Preoperative MRI-based Vertebral Bone Quality (VBQ) Score Assessment in Patients undergoing Lumbar Spinal Fusion

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Introduction

The importance of **bone status assessment** in spine surgery is well recognized.

The current gold standard for assessing bone mineral density is dual-energy X-ray absorptiometry (**DEXA**), however the majority of patients undergoing spinal fusion do not have preoperatively available DEXA data.

Furthermore, DEXA has been shown to overestimate BMD in patients with spinal degenerative disease and obesity.

Consequently, alternative radiographic measurements using data routinely gathered during preoperative evaluation of spine patients have been explored for the evaluation of bone quality and fracture risk.

Opportunistic quantitative computed tomography (**QCT**) and more recently the MRI based vertebral bone quality (**VBQ**) score both have been shown to correlate with DEXA T-scores and predict osteoporotic fractures.

However, to date the correlation between those two modalities has not been studied.

The **objective** of this study was to assess whether the recently described novel VBQ score can predict the prevalence of QCT based osteopenia/osteoporosis and to evaluate the correlation between VBQ and spine QCT BMD measurements.
Methods

Patients undergoing lumbar spinal fusion from 2014-2019 at a single, academic institution with available preoperative CT and T1-weighted MRIs of the lumbar spine were included in this study.

For BMD assessment, asynchronous quantitative computed tomography (QCT) measurements of L1-L2 were performed.

The average BMD of L1-L2 was calculated and patients were categorized as either normal BMD (>120 mg/cm³) or osteopenic/osteoporotic (≤120 mg/cm³) based on the definition by the American College of Radiology.

VBQ measurements were performed by placing circular regions of interest within the medullary portions of the vertebral bodies of L1-L4 and within the cerebrospinal fluid space at the level of L3 on a midsagittal T1-weighted MRI image (Figure 1). The VBQ score was then calculated by dividing the median signal intensity of the L1-L4 vertebral bodies by the signal intensity of the cerebrospinal fluid at the L3 level.

To assess inter-observer reliability of the VBQ measurements, a validation study was performed on 37 randomly selected patients. The interclass correlation coefficient (ICC) was calculated.

Demographic data and the VBQ score were compared between the normal and osteopenic/osteoporotic group. To determine the area-under-curve (AUC) of the VBQ score as a predictor of osteopenia/osteoporosis receiver operating characteristic (ROC) analysis was performed. VBQ scores were compared with QCT BMD using Pearson’s correlation.

Figure 1: Representative image of a VBQ measurement
Results: Reliability and Patient Demographics

- The inter-observer reliability of the VBQ measurements was excellent (ICC of 0.90; 95% confidence interval: 0.82, 0.95).
- A total of 198 patients were included in the study.
- When comparing the patients with normal QCT BMD to those with osteopenia/osteoporosis, no significant differences existed in terms of sex, race, and BMI.
- However, the patients with osteopenia/osteoporosis were significantly older compared to the patients with normal BMD (64.9 vs 56.7 years, p <0.0001). The osteopenic/osteoporotic group had significantly higher VBQ scores (2.6 vs 2.2, p<0.0001) (Table 1).

<table>
<thead>
<tr>
<th></th>
<th>Normal BMD (n=70)</th>
<th>Osteopenia/Osteoporosis (n=128)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD)</td>
<td>56.7 (12.4)</td>
<td>64.9 (9.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male, N (%)</td>
<td>36 (51.4%)</td>
<td>58 (45.3%)</td>
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<tr>
<td>Female, N (%)</td>
<td>34 (48.6%)</td>
<td>70 (54.7%)</td>
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</tr>
<tr>
<td>BMI, mean (SD)</td>
<td>29.0 (6.0)</td>
<td>27.7 (5.6)</td>
<td>0.128</td>
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<tr>
<td>Race</td>
<td></td>
<td></td>
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<tr>
<td>Caucasian, N (%)</td>
<td>63 (90%)</td>
<td>117 (91.4%)</td>
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<td>Black or African American, N (%)</td>
<td>6 (8.6%)</td>
<td>4 (3.1%)</td>
<td></td>
</tr>
<tr>
<td>Asian N, (%)</td>
<td>0 (0%)</td>
<td>2 (1.6%)</td>
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</tr>
<tr>
<td>Other/Unknown, N (%)</td>
<td>1 (1.4%)</td>
<td>5 (3.9%)</td>
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</tr>
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<td>BMD, mean (SD)</td>
<td>147.2 (27.1)</td>
<td>95.2 (18.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>VBQ, mean (SD)</td>
<td>2.2 (0.5)</td>
<td>2.6 (0.6)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Table 1: Demographic and radiologic data of the study population
Results: Correlation

• The VBQ score showed a statistically significant moderate correlation with QCT BMD (correlation coefficient = -0.358, 95% CI -0.473 to -0.23, p < 0.001) (Figure 2).

Figure 2: Correlation between VBQ score and BMD measured by QCT
To the authors' knowledge this is the first study to correlate MRI VBQ scores with QCT BMD measurements.

There was **significant correlation between VBQ and BMD**, but the correlation was only moderate.
Summary Points

The novel VBQ score showed moderate diagnostic ability of predicting osteopenia/osteoporosis diagnosed with QCT.

Due to the fact that QCT and more recently VBQ scores have both been shown to predict osteoporotic fractures, the weak correlation of the two modalities suggests that VBQ might not solely be a measurement of bone density, but rather factors related to bone quality.

VBQ may be an interesting adjunct to clinically performed bone density measurements.