REVIEW ARTICLE

Diagnosing Osteoporosis at Menopause: Options Available Apart from DEXA

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Abstract

Bone resistance to fractures is helped by micro and macrostructures, bone marrow density (BMD), and adjacent tissues (e.g., cartilages, muscles). Such complementary factors shall be analyzed when BMD alone does not explain increased fracture risk (e.g., the presence of desmophytes in the vertebral column). Initial evaluation of fracture risk can be carried out automatically based on a single abdomen or chest computed tomography (CT) when FRAX without BMD is not available. As CT has high radiation exposure risk and cost concerns opportunistic screening of osteoporosis can be done when CT is done for other health conditions (from chest, abdomen, pelvis, and spine). Trabecular bone score (TBS) can assess patients with osteophytes as osteophytes lead to inaccurate BMD measurements. Trabecular bone score and quantitative ultrasound assess different characteristics of bones. Magnetic resonance imaging (MRI) may allow the identification of patients with fracture risk not detected by DXA.

Keywords: Bone, Osteoporosis, Quantitative computed tomography, Trabecular bone score.

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Introduction

Osteoporosis affects 200 million women worldwide. Dual energy X-ray absorptiometry (DEXA) is the clinical reference standard for diagnosing osteoporosis. Other imaging modalities have their benefits and limitations for the diagnosis of osteoporosis. This chapter focuses on the measurement of bone quality, quantity and evaluation of osteoporosis apart from DEXA. Complementary techniques include vertebral fracture assessment and trabecular bone score.

Vertebral Fracture Assessment (VFA)

International Society for Clinical Densitometry (ISCD) recommends VFA when T-score is less than –1 associated with one (or more) of the following:[1]

- Women >70 years of age
- Men >80 years
- Height loss >4 cm
- History of vertebral fracture
- History of glucocorticoid therapy for three months

In addition to the above United Kingdom National Osteoporosis Guidelines Group (UK NOGG) recommends VFA for women >50 years of age with bone marrow density (BMD) T-score ≤ –2.5 at either the spine or hip or in cases of acute onset back pain with risk factors for osteoporosis (Fig. 1).[2]

Magnetic Resonance Imaging (MRI)

Magnetic resonance imaging assesses the microarchitecture of trabecular bone and can better predict fracture risk compared to DEXA. MR Spectroscopy can assess quantitative nonmineralized bone compartments by extracting bone marrow fat fraction. Chemical shift encoding-based water-fat MRI can differentiate pathological from an osteoporotic fracture. This is a boon of clinical significance. Post-procedure image analysis tools have the potential to improve MRI-based fracture risk assessment.

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Advantages

- High spectral resolution
- High accuracy
- High sensitivity
- Disadvantage
- Expertise is needed for processing the spectra
- Manual planning is needed

Trabecular Bone Score (TBS)

A useful index to assist the osteoporotic fracture risk in postmenopausal women is trabecular bone score. Assessment of trabecular bone has a role in assessing bone quality along with BMD measurement. It images heterogeneous type vs homogeneous type bone. Dense trabecular bone has high TBS while more porous, osteoporotic trabecular bone has a low TBS value and is associated

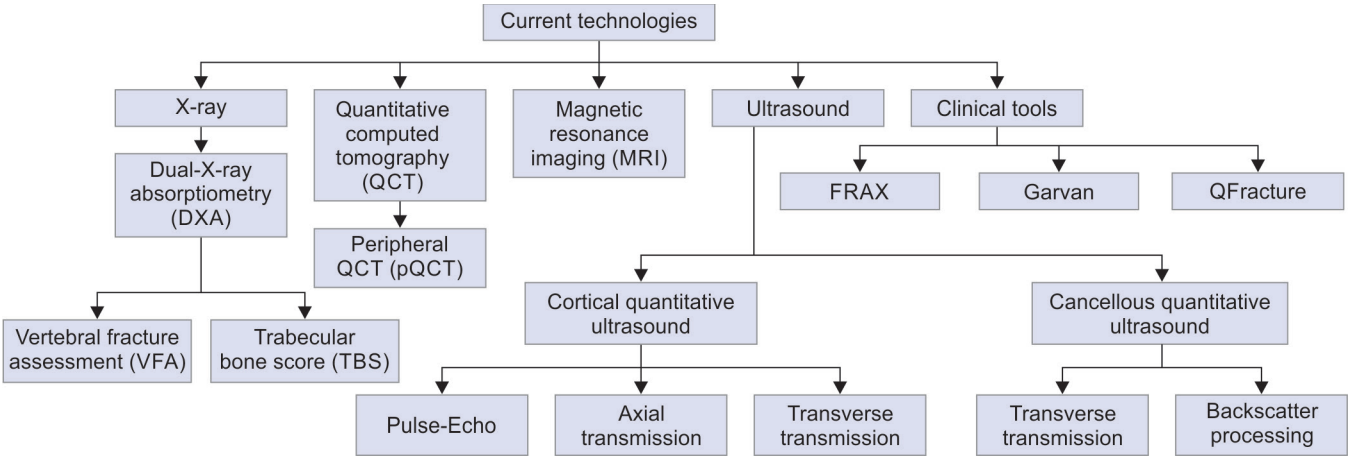

Fig. 1: Current technologies in diagnosing osteoporosis

with more fragility fractures in postmenopausal women. Value for the total lumbar spine is given without any units and for L1–4 it is given separately.

Normal bone TBS >1.31.

Partially degraded 1.23–1.31.

Degraded bone is <1.23, i.e., high value is fracture resistant. However, it is not used for follow-up as a correlation with increasing BMD is not established.

Trabecular bone score and a vertebral fracture severity index.[3]

Quantitative Computed Tomography (QCT)

Quantitative computed tomography has some pertinent advantages over DXA.

Quantitative computed tomography separates trabecular and cortical compartments and this is more sensitive to therapy than combined trabecular/cortical measurements as in DXA. It gives a BMD and not a Q score. To document bone loss QCT is superior to DEXA. Spine BMD QCT is not influenced by osteoarthritis of the spine. vertebral strength can also be assessed. Images obtained from the hip and lumbar spine though the proximal femur, forearm, and tibia are also been investigated.

In advanced osteoarthritis, QCT may be superior to DEXA but the cost and high radiation exposure are the limiting factor for its use.[4]

For Spine

- BMD >120 mg/mL is normal
- 80–120 mg/mL osteopenia
- <80 mg/mL osteoporosis

For Hips

In premenopausal women, men younger than 50, and children Z-scores are used, Z-score ≤ –2.0 is abnormal.[5]

Trabecular BMD is affected more by metabolic diseases and it measures the same so it is an important tool for diagnosing BMD and it has superior soft tissue differentiation. Quantitative computed tomography is less influenced by confounding factors like superimposition of overlying structures, spinal degenerative changes, aortic calcification, bone size, and BMI.[6]

Disadvantage

- Higher radiation dose
- Movement artifacts during QCT scanning

Peripheral Quantitative Computed Tomography

- Can assess at arms or legs
- Cost and radiation is less compared to general CT

Quantitative Ultrasound

Cheap and non-invasive done on the forearm or calcaneus.

It is a predictor of fracture risk in osteoporotic women. If DEXA is not available or cannot be done, one can initiate pharmacological treatment if risk factors and probability of fractures are high with ultrasound. In one study it has been found comparable to DEXA. The drawback is both technical parameters and techniques lacks standardization.

Blood and urine tests can diagnose metabolic bone diseases leading to secondary osteoporosis.

Bone Turnover Markers

Markers of Osteoblastic Bone Formation

- Alkaline phosphatase ALP has a low sensitivity and specificity in metabolic bone disorders and
- Osteocalcin (OC)
- Collagen type I protein produced by the osteoblasts bone formation marker

Markers of Osteoclastic Bone Resorption

- Pyridinoline (Pir) and deoxypyridinoline
- ICTP c-terminal telopeptide of type I collagen (ICTP) and
- β-cross laps (β-CTX) and NTX peptides released during the process of bone resorption have great clinical significance

Bone Biopsy

It is invasive and is advised only when the tumor is suspected or diagnosed.[7]

Conclusion

Electromechanical impedance is an emerging technology that is free of ionizing radiation. Stimulus-response measures bone

response resulting from the mechanical stimulus. Quantitative computed tomography has the potential to diagnose and monitor osteoporosis. Newer technologies have promising preliminary results, but further investigations to prove their potential to diagnose osteoporosis are needed.

Future Perspective

Finite element models and peripheral QCT have also been successfully applied to calculate bone strength and stiffness of distal radius. Quantitative indices in MRI to characterize cortical strength have also been proposed. Cone-beam computed tomography (CBCT), used in oral and maxillofacial surgery, can be used as a screening tool for early detection of osteoporosis. The need of the hour is to develop technology to complement the existing procedures for osteoporosis diagnosis, to improve the results, and to reduce the associated costs. Computer-based algorithms can be used clinically. Microwaves applied to ribs needs future studies.

Recommendations

Bone resistance to fractures is helped by micro- and macro-structures, BMD, and adjacent tissues like cartilages, and muscles. Such complementary factors shall be analyzed when BMD alone does not explain increased fracture risk (e.g., the presence of desmophytes in the vertebral column). Trabecular bone score, QCT, quantitative ultrasound (QUS), high-resolution peripheral quantitative computed tomography (HR-pQCT), multidetector CT (MD-CT), and MRI have their significance in diagnosing Osteoporosis apart from DEXA.

High-risk populations should be screened to find the persons who are eligible for treatment.

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