The use of vertebral fracture assessment (VFA) for the identification of vertebral fractures

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By Anne Coggins
MPhil, DCR(R), CDT, Applications Specialist, Vertec Scientific

Osteoporosis is known as the “Silent epidemic” because it is asymptomatic until a fracture occurs. The major osteoporotic fractures are hip and vertebral fractures; 30-50% of women and 15-30% of men will suffer an osteoporotic fracture in their lifetime.¹

A 10% loss of bone mass in the vertebrae doubles the risk of vertebral fractures.² Hip fractures cause the most morbidity with reported mortality rates up to 20-24% in the first year after the fracture.³,⁴

Although hip fractures rarely go undiagnosed, vertebral fractures are often undiagnosed until major deformity occurs. Vertebral fractures occur at a younger age and are often the earliest sign of the presence of osteoporosis.

The great majority of individuals at high risk, who have already had at least one osteoporotic fracture, are neither identified nor treated.⁵ Gehlbach et al showed, in a retrospective study of chest x-rays in 934 women, that vertebral fractures were present in 130 of them. Of these, only 7% went on to receive treatment for osteoporosis (figure 1).

A 50-year-old white woman has a 16% lifetime risk of experiencing a vertebral fracture (5% in white men).⁶ Vertebral fractures can lead to back pain, height loss, deformity, immobility, increased number of bed days and even reduced pulmonary function.⁷

The choice of treatments available for osteoporosis is dependent on the prevalence and number of vertebral fractures. Further incident fractures may indicate the need to re-evaluate the treatment regime. The FRAX calculator includes fractures as one of the clinical risk factors for further fracture (figure 2).

How to diagnose vertebral fractures
1. Conventional radiography
2. CT
3. MRI

VFA is an imaging tool, using dual energy x-ray absorptiometry (DXA) scanners more commonly used to measure the bone mineral density (BMD) at the spine and hip. Vertebrae T4 through to L4 are viewed in the PA and lateral projections.

Hologic densitometers uses the term “Instant vertebral assessment” (IVA). Lunar densitometers use the term “Dual energy vertebral assessment” (DVA).

Both manufacturers are able to produce PA and lateral images (PA because the tube lies beneath the patient). However, Hologic scanners are able to perform supine laterals with the use of a rotating C-arm (figure 3), thus reducing the need of turning patients, with deformities and in pain, on to their side for a lateral decubitas view. A supine lateral also reduces the appearance of bean can effect and parallax due to poor positioning. When looking for end plate deformities (see later) this is very important.

http://www.shef.ac.uk/FRAX/tool

http://www.who.int/chp/osteoporosis.pdf

FIGURE 1

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FIGURE 2

4. Vertebral Fracture Assessment (VFA).

This article will look at the use of VFA.

What is VFA?

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FIGURE 3
Hologic Discovery bone densitometer.
The advantages of using VFA to conventional radiography are:
1. Reduced dose
   • VFA 12µSv (ED) cf radiography 500µSv (ED)
2. Can be done at the same time as having the BMD. Many DXA scanners are situated away from the radiology department (eg Medical Physics, outpatient departments).
3. Supine lateral
4. Ability to view baseline and subsequent images together

The disadvantage is that the resolution is not as good as conventional radiography in the upper thoracic spine in a small minority of patients. However, the difference is less compared with digital radiography.

Acquiring these images on DXA scanners still requires appropriate training and skilful operators.

When should we use VFA?
As yet the National Osteoporosis Society (NOS) has not published its guidelines for the use of VFA. The International Society of Clinical Densitometrists (ISCD) has published the following:

• Consider VFA when the results may influence clinical management
• Postmenopausal women with osteopenia by BMD PLUS
  o >70 years
  o historical height loss >4cm
  o self-reported vertebral fracture (not documented)
  o two or more of following:
    – 60-69 years
    – self-reported prior non-vertebral fracture
    – historical height loss >2cm
    – disease associated with vertebral fracture (eg COPD, rheumatoid arthritis, Crohn’s disease)
• Men with osteopenia by BMD PLUS
  o >80 years
  o historical height loss >6cm
  o prospective height loss >3cm
  o self-reported vertebral fracture (not documented)
  o two or more of following:
    – 70-79 yrs
    – self-reported prior non-vertebral fracture
    – historical height loss >3cm–6cm
    – disease associated with vertebral fracture (eg COPD, rheumatoid arthritis, Crohn’s disease)
    – androgen deprivation therapy
• All on glucocorticoid therapy
• Post-menopausal women or men with osteoporosis by BMD if documentation of presence of vertebral fracture will alter clinical management.

In addition, many centres here in the UK will also perform VFA
• If any deformity is seen on the lumbar spine BMD
• History of back pain
• Kyphosis.

How should we interpret VFA?
Not all vertebral deformities are fractures and this causes many problems in identifying the cause of the deformity. Normal vertebrae may appear to have a deformity purely by poor positioning. Hence, the need for a PA projection as well as a lateral.

There are both quantitative and qualitative methods of identifying vertebral deformities.

The International Osteoporosis Foundation (IOF) has produced an informative CD designed the help in fracture recognition.

Hologic DXA scanners allow the images to be viewed either within the scanning software, using visual and quantitative methods, or on a Physicians Viewer software which allows the images to be sent as Dicom files to another PC remote from the scanner.

A vertebral fracture is usually associated with a loss of vertebral height. However, there are a number of other pathologies which also show a vertebral height loss. Also, endplate deformities may not necessarily result in vertebral height loss. Therefore a visual assessment should be the primary choice of diagnosis. Consequently, whether using visual or quantitative methods, VFA should be interpreted only by personnel experienced in reading spinal radiographs.

Examples of other spinal abnormalities resulting in deformity
Degenerative disc disease
Scheuermann’s disease
Paget’s
DISH
Scoliosis
Cupids bow
Ankylosing spondylitis
Traumatic fractures

What methods are used for interpretation?
Quantitative methods (QM) and semi-quantitative methods (SQ) These methods use the placement of six points on the anterior, mid and posterior points on the superior and inferior borders of the individual vertebrae. These points can be placed automatically within the software or independently by the operator. Even when placed automatically, the points need to be checked and may need correct repositioning. Both methods obviously introduce subjectivity and possible errors. The most common error is to place the superior-inferior marker too high up the uncinate process and give false positive wedge deformity. Osteophytes and “bean can” effect can also cause incorrect results.

The vertebrae are graded according to the height reduction.

\[
\begin{align*}
20\%-25\% & = \text{mild/grade 1 fracture} \\
25\%-40\% & = \text{moderate/grade 2 fracture} \\
>40\% & = \text{severe/grade 3 fracture}
\end{align*}
\]

These deformities may be a wedge, biconcave or crush fracture. However, as previously stated, there are many reasons why a vertebra may be deformed. Distinguishing these deformities from grade 1 fractures remains problematic.

Because of the false positives with height measurements, it is recommended that there is expert visual assessment of the images. Assessment would be of the integrity of the endplates and comparison to adjacent vertebrae.

Algorithm-based qualitative method (ABO)
This method intends to remove the subjectivity involved with the two previously described methods.

Experienced readers, trained in the visual assessment of the endplates, will diagnose fractures irrespective of any presence, or not, of reduced vertebral height.

The classification of fractures is described by an algorithm which can be referred to. In a study of post-
menopausal women, this method produced fewer fractures than the QM method.\(^\text{15}\)

**The future**

The University of Manchester has been looking at the development of a semi-automated technique using Active Appearance Models (AAM).\(^\text{16}\) It has stated good accuracy on VFA images and radiographs.\(^\text{17}\)

**Conclusion**

- The diagnosis of vertebral fractures is difficult.
- VFA can be used but, as with all DXA BMD measurements, should be performed only by experienced trained operators.
- As with radiographs, VFA should be read only by experienced operators.

**References**