



Radiology Rounds

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Bone Density and Osteoporosis

- Low bone mineral density (BMD) is a good predictor of future bone fractures
- Bone mineral density (BMD) scans are indicated for
 - Women over 65 yrs
 - Men over 75 yrs
 - Individuals with fragility fractures and silent vertebral fractures
 - Individuals with major risk factors for osteoporosis

Approximately 10 million people in the United States currently have osteoporosis and about 1.5 million people suffer an osteoporosis-related fracture each year. These fractures have a major impact not only on health and quality of life of the individual but also on the costs of health care delivery. Hip fractures frequently result in the end of independent living and are associated with a mortality rate of 20% within the first year. In 2002, annual direct care expenditures on osteoporotic fractures were \$12-18 billion.

Low bone mineral density (BMD) in white women has been demonstrated to be a better predictor of future fractures risk than many other commonly accepted screening tests. Therefore, screening for low BMD to identify individuals with dangerously low BMD is appropriate and, as pointed out in a recent report of the Surgeon General, prevent many osteoporotic fractures.

Populations at High Risk for Osteoporosis

The largest high-risk population comprises post-menopausal women over 65 yrs. Men develop osteoporosis about a decade later at age over 75 yrs. Other factors that increase risk for osteoporosis include low body weight (BMI < 23), family history of osteoporosis, significant history of smoking or alcohol excess, early menopause, testosterone deficiency in men, and therapy that weakens bones, such as corticosteroids.

One of the most important "red flags" of inadequate bone strength is a fragility fracture, defined as a fracture resulting from a fall from less than curb height. These include "silent" fractures due to collapse of spinal vertebrae, which often are not recognized as fractures but may present as back pain. People with a vertebral fracture, either silent or symptomatic, have an increased risk of future vertebral fractures and future hip fractures.

Common Indications for Bone Density Scans

Women over 65 yrs

Men over 75 yrs

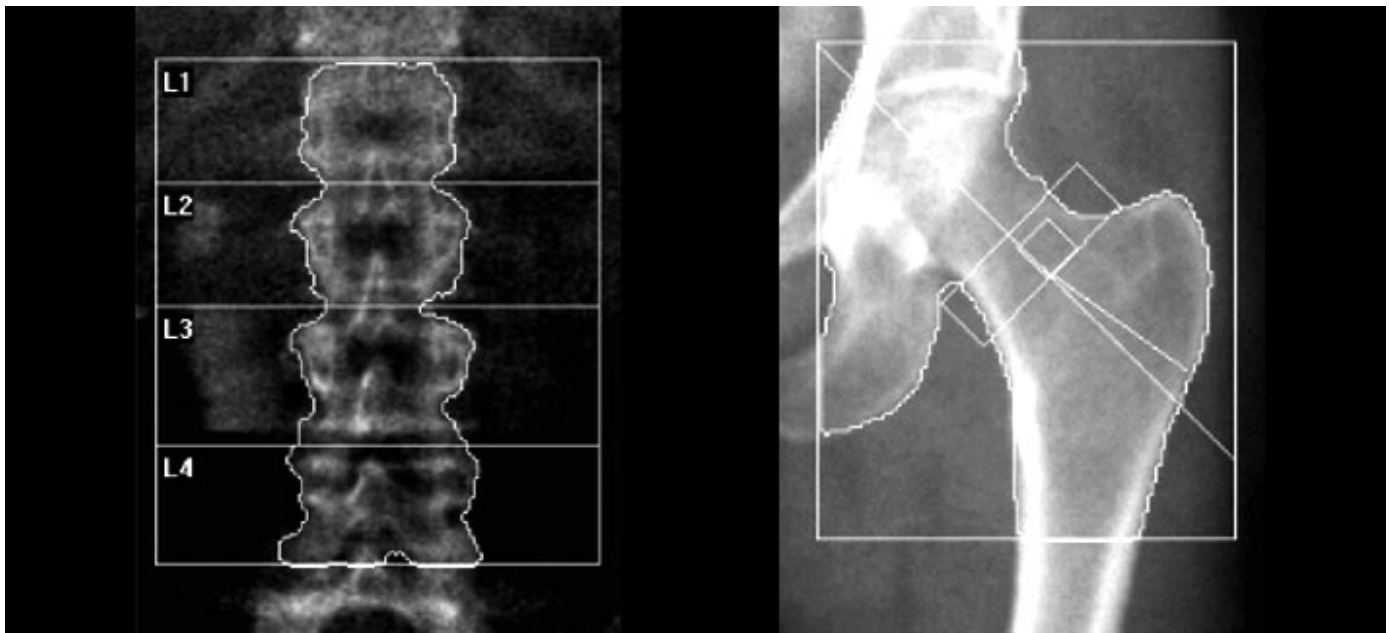
Younger individuals with major risk factors:

- History of prior fracture with minimal trauma
- Low body weight (BMI <23)
- Premature menopause
- Testosterone deficiency in men
- Chronic glucocorticoid therapy

Screening for Osteoporosis

All patients with major risk factors for osteoporosis should be screened for osteoporosis by bone densitometry of the spine and hip. Dual-energy x-ray absorptiometry (DEXA) is the imaging method of choice in most cases. This is a very low dose x-ray scan in which the amount of x-ray energy absorbed by bone mineral is measured and the bone mineral content calculated. Bone mineral content divided by bone area gives the BMD. Because DEXA measurements are not corrected for thickness of the bone in the direction of the x-ray beam, DXA BMD measures a combination of bone size and true bone mineral density.

Quantitative CT (QCT) is an alternative examination for measuring BMD that requires a somewhat greater exposure to ionizing radiation than DEXA. QCT is generally reserved for special cases in which DEXA scans are difficult to interpret because of scoliosis or osteoarthritis, or when it is necessary to document the earliest changes in trabecular bone. QCT is a three dimensional analysis, which gives BMD by volume and which can be segmented into cortical and trabecular bone. QCT is more sensitive than DEXA but is not as reproducible.



DEXA images of lumbar spine and hip of 60 yr old female. The T-score from the lumbar spine was -2.7 and the Z-score was -1.3 . At the hip, the T-score was -2.0 and the Z-score was -0.9 . The patient was diagnosed with osteoporosis.

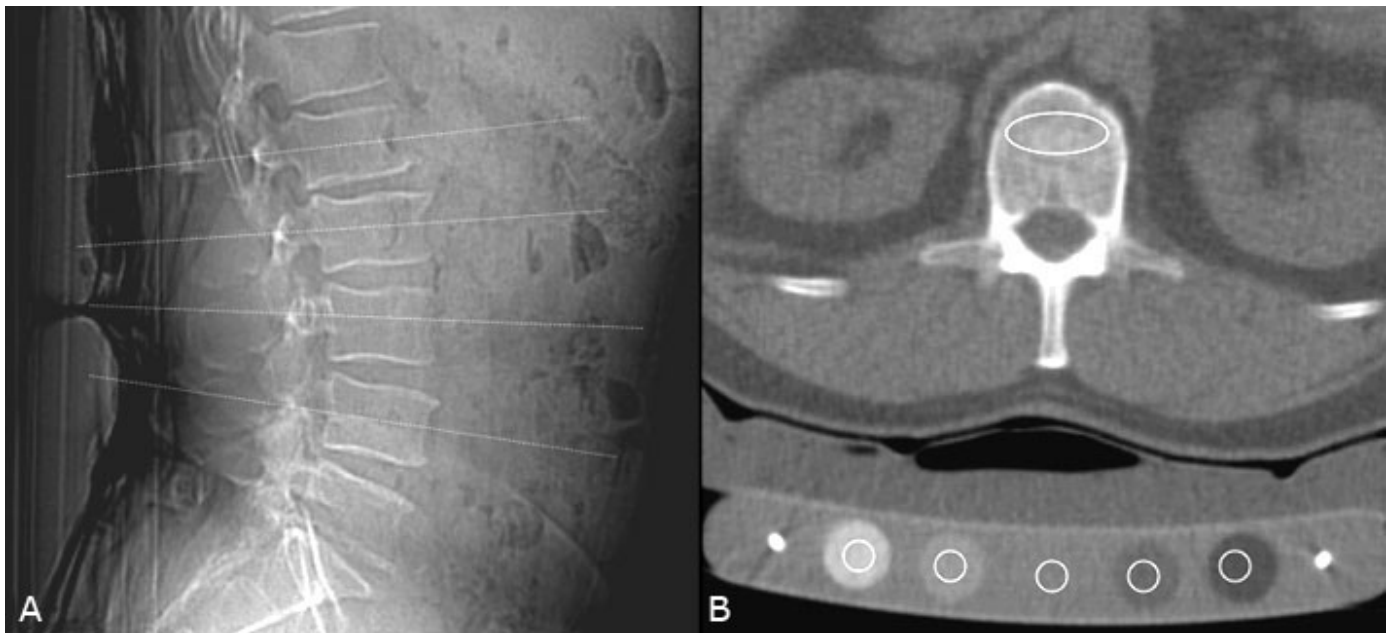


Figure A: Lateral scout image of the spine used to place the scans in the center of the L1, L2, L3, and L4 vertebrae, parallel to the endplate.

Figure B: Sample axial image through the L1 vertebra, showing placement of the region of interest in a region of pure trabecular bone. The densitometry “phantom” used to quantify the CT image is also shown below the patient.

Bone Density Scan Interpretation

Bone densitometry results are reported in standard deviation (SD) as T-scores and Z-scores, both of which determine the difference between an individual’s BMD with a population mean. The T-score references a young healthy population of the same sex whereas the Z-score population standard is adjusted to match the patient age. A low T-score is a measure of future fracture risk, since this risk is due to absolute bone

loss. A low Z-score indicates that the patient’s BMD is worse than others of the same age. If so, an evaluation for a secondary cause of osteoporosis may be indicated.

Although the World Health Organization defines osteopenia as a T-score of -1 to -2.5 , 15% of a young healthy population might have a T-score of -1.0 or lower on statistical grounds alone, whereas only 5%

might have a T-score of – 2.0 or lower. Osteoporosis is defined as a BMD T-score <-2.5. However, for each SD drop in bone density, the risk of fracture doubles. Patients with T-scores of <-2.0 should be considered at risk for future fractures and are candidates for treatment, as are elderly patients with T-scores of <- 1.5.

T- and Z-scores may vary considerably among skeletal sites, both because of normal variations in the proportions of cortical and trabecular bone, as well as variations in the rate of bone loss, which is often greater in trabecular bone. For example, lumbar spine T-scores are often much lower than those from the femoral neck because vertebral bodies are largely made up of trabecular bone. Thus the spine is generally most useful for detecting osteoporosis, if the interfering effects of spinal osteoarthritis are avoided. If the T-scores vary from site to site, it is generally recommended that treatment decisions be based on the lowest T-score. Modified scans are available for special purposes. Forearm scans are useful in patients with hyperparathyroidism or hyperthyroidism, diseases which selectively affect cortical bone.

Monitoring Disease Progression

Bone densitometry can also be used to monitor disease progression or the effectiveness of therapy over time. Changes in posterior-anterior lumbar spine BMD >0.03 gm/cm² are considered to be true changes. Similarly, changes of >0.04gm/cm² in the lateral lumbar spine, total hip, or femoral neck are almost always due to true changes in the patient's skeleton. Changes are most often seen in the lumbar spine.

References

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Comparison of DEXA and QCT	
DEXA	QCT
Low radiation dose 400 rems	Somewhat higher radiation dose
Bone mineral density of area (2D)	Bone mineral density of volume (3D); can be segmented into cortical and trabecular bone
High reproducibility	Less reproducible than DEXA
Accuracy may be limited by: Spinal deformity Vertebral compression fracture Osteoarthritis	High accuracy

Scheduling

The MGH Department of Radiology and the Endocrine Unit are now collaborating in the performance of bone density examinations. Appointments at all sites can be scheduled through the Radiology Order Entry system, <http://mghroe/> or by calling 617-724-9729 (Radiology) or 617-726-3839 (Bone Density Laboratory, Endocrine Unit).

Further Information

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