Original Article

The utility of MRI-based S1 vertebral bone quality score in assessing bone mineral density for adolescent idiopathic scoliosis

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Background: Several studies have confirmed that magnetic resonance imaging (MRI) vertebral bone quality (VBQ) score can be used as a tool for opportunistic osteoporosis screening. However, obtaining the original VBQ score for patients with adolescent idiopathic scoliosis (AIS) can be challenging, especially in cases of severe scoliosis, and its stability may be affected. We aimed to assess the diagnostic potential of the VBQ method based on T1-weighted MRI of the first sacral vertebra (S1) in assessing bone mineral density (BMD) for patients with AIS.

Methods: A total of 137 patients with AIS were retrospectively enrolled in the study. The S1 VBQ score and S1 Hounsfield units (HU) were measured based on MRI and computed tomography (CT), respectively. The S1 VBQ score was calculated based on the T1-weighted signal intensity of the S1 vertebra. Univariate analysis was performed to compare the differences between the normal-BMD cohort (QCT Z-score >–2.0) and low-BMD cohort (QCT Z-score ≤–2.0). Pearson correlation analysis was applied to determine the associations among S1 VBQ, S1 HU, and QCT Z-score. Independent factors associated with low BMD were determined through multivariate logistic regression. A receiver operating characteristic analysis was performed to assess the diagnostic performance of S1 VBQ in assessing low BMD.

Results: Among the included patients, there were 93 in the normal-BMD group and 44 in the low-BMD group. A significantly higher S1 VBQ score was found in the low-BMD cohort than in the normal-BMD cohort (P<0.001). There was a moderate correlation of S1 VBQ with QCT Z-score (r=–0.450; P<0.001) and S1 HU (r=–0.405; P<0.001). The S1 HU had a strong correlation with the QCT Z-score (r=0.671; P<0.001). The multivariate logistic regression analysis revealed that the S1 VBQ score was independently correlated with low BMD [odds ratio =3.394; 95% confidence interval (CI): 1.498–7.689; P=0.003]. An S1 VBQ score threshold of 3.2 yielded 86.4% sensitivity, 74.2% specificity, and an area under the curve of 0.836 in identifying low BMD.

Conclusions: The MRI-S1 VBQ score provides a novel means for assessing BMD in patients with AIS. It could serve as a tool for the opportunistic screening of low BMD before spinal surgery.

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Keywords: Magnetic resonance imaging (MRI); adolescent idiopathic scoliosis (AIS); vertebral bone quality (VBQ); signal intensity vertebra (SI vertebra); bone mineral density (BMD)

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Introduction

Adolescent idiopathic scoliosis (AIS), a condition of unknown origin, is recognized as the prevalent spinal deformity among adolescents, distinguished by its complex, three-dimensional spinal curvatures and the potential for worsening over time (1). Studies have indicated that a considerable proportion of individuals with AIS exhibit reduced bone mineral density (BMD) as compared with the general population (2-4). Low BMD is a significant and independent predictor of scoliotic curve progression (5,6). In addition, bone density has a significant impact on the outcome of patients who undergo spine surgery, and thus it is critical to evaluate the bone quality of patients with AIS.

Dual-energy X-ray absorptiometry (DXA) is a prevalent clinical method for assessing BMD, favored for its minimal radiation, affordability, and strong applicability. However, spine deformities or anatomical variations can lead to distorted BMD measurements when DXA is used for assessment (7,8), particularly in patients with AIS. Quantitative computed tomography (QCT) overcomes such limitations by enabling adjustment for the scoliosis curve and providing precise quantification of actual volumetric BMD in trabecular bone, albeit at a higher radiation dose. Recently, Ehresman *et al.* proposed a novel L1–L4 vertebral bone quality (VBQ) score based on magnetic resonance imaging (MRI), and it has been validated as a useful tool for evaluating BMD (9). The development of this method can enable surgeons to simultaneously evaluate the condition of neurological or spinal cord and preliminarily assess BMD.

However, obtaining the L1–L4 VBQ score in the midsagittal plane of patients with AIS and lumbar curves can be challenging, especially in cases of severe scoliosis, and its stability may be affected. Recently, a simplified first sacral vertebra (S1) VBQ score has been verified as a promising tool for assessing the BMD of patients with lumbar degenerative diseases, especially in cases where the previously reported L1–L4 VBQ score method is unavailable due to infection, trauma, etc. (10). Consequently, we were curious as to whether the simplified S1 VBQ method has the ability to assess BMD for patients with AIS, as this has not been reported on previously. Moreover, the S1 is a site commonly involved in lumbar decompression and fusion procedures that use pedicle screw fixation (11); therefore, directly evaluating the BMD of the S1 vertebra holds significant clinical importance. A previous study also confirmed that the Hounsfield Unit (HU) based on S1 computed tomography (CT) data is effective in directly assessing the BMD of the S1 (12).

Therefore, in this study, we aimed (I) to evaluate the ability of the simplified S1 VBQ score derived from T1-weighted MRI of the S1 in assessing the BMD in patients with AIS and (II) to evaluate the correlation between QCT Z-score, S1 VBQ, score and S1 HU. We present this article in accordance with the STROBE reporting checklist (available at https://qims.amegroups.com/article/view/10.21037/qims-24-2209/rc).

Methods

Patient cohorts

This study was conducted in accordance with the Declaration of Helsinki and its subsequent amendments and was approved by the Institutional Ethics Board of the Third People's Hospital of Chengdu (No. 2024-S-169). Due to retrospective analysis, the requirement for informed consent was waived. We conducted a retrospective study that included 137 patients diagnosed with AIS between January 2020 and February 2024, including 93 patients in the normal-BMD group and 44 patients in the low-BMD group, with an overall mean age of 14.99±2.45 years and a higher proportion of females (69.3%). The inclusion criteria were as follows: (I) patients aged 10–18 years; (II) availability of noncontrast T1-weighted MRI, X-ray images of the spine, and QCT measurements; and (III) the presence of lumbar scoliosis. Meanwhile, the exclusion criteria were as follows: (I) presence of other diseases affecting bone metabolism or a history of lumbar surgery for reasons other than AIS, (II) a history of brace treatment or surgery, and (III) poor-quality images. The demographic data and imaging information were reviewed and recorded.

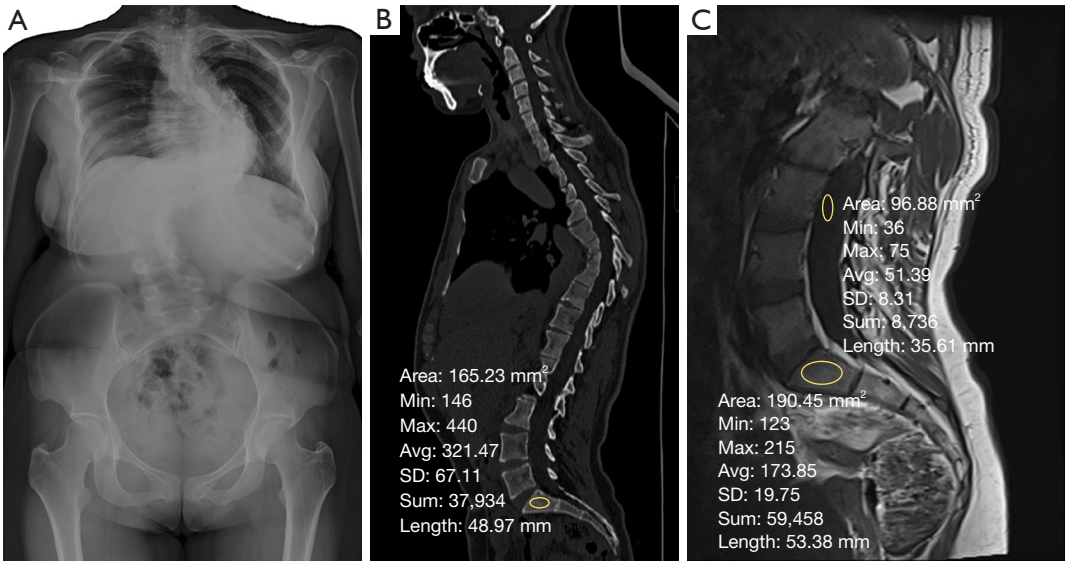

Figure 1 Illustration of the S1 VBQ and S1 CT HU calculation process. (A) A standing, full-length posteroanterior X-plain radiography of a 16-year-old patient with AIS. (B) The measurement of S1 HU. The ROI was placed at the S1 medullary bone, and the S1 HU value was then obtained via the PACS system. (C) The measurement of S1 VBQ score. Corresponding signal intensities were obtained by placing the ROI in the S1 medullary bone and L3 cerebrospinal fluid space via the PACS system. AIS, adolescent idiopathic scoliosis; CT, computed tomography; HU, Hounsfield unit; L3, third lumbar vertebra; PACS, picture archiving and communication system; ROI, region of interest; S1, first sacral vertebra; VBQ, vertebral bone quality.

Radiographic assessment

Risser sign and the pelvic triradiate cartilage (TRC) status were obtained through spine X-ray (*Figure 1A*) to assess skeletal maturity. The Risser sign was determined based on the degree of ossification of the iliac bone, typically divided into grades 0 to 5, with the higher numbers denoting advancement toward skeletal maturity (13). Grade 0 indicated no ossification had occurred, while grade 5 indicated complete ossification and fusion of the iliac apophysis. TRC status was divided into three stages based on whether the TRC was closed: open, closing, and completely closed (14). In addition, the Nash-Moe sign was used to assess the degree of vertebral rotation in scoliosis (15), with the degree of spinal rotation being determined according to the positional changes of the pedicles on X-ray films, which are typically divided into five grades (grades 1 to 5).

QCT measurement

The trabecular BMD of the four consecutive lumbar (L1–L4) vertebrae was measured with the application of Mindways QCT Pro v. 6.1 analysis software (Mindways Software, Inc., Austin, TX, USA). The mean BMD (mg/cm^3) was recorded. Normative data for vertebral BMD Z-scores, adjusted for age and sex, were provided by Mindways Software, Inc. In accordance with the latest recommendations from the International Society for Clinical Densitometry (ISCD) for children and adolescents (16), a QCT Z-score of –2.0 or lower is indicative of low BMD. Consequently, the enrolled patients were divided into a normal-BMD group (Z-score of >–2.0) and a low-BMD group (Z-score of ≤–2.0).

S1 HU and S1 VBQ score calculation

The first lumbar vertebra (L1) vertebral level was identified as the first non-rib-bearing vertebra, with the S1 level being sequentially counted from L1.

The S1 HU value was measured using the method introduced by Zou *et al.* (12). A region of interest (ROI) was positioned on the midsagittal CT images of the S1 vertebral body to maximize the coverage of the trabecular bone while circumventing the cortical bone. The average HU value was then displayed through the picture archiving and communication system (PACS), as shown in *Figure 1B*.

The T1-weighted image acquisitions had the following

parameters: repetition time (ms) =400–850, echo time (ms) =8–20, slice thickness (mm) =3, matrix =320×210 or 384×185, and field of view (cm) =240×240.

According to the description of Ehresman *et al.* (9), the original VBQ score was calculated based on a noncontrast T1-weighted MRI of the L1–L4 vertebral body on the midsagittal plane. First, an ROI was manually delineated within the medullary bone of the L1 to L4 vertebral bodies and also within the cerebrospinal fluid (CSF) space at the level of the third lumbar vertebra (L3). The placement of ROIs avoided the posterior vertebral venous plexus and the cortical bone and covered as large an area of the trabecular region as possible. Subsequently, the signal intensity (SI) of the ROI was automatically calculated through the PACS. The standardization of the VBQ score was achieved by dividing the median SI of the L1–L4 vertebrae by the mean SI of the CSF at the L3 level. As for the S1, we applied a similar technique. *Figure 1C* presents the measurement procedure. The SI of the S1 was obtained by placing an ROI on the S1 from the midsagittal slice. The S1 VBQ score was then calculated using a method similar to that of the original score:

$$VBQ_{S1} = \frac{MeanSI_{S1}}{MeanSI_{L3\text{-}CSF}} \quad [1]$$

To assess the interrater reliability, two independent researchers conducted the measurement. Each researcher was unaware of the patient's information, which ensured a blind evaluation. To evaluate the intrarater reliability, the first researcher measured each patient twice, with approximately 1 week between trials.

Statistical analysis

The data processing and graphical representations were carried out with SPSS version 23.0 (IBM Corp., Armonk, NY, USA) and GraphPad Prism version 9.0 (Dotmatics, Boston, MA, USA). Continuous variables are presented as the mean ± standard or median, and categorical variables are presented as proportions. For continuous variables, group differences were evaluated for statistical significance via the Kruskal-Wallis test or the Student's *t*-test depending on the data distribution. Categorical variables were analyzed with the chi-squared test and, when appropriate, the Fisher exact test. Receiver operating characteristic (ROC) analysis was performed to determine the area under the curve (AUC). Sensitivity and specificity values at various thresholds were derived from this analysis. The threshold with the best diagnostic performance was determined based on the Youden index. Pearson correlation and linear regression were used to analyze the associations among S1 VBQ score, S1 HU, and QCT Z-score. Independent factors associated with low BMD were determined through multivariate logistic regression analysis. The results are expressed as odds ratios (ORs) along with the corresponding 95% confidence intervals (CIs). Variables that demonstrated a P value of less than 0.1 in the univariate analysis were considered for inclusion in the multivariate model, which indicated their potential relevance to low BMD. To evaluate the intrarater or interrater reliability, the intraclass correlation coefficient (ICC) along with its 95% confidence interval (CI) was calculated. A P value <0.05 was considered statistically significant.

Results

General data

The detailed general characteristics of patients are shown in *Table 1*. There were statistically significant differences in Cobb angle (P<0.001), height (P=0.001), corrected height (P=0.006), QCT Z-score (P<0.001), S1 VBQ score (P<0.001), and S1 HU value (P<0.001) between the two groups. The low-BMD group exhibited a larger Cobb angle, shorter height, higher S1 VBQ score, and lower S1 HU value as compared to the normal-BMD group. No statistical differences were found in the Risser Sign, Nash-Moe sign, or open TRC (P>0.05). *Figure 2* illustrates the S1 VBQ distribution between low BMD and normal BMD in all patients, females, and males. The interrater reliability in measuring S1 VBQ and S1 HU was excellent, with ICCs of 0.93 (95% CI: 0.88–0.98) and 0.97 (95% CI: 0.92–0.99), respectively. The intrarater reliability in measuring S1 VBQ and S1 HU was also excellent, with ICCs of 0.96 (95% CI: 0.90–0.99) and 0.98 (95% CI: 0.93–0.99), respectively.

Association of S1 VBQ, S1 HU, and QCT Z-score

Figure 3 shows the associations among the S1 VBQ, S1 HU, and QCT Z-score, indicating statistically significant correlations between these three metrics. The results showed that there was a moderate correlation of S1 VBQ with QCT Z-score (r=−0.450; P<0.001) and S1 HU (r=−0.405; P<0.001). The S1 HU value showed a strong correlation with the QCT Z-score (r=0.671; P<0.001).

After univariate analysis, a subsequent multivariate

Table 1 General characteristics of patients

Variable	Value	Z-score			Sex		
		>−2.0 (n=93)	≤−2.0 (n=44)	P value	Female (n=95)	Male (n=42)	P value
Age, years	14.99±2.44	14.94±2.62	15.14±1.70	0.789	15.16±1.93	14.65±3.26	0.016
Weight, kg	44.11±9.58	44.67±9.54	42.93±9.68	0.373	43.08±8.24	46.14±11.65	0.111
Height, cm	151.51±12.18	154.26±12.55	145.86±9.19	0.001	150.30±10.96	153.89±14.15	0.042
Corrected height, cm	155.11±11.10	157.11±11.76	150.99±8.30	0.006	153.46±9.93	158.36±12.62	0.118
BMI, kg/m^2	18.22±3.15	17.95±2.71	18.76±3.87	0.210	18.26±3.07	18.13±3.33	0.684
Cobb angle, degree	74.69±35.75	65.80±31.21	93.46±37.76	<0.001	71.03±32.66	82.95±41.16	0.070
Risser sign	3.59±1.27	3.74±1.15	3.23±1.51	0.116	3.69±1.12	3.37±1.57	0.179
Nash-Moe sign	2.16±1.04	2.23±1.01	2.14±1.25	0.744	2.07±1.02	2.37±1.07	0.661
OTRC	4 (2.9%)	3 (3.2%)	1 (2.2%)	0.852	2 (2.1%)	2 (4.8%)	0.091
QCT, mg/cm^3	130.96±40.76	155.06±19.89	80.01±22.23	<0.001	130.78±41.11	131.37±40.43	0.842
T-score	−1.30±1.43	−0.45±0.64	−3.09±0.86	<0.001	−1.40±1.40	−1.09±1.50	0.437
Z-score	−1.38±1.26	−0.60±0.59	−3.00±0.54	<0.001	−1.36±1.29	−1.42±1.22	0.779
S1 VBQ	3.31±1.07	2.92±0.83	4.10±1.06	<0.001	3.26±1.02	3.41±1.18	0.362
S1 HU	229.84±64.23	259.17±49.52	167.82±44.76	<0.001	235.45±64.62	217.14±62.25	0.931

The values are presented as mean ± standard deviation or number (frequency). BMI, body mass index; HU, Hounsfield unit; OTRC, open triradiate cartilage; QCT, quantitative computed tomography; S1, first sacral vertebra; VBQ, vertebral bone quality.

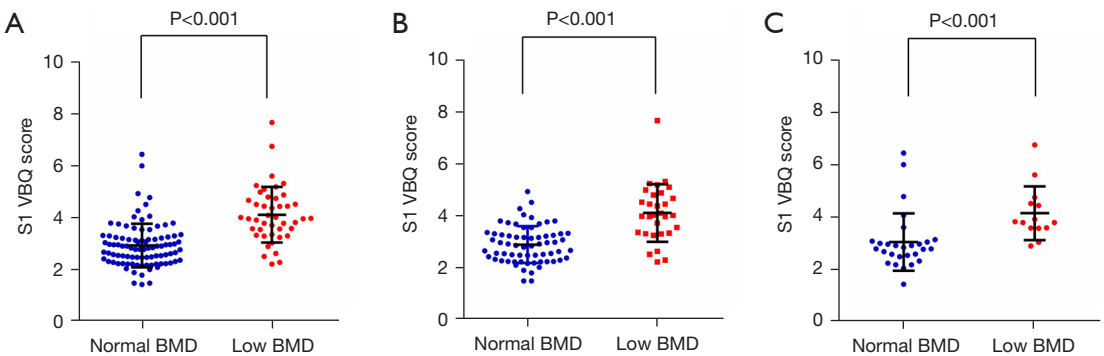

Figure 2 The distribution of S1 VBQ score between the low-BMD group and normal-BMD group in all patients (A), females (B), and males (C). BMD, bone mineral density; S1, first sacral vertebra; VBQ, vertebral bone quality.

logistic regression analysis was conducted, adjusting for height, age, Cobb angle, S1 HU, and S1 VBQ. The results revealed that S1 VBQ was independently correlated with low BMD [odds ratio (OR) =3.394; 95% CI: 1.498–7.689; P=0.003].

Diagnostic performance of S1 VBQ

Through ROC analysis, the S1 VBQ was shown to be able to distinguish low BMD, with an accuracy of 0.836, as shown in *Figure 4*. *Table 2* shows the diagnostic efficacy

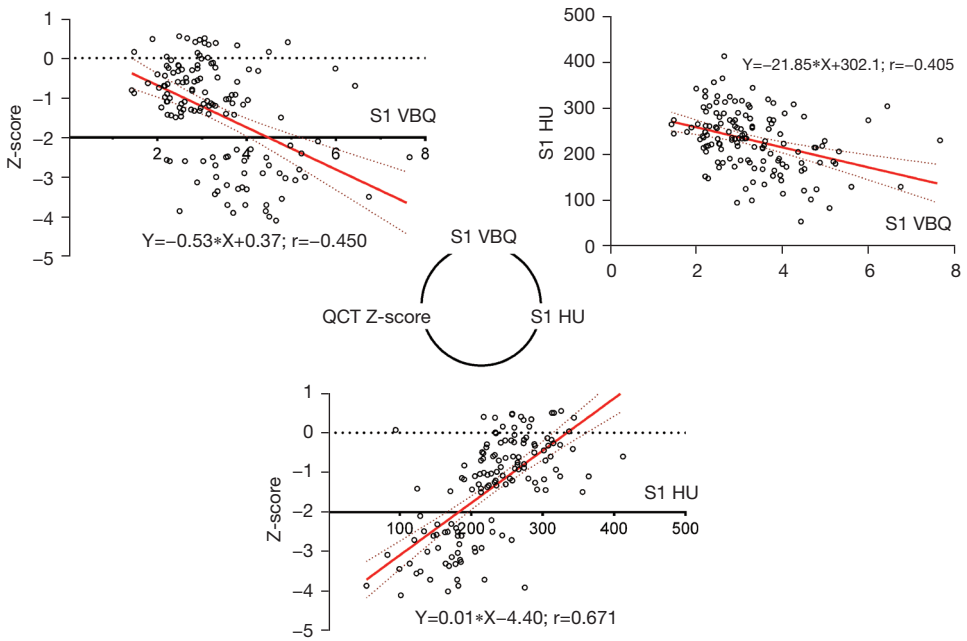

Figure 3 The correlation between S1 VBQ, S1 HU, and QCT Z-score. HU, Hounsfield unit; QCT, quantitative computed tomography; S1, first sacral vertebra; VBQ, vertebral bone quality.

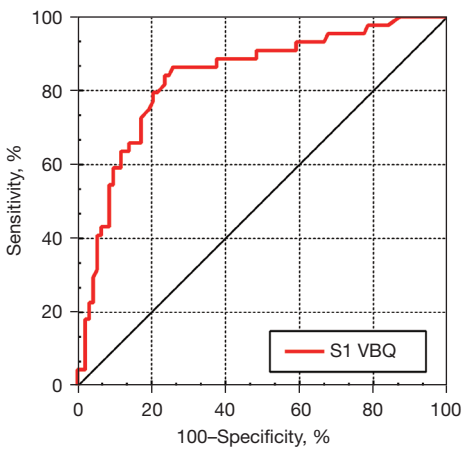

Figure 4 ROC of S1 VBQ showing the sensitivity and specificity. ROC, receiver operating characteristic; S1, first sacral vertebra; VBQ, vertebral bone quality.

of S1 VBQ when different suggested thresholds were employed to identify low BMD. The S1 VBQ threshold, achieving a sensitivity of 90.9%, was 2.9, while the threshold for a specificity of 90.3% was 3.8. When the cutoff value was 3.2, the optimal diagnostic performance of the S1 VBQ score for identifying low BMD in patients with AIS was achieved, striking a balance between sensitivity and specificity.

Discussion

This study is the first of its kind to examine the application of the simplified S1 VBQ score derived from S1 T1-weighted MR images in assessing the BMD in patients with AIS. The results showed that the S1 VBQ score demonstrated high sensitivity and moderate specificity in detecting BMD, supporting its potential as an opportunistic assessment method for BMD in patients with AIS.

Previous studies have reported that patients with AIS often have a low BMD, with its prevalence being approximately 20–38% among these patients (2-4,17). In our study, 32.1% of patients had a low BMD. Studies with follow-up have indicated that the presence of a low BMD in patients with AIS tends to be enduring, which could result in a higher likelihood of osteoporosis in adulthood (5,18). More importantly, persistent low BMD can significantly affect the progression of the scoliosis curve (5,6). Spinal fusion is the ultimate intervention for patients with AIS, with bone quality being one of the determinants of good outcomes. Low BMD can lead to an increased risk of vertebral body collapse, fusion failure, screw loosening, etc. (19,20). Therefore, assessing BMD both before and after

Table 2 Diagnostic performance of S1 VBQ in distinguishing low bone mineral density in patients with AIS

Variable	Cutoff value with high sensitivity (about 90%)	Cutoff value with high specificity (about 90%)	Cutoff value with balanced sensitivity and specificity
S1 VBQ	2.9	3.8	3.2
Sensitivity (95% CI), %	90.9 (78.3–97.5)	59.1 (43.3–73.7)	86.4 (72.7–94.8)
Specificity (95% CI), %	51.6 (41.0–62.1)	90.3 (82.4–95.5)	74.2 (64.1–82.7)

AIS, adolescent idiopathic scoliosis; CI, confidence interval; S1, first sacral vertebra; VBQ, vertebral bone quality.

surgery is particularly critical.

Although DXA is a widely used tool for assessing BMD, its reliance on two-dimensional imaging makes it unsuitable for patients with scoliosis (21). Moreover, DXA does not account for variations in body or skeletal size as individuals grow, which restricts its applicability in longitudinal studies. In contrast, QCT is capable of assessing bone volume along with density across the axial and appendicular skeletons, which suggests that it may hold greater advantages compared to DXA when used for adolescents (22). However, QCT is not suitable as a repeatable means for monitoring BMD because it exposes patients to relatively large quantities of radiation.

Therefore, researchers have been investigating opportunistic methods for assessing BMD using routine data, such as CT HUs, obtained during preoperative spinal evaluations. Applying CT-HUs to evaluate BMD and screen for osteoporosis has been widely reported since 2011. Pickhardt *et al.* (23) demonstrated that L1 HU obtained for other reasons could be used to identify patients with osteoporosis or those with normal BMD. Furthermore, Zou *et al.* (12) evaluated a simple method for directly assessing S1 BMD using the HU of the S1 body, with an overall diagnostic accuracy exceeding 85%. CT HUs potentially offer an alternative method for assessing regional BMD, with the advantage of requiring no additional cost or radiation exposure.

More recently, studies have focused on creating an MRI-based method for quantifying BMD. Early histological studies have demonstrated that osteoporotic bone is characterized by trabecular atrophy and replacement by local adipocytes, and an increase in bone marrow fat may be associated with a compensation mechanism for osteoporosis-related changes in trabecular microarchitecture (24). T1-weighted imaging is the best option for evaluating the cellular content in bone marrow because of the high fat content interspersed with hematopoietic elements (25). Diffusely increased T1-weighted hyperintensity also indicates decreased cellularity of bone marrow and increased fat content. Previous studies have confirmed that the bone marrow SI on the T1-weighted imaging is negatively correlated with BMD and osteoporosis (26-28). The implementation of the MRI-VBQ approach in clinical settings offers certain benefits. First, it is readily available via MRI and is radiation-free. Moreover, MRI is a routine preoperative examination for spinal surgery, which can directly evaluate nerve and spinal cord structures. Therefore, useful data for assessing BMD could be obtained from patients via the VBQ method without the need of additional imaging, radiation exposure, cost, or patient time. Moreover, unlike CT HU, the VBQ method applies the SI of CSF for standardization to reduce the differences across scanners, and so it can be generalizable across multiple MR systems from different manufacturers (9). Since the VBQ score was first proposed, it has been proven to be a valuable tool for assessing BMD (29,30). Due to the difficulty in using L1–L4 vertebrae the original method to measure VBQ in patients with AIS, we first confirmed that the simplified S1 VBQ score exhibited good diagnostic performance for the assessment of BMD in patients with AIS.

In our study, the low-BMD group had a higher S1 VBQ score, aligning with the outcomes of previous research (29,30). A moderate negative linear correlation was observed between the S1 VBQ score and the QCT Z score. A higher S1 VBQ score was significantly associated with lower BMD. In addition, the study revealed that the S1 VBQ score was able to independently predict the presence of low BMD in patients with AIS. Although the best implementation of the MRI-based S1 VBQ method has yet to be established for low BMD, our data suggest ways that it could be applied in practice, contingent upon the clinical goals. Identifying patients with AIS with very high S1 VBQ score by MRI (for example, >4) might allow for the rapid identification of high-risk patients in whom further evaluation (e.g., using QCT or DXA) or treatment is warranted. In clinical practice, various threshold selections could be considered,

perhaps on the basis of a priori risk or pretest probability. For example, an S1 VBQ score threshold of 2.9 (with 91% sensitivity for distinguishing low BMD from normal BMD) may be suitable for high-risk individuals to minimize false-negative results; a significant proportion of low BMD cases would be included in this population, resulting in low specificity. Alternatively, an S1 VBQ score threshold of 3.8 (90% specificity) may be appropriate for a group considered to be at lower risk to minimize false-positive results while still detecting slightly more than half (59%) of patients with low BMD. When the S1 VBQ threshold value was 3.2, it displayed the best diagnostic performance for distinguishing low BMD from normal BMD.

This study further explored the correlation among QCT Z score, S1 VBQ, and S1 HU. Although the correlation coefficients between S1 VBQ and QCT Z-score (r=–0.450) and S1 HU (r=–0.405) were not particularly strong, the significant P values (P<0.001 for both) indicated that there is a nonnegligible relationship between these parameters. This might be partially explained by the three bone mass assessment metrics' internal concordance. S1 VBQ and QCT reflect bone-related information from different perspectives, implying that they have different emphases in evaluating bone status. This provides us with novel perspectives regarding the comprehensive assessment of BMD. Previous studies have demonstrated that VBQ scores or CT HU are effective in assessing BMD. However, it is worth noting that the correlation between the S1 HU and QCT Z score was stronger than that between the S1 VBQ and S1 HU or QCT Z score. One possible explanation is that the CT HU directly evaluates bone mass, whereas the S1 VBQ evaluates bone density by measuring the SI of fat infiltration. This suggests that a combination of CT HU and S1 VBQ may be helpful in improving the diagnostic performance for BMD assessment, which should be explored in future studies.

The S1 VBQ has several outstanding advantages over the L1–L4 VBQ. First, the simplified S1 VBQ method is more straightforward than is L1–4 VBQ in practical application. Second, S1 is often involved in lumbar decompression and fusion surgery with pedicle screw fixation (11); therefore, in surgeries involving the S1, the S1 VBQ can more directly reflect the bone quality status of the S1. Moreover, the analysis of interrater and intrarater reliability indicates that the S1 VBQ method has satisfactory repeatability, suggesting its potential feasibility for practical clinical application.

The strength of this study is that the lumbar BMD in patients with AIS, unlike previous studies, was obtained via QCT, which is more accurate than is the DXA method. However, this study involved a few limitations that should be noted. First, this study may have some potential biases due to its retrospective nature and relatively small sample size. In future studies, we plan to expand the sample size and conduct multicenter, prospective studies to further validate these findings and address the potential limitations. Second, the histological analysis of bone specimens is typically performed through a bone biopsy, which is an invasive procedure. Therefore, it was difficult to carry out due to ethical issues and the retrospective design. Further research using animal models is necessary to validate the biological link between BMD and the VBQ score. Third, this study included only nonsurgical patients with AIS, and the potential influence of adjacent-segment screws on S1 SI was not evaluated. Further studies with a larger sample size and more detailed analyses are needed to precisely evaluate the impact of adjacent-segment screws on the results. Finally, the science behind the VBQ method is robust, with various studies demonstrating its usefulness. As a simple, radiation-free technique, it may serve as an opportunistic screening tool; however, it cannot replace DXA or QCT for the assessment of low BMD or osteoporosis at the present stage.

Conclusions

This study examined a novel S1-VBQ scoring method for identifying patients with AIS at elevated risk of low BMD. Our findings demonstrated that the routine spinal MRI can be used as an opportunistic screening tool for low BMD, with accuracy values around 84% when QCT is used as a reference standard. The S1-VBQ score method is an effective alternative when the L1–L4 VBQ score is difficult to measure due to spinal deformities. Notably, the S1-VBQ method, derived from MRI, is not intended to replace QCT or DXA. Rather, it may serve as a reliable, easy-to-use, and reproducible tool, allowing for the more selective utilization of these screening methods and the ability to avoid unnecessary radiation exposure.

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None.

Footnote

Reporting Checklist: The authors have completed the

STROBE reporting checklist. Available at https://qims.amegroups.com/article/view/10.21037/qims-24-2209/rc

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