Accuracy of vertebral fracture assessment (VFA) by GE-iDXA scanner in comparison to conventional radiography

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Aims and objectives

Vertebral fractures (VF) are the most common of all osteoporotic fractures, occurring in approximately 25% of postmenopausal women (1,2) and men (3). Most of VFs are clinically asymptomatic and as a consequence they often remain undiagnosed, and therefore not treated especially if occurred in the absence of specific trauma (4).

It's important to identify vertebral fractures (VF) because of a high prognostic value and for the management of osteoporotic patients, in fact patients with a mild vertebral fracture have approximately 5-fold increased risk of further vertebral fractures and 3-fold increased risk of hip fracture (5-6).

Furthermore multiple vertebral fractures are associated with an impaired quality of life and increased mortality rate (7).

The most widely used method for diagnosing osteoporotic VF is the visual semiquantitative (SQ) of conventional radiographs (XR) described by Genant et al (8).

Because of the high radiation exposure (about 600 µSv), radiographs of the thoracic and lumbar spine are often requested only in patients with back pain. (9).

In the last decade, new developments in dual-energy X-ray absorptiometry (DXA) technology have allowed the densitometry devices to acquire lateral images of the thoracic-lumbar spine (10-11) DXA images have lower spatial resolution with respect to conventional radiography but have several advantages, which include a significantly lower effective radiation dose to the patient (with doses reported to be from 2 to approximately (50 µSv), fast acquisition of a single image of the entire spine paired with bone density measurement and with lower costs (12).

The aim of this study was to evaluate the diagnostic accuracy of VFA( by dual-energy X-ray absorptiometry using iDXA device compared to conventional radiography (CR).
Methods and materials

We enrolled 550 subjects (425 females, range 35-84 yrs) consecutively referred to our Mineral Metabolism Centre. Lateral images of the spine, from T4 to L4, by both conventional radiography (CR) and iDXA densitometer (GE Medical Systems Lunar, Madison, WI, USA), were acquired in each subject on the same day.

Conventional radiographs of the thoracic and lumbar spine in antero-posterior and left lateral projections were acquired by using a full digital radiographic system (Apollo DRF, Villa Medical Systems, Milan, Italy) with the patients positioned in their left side with knees and hips flexed.

Tube-to-film distance was set at 105 cm and X-ray beam was centered at T7 and L3 for the thoracic and lumbar views respectively. Radiographs were examined for vertebral fracture identification by two skeletal radiologists who used ABQ in order to discriminate non-fracture vertebral deformities and then classified the true vertebral fractures according to visual semiquantitative assessment (SQ-Rx) (8).

iDXA densitometer uses a stable X-ray source with a current of 2.5 mA and a peak X-ray energy of 100 kVp that is filtered by a K-edge filter at 46 keV for low energy and 81 keV for high energy. This device uses a narrow angle (4.5°) fan beam oriented orthogonal to long axis of body. The limited angle fan beam avoids image distortion in the transversal direction observed with wide fan beam devices. The iDXA system uses a staggered array of 64 direct-digital High-Definition Cadmium Zinc Telluride (CZT-HD) detectors- 51mm x 5 mm wide - to eliminate dead space between detectors creating a high resolution image. The enhanced digital detectors increase the image resolution especially for bone. Spatial resolution, evaluated by iDXA scan of a 10 line pair phantom, was 3 LP/mm.

The patient was positioned in the left lateral decubitus, according to the manufacturer's guidelines, similar to standard spinal radiographs.

The effective radiation dose for a DXA lateral spine scan set on standard thickness using iDXA was ~12 µSv, as declared by the manufacturer.

VFA

On spine DXA images the enCORETM Software v13.5 (Encore Software, San Jose, CA) automatically performed vertebral morphometry, placing six points in each vertebral
body from L4 to T8 to calculate the anterior (Ha), middle (Hm), and posterior (Hp) heights and their ratios (Ha/Hp, Hm/Hp) as well as the average height (HAVG) of each vertebra. The software automatically estimated the extent of anterior or middle vertebral height reduction with respect to posterior height, classified the vertebrae as normal (≤20 % reduction) or fractured (wedge, biconcave, or crush), grading as mild (20-25 % reduction), moderate (25-40 % reduction), or severe (>40% reduction) fractures according to the criteria of Genant et al. (8).

Finally the radiologists checked the automatic vertebral height measurements of iDXA software and manually corrected the point placement according to Hurxthal criteria (13). All vertebral deformities not due to fractures (artefacts, developmental abnormalities, Scheuermann's disease...) were excluded by radiologists according to algorithm based qualitative (ABQ) approach (14).
Fig. 1: Vertebral morphometry on spine iDXA images automatically performed by the enCORETM Software v13.5.

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Results

7090/7150 (99.2%) vertebrae from T4 to L4 were visualized by CR compared to 7030/7150 (98.3%) by iDXA. 280 and 275 were identified as non-fracture deformities by reading of radiographs and VFA, respectively. Vertebral fractures (VFs) were 330 in 280 patients and 326 in 279 patients by SQ-Rx and by VFA, respectively. There was excellent agreement between the two techniques and high diagnostic performance of VFA (k-score = 0.984, 95% CI 0.972-0.996; sensitivity 98.7%, specificity 99.9%, PPV 98.3%, NPV: 99.9%) and on a per patient basis (k-score: 0.957, 95%, CI 0.925-0.988; sensitivity 96.83%; specificity 98.66%; PPV 97.60%; NPV: 98.22%).
Images for this section:

Fig. 3: Spine images by iDXA showing vertebral fractures a) moderate wedging of T11 b) severe wedging of L1 c) severe wedging of L1, moderate wedging of T7 and T12

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Fig. 4: Moderate fracture of T5 with anterior height reduction > 25% (wedging) and mild fracture of L2 with middle height reduction > 20% and (concavity) as identified by VFA (a) and conventional radiography (b).

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Fig. 2: Non-fracture vertebral deformities identified by VFA images. A) Scheuermann's disease: vertebrae T6 through T11 are wedged-shaped (T7 and T8 with height reduction > 20%) with undulated endplates, multiple Schmorl's nodes and disc space narrowing. Anterior osteophytes are also present at vertebrae T8 through T10. B) Large Schmorl's node at the inferior endplate of vertebra T12 producing a monoconcave appearance. C) Degenerative changes: osteoarthritis with remodeling at vertebrae T6 through T9 into wedge shape. Haemangioma of vertebra L2.

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Conclusion

This study demonstrated high diagnostic accuracy of VFA by DXA technique compared to SQ assessment of the conventional radiology.

In fact only 1.7% of the vertebrae were unreadable by VFA all localized at the upper thoracic level (T4-T6), where fracture more rarely occurs, resulting a minimal clinical impact. Only one patient resulted misclassified by VFA depending of insufficiently visualized vertebrae by DXA images.

The opportunity to adequately visualize most of vertebrae included in the scan region improved the diagnostic performance of VFA that showed an high sensitivity and specificity and an excellent agreement with SQ Rx assessment, misclassifying only sixty among 7090 vertebrae.

A similar high performance of VFA was reported in some recently published studies using Hologic Discovery-A device (Hologic Inc., Bedford, MA, USA), a densitometer with the scanner arm rotated of 90°and with the patient in the supine position throughout the procedure (15-16)

The high quality of images by iDXA allowed to discriminate vertebral fractures from several other causes of vertebral deformities, using ABQ approach in combination with SQ method.

Considering the high performance of new DXA scanners in identifying even mild vertebral fractures, recent guidelines of ISCD (International Society for Clinical Densitometry) (17) suggest the introduction of VFA as alternative to conventional radiography in patients at high risk of VF taking into account its low radiation effective dose. However, it should be recommended to integrate the advanced DXA technology with operator adequate training in VFA images interpretation.

Declaration:

Parts of the study presented in this poster have already been published in 'Calcified Tissue International', November 2012, Volume 91, Issue 5, pp 335-342.


