Diagnostic Tools for Osteoporosis in Older Adults

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Low bone density is major risk for osteoporotic fracture. In older adults special precautions apply in interpreting bone mineral density measurements (either by central dual energy X-ray absorptiometry [DXA] or peripherally with calcaneal ultrasonography). Clinical assessment for vertebral fractures is an important part of the management. Therapeutic regimes for osteoporosis treatment are complicated and require repeated reinforcement to ensure long term compliance. Adequate compliance (80%) is required for optimal therapeutic benefit.

Key words: *calcaneal ultrasonography, central dual energy x-ray absorptiometry (DXA), bone mineral density (BMD), older adult, special precautions*

Introduction

Osteoporosis is a disorder of bone microarchitecture resulting in an increased susceptibility to fracture. Bone strength is dependent on both bone mineral density (BMD) and bone quality. At present, we only have tools to measure BMD, and we use this information as a major factor to help us define a patient's fracture risk. The only clinically available indicator of bone quality is the presence of a prior "fragility fracture" in adulthood (usually after age 40). A fragility fracture is one occurring with low trauma, such as might occur after a fall from a standing height or less.

Measuring Bone Mineral Density

Bone mineral density can be measured both peripherally (appendicular skeleton) and centrally (axial skeleton). Central measurement of spine and hip BMD, with dual energy x-ray absorptiometry (DXA) is the most widely used technology and has the most data validating it as a predictor of fracture risk. Bone mineral density as measured by DXA is actually an estimate of density extrapolated from a two dimensional x-ray projection and expressed as grams of calcium per square centimetre. An individual's result is then expressed as the number of standard deviations from the mean BMD of a healthy young-adult reference population (known as the T-score). Based on this measurement patients are categorized by the World Health Organization (WHO)[1] into normal, low bone mass (formerly "osteopenia"), or osteoporosis categories (Table 1); this information is used to assess relative fracture risk.

A variety of methods are available to measure bone in the appendicular skeleton, the most popular being ultrasound. These methods are often used for screening programs in community settings, such as drugstores. However, in some communities where DXA is not readily available, these tools may also be used for diagnosis. Diagnostic cut-offs are not comparable to the WHO diagnostic criteria as the latter are based on central DXA measurement. Diagnostic cut-offs are usually defined per individual instrument. A recent position statement was published by the International Society for Clinical Densitometry (ISCD)[2] on the use of quantitative ultrasonography (QUS) tools in the management of osteoporosis. The ISCD statement concluded that the heel is the best site for fracture risk assessment, and that validated QUS devices predict fragility fracture in postmenopausal women and men over the age of 65, independently of central DXA BMD. They also stated that osteoporosis cannot be diagnosed by QUS according to the WHO classification for DXA, but that each instrument can identify specific thresholds. Quantitative ultrasonography cannot be used to monitor the skeletal effects of osteoporosis treatment. There are also many technical challenges with QUS that can lead to errors, including positioning and the coupling medium used. The authors concluded that QUS use is only justified in situations where central DXA is unavailable.

Table 1: T-Score Cut-Offs

Status	T-Score
Normal	+2.5 to –1.0 inclusive
Low bone mass (osteopenia)	Between –1.0 and –2.5
Osteoporosis	≤–2.5
Severe osteoporosis	≤–2.5 and fragility fracture

Central Dual Energy X-Ray Absorptiometry

T-score cut-offs are derived from comparison to young healthy women, not age-matched women (as with a z-score). The T-score cut-offs (see Table 1) have now also been applied to men, but there is still debate about their validity in premenopausal women and children. In the latter, z-scores are used in preference to T-scores.

When to Measure Bone Mineral Density

Table 2 provides details on when to order a DXA test. Dual energy x-ray absorptiometry is measured as a baseline at the start of treatment and for diagnostic purposes, although if a patient has already had a fragility fracture (defined as a fracture of wrist, arm, shoulder, rib, spine, pelvis, or hip resulting from low trauma; e.g., a fall from a standing height or less), the diagnosis is osteoporosis irrespective of the DXA result. New Canadian DXA reporting guidelines[3] recommend that an absolute 10-year fracture risk be calculated based on the lowest T-score and the patient's age. Risk categories are raised by prior fragility fracture, or chronic use (>3 months) of glucocorticoids (Figure 1).[3]

There is ongoing debate as to the frequency of follow-up DXAs. In most cases, it takes several years for BMD to undergo a change that is outside the margin of error of the measurement (least significant change). In certain conditions (e.g., chronic glucocorticoid therapy), significant loss of BMD can occur in one year. Current Canadian Guidelines recommend testing BMD one year after initiation of an osteoporosis therapy, to rule out failure to respond to the therapy (and obtain provincial drug plan permission to switch to a newer, often more expensive, medication).[4] Table 3 summarizes some recommendations as to when to order a DXA for follow-up and the special cautions that are needed.

Special Issues for Older Adults

Osteoarthritis can make interpretation of the spine BMD impossible. Hip

Table 2: When to Order Bone Mineral Density Testing for Fracture Risk Assessment*

A. Postmenopausal women and men over age 50, with one of the following:
Fragility fracture† after age 40
Radiographic evidence of osteoporosis (osteopenia or asymptomatic vertebral fracture)
Secondary causes of osteoporosis, such as chronic (>3 months) glucocorticoid therapy, chronic heparin therapy, malabsorption syndromes, or primary hyperparathyroidism
Family history of fragility fracture (especially maternal hip fracture)
Male hypogonadism; menopause before age 45
Two of the following lesser risk factors: • Low body mass (<57 kg) • Weight loss >10% of young adult weight • Rheumatoid arthritis or previous hyperthyroidism • Smoker >20 cigarettes per day • Alcohol intake >2–4 drinks per day • 1,000 mL (4 cups) or more of caffeinated coffee per day • Low dietary calcium intake • Age ≥65 years
B. Younger Men and Premenopausal Women
Select patients with high-risk conditions such as having undergone organ transplantation, glucocorticoid therapy, significant fragility fracture history, eating disorders, hypoestrogenic amenorrhea, and male hypogonadism

*Bone mineral density should be measured using dual energy x-ray absorptiometry.
†Fragility fracture = fracture with low trauma (i.e., a fall from a standing height or less) of wrist, arm, shoulder, rib, spine, pelvis, or hip.

Table 3: When to Order Dual Energy X-Ray Absorptiometry Bone Mineral Density for Follow-Up

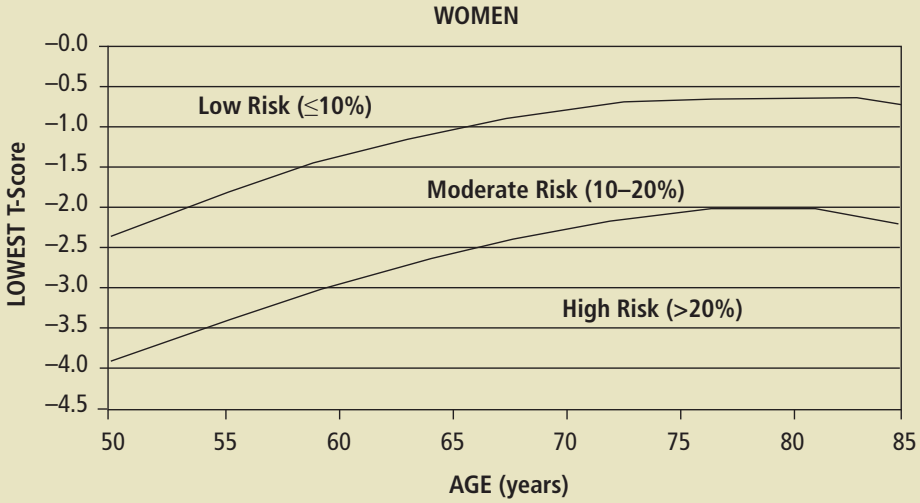
Cautions
BMD is much more useful for diagnosis (risk assessment) than for follow-up.
Follow-up BMD should always be done on the same machine as the first measurement.
Follow-up is limited by precision error of DXA: • A significant change in the spine is >2–3%. • A significant change in the hip is >4–5% (more than can be expected with most treatments). • A change of 10% or more in 1 year usually represents technical problems with the measurements, but a major illness or weight change >10% can cause DXA BMD to change this much.
A. Follow-Up of Treatment
Measure at 1–2 years to identify possible treatment failure (significant loss).
Subsequent measurements should be done at 2- to 5-year intervals.
Measure a new baseline BMD when the treatment changes.
B. Follow-Up, No Therapy
Measure after 3–5 years.
C. Yearly Follow-Up BMD Recommended for Patients with Secondary Causes of Osteoporosis
Secondary causes include chronic glucocorticoid therapy, chronic heparin therapy, malabsorption syndromes, and primary hyperparathyroidism.

BMD = bone mineral density; DXA = dual energy x-ray absorptiometry.

Figure 1: Using Bone Mineral Density and Age to Assess 10-Year Fracture Risk*

Use patient's lowest T-score (lumbar spine, femoral neck, or total hip) to define 10-year fracture risk

Raise fracture risk to next category if patient has:
(1) had a prior fragility fracture† or (2) ever used chronic (>3 months) glucocorticoids
A patient >50 with both (1) and (2) is in high-risk category, irrespective of BMD



BMD = bone mineral density.
*Fracture risk category is only for untreated patients; most osteoporosis therapies reduce risk by 40–60% (i.e., 20% becomes 10%).
†Fragility fracture = fracture with low trauma (i.e., a fall from a standing height or less) of wrist, arm, shoulder, rib, spine, pelvis, or hip.

Source: Siminoski K et al., 2005.[3] Reproduced with permission from the Canadian Association of Radiologists Journal.

Table 4: Evaluation of Response to Therapy

Height Loss (see Figure 2)
1. Historical height loss = Patient's tallest recalled height – Measured height Diagnostic threshold >6 cm
2. Prospective height loss = Measured height 1 – Measured height 2 Diagnostic threshold >2 cm over 1–3 years of monitoring
Wall-Occiput Distance (see Figure 2)
Patient stands straight, with heels to the wall, facing forward
Lower margin of eye in line with upper edge of tragus
Measure with tape measure (or use fingerbreadths and measure fingers)
Diagnostic threshold >6 cm
Rib-Pelvis Distance (see Figure 2)
Locate lower rib and superior iliac crest in midaxillary line
Measure distance using hand and quantify in fingerbreadths
Diagnostic threshold >2 fingerbreadths (1 fingerbreadth = 1.75 cm)

osteoarthritis can cause difficulties in positioning the patient correctly for hip measurement. However, as long as the hip is positioned consistently with each DXA, it is still possible to follow hip BMD.

A previously fractured hip cannot be used in the assessment of BMD. Similarly, interpretation of BMD in a fractured vertebra is not possible; thus, an average value of vertebral BMD can be misleading in some cases.

Decreased mobility in older adults may prevent DEXA testing due to the patients' difficulties in getting to the testing facility or getting onto the examination table.

Changes in weight may cause a change in BMD values not related to bone health.

Finally, vascular calcification can be included in the BMD measurement of the vertebra and may result in falsely elevated BMD measurements.

Conclusion

Inadequate BMD is an additional risk factor for fracture, along with advancing age. Bone mineral density assessment needs to be interpreted with caution in older adults. Appropriate medical management of osteoporosis should not be withheld because of a lack of BMD assessment. Response to therapy can be evaluated clinically with height, wall-occiput distance, and rib-pelvis distance evaluation (Figure 2 and Table 4).

Adherence with therapy remains the biggest challenge, and appropriate directions need to be repeated regularly for oral bisphosphonate users. Pharmacists also need to be educated to package the oral bisphosphonates separately in dosettes and blister packs. Once-weekly therapy has been available for some time. There are now two additional oral regimes for residronate: two consecutive days monthly (75 mg daily for two days); and once monthly (150 mg). A once yearly intravenous bisphosphonate is now also available in Canada (zoledronic acid 5 mg IV yearly). These options may enhance compliance in some patients.

Figure 2:
Changes in the Spine with Vertebral Fracture

A height loss
B wall-occiput distance
C rib-pelvis distance

Height loss

There are two types of height loss; historical height loss and prospective height loss.

HHL = Patient's tallest recalled height – Measured height

diagnostic threshold: HHL >6 cm

PHL = Measured height 1 – Measured height 2

diagnostic threshold: PHL >2 cm over 1–3 years of monitoring

Wall-Occiput distance

Patient standing straight
Heels to wall
Facing forward
Lower margin of eye in line wtih upper edge of tragus
Measure with tape measure (or use fingerbreadths and measure fingers)

diagnostic threshold: WOD > 6 cm

Rib-Pelvis distance

To measure this distance locate the lower rib and superior iliac crest in midaxillary line. Measure the distance using fingerbreadths.

diagnostic threshold: RPD <2 fingerbreadths 1fb = 1.75 cm

diagnostic cut-offs:
HHL >6 cm
PHL >2 cm
WOD >6 cm
RPD <2 fingerbreadths

Key Points

- Dual energy x-ray absorptiometry T-score cut-offs are applicable in older men and women.
- The lack of a bone mineral density measurement should not prevent treatment after a fragility fracture.
- Dual energy x-ray absorptiometry results should be interpreted with caution among older adults as technical errors have the potential to be more prevalent in this population.
- Clinical methods should be used to evaluate efficacy.
- Medication administration instructions and compliance should be reinforced often.

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References

1. World Health Organization. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis. Technical report series no. 843. Geneva, Switzerland: The Organization; 1994.
2. Krieg M, Barkmann R, Gonnelli S, et al. Quantitative ultrasound in the management of osteoporosis: the 2007 ISCD Official Positions. J Clin Densitom 2008;11:163–87.
3. Siminoski K, Leslie WD, Frame H, et al. Recommendations for bone mineral density reporting in Canada. Can Assoc Radiol J 2005;56:178–88.
4. Scientific Advisory Council of the Osteoporosis Society of Canada. 2002 clinical practice guidelines for the diagnosis and management of osteoporosis in Canada. CMAJ 2002;67 Suppl:S1–34.