Vertebral fracture assessment: can dual-energy x-ray absorptiometry replace spine radiographs?

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Vertebral fractures (VF) are the most common fractures related to osteoporosis (50%) and represent a hallmark of the disease; these fractures are also associated with increased morbidity, mortality, impaired quality of life for patients and also increased health costs.

Although many VFs are clinically silent, it has been shown that they are associated with increased risk for subsequent osteoporotic fractures; moreover, the detection of VFs strongly predicts the future fracture risk independently from bone density criteria.

Several techniques were born and developed to identify spine deformities.

The visual semiquantitative (VSQ) assessment on conventional spine radiograph proposed in 1993 by Genant et al. remains the most validated and used in the clinical practice. However, a combination of semiquantitative visual and quantitative morphometric methods has been proposed to be the best approach to fracture definition and detection.

A spine assessment for the detection of VFs may be performed on both conventional radiography and dual-energy X-ray absorptiometry (DXA) images. Spine radiography is considered the "gold standard" for vertebral fracture identification but some important advantages can be found in densitometric technologies.

The aim of this study was to investigate the diagnostic performance of new dual-energy x-ray absorptiometry (DXA) technologies in the detection of VFs (Fig. 1 on page 3).

The analysis also considered intra- and inter-observer agreement for densitometric methods and for radiographic ones with remarks on experience-related performance.
Fig. 1: Conventional radiography and dual-energy X-ray absorptiometry (DXA) images.

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Methods and Materials

Sixty-eight patients were prospectively enrolled in the study (38 males and 30 females; age 58.1±9.6 years old, range 32-83 years).

Lateral spine images were obtained with densitometric and radiographic techniques on the same day by an expert technologist.

Images of the spine were independently evaluated by three radiologists with different experience (10, 5 and 3 years) in skeletal imaging.

The T4-L4 segment of the spine was the target of our analysis.

The designed diagnostic approach was based on VSQ, as described by Genant et al., with complementary morphometric analysis when VFs were suspected on radiographs or DXA images.

All the three physicians involved in the study anonymously read radiographs and DXA studies in two sessions with at least 7 days between evaluations of images of the same patients. The most expert physician repeated the analysis in a further reading session.

Sensitivity, specificity and accuracy of VFA in the detection of VFs (or fractured patients) were calculated considering results from expert XR evaluation as gold standard.

Accuracy was expressed by means of the area under the receiver operating characteristic (ROC) curve (AUC) ± standard error of the means (SEM). Intra- and inter-observer agreement was evaluated by means of the Cohen kappa statistic.
Results

Seventy vertebrae (70/884, 7.9%) were excluded from the lesion-based analysis of results, as not evaluable with one or both of the two techniques: 14/70 (20.0%) with radiography, 59/70 (84.3%) with DXA (upper thoracic spine).

Out of the 814 vertebrae considered in the analysis, 40 "true" fractures were detected (40/814, 4.9% vertebrae; 25/40, 62.5% mild fractures) in 26 affected patients (38.2% of the 68 studied patients) (Fig. 2 on page 6, Fig. 3 on page 6).

On a lesion-based analysis DXA sensitivity and specificity were 70.0% and 98.3% showing a good accuracy (AUC=0.842±0.044). Performance of DXA on a patient-based evaluation achieved similar results: sensitivity 73.1%, specificity 90.5%. The experience of radiologists did not significantly influence DXA accuracy, sensitivity and specificity on both lesion- and patient-based analysis (p=0.748 and p=0.994, respectively).

Inter-observer agreements among the 3 observers was higher for XR (k=0.824 for XR, 0.720 for DXA, p=0.011) (Fig. 4 on page 7).

Intra-observer agreements were excellent (k=0.954 and 0.915, for XR and DXA respectively, p=0.322) (Fig. 5 on page 8).

As previously said, accuracy of DXA was not influenced by radiologist experience; moreover, reproducibility and repeatability of the two techniques were independent from sex, age, body mass index of patients, arthrosis, and vertebral level of lesions. However DXA sensitivity was affected by mild VFs.
Fig. 2: Suspect of mild fracture of T7.

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Fig. 3: Visual semiquantitative method allowed to identify a mild fracture of T7 (morphometric X-ray radiography confirmed the diagnosis).

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Fig. 4: Inter-observer agreement among the 3 observers for XR and DXA.

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**Fig. 5:** Intra-observer agreement for XR and DXA.

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Conclusion

DXA equipments allow a semiquantitative visual inspection of the spine (vertebral fracture assessment - VFA) or, thanks to integrated software component, quantitative morphometric vertebral analysis (morphometric X-ray absorptiometry).

Moreover, DXA offers the opportunity to assess in a single session with very low radiation exposure the two most clinically relevant and followed markers of bone metabolism, from an imaging point of view: bone mineral density (BMD) and VFs. Therefore scientific attention and emphasis have been addressed to DXA in the last few years.

In conclusion our study confirms that latest improvements in DXA technology allow a very reliable assessment of VFs and make VFA more competitive with traditional radiographic gold standard. Although consistent advantages and attractions are provided by new DXA, few limitations still affect diagnostic performance and need to be overcome.
References


