The Usefulness of Magnetic Resonance Imaging based Vertebral Bone Quality Score in Evaluating the Risk of Osteoporotic Vertebral Fractures

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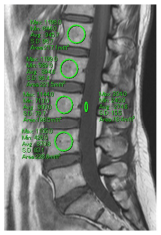
INTRODUCTION:
The prevention of osteoporotic vertebral fractures (OVFs), which have implications not only for activities of daily living (ADL) and quality of life (QOL), but also for long-term prognosis, necessitates early detection and intervention in osteoporosis. Screening through dual-energy X-ray absorptiometry (DEXA) is recommended for women over 65 years old and men over 70 years old. However, numerous cases have been reported wherein individuals diagnosed as non-osteoporotic by DEXA experience OVF. This is likely due to the limitations of DEXA in capturing comprehensive bone quality factors, including remodeling, bone tissue composition, and microstructure, which are essential for assessing bone strength. Recently, a novel assessment method known as the Vertebral Bone Quality (VBQ) score, which utilizes magnetic resonance imaging (MRI) signal intensity, has been reported. Although a correlation with DEXA has been reported, the extent to which the VBQ score is associated with OVF remains uncertain. The aim of this study was to evaluate the usefulness of the VBQ score in assessing the risk of OVFs.
METHODS:
This study was a retrospective cross-sectional study that included 447 patients who underwent DEXA between January 2021 and March 2022. The inclusion criteria were individuals aged over 60 years old who had undergone MRI within a 3-month period before or after DEXA. Exclusion criteria consisted of vertebral tumors, spinal infections, and a history of lumbar spine surgery. The primary outcome was the presence of OVFs diagnosed by MRI and plain X-ray. The measurements included demographic data such as age, sex, body mass index (BMI), and lumber disease diagnosed by MRI, and radiological measurements including L1-4 and total hip bone mineral density (BMD) and T-score by DEXA, the VBQ score and the occurrence of acute OVFs and prevalent OVF assessed by MRI. Patients exhibiting OVF on MRI and plain X-ray, regardless of acute or prevalent, were categorized as the OVF (+) group. Patients without any evidence of OVF were categorized as the OVF (-) group. The VBQ score was computed based on the signal intensity (SI) derived from non-contrast T1WI of the lumbar spine. The measurements were performed on mid-sagittal slices. Initially, regions of interest (ROI) were positioned within the medullary regions of the L1-L4 vertebral bodies and within the cerebrospinal fluid (CSF) space at the L2 or L3 level (Figure 1). Mean signal SIs within each ROI were recorded. Fracture sites were excluded from the calculations, and the VBQ score was determined solely based on the remaining vertebrae. The median value of the L1-L4 vertebrae was then divided by the CSF SI to obtain the VBQ score. The correlation between VBQ score and BMD, as well as T-score, was evaluated, and the association between VBQ score and OVF was investigated using univariate and multivariate logistic regression analysis. age, sex, BMI, and the lowest T-score between L1-4 and total hip, which have been previously identified as risk factors for OVFs, were included as covariates in the multivariate logistic regression analysis. Additionally, the strength of the association between OVF and VBQ score was compared to that of lowest T-score using receiver operating characteristic (ROC) analysis.
RESULTS:
Among the total of 447 cases, 158 cases that underwent MRI within a 3-month period before or after DEXA, excluding 4 cases with a history of lumber spine surgery and 2 cases with spinal infections, a total of 152 cases were analyzed. Lumber disease diagnosed by MRI were as follows: 74 cases of OVFs (46%), 32 cases of lumbar spinal stenosis (21%), 19 cases of lumbar degenerative scoliosis (12%), 16 cases of lumbar degenerative spondylolisthesis (11%), and 11 cases of lumbar disc herniation (7%). The OVF (+) group consisted of 86 cases, while the OVF (-) group consisted of 66 cases. The mean VBQ score was 3.7±0.7. Poor negative correlations were observed between VBQ score and L1-4 BMD ($r = -0.35$, $p < 0.01$), L1-4 T-score ($r = -0.35$, $p < 0.01$), total hip BMD ($r = -0.35$, $p < 0.01$), and total hip T-score ($r = -0.35$, $p < 0.01$). The OVF (+) group had a significantly older ($p = 0.01$), lower L1-4 BMD ($p < 0.01$) , lower total hip BMD ($p < 0.01$), lower L1-4 T-score ($p = 0.03$), lower total hip T-score ($p < 0.01$), the lowest T-score (-3.5±1.5 vs. -2.5±1.4; $p = 0.02$), and significantly higher VBQ score (4.0±0.7 vs. 3.4±0.5; $p < 0.01$) compared to the OVF (-) group. In the multivariate logistic regression analysis with age, sex, BMI, and lowest T-score as covariates, the VBQ score (odds ratio 5.47; 95%CI 1.40 - 29.1; $p < 0.01$) and lowest T-score (odds ratio 0.40; 95%CI 0.22 - 0.73; $p<0.01$) were found to be independently associated factors with OVF (Table 1). The ROC analysis suggested that VBQ score might be a superior predictive factor compared to lowest T-score (AUC 0.76 vs. 0.69) (Figure 2).
DISCUSSION AND CONCLUSION:

The VBQ score demonstrated correlations with BMD and T-score. This study suggests that the VBQ score may be a superior indicator compared to T-score in assessing bone strength and OVF risk. Further investigation, including prospective longitudinal studies and basic research, are desirable.

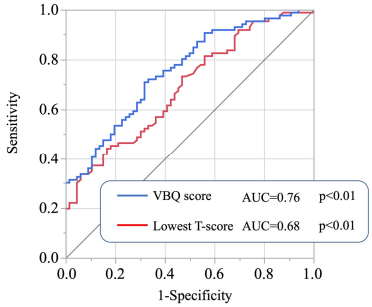
Figure 1, Sagittal non-contrast T1-weighted MRI of the lumbar spine.



$$\text{VBQ score} = \frac{SI_{L1\text{-}L4}}{SI_{CSF}}$$

VBQ score, vertebral bone quality score; SI, signal intensity;
CSF, cerebrospinal fluid; $SI_{L1\text{-}L4}$; The median value of the L1-L4 vertebral signal intensity;
SI_{CSF}, signal intensity of CSF space at the L2 or L3 level

Figure 2, Comparison of receiver operating characteristic (ROC) curve for osteoporotic vertebral fractures.



VBQ score, vertebral bone quality score; AUC, area under the curve
p value<0.05 statistically significant difference

Table.1, Univariate and multivariate logistic regression analysis of factors associated with Osteoporotic vertebral fractures

	Univariate analysis			Multivariate analysis		
	OR	95% CI	P-value	OR	95%CI	P-value
Age, years	1.1	1.0 - 1.1	0.01	1.0	0.9 - 1.1	0.5
Sex, Women	1.2	0.6 - 2.4	0.66	1.1	0.6 - 9.7	0.9
BMI	0.9	0.8 - 1.0	0.09	0.4	0.9 - 1.2	0.6
L1-4 BMD	0.02	0.002 - 0.1	<0.01			
L1-4 T-score	0.6	0.4 - 0.8	<0.01			
Total hip BMD	0.002	0.0001 - 0.05	<0.01			
Total hip T-score	0.6	0.5 - 0.8	<0.01			
The lowest T-score	0.6	0.4 - 0.8	<0.01	0.4	0.2 - 0.7	<0.01
VBQ score	6.1	2.9 - 12.5	<0.01	5.5	1.4 - 29.1	<0.01

BMI, body mass index; BMD, bone mineral density; VBQ score, vertebral bone quality score;
OR, odds ratio; CI, confidence interval
p value<0.05 statistically significant difference