluated either by QCT or DXA, while serum uric acid was considered a protective
factor. In the case of diabetes mellitus, there was a tendency toward a protective effect on the
quality of QCT measurements after adjusting for age, BMI, AAC, 25(OH)D, serum uric acid,
creatinine clearance and alkaline phosphatase. (Table 4)

Subgroup analysis of BMD measurement at the specific levels

Significant differences were observed in both QCT-derived BMD and DXA BMD at different
lumbar vertebral levels. Scatter plots (Figure 2) were drawn to analyze correlations between
level-specific lumbar BMD measured using QCT and DXA. Significant correlations in
level-specific BMD between DXA and QCT were observed (p < 0.001), with Pearson’s
correlation coefficients ranging from 0.662 to 0.728. The correlation strength was in the order
of L1 > L2 > L3 > L4.

Stacked bar plots (Figure 3) were plotted to compare different level-specific BMDs as
assigned by DXA and QCT. DXA had a better detection rate than QCT for low BMD at L1
and L2, but this was not statistically significant. However, the low BMD detection rate for
QCT was significantly higher than that of DXA at the L3 and L4 levels (65% vs. 47.9% and
68.1% vs 43.7, respectively, p < 0.001).

BMD distributions were plotted separately for the four lumbar levels in Figure 4. The BMD
distribution curves for both DXA and QCT were relatively symmetric bell curves with similar
distributional characteristics at L1 and L2. However, at L3 and L4, the QCT-derived BMD
frequency distributions were positively skewed, while the DXA data retained normality. The
mean and mode for the QCT-derived BMD at L3 were 64.3 and 62.3 mg/cm$^3$ and 64.7 and
62.1 mg/cm$^3$ at L4.
Patients with OVCF showed significantly lower BMD (47.2 mg/cm$^3$ versus 83.2 mg/cm$^3$, p < 0.001) and T-score (-3.39 versus -1.98, p < 0.001) than those without OVCF (Supplementary Figure 1). Among these patients, 82.8% (101/122) were diagnosed with osteoporosis by QCT measurement, while only 74.6% (91/122) were diagnosed by DXA (Supplementary Figure 2). For discrimination between patients with and without OVCF, QCT-BMD showed better performance (AUC range from 0.769 to 0.801) than DXA T-score (AUC range from 0.696 to 0.753) (Figure 5).

Discussion

The present study compared lumbar (L1-L4) BMD measurements in postmenopausal women using QCT and DXA. There was a moderate relationship between QCT-derived BMD and DXA T-score. This is to be expected given the considerable overlap in the ROIs measured using QCT and DXA.

A discordance in osteoporosis diagnoses between DXA and QCT was observed in 102 patients. The ability of QCT-derived BMD measurements to identify osteoporosis was superior to that of DXA BMD overall. The authors hypothesize that this difference is because DXA measures both cortical and trabecular bone, while QCT specifically quantifies the BMD of trabecular bone using three-dimensional imaging.22 Although postmenopausal-related microarchitectural deterioration is evident in both cortical and cancellous bone, the latter is known to occur at a more rapid rate.23 This suggests that QCT is more sensitive to trabecular-dominated bone loss than DXA, which may justify its better performance in the diagnosis of spinal osteoporosis. Another likely contributing factor to the superiority of QCT
is that DXA relies on two-dimensional X-ray imaging, whose sensitivity may be limited by aortic calcifications and degenerative disease. Missed osteoporosis diagnoses on DXA in patients with osteoporotic vertebral compression fractures have also been previously reported.

In the field of spinal osteoporosis, QCT-derived BMD measurements are now widely used clinically. Emerging evidence supports the potential value of QCT in the diagnosis of spinal osteoporosis because it provides a more precise estimate of cancellous BMD than DXA. Arvind et al. reported that QCT diagnosed spinal osteoporosis almost twice as often as DXA in a matched study sample (58.16% osteoporosis for QCT vs 30.63% osteoporosis for DXA). A significant difference in the osteoporosis detection rate between DXA and QCT was also observed in the present study, but our measured difference was not as pronounced (61.1% osteoporosis for QCT vs 54.1% osteoporosis for DXA). A plausible explanation for this could be that Arvind et al. assigned a T-score = -2.5 diagnostic category based on a QCT spine T-score, which likely resulted in an overestimation of osteoporosis. The T = -2.5 criterion introduced by the WHO is primarily based on the relationship between forearm BMD and the risk of a hip fracture and is therefore not suitable for cross-application to QCT. According to reference data published by the manufacturer, a DXA T-score of -2.5 would correspond to an equivalent QCT T-score of -3.4. To avoid diagnostic confusion that could result from different T-scores and facilitate the interpretation of QCT spine results, diagnostic cut points (120 mg/cm³ and 80 mg/cm³) were used to assign a diagnostic category based on QCT measurements. Based on these guidelines, the present study demonstrated that QCT is more sensitive than DXA in the detection of osteoporosis in postmenopausal
women, and a similar result was also found in elderly men by Xu et al.\textsuperscript{17} Several studies also highlighted the superior performance of QCT in the measurement of BMD in patients with diabetes, chronic kidney disease and bone mineral disorders.\textsuperscript{29,30}

The paucity of evidence-based data regarding level-specific BMD prompted us to perform the current study. This comparative study, which consisted of a relatively large sample size, indicated that QCT was significantly better at detecting level-specific low BMD than DXA. Notably, the subgroup analysis revealed that the most pronounced difference was at the L3 and L4 levels (Figure 3). QCT detected vertebral low BMD at 65.0\% and 68.1\% of L3 and L4 levels, respectively, while DXA detected it at 47.9\% and 43.7\% of these same levels. One plausible interpretation for this difference is that the vertebral BMD at different levels may be differentially impacted by the location and severity of calcific lesions of the abdominal aorta.

A correlation between abdominal aortic calcification and lumbar vertebral BMD has been well established by previous literature.\textsuperscript{31,32} Kauppila et al. developed reliable indices of abdominal aortic calcification in a 25-year longitudinal study and found that aortic calcific deposits in the posterior and anterior wall most commonly occurred at the L3 and L4 levels.\textsuperscript{33} Due to the nature of 2D imaging with respect to overlapping structure, DXA measurements may underestimate level-specific spinal BMD, especially at L3 and L4. In such a case, QCT should be considered a more powerful approach for cancellous bone evaluation.

As shown by the BMD distribution curves at L3 and L4 (Figure 4C, 4D), QCT-derived BMD was positively skewed (red), while DXA data exhibited no deviation from normality (blue). This means that a large percentage of QCT-derived vertebral BMD belonged to the more extreme side of the spectrum (extremely low BMD) than the relatively symmetric DXA curve.
After drawing a black reference line to mark the threshold for low BMD (T = -2.5 and QCT = 80 mg/cm³), it is evident that the cutoff point for identifying low BMD using QCT was lower than that for DXA. The low BMD detection rate for QCT initially peaked with decreased BMD but gradually declined with further decreased BMD. In contrast, DXA accuracy declined continuously with decreased BMD. This indicates that QCT has a higher sensitivity in the detection of extremely low BMD. This difference between QCT and DXA can also be explained by the severity of abdominal aortic calcifications at L3 and L4. Previous studies have confirmed an independent inverse relationship between abdominal aortic calcifications and vertebral BMD.32,34 Lower BMD was often accompanied by severe abdominal aortic calcifications, making DXA more prone to error in these patients. In other words, the greater differences in the lower BMD detection rates of QCT and DXA would have been seen in these patients as the lower the BMD, the more severe the abdominal aortic calcifications and the worse the accuracy of DXA.

Our current study has some unique strengths. It is a targeted comparison of the level-specific BMD measurements of patients who simultaneously completed DXA and QCT. Unlike previous studies, which compared DXA and QCT measurements from different patient populations, BMD data derived from the same individuals can almost completely eliminate the impact of individual differences.

The present study also has several limitations. First, the study population is highly homogeneous, including only postmenopausal women scheduled for spine surgery. Its generalizability to males and younger women may therefore be limited. Second, the study used different criteria to define BMD diagnostic groups, calling into question the reliability of
our results. However, to address this concern, we only compared the osteoporosis detection rates rather than raw BMD values. Third, L5 and S1, levels at which most spine surgeries are indicated, were not incorporated into the study design. The QCT could not be performed on L5-S1 levels, which has likely prevented a final comparative analysis of those levels. Finally, QCT scans are a much greater financial burden and lead to more radiation exposure than DXA. However, the real value of QCT is not restricted to BMD measurements in spine surgery patients. The above concern can be avoided by using asynchronous QCT techniques to analyze readily available preoperative lumbar CT imaging. Further prognostic studies, including longitudinal comparisons to assess the effects of discordance on fracture risk, instrumentation failure and cage subsidence, should also be performed.

In postmenopausal women who underwent spinal surgery, QCT provided a more accurate evaluation of lumbar osteoporosis than DXA. The QCT-derived BMD measurements at a specific lumbar level have a high diagnostic performance for OVCF. In terms of level-specific BMD evaluation, much consideration should be given to the anatomical location of analyzed spinal segments.
Figure legends

Figure 1: Schematic diagram of a region of interest for QCT measurement.

Figure 2: Scatter plot demonstrating a linear fit between QCT-derived and DXA T-score BMD measurements.
Figure 3: Stacked bar plots comparing low BMD detection rates using QCT and DXA. The detection rate of low BMD by QCT was significantly higher at L3 and L4 than those by DXA.
Figure 4: Curve fitting using a nonlinear least-squares program was performed to depict the distribution of QCT-derived BMD (red) and DXA T-score (blue). A, B, C, D indicate L1, L2, L3 and L4, respectively.
Figure 5: ROC plots for DXA- (A) and QCT-based (B) BMD measurement used for identifying patients with osteoporotic vertebral compression fracture.
References


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doi.org/10.1097/BRS.0000000000004224.


Table 1 Classification of the discordance of BMD category by degree

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<thead>
<tr>
<th>Minor discordance</th>
<th>Major discordance</th>
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<tbody>
<tr>
<td>QCT, osteoporosis; DXA, osteopenia</td>
<td>QCT, osteoporosis; DXA, normal</td>
</tr>
<tr>
<td>QCT, osteopenia; DXA, osteoporosis or normal</td>
<td></td>
</tr>
<tr>
<td>QCT, normal; DXA osteopenia</td>
<td>QCT, normal; DXA, osteoporosis</td>
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</table>

BMD, bone mineral density; QCT, quantitative computed tomography; DXA, dual x-ray absorptiometry.
Table 2 Baseline characteristics of study participants

<table>
<thead>
<tr>
<th>Variables*</th>
<th>Total</th>
<th>DXA-category</th>
<th>QCT-category</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Normal</td>
<td>Osteopenic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Normal</td>
<td>Osteopenic</td>
</tr>
<tr>
<td>Number, n</td>
<td>296</td>
<td>49 (16.6%)</td>
<td>87 (29.4%)</td>
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<tr>
<td>Age, year</td>
<td>66.9+10</td>
<td>60.7+11.1</td>
<td>66.2+9.5</td>
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<tr>
<td>Weight, kg</td>
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<td>62.7+7.7</td>
<td>59.2+8.1</td>
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<tr>
<td>Height, cm</td>
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<td>155.9+5.4</td>
<td>155.2+5.5</td>
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<tr>
<td>Body mass</td>
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<td>25.8+3.1</td>
<td>24.6+3.3</td>
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<td>Serum</td>
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<td>2.33+1.44</td>
<td>2.32+0.1</td>
</tr>
<tr>
<td>Serum creatinine</td>
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<td>85.3+26.5</td>
<td>73.2+22.2</td>
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<tr>
<td>25-</td>
<td>27.1+9.9</td>
<td>26.2+10.3</td>
<td>26.3+8.8</td>
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<td>Parathyroid</td>
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<td>47.4+16.5</td>
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<td>72.5+39.6</td>
<td>71.5+33.5</td>
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<td>39 (44.8)</td>
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<td>45</td>
<td>10 (20.4)</td>
<td>14 (16.1)</td>
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<td>AAC, n (%)</td>
<td>178</td>
<td>30 (16.1)</td>
<td>47 (54)</td>
</tr>
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</table>

*Continuous variables were expressed as means and standard deviation; Categorical variables represent counts and frequencies.

DXA, dual x-ray absorptiometry; QCT, quantitative computed tomography; AAC, abdominal aortic calcification.

Bold values denote statistical significance. P < 0.05.
Table 3 Distribution of diagnostic category for lumbar BMD

<table>
<thead>
<tr>
<th>QCT</th>
<th>Normal</th>
<th>Osteopenia</th>
<th>Osteoporosis</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>DXA Normal</td>
<td>22 (7.4%)</td>
<td>22 (7.4%) (^a)</td>
<td>5 (1.7%) (^b)</td>
<td>49 (16.6%)</td>
</tr>
<tr>
<td>DXA Osteopenia</td>
<td>3 (1%) (^a)</td>
<td>40 (13.5%)</td>
<td>44 (14.9%) (^a)</td>
<td>87 (29.4%)</td>
</tr>
<tr>
<td>DXA Osteoporosis</td>
<td>0 (^b)</td>
<td>28 (9.5%) (^a)</td>
<td>132 (44.6%)</td>
<td>160 (54.1%)</td>
</tr>
<tr>
<td>Total</td>
<td>25 (8.4%)</td>
<td>90 (30.4%)</td>
<td>181 (61.1%)</td>
<td>296 (100%)</td>
</tr>
</tbody>
</table>

DXA, dual x-ray absorptiometry; QCT, quantitative computed tomography; a, minor discordance; b, major discordance.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Osteoporosis detected by DXA</th>
<th>Osteoporosis detected by QCT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adjusted OR</td>
<td>95%CI</td>
</tr>
<tr>
<td>Age</td>
<td>1.054</td>
<td>1.009-1.293</td>
</tr>
<tr>
<td>BMI*</td>
<td>0.946</td>
<td>0.856-1.045</td>
</tr>
<tr>
<td>AAC</td>
<td>0.814</td>
<td>0.446-1.486</td>
</tr>
<tr>
<td>25(OH)D</td>
<td>1.004</td>
<td>0.972-1.037</td>
</tr>
<tr>
<td>Serum uric acid</td>
<td>0.996</td>
<td>0.992-0.999</td>
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<tr>
<td>Creatinine clearance</td>
<td>0.979</td>
<td>0.958-1.001</td>
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<tr>
<td>Alkaline phosphatase</td>
<td>1.018</td>
<td>1.005-1.032</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>0.547</td>
<td>0.231-1.293</td>
</tr>
</tbody>
</table>

BMD, body mass index; AAC, abdominal aortic calcification. 25(OH)D, 25-hydroxyvitamin D; DXA, dual x-ray absorptiometry; QCT, quantitative computed tomography.

Bold values denote statistical significance. P < 0.05.