Focus

Assessing fracture risk with bone densitometry

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Key points

- Bone densitometry has a central role in the diagnosis of osteoporosis
- Ultrasound is used less because of concerns regarding reproducibility of measurements and failure to demonstrate changes in bone mass with anti-osteoporotic interventions
- Problems interpreting bone density measurements have been addressed by expressing bone densities as a number of standard deviation units from the mean normal value
- The T score is the best indication of absolute fracture risk and provides a useful threshold for the use of interventions

In the last decade, bone densitometry has emerged from the research laboratory and become a routine part of clinical practice. In 1994, the World Health Organization published definitions of osteoporosis couched entirely in terms of bone density, giving this technology a central place in the making of this diagnosis.

A number of factors have contributed to the current emphasis placed on bone densitometry. First, there have been major developments in the technology, particularly the advent of dual-energy x-ray absorptio-metry (DXA), which is faster and more precise than the technique it replaced and does away with the need for radioisotopes. The cost of densitometers has decreased, as has the cost of their maintenance. Thus, the technology is more convenient, affordable and cost-effective.

Equally important has been the prospective validation of these techniques. There are now numerous studies demonstrating that bone density measurement is predictive of future fractures. This applies to a variety of both measurement and fracture sites. In general, any bone density measurement will predict any fracture with a relative risk per standard deviation change in bone density of 1.6. However, improved fracture prediction is possible with measurement of bone density at the same site as a fracture that is to be predicted. For example, proximal femur bone densities predict future hip fractures with a relative risk per standard deviation of 2.6, and vertebral fractures are predicted by vertebral densitometry with a relative risk of 2.0.[1]

The techniques in routine clinical use are summarised in the table on page 35. X-ray absorptiometry is the preferred technique because of its low radiation dose and high precision. The spine and hip are the most commonly measured sites because they are common sites of fracture. In addition, the spine responds rapidly to skeletal insults (eg, oestrogen deficiency, glucocorticoid excess) and to therapeutic interventions. The precision of spine measurements is substantially better than that of the hip, so the spine is the preferred site for the monitoring of therapy. However, the presence of osteophytes, aortic calcification, vertebral fractures or loss of intervertebral disc height can artifactually elevate bone density in the spine, making spinal measurement a less

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reliable predictor of future fracture risk in the elderly, in whom the proximal femur is preferred.

Recently, ultrasound has been used to assess future fracture risk. Either the attenuation of the ultrasound beam or its speed of transmission is measured. The common site used is the calcaneus, although there are also instruments that assess the phalanges or the patella.

Current data suggest that calcaneal ultrasound has a predictive value comparable to that of x-ray based densitometry,[2] but simultaneous use of the two techniques will not necessarily identify precisely the same individuals. This is analogous to scanning a population at both the hip and spine, in which case some individuals will be found to have low bone density at both sites, some at one and some at the other. While this may be confusing from the point of view of diagnosing osteoporosis, it is a reflection of the heterogeneity of bone density throughout the skeleton and the fact that densitometry, by whatever technique, is only assessing relative risk of fracture along a continuum. Any dichotomising of bone densities is a purely arbitrary imposition upon a normal distribution of values.

Despite its satisfactory performance in prospective studies, ultrasound is not as widely used in clinical practice as DXA. This is because of concerns regarding the long term reproducibility of measurements in some systems, uncertainty as to whether results found with one model in prospective studies are applicable to the newer instruments being introduced into clinical practice, and because ultrasound has not been demonstrated to be able to detect changes in bone mass with antiosteo-
porotic interventions such as bisphospho-nates and oestrogen.

A number of practical issues complicate the interpretation of bone density measurements. Even within the same technology (eg, DXA), bone density measurements vary from one instrument to another and are very different in different regions of the skeleton. As a result, there is no single value for normal bone density.

COMPARISON OF BONE DENSITOMETRY TECHNIQUES

Technique	Site	Precision (%)	Dose (μSv)
Single-energy absorptiometry (SPA or SXA)	Forearm	1	1
	Heel	1-2	1
Dual-energy absorptiometry (DXA)	Spine	1	1-10
	Hip	2	1-10
	Total body	0.5	<1
	Any region of interest	Varies	<1-10
Quantitative computed tomography (QCT)	Vertebral body	1-7	60

The issue becomes even more complicated when different technologies (eg, quantitative CT scanning, ultrasound) are considered. Not only are the numerical values different, but so are the units of measurement.

This problem has been addressed by expressing bone densities as a number of standard deviation units from the mean normal value. The normal comparator population can be of young adults, in which case the standard deviation score is a T score, or it can be age-matched in which case the resulting value is referred to as a Z score.

In general, the Z score is an indication of the likelihood of an underlying pathology being present, whereas the T score is effectively an absolute bone density measurement. Thus, in an elderly population, many individuals will have T scores in the osteoporotic range, but the Z scores will still be normally distributed around a mean value of zero.

In general, the T score is the best indication of absolute fracture risk and it provides a useful threshold for the use of interventions to prevent osteoporosis. In general, a T score *above 1* indicates a low absolute fracture risk in the short term, a value in the osteopenic range (ie, between *1 and -2.5*) indicates that some measures are probably indicated to prevent further bone loss, and a value less than *-2.5* suggests pharmaceutical measures are necessary to prevent fractures.

In the assessment of osteoporosis, the key variable is fracture risk, not bone density itself. Bone density gives important information regarding fracture risk but is not the only factor that impacts on it. Some clinical risk factors give almost as much information as bone density, particularly the prior occurrence of a fracture after minimal trauma. In addition to this, age, European race, low body weight (eg, < 60 kg in a European postmenopausal woman of average height) and cigarette smoking are all significant risk factors.

The presence of two or more of these risk factors incurs a risk comparable to a 1-2 standard deviation decrease in bone density. However, in many postmenopausal women, none of these risk factors is present and so clinical assessment does not give useful information. Bone density can be measured in everybody and, therefore, always permits an evaluation of fracture risk. Having been measured, bone density needs to be interpreted in the context of other risk factors. Thus, an individual with low bone density and a past history of fractures has a much higher future fracture risk than the individual who has only one or other of these risk factors.

• *References available on request*