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# The Importance of High Resolution for Vertebral Fracture Analysis

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The identification of vertebral fracture is important in the diagnosis of osteoporosis because the presence of one or more of these fractures is a strong indicator of a patient's future fracture risk at the spine, hip and other sites. This risk is independent of bone density and becomes stronger as the number of vertebral fractures increase<sup>1</sup>. Accurate identification of vertebral fractures enables clinicians to target drug therapy (that can reduce new fractures by up to 50%) more effectively, and provides important information during follow-up about the efficacy of the treatment regimen.

Many vertebral fractures go undiagnosed<sup>2</sup>, either because they are asymptomatic, or because they are not clinically recognized<sup>3</sup>. However, patients are rarely referred for routine screening, because the standard approach, spinal radiography, incurs a large effective radiation dose. Over recent years, technological advances in the field of bone densitometry have led to the availability of vertebral imaging capabilities at a fraction of the radiation dose associated with standard radiography<sup>4</sup>. This approach is known as Vertebral Fracture Assessment (VFA). Image resolution for VFA is not as good as for conventional radiography, but efforts to improve this are ongoing, and in comparison studies, good agreement for the identification of vertebral fractures has been shown between visual assessment of VFA scans and spinal radiographs<sup>5-7</sup>.

Image resolution for VFA is an important consideration in the imaging of osteoporotic vertebral fracture because it is crucial that the vertebral endplates are clearly demonstrated. Osteoporotic vertebral fracture is characterized by collapse of the central vertebral endplate from pressure from the intervertebral disc. This is demonstrated on a lateral projection of the spine as a concave line that represents the depressed endplate. The line representing the vertebral ring (ring apophysis) may or may not be visible above the endplate line, depending on bone density and image quality. The vertebral ring is much stronger than the endplate and may remain intact, or there may be radiological evidence of anterior or lateral displacement, and fracture or buckling

of the anterior cortex of the vertebral body<sup>7</sup>. Poor image resolution may result in underdiagnosis of mild osteoporotic vertebral fractures when visualization of the endplate is difficult (particularly in the case of mild concave fractures), especially when bone density is low.

Furthermore, VFA image resolution must allow differentiation between true osteoporotic vertebral fractures and deformities of the endplate that are related to degenerative changes or developmental abnormalities, balloon discs and deep or step-like endplates. Non-fracture deformities in the spine are far more common than osteoporotic fractures, representing over 50% of all vertebral deformities<sup>7</sup>, and mis-

classification of these deformities is probably a major cause of false positive identification of vertebral fracture. Degenerative deformities of the endplate are frequently seen in patients with history of adolescent Scheuermann's disease (juvenile epiphysitis) and the radiological appearances include waving and sclerosis of the endplate, the presence of "Schmorl's nodes" and elongated wedge-shaped vertebral bodies. Schmorl's nodes are the result of invagination of the intervertebral disc into the endplate. These

nodes are also commonly seen in the elderly and are demonstrated as focal depressions in the endplate with sclerotic rounded borders, often with symmetrical appearances at adjacent endplates. However, large nodes could be mistaken for endplate fractures, and endplate fracture may occur at the site of a Schmorl's node if bone density is low. The radiological appearances associated with degenerative disc disease (caused by desiccation of the intervertebral disc with ageing) include narrowing of the disc spaces, sclerosis of the endplates and the presence of osteophytes. Overgrowth at the anterior border in vertebrae with degenerative disc disease may be mistaken for wedge fracture unless image resolution is sufficiently adequate to visualize the original anterior border, and large osteophytes on the lateral border of the vertebral body may simulate a depressed endplate on a lateral projection.

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Finally, near radiographic image resolution is essential to allow adequate visualization of the vertebral endplate when there is oblique projection of the vertebral body. Orthonormal images are much easier to achieve using rotating C-arm densitometers because the patient remains supine for the lateral scan, whereas fixed C-arm devices require the patient to be scanned in the lateral decubitus position. This positioning can be problematic because the curvature of the hips and shoulders often causes tilting of the vertebral bodies in the longitudinal axis, and rotation of the trunk leads to oblique projection in the medio-lateral plane. In general, provided the patient is correctly positioned for the lateral scan, oblique projection is less likely to be a problem for VFA than for standard radiography. This is because the fan-beam geometry for VFA largely eliminates the problem of the parallax effect (oblique projection of the vertebral bodies due to the divergent X-ray beam) that is associated with conventional cone-beam radiography. The beam geometry used in VFA is a major advantage of the technique over standard radiography, because fracture of the endplate can be either mimicked (the endplate may appear to be concave) or masked (a depressed endplate may be superimposed on the vertebral ring line) by oblique projection. Vertebral fractures that have been missed on radiological reading of spinal radiographs due to oblique projection have been positively identified by the same reader from Hologic IVA scans acquired in the same patients (personal communication, Dr G. Jiang).

When the comparatively low radiation dose to the patient is also taken into account, VFA presents as an attractive diagnostic tool. However, the effectiveness of VFA for diagnosis of vertebral fractures depends largely on the image resolution, which needs to be as near-radiographic quality as possible.

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