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The Clinical Utility of Vertebral Fracture Assessment in Predicting Fractures

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Abstract

Vertebral fracture (VF) is the most common type of osteoporotic fracture. VFs are associated with diminished quality of life and high morbidity and mortality. The presence of a VF, especially a recent one, is an important risk factor for developing another fracture. However, most VFs are not clinically recognized. VF assessment by dual-energy X-ray absorptiometry is a convenient, low-cost, low-radiation, reliable method to identify VFs during bone mineral density measurement. The finding of a previously unrecognized VF may change the diagnostic classification, assessment of fracture risk, and treatment strategies. This paper focuses on the utility of VF assessment in clinical practice.

Key Words: Bone mineral density; osteoporosis; vertebral fracture assessment; vertebral fractures.

Introduction

Osteoporosis is a systemic skeletal disease characterized by low bone mineral density (BMD) and poor bone quality, resulting in low bone strength and increased risk of fracture *(1)*. It is estimated that osteoporotic fractures will increase by more than 3-fold over the next 50 years in women and in men because of the aging of the population *(2)*. Vertebral fractures (VFs) are the most common type of osteoporotic fracture, especially in postmenopausal women. Most VFs are not clinically recognized and not diagnosed *(3–5)*.

The prevalence of osteoporotic fractures is approximately 40% in postmenopausal women, and 25%–33% in elderly men *(6)*. It is well documented that a previous osteoporotic VF increases the risk of subsequent fractures, both VFs, and fractures at other skeletal sites. History of prior fracture in the elderly population is an important risk factor for developing future fractures, independently of BMD *(6,7)*.

VFs have a negative impact on the quality of life compared with patients with osteoporosis without fractures *(7)*. Chronic pain, physical limitations, loss of independence, institutionalization, and an increased morbidity and mortality are some of the consequences of VFs *(8,9)*.

VFs can be diagnosed by plain film X-rays, computed tomography (CT), magnetic resonance imaging, nuclear bone scanning, and vertebral fracture assessment (VFA) by dual-energy X-ray absorptiometry (DXA) *(10)*. CT provides excellent image resolution but is less available, more costly, and exposes the patient to greater radiation than conventional radiography. Magnetic resonance imaging can be useful to evaluate malignancy, estimate the time when the fracture occurs and, unlike CT, no ionizing radiation is used; however, the cost is high, and availability is limited *(11)*. Conventional X-ray images of the thoracic and lumbar spine with VF grading using the Genant semiquantitative technique is one of the most widely used methods to diagnose VFs *(12)*. VFA has lower image resolution than these methods but can be conveniently performed along with BMD measurement by DXA, with lower cost than the other methods and less radiation than CT or conventional radiography. The aim of this review is to discuss the clinical utility of VFA as a tool for diagnosing VFs and managing patients with osteoporosis.

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Vertebral Fracture Assessment

VFA is a fast low-radiation method performed during BMD measurement, using DXA technology, to identify moderate to severe VFs *(13,14)*.

The International Society for Clinical Densitometry (ISCD) Official Positions state that VFA is indicated when T-score is less than −1.0, and when 1 or more of the following conditions is present: women aged ≥70 years and men aged ≥80 years, historical height loss >4 cm (>1.5 inches), self-reported prior VF, or glucocorticoid therapy ≥5 mg of prednisolone or equivalent per day for ≥3 months *(15)*. A study using an algorithm based on the ISCD Official Positions to select patients for VFA was recently reported *(16)*. Implementation of the algorithm at 3 healthcare organizations improved the identification of individuals for VFA at the same visit as the BMD assessment. The algorithm was an efficient tool for testing older individuals for VFs and was found to enhance the appropriate prescription of fracture prevention therapy without requiring an additional spine image.

Advantages of VFA over conventional radiographic assessment include a significantly lower radiation dose and lower cost, point-of-care service at the same visit as the BMD measurement, and less obliquity (angulation of the vertebral end plate to the plane of the X-ray beam) *(10,14,17)*. The radiation dose for VFA is about 3 microsieverts (μSv) as compared with 600 μSv for a lateral radiographic lumbar spine *(11)*. The main limitation is that thoracic spine levels above T7 are poorly visualized when compared with conventional radiograph images *(15,18)*. However, the majority of significant VFs occur from T10 to L2, which can be easily identified by VFA *(10)*.

It has been recommended by the ISCD and others that the Genant visual semiquantitative technique is recognized as the method of choice for diagnosing VFs using VFA because it has good interobserver reliability and predictive validity, as well as its efficient use in clinical practice *(14,19)*. This technique grades VFs according to loss of vertebral height in anterior, middle, or posterior areas relative to the same or adjacent vertebrae as grade 1 or mild (20%–25% height loss), grade 2 or moderate (25%–40% height loss), and grade 3 or severe (greater than 40% height loss) *(11)*. VFs can also be classified by a morphometric methodology involving measurement of the height of vertebral bodies and comparison with standard reference values or with adjacent vertebral bodies. VFs can be diagnosed if there is more than a 3 standard deviation (SD) difference in vertebral heights *(20,21)*. This method places 6 points on each vertebra. The 6 points marked are the anterior, middle, and posterior locations of the inferior and superior end plate. The method identifies a fracture according to 2 criteria: (1) there must be a 3 SD reduction in one of the ratios of measured vertebral heights (anterior-posterior, middle-posterior, or posterior-adjacent posterior) when compared with a database, and (2) there must be a 3 SD decrease in a similar ratio calculated using the "predicted posterior height" instead of the posterior height. The predicted posterior height is calculated from the patient's adjacent vertebrae.

The algorithm-based qualitative method is another technique that has been recently proposed. It is based on radiological evidence of central vertebral end plate deformity as the first sign to identify prevalent VFs *(19)*. There seems to be good agreement between VFA and conventional radiographic assessment using algorithm-based qualitative method to identify prevalent VFs in women, yet further studies are needed to validate its applicability in clinical practice *(22)*.

VFA Compared With Conventional Radiography

Several studies have demonstrated good agreement between VFA and radiographs, with very good sensitivity and specificity, notably for moderate and severe fractures *(23)*. A multicenter study compared VFA scans using modern DXA equipment with conventional radiographic using Genant's semiquantitative technique. There was good agreement between VFA and X-ray assessments for the diagnosis of moderate and severe VFs, with sensitivity and specificity ranging from 0.70 to 0.86 and from 0.99 to 0.998, respectively. Image quality was inferior with VFA, resulting in 14 missed VFs in the consensus VFA results *(24)*.

Another study performed to evaluate the reliability and accuracy of VFA in older women found good sensitivity (87% for reader 1 and 93% for reader 2) and specificity (93 for reader 1 and 95% for reader 2) of VFA for diagnosing grades 2 and 3 VFs, but did not perform well for identifying grade 1 VFs, or in the presence of deformities in the spine, such as scoliosis and osteoarthritis (sensitivity of 69% for reader 1 and 77.8% for reader 2), ergo follow-up X-ray images were required. These issues can be addressed by obtaining an anterior-posterior image of the spine by VFA together with a lateral view for patients with scoliosis and following VFA with conventional radiography in selected cases *(25)*. In individuals with suboptimal vertebral visualization, reverse positioning (right lateral decubitus) may improve recognition of VFs *(26)*.

The main limitation related to VFA is the inferior resolution of image quality compared with other techniques, particularly in the upper thoracic spine. A retrospective study from Denmark in individuals with severe osteoporosis demonstrated that VFA was inferior to X-ray in visualizing upper spine VFs (T10 and above), with 18.5% of vertebrae being considered unreadable. Moreover, mild-grade fractures were poorly identified, with almost 50% being misclassified as normal *(18)*.

Recent improvements in DXA technology have resulted in higher image resolution, leading to greater accuracy in detecting VFs when these instruments are used. Most of the vertebrae were fairly identified in VFA images using Lunar iDXA scanner (98.4%) *(14)*. A study demonstrated considerable improvements in vertebral bodies